GRENADA, CARRIACOU & PETITE MARTINIQUE

Second National Communication to the United Nations Framework Convention on Climate Change

The Government of Grenada

JULY 2017

FOREWORD

I am pleased to present this the Second National Communication (SNC) on the behalf of the Government of Grenada, to the United Nations Framework Convention on Climate Change. Over the past few years Grenada has experienced several climate-related disasters that have destroyed entire sectors and set the country back in terms of national development. However despite these setbacks we have continued to show our commitment to the reducing climate change and its impacts on the society.

With the assistance of bilateral and multilateral partners we have been able to make many strides with respect to our work on reducing greenhouse gas emissions and building resilience to the impacts of climate change. Development of a national energy policy, a national climate change policy and action plan, integrating climate change into our national development plans and several ministerial corporate plans, climate proofing plans and piloting examples of climate change adaptation and mitigation actions at the national, local and community level are just a few of the actions we have undertaken. While they have started yielding results, there is still quite a lot to be done.

As one of the first countries to sign and ratify the Paris agreement, this SNC process has taken place in a very timely manner, a time when we are developing national plans and policies, not only for climate change adaptation and mitigation, but integrating climate change considerations into our overall national development planning. The SNC process has therefore proven to be very integrated, taking into consideration and building on the Nationally Determined Contributions, the National Adaptation Plan process, the Technology Needs Assessment process and the development of the first Nationally Appropriate Mitigation Action for the country.

Our SNC outlines our actions and commitment to reducing GHG emissions, our vulnerabilities and the potential solutions to protect our ecosystems and livelihoods from the impacts of climate change.

While we are encouraged by the commitments made by the (I)NDCs put forward thus far we are aware that there is need for scaled up commitment and action to secure a safe healthy planet for future generations. In that light I would like to take this opportunity to encourage and urge all countries to undertake actions that are truly reflective of their national circumstances.

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The Honourable Simon Stiell

Minister of State, Responsible for Human Resource Development and the Environment

ACKNOWLEDGEMENTS

The preparation and publishing of this Second National Communication to the United Nations Framework Convention on Climate Change (UNFCCC) represents the considerable, collective effort of several personnel and agencies over the period January 2016 – June 2017.

Foremost, gratitude is extended to the Global Environment Facility (GEF), the United Nations Development Programme (UNDP) Sub-Regional Office for Barbados and the OECS, and the Global Support Programme by UNDP and the United Nations Environment Programme (UNEP) for the financial and technical support that made this submission possible. Gratitude is extended specifically to Ms. Danielle Burnham, Programme Manager – Climate Change and Disaster Risk Resilience for her guidance and oversight.

Special thanks are also extended to those key personnel serving in their capacities as UNFCCC and GEF National Focal Points, Operational Focal Points and members of the National Climate Change Committee (NCCC) over the project's duration for their invaluable time and contributions of data, information and expertise to the preparation and review processes:

- Ms. Jacinta Joseph — UNFCCC National Focal Point; Permanent Secretary with responsibility for Human Resource Development and the Environment
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- Mr. Leon Charles — Member, National Climate Change Committee
- Dr. Spencer Thomas — Ambassador for Multilateral Environmental Agreements; member, National Climate Change Committee
- Mr. John Auguste — Head – Energy division; member, National Climate Change Committee

Special mention is made of the Gesellschaft für Internationale Zusammenarbeit (GIZ) Grenada team members who were simultaneously lending support to the Government of Grenada in the preparation of Grenada's National Climate Change Adaptation Plan (2017-2021) and Revised National Climate Change Policy (2017-2021) under the Integrated Climate Change Adaptation Strategies (ICCAS) programme. The fortuitous coincidence of these initiatives enabled synergistic efforts that helped to enhance outputs.

The time and contributions from stakeholders across Grenada are also recognised, representing ministries and agencies in the public sector, private and non-governmental entities, as well as research and academic institutions, who participated in the various consultations held as part of the project.

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COVER PHOTO: Grand Etang Lake, Grenada

SUMMARY FOR POLICY MAKERS

Greenhouse gas (GHG) climate change/global warming is one of the most pressing environmental concerns today. Furthermore, Small Island States such as Grenada and its dependencies (Carriacou and Petite Martinique) are highly vulnerable to climate change because of their small size and low elevation, which increases their sensitivity to climate change and limits their ability to adapt. In fact, the IPCC (Intergovernmental Panel on Climate Change) claims that adaptive capacity of human systems is generally low in Small Island States as Grenada, and vulnerability high. Small Island States, like the tri-state of Grenada, are therefore likely to be among the countries most seriously affected by climate change and its impacts. One of the most important consequences of climate change, especially for small islands, is sea level rise and storm surge events, which in turn can severely impact upon coastal waters and coastal infrastructure, access roads and bridges and buildings, well into the future.

Non-Annex I Parties are mostly developing countries. Certain groups of developing countries, such as Grenada and its dependencies (Carriacou and Petite Martinique) are recognized by the UNFCCC (United Nations Convention on Climate Change) as being especially vulnerable to the adverse impacts of climate change, including countries with low-lying coastal areas and those prone to desertification and drought. The Convention emphasizes activities that promise to answer the special needs and concerns of these vulnerable countries, such as investment, insurance and technology transfer.

Over the past few years Grenada has experienced several climate-related disasters that have destroyed entire socioeconomic sectors and set the country back in terms of national development. However, despite these setbacks Grenada continues to demonstrate its commitment to the reducing climate change and its impacts on the society.

With the assistance of bilateral and multilateral partners the tri-state of Grenada has made significant strides with respect to its work on reducing greenhouse gas emissions and building resilience to the impacts of climate change. Development of a national energy policy, a national climate change policy and action plan, integrating climate change into its national development plans and several ministerial corporate plans, climate proofing plans and piloting examples of climate change adaptation and mitigation actions at the national, local and community level are just a few of the actions that the tri-sate of Grenada has undertaken.

The recent entry into force of the Paris Agreement has reinforced Grenada's commitment to addressing climate change. The Agreement places unprecedented importance on climate change impacts on the most vulnerable nations and highlights the actions needed, both nationally and globally, to help people adapt, and to promote greater resilience to climate change.

The tri-state of Grenada is currently developing national plans and policies, not only for climate change adaptation and mitigation, but integrating climate change considerations into its overall national development planning. These plans include the Nationally Determined Contributions, the National Adaptation Plan process, the Technology Needs Assessment process and the development of the first Nationally Appropriate Mitigation Action for the country.

National Circumstances

Grenada is a Small Island Developing State (SIDS) located in the south-eastern Caribbean, made up of several islands all with its own individual characteristics. Grenada is comprised of three islands, including Grenada, Carriacou and Petite Martinique: combined land area of all three islands is 345 km2 and is the southernmost of the Windward Islands: 12.07° N and 61.40° W.

The recent entry into force of the Paris Agreement has reinforced Grenada's commitment to addressing climate change. The Agreement places unprecedented importance on climate change impacts on the most vulnerable nations and highlights the actions needed, both nationally and globally, to help people adapt, and to promote greater resilience to climate change. A new requirement under this Agreement is for Parties to prepare and submit successive Nationally Determined Contributions (NDCs) reports that outline the greenhouse gas emission reduction targets to which the respective Party commits, and the ways in which these targets are intended to be achieved. Grenada was one of the first Parties to have met its NDC obligation to the Agreement. The INDC outlines the nation's target for reducing national greenhouse gas emissions by 30% of 2010 national emission levels by 2025.

Grenada's INDC will cost USD$161,430,500.00 to implement through 2025. Grenada anticipates meeting these costs through access to multilateral and bilateral support including through the Green Climate Fund, multilateral agencies and bilateral arrangements with development partners. These funds will be used to leverage the limited national resources and technical capacities that are available for combatting climate change.

The tri-state of Grenada is currently developing national plans and policies, not only for climate change adaptation and mitigation, but integrating climate change considerations into its overall national development planning. These plans include the Nationally Determined Contributions, the National Adaptation Plan process, the Technology Needs Assessment process and the development of the first Nationally Appropriate Mitigation Action for the country. The Second National Communication (SNC) outlines the county's actions and commitment to reducing GHG emissions, its vulnerabilities and the potential solutions to protect its ecosystems and livelihoods from the impacts of climate change.

The islands of Grenada are predominantly volcanic in origin and are almost entirely composed of andesite lava (in the centre of the island) and basalt and pyroclastic rocks (in a belt along the rim). The topography of mainland Grenada is varied, but is generally steep: seventy one percent of the land has a slope of over 20 degrees. Carriacou's terrain is less hilly with only 50% of the land having slopes greater than 20 degrees, while Petite Martinique's terrain is rugged with 90% of the lands having slopes greater than 20 degrees. Mainland Grenada's interior mountains produce heavy orographic rainfalls, especially in the wet season and this results in an abundance of watersheds (71) and surface streams that flow towards the coast in a distinct radial pattern. Carriacou and Petite Martinique also have mostly intermittent surface streams, Grenada, Carriacou and Petite Martinique enjoy a humid tropical marine climate that is strongly shaped by their location and topography. The climate is influenced by Tropical North Atlantic Hurricane activity, the North Atlantic Sub-Tropical High, the North-East Trade Winds, by weather associated with the migrating Inter-Tropical Convergence Zone (ITCZ) and by the El Nino/ La Nina (ENSO) phenomenon.

In Grenada and its dependencies, observed average annual temperatures do not vary significantly, with a minimum average of 28.3°C and a maximum average of 33.3°C. The tri-state of Grenada experiences most of its rainfall during the Tropical Atlantic Hurricane wet season which normally lasts from June to December (Government of Grenada, 2015g). The ITCZ activity also influences the weather in tri-state Grenada when the ITCZ is at its most northern position during the middle months of the year. The dry season, when the least rainfall is generally recorded, occurs during the January to May period. On mainland Grenada, topography and orographic processes are key factors causing the significant spatial variations in rainfall, with annual averages ranging from approximately 1,000 - 1,500 mm per year in drier coastal locations, to approximately 4,000 mm in the central mountainous areas; Carriacou and Martinique are much smaller and flatter, and thus have little or no orographic influences on total rainfall: therefore, lower rainfall figures are generally recorded, and climate tends to be relatively even across both islands (Government of Grenada, 2011c).

Tropical Storms and Hurricanes occur less frequently in Grenada due to its proximity to the equator. However, hurricanes such as Ivan in 2004 and Emily in 2005 have hit the islands causing destruction to ecosystems and infrastructure and economic declines.

Grenada's total population was estimated at 109,374 in 2014 (Government of Grenada, 2015e) and the vast majority of the population was between the ages of 15 to 55 years.

Key contributors to GDP in 2013 were: education (18.78 %); real estate renting and business activities (14.33 %); transport, storage and communications (13.39 %); wholesale and retail trade (7.87 %) and construction (7.38 %) (ECCB, 2016b). However, the Tourism sector is extremely important to the economy of Grenada due to its contribution to GDP, employment creation and foreign exchange earnings: in 2014, it is estimated that tourism directly contributed XCD $154.4 million to the country's economy. In 1977, Agriculture (including production of crops, livestock and forestry) contributed 20% to Grenada's GDP; however, by 2014 the sector was estimated to account for 5.82% of GDP. In 2014, Grenada's fishing industry projected contribution to GDP was 1.74%.

As for trade, there is a significant balance between imports (916.79 million XCD) compared exports (99.75) million XCD in 2014 (ECCB, 2016b).

In regard to national policy and regulation relevant to climate change, activities at the national level in Grenada over the last decade have been foremost guided by the National Climate Change Policy and Action Plan (NCCPAP) 2007 – 2011 (Government in Grenada, 2007). Eight (8) strategies were outlined to achieve this objective, presented in the Policy as follows:

- Climate-proofing present and future national development activities by requiring a climate risk analysis of all ongoing and new development initiatives;
- Strengthening the collection, analysis and use of climate-related data and impacts;
- Building local human capacity to assess and respond to climate change, including through the access and use of appropriate technologies;

- Reducing greenhouse gas emissions through increased energy efficiency and the use of renewable energy;
- Eliminating unsustainable livelihood and development practices that increase climate change vulnerabilities;
- Sustained public awareness and education programming;
- Foreign policy advocacy for international action on climate change;
- Joint Implementation and networking with OECS and CARICOM partners and other SIDS.

GHG Emission Trends

The methodology used to compile the greenhouse gas (GHG) inventory for Grenada for the years 2000 to 2014 was the IPCC 2006 Guidelines for National Greenhouse Gas Inventories. Based on data availability, estimates of GHG emissions and removals by sinks for the following sectors were undertaken:

- Energy (including transport)
- Industrial processes
- Waste
- Agriculture, Forestry and Other Land Use (AFOLU)

The following direct GHGs were considered: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and the F-Gases (HFCs, PFCs and SF_6). Indirect GHGs (Non-Methane Volatile Organic Compounds (NMVOC), nitrogen oxides (NOx), sulphur dioxide (SO_2) were not estimated for lack of data. All GHG emissions values were converted to equivalent CO_2 values (CO_2e) based on their global warming potentials: methane (CH_4) being 21 and nitrous oxide (N_2O) being 310.

Due to limited data availability, in all cases a Tier 1 methodology was used and extensive use of default Activity data (even compiled from similar countries) and Emission Factors from the IPCC Emission Factors Data Base (EFDB).

Energy (including Domestic Transport)

For the Energy (including domestic transport) sub-sector GHG emissions in 2000 was 212.8 Gg CO_2e and rose to 285.5 Gg CO_2e in 2014, an increase of 34.2%. This increase was mainly attributed to Energy industries (power plants).

Industrial Processes

Important industrial sectors include cement (producing CO_2 from the use of primarily limestone feedstock) and food and drink manufacture, chiefly sugar NMVOCs from fermentation and food production processes). In addition to the large manufacturing processes, emission from the use of fluorinated gases (HFC and SF_6) used in refrigeration, air conditioning, fire equipment, aerosols and some foams are included in the industrial processes sector.

For the Industrial Processes, sub-sector GHG emissions in 2000 was 1.4 Gg CO_2e and rose to 58.3 Gg CO_2e in 2014, 41 times the 2000 figure. This increase was mainly attributed to the dramatic increase since 1995 as chlorofluorocarbons (CFCs) banned by the Montreal Protocol were substituted by other agents.

Agriculture, Forestry and Other Land Use

In spite of ravages to the main commercial crops, namely nutmeg and cocoa, emissions from the sub-sector in 2000 was 16.6 Gg CO_2e and rose modestly to 18.3 Gg CO_2e in 2014, a meagre increase of 9.3 %. This small increase was mainly attributed to drought conditions even in the rainy season and to the destruction of crops caused by tropical storms and hurricanes. But enteric fermentation from animals and manure management showed slight increases in CH_4 emissions.

For the Forestry and Other Land Use sub-sector GHG emissions/removals in 2000 was 0.2 Gg CO_2e and 0.0 Gg CO_2e in 2014. This trend in this sub-sector was mainly because in 2004 and 2005 the sub-sector became a source of GHG emissions (887.1 Gg CO_2e instead of a sink following ravages of the forests and other ecosystems by Hurricane Ivan (2004) and Tropical Storm Emily (2005): the fermentation of the destroyed forests and other ecosystems led to GHG emissions. But starting in 2006 and leading up to 2010, the regrowth of the forests and other ecosystems led the sub- sector to become once again a sequestration sink (-177.4 Gg CO_2e).

Waste

For the waste sub-sector, the main GHG emitted is Methane (CH_4) from landfills and wastewater handling. For the Waste, sub-sector GHG emissions in 2000 was 41.2 Gg CO_2e and rose to 44.5 Gg CO_2e in 2014, an increase of 8%. This increase was mainly attributed to the slight increase in population and residential, commercial and industries, especially tourism related activities, generating more solid waste and waste water.

In summary then, in 2014 the Energy subsector (including domestic transport) accounted for 70.22%; the Industrial Processes sub-sector accounted for 14.34%; the Waste sub-sector accounted for 10.94% and the Agriculture sub-sector accounted for 4.49% of GHG emissions when expressed as CO_2e.

In conclusion then, it is recommended that for future National Communications that every effort be made to collect insofar as possible, the relevant activity data and develop local emission factors. Furthermore, it is recommended that there be a centralized agency responsible for collecting all activity data and emission factors and performing data quality controls so as to adhere to, consistency, completeness and comparability of the relevant data.

Current and Recommended Mitigation Measures

Grenada is committed to implementing mitigation strategies that will reduce GHG emissions, promote sustainable development and facilitate Grenada’s drive towards becoming a low-carbon economy. Appropriate mitigation strategies also serve as a no-risk option, which, although needing investment offer additional social, economic and environmental benefits in the long term.

As outlined by its Intended Nationally Determined Contribution (INDC) submitted to the UNFCCC in 2015, Grenada aims to reduce its greenhouse gas emissions by 30% by 2025 compared to a 2010 baseline. Since 2010, emissions in Grenada have seen an overall increase from 217 Gg CO_2e to 406.6

Gg CO_2e, representing an increase of 87%. This is largely due to unusually low carbon sequestration in 2010, as a result of the AFOLU sector acting as a carbon sink between 2006 and 2010, following the catastrophic impact of the hurricanes Ivan (2004) and Emily (2005) that made the AFOLU sub-sector a carbon source in 2004 and 2005 due to the deterioration of the destroyed forests and agricultural ecosystems. Not accounting for the AFOLU sector then, emissions in Grenada have only increased 3% between 2010 and 2014. Energy represents the only sector that has seen an overall emissions reduction since 2010, with an overall emissions reduction of 3%. The largest sub-sectors reductions have been achieved by the stationary combustion in manufacturing industries and construction, and electricity and heat production with reductions of 42% and 7% respectively. The main source of electricity demand is generally air conditioning by the hotel sector, accounting for up to 48% of total electricity demand.

However, mitigation actions such as improved energy efficiency and improved energy management have the potential to achieve substantial emissions reductions: for instance, Grenada's hotel sector has seen GHG reductions of 5,800 tCO_2 annually (Duffy-Mayers, 2014).

Analyses of potential future scenarios undertaken as a part of Grenada's preparation of the INDC (September 2015), and subsequently updated for the preparation of its Second National Communication (2017) assessed the likely future projected GHG emissions and removal scenarios, including and excluding implemented, planned, proposed, and possible mitigation actions divided into the following scenarios:

- The 'INDC' scenario (dark red line) shows the planned path to the target of a 30% reduction by 2025, and the indicate target of a 40% reduction by 2030 compared to a 2010 baseline.
- The BAU baseline (blue line) suggests that, due to projected GDP growth (forecasted to grow approximately 4 % per year between 2014 and 2030) (IMF, 2014), energy demand (and associated emissions) are likely to steadily increase to 2030. This represents a challenge for Grenada. However, it also offers opportunities to achieve economies of scale and reasonable returns on investment in renewable energy generation and energy efficiency implementation.
- The 'With Existing Measures' (WEM) scenario (purple area) includes implemented actions or actions in an advanced planning stage. These actions are most likely to be implemented. They assume no further action beyond those specified in the action plan. Any additional carbon reductions planned would be included under WAM and or WPM.
- The 'With Additional Measures' (WAM) scenario (pink area) includes additional actions deemed possible in the medium to long-term that are reasonably certain to be undertaken, including implementation beyond 2020 or 2025.
- The 'With Possible Measures' (WPM) scenario (orange area) includes any additional actions deemed possible in the medium to long-term, utilising the near-full potential for identified renewable energy sources in Grenada and would mainly be implemented beyond 2025.

The introduction and implementation renewable energies such as intermittent wind and solar and energy conservation measures such as cogeneration and Waste-to-Energy have the potential to reduce GHG emissions. However, the analyses further revealed that due to economic growth, the Government of Grenada should make sure its focus includes ensuring that efforts are sustained beyond 2020;

Furthermore, the analyses suggest that adequate emphasis should be put on developing a low-carbon economy, and decoupling economic growth from GHG emissions: this focus will then reduce electricity generation costs as well as GHG (particularly CO_2) emissions and Grenada's long-term dependency on fossil fuels.

The Government's key role in country's GHG mitigation and sustainable energy strategy is in the development and improvement of comprehensive energy conservation and efficiency programmes. These programmes will be developed to maximise the efficient use of energy, the diversification and expansion of the energy mix, and increased the role of renewable energy in the economy. In this regard, developing tax and custom duty incentives on energy-efficient products and renewable energy generation to encourage efficiency measures and energy conservation could prove useful.

Current and planned public and private initiatives, policies and programmes identified as a part of the development of a programmatic energy policy-based loans to encourage sustainable energy initiatives, public education and awareness, institutional strengthening, and help diversify Grenada's energy mix, include:

- Continuing development of national **geothermal energy** resources through grants supplied to Grenada by the Global Environment Facility through the Inter-American Development Bank, with the CDB in 2017 (Government of Grenada, 2017).
- Funding the continued sustainable development of renewable and efficiency measures through projects such as the Energy for Sustainable Development project to **reduce GHG emissions in residential and commercial buildings** (GEF, 2016).
- Leveraging private finance for development of renewable energy generation and alternative transport modes such as electric vehicles (GRENLEC, 2016).
- Encouraging improved energy efficiency and renewable energy generation in the hotel and tourism sectors through schemes such as the Caribbean Hotel Energy Efficiency Action Program completed in 2017.

The following are identified, implemented, planned, and potential climate mitigation actions 2014 – 2030:

Scenario	ID	Action name	Description	Gg CO_2e reduction by 2030	% reduction
With Existing Measures (WEM)	30	Mt. St. Catherine Geothermal energy	Development of 15 MW geothermal energy site at Mt. St. Catherine	76.6	14%
	33	Solar farm	11 solar PV installations at Grand Anse, Queen's Park and Plains carried out by	0.9	0%

			GRENLEC in 2016		
	36	Solar system (Korean funded)	Emission reductions from off-grid solar PV (24 kW) funded by the Republic of Korea	0.0	0%
With Additional Measures (WAM)	32	Electric Vehicles	Policy promoting the uptake of electric vehicles in Grenada	0.5	0%
	34	Wind power	Development of a 2 MW wind power farm by 2030 with a total annual generation of 15,770 MWh	9.3	2%
	37	LED public lighting	Uptake of 1% LED public lighting by 2020, and 15% by 2030	0.2	0%
	39	G-Hydro In-Conduit hydropower	Development of 0.2 MW In-Conduit hydropower with a total annual generation of 600MWh	0.4	0%
	40	PV systems	Development of up to 25 MW solar PV installations (additional 23.33 MW beyond current installed capacity of 0.937 MW and Petite Martinique PV system treated as separate mitigation action) with total annual generation of 52,809 MWh	19.9	4%
	54	Petite Martinique off grid solar PV system	Development of solar PV off-grid PV system incl. battery storage for the island of Petite Martinique off the coast of Grenada. Annual generation estimated to approximately 1,668 MWh by 2030.	1.0	0%
	56	15 MW additional geothermal	Development of additional 15 MW geothermal energy beyond the 15 MW currently under development	76.6	14%
With Potential Measures (WPM)	45	Biogas systems in agriculture, tourism and residential sectors	Development of biogas systems in agriculture, tourism and residential sectors	1.3	0%
	55	Integrated solid waste management	Capture of landfill gas at existing landfill site	24.6	4%
	57	10 MW additional wind power	Development of an additional 10 MW wind power farm with a total annual generation of 83,000 MWh	46.4	8%

However, these mitigation measures may be confronted by a variety of constraints and gaps. But the work on the Second National Communication provided several recommendations on how to best address constraints and gaps, and how to enhance and facilitate the implementation of identified mitigation actions including:

- Strengthen legal and regulatory frameworks regarding renewable energy, energy efficiency, and GHG emissions;

- Improve public awareness of environmental challenges related to climate change mitigation and adaptation, improving acceptance and behaviour change;
- Improve capital investment, funding and leveraging of private capital, and encourage public and private sector partnerships to address cases of high investment costs;
- Develop skills and technical capacity building for energy efficiency and renewable energy technologies;
- Improve data quality and availability, as well as analysis to monitor/measure, report/communicate and verify progress and potential challenges (MRV);
- Increase research and development of renewable energy and energy efficiency solutions such as solar, seawater air conditioning and biomass cogeneration relevant to Grenada;

These aforementioned recommendations support Grenada's vision for a low carbon and sustainable economy as outlined by its National Energy Policy (Government of Grenada, 2011). Priority Sources and Categories for Mitigation Action and Sustainable Development for targeted sub-sectors include:

1. **Energy Industries (Electricity generation):**
   - Driven by increased demand for heat and power through economic growth: represents 32% of 2014 emissions;
   - Solutions: Include increasing generation of renewable energy, and reduced demand for electricity through behaviour change and energy efficiency measures such as LED light bulb replacement programmes.
2. **Domestic Transport:**
   - Driven by increased use of vehicles, airplanes and maritime navigation due to economic growth and increased mobility: represents 26% of the 2014 emissions;
   - Solutions: Improve transport efficiency, switch to low carbon transport forms and integrate biofuels into the fuel mix.
3. **Waste landfill:**
   - Driven by increasing amounts of waste disposed to landfill due to economic growth and increased availability of products;
   - Solution: Reduce waste to landfill through waste prevention and recycling. Increase waste to energy if possible.

Targets and Mitigation Progress to 2014

In its INDC Grenada commits to reducing its Greenhouse gas emissions by 30% of 2010 by 2025, with an indicative reduction of 40% of 2010 by 2030.

Grenada identifies a number of targets on energy in its Clean Energy Goals.

These include:

- 10% of all buildings equipped with renewable energy technologies by 2015;
- 20% of all electricity and transportation energy from renewable energy sources by 2020;
- 20% reduction of greenhouse gas emissions by 2020;
- 100% renewable energy by 2030.

In addition, GRENLEC previously set a goal of meeting 35% of electrical consumption from renewable energy sources by 2016, independent of the energy goals set by the Government of Grenada.

Financial Investment and Strategic Programmes for Energy Sustainability, Transport and Greenhouse Gas Mitigation

In order to meet its Financial Investment and Strategic Programmes for Energy Sustainability, Transport and Greenhouse Gas Mitigation, Grenada intends to leverage the following funding sources:

1. **International Funding Sources:** In 2017, Grenada received a grant for geothermal energy development by the Global Environment Facility, through the Inter-American Development Bank's Sustainable Energy Facility, with the CDB: the grant of US $231,630 or approximately XCD $625,401 will facilitate the Government's capacity for planning and implementing its Geothermal Energy Development Roadmap (GEDR);
2. **International Market Mechanism:** Not used to date;
3. **Private Finance:** The high potential for solar energy on Grenada due to the country's high irradiation has led to a burgeoning uptake of small-scale solar PV installation.

Possible Future Climate Actions in Grenada and Emissions Reductions by 2020 and 2030 in Gg CO_2e

1. **Total Emissions Reductions with Existing Measures (WEM) Gg CO_2e by 2020 and 2030:** Mount Saint Catherine Geothermal Energy; Solar farm; and solar system: total emissions reductions by 2020: 0.9 Gg CO_2e and by 2030: 77.5 Gg CO_2e.
2. **Total Emissions Reductions with Additional measures (WAM) in Gg CO_2e by 2020 and 2030: Electric vehicles;** Wind Power; LED public lighting; Hydropower development; Photo-voltaic systems, Petite Martinique off grid solar PV and 15 MW additional geothermal: total emissions reductions by 2020: 6.2 Gg CO_2e and by 2030: 107.8 Gg CO_2e.
3. **Total Emissions Reductions with Potential Measures (WPM) in Gg CO_2e by 2020 and 2030:** Biogas systems in agriculture; tourism and residential sectors; Integrated solid waste management; and 10 MW additional wind power: total emissions reductions by 2020: 1.1 Gg CO_2e and by 2030: 72.4 Gg CO_2e.

Other Initiatives

Grenada has shown its commitment to the reduction of its greenhouse gas emissions over the years by signing on to several international and regional initiatives and expressing commitment to a number of United Nations processes relative to Climate Change, Small Island Developing States, Biological Diversity, and the Millennium Development Goals. Additionally, Grenada is committed to energy related initiatives articulated at the global level through: Vision 20/30 GSEII, Carbon War Room Initiative for Renewable Energy, Caribbean Challenge Initiative, Sustainable Energy for All, the Caribbean Renewable Energy Development Programme, the Blue Economy Initiative, and the Energy and Climate Partnership for the Americas Caribbean Initiative.

In addition to these global and regional initiatives, the locally created "homegrown programme" Energy for the Poor/Sustainable Energy, is being implemented.

Grenada's National Energy Policy serves as the main guideline for the Government to achieve sustainable energy and low carbon development. Its purpose is to:

- Create an appropriate, enabling and dynamic incentive regime, both regulatory and institutional, to achieve a more diversified and sustainable energy sector;
- Place energy sector management and development within the framework and principles of sustainable development to facilitate the transition to sustainable energy production and use; and
- Use energy as a tool for sustainable development and build resilience into a newly restructured economy to guarantee its citizens a sustainable quality of life.

Observed Climate Changes and Their Impacts

Current climate and sea level, including storm surges, impacts and adaptation measures for key sectors, namely coastal resources, water, agriculture, tourism, human health and human settlements and insurance are discussed in this section.

Rising Air Temperatures

As a result of its location close to the equator and a strong marine influence, the climate of tri-state Grenada is characterised by high and relatively unchanging temperatures year-round, as well as a dry season that lasts from January to May and a wet season that lasts from June to December.

The temperature profile of Grenada includes a period of Northern hemisphere summer warming which begins in April, followed by a period of winter cooling, beginning in December (CCCCC, 2015). The annual average temperature ranges from a low of 28.3°C to a maximum average of 33.3°C (Government of Grenada, 2015). Decadal trends in monthly temperature recordings from the Maurice Bishop International Airport show that temperatures have risen steadily over time, with the 2000s being the hottest decade on record (CCCCC, 2015).

Changing Rainfall Patterns

Grenada experiences most of its rainfall during the North Atlantic Hurricane season which runs from June-December (Government of Grenada, 2017). Monthly rainfall observations at the Maurice Bishop International Airport indicate that the island of Grenada receives a total of 116 cm of rainfall per year (CCCCC, 2015). Decadal rainfall observations from the Maurice Bishop International Airport were analysed and based on this report, it was noted that while overall, the rainfall pattern of early season months and late wet season months has remained the same, and there has been a change in the amount of rainfall observed throughout the year, especially during the late wet season (CCCCC, 2015). There has also been a fluctuation in the number and timing of rainfall peaks throughout the year. In addition, the 1990's have been the driest decade since 1986, as monthly rainfall was below 14 cm for majority of the rainy seasons (CCCCC, 2015).

During the late 2000's, Grenada was impacted by severe drought conditions which affected a number of areas of the country's economy. The 2009-2010 drought began in October, 2009 ended in March 2010 (Trotman & Farrell, 2010). Total annual rainfall recorded in 2009 at Point Saline Airport was the lowest in 24 years of records (Trotman & Farrell, 2010). While Carriacou and Petite Martinique generally receive lower levels of rainfall and can experience severe drought conditions during the dry season (Government of Grenada, 2000), during the 2009-2010 drought, conditions in Carriacou, were particularly severe; the majority of the rainwater cisterns that supply water to critical institutions and the public dried out and water had to be barged from Grenada to meet the needs of residents (Trotman & Farrell, 2010).

Increased Sea Surface Temperatures

Sea surface temperature (SST) has significantly warmed during the past 30 years over 70% of the world's coastline with the average rate of rise being 0.18 ± 0.16°C per decade (IPCC, 2014b). A recent study that examined the magnitude of long-term SST trends in the Wider Caribbean (WC) and the Antilles found that annual mean SST trends combining the sub-periods 1906–1969 and 1972–2005 are 1.32±0.41°C per century for the Antilles and 1.08±0.32°C per century for the WC. However, for the same regions during the sub-period 1972–2005, the corresponding trends are 1.41±0.68 °C per century and 1.18±0.49 °C per century, illustrating the warming intensification during the last four decades (Antuña-Marrero et al., 2015).

Greater Intensity of Hurricanes

A recent report (CCCCC, 2015) examined current trends in tropical cyclone activity for Grenada and the report indicates that over the period 1856 to 2012 there has been an increase in the number of hurricanes passing within a 100-km radius of Grenada. The report also notes a period of increased hurricane activity beginning in the year 2000 and that there was a sharp increase in the number of more intense storms (Category 4 and 5 hurricanes) starting in 2002. From 1950 to 2014, Grenada was impacted by three hurricanes that passed within 50 km of St. Georges; Hurricane Janet (1955), Hurricane Ivan (2004) and Hurricane Emily (2005). The report also notes that between 1950 and 2014 the islands of Petite Martinique and Carriacou have only been impacted by two hurricanes that passed within a radius of 50 km and the islands of Petite Martinique and Carriacou have not been impacted by a hurricane in the last 60 years.

The IPCC has concluded that the frequency and intensity of the strongest tropical cyclones in the North Atlantic have increased since the 1970s (IPCC, 2014b) and other studies also indicate an increase in the annual number of tropical storms over the last 30 years (Simpson, et al., 2012). In the Caribbean, inter-annual variations in rainfall and drought incidence are associated with the El Niño Southern Oscillation (ENSO) phenomenon. These cycles normally range from 3 to 7 years and are characterised by the warm phase El Nino period, where there are less active Tropical Atlantic Hurricane seasons and by the cool phase La Nina period of more active stronger storms.

Sea Level Rise

From 1901 to 2010, global mean sea level rose by 0.19 m and the rate of rise since the 1850s was larger than the average rate during the previous 2,000 years (IPCC, 2013). Global mean SLR is projected to continue during the 21st century, with the rate of rise being greater than observed in recent decades and not uniform across regions (IPCC, 2013). Observations from tidal gauges which are deployed across the Caribbean basin indicate that regional SLR is relatively consistent with global trends and range from 1.64 (+/- 0.80) mm/yr (Guantanamo Bay, Cuba) to 2.78 (+/- 0.60) mm/yr (Vaca Key, Florida) (Simpson, et al., 2012).

Storm Surges

Grenada has historically been impacted by storm surges which are associated with weather events such as tropical storms and hurricanes. The storm surge produced by Hurricane Lenny in 1999 caused extensive damage to infrastructure along the west coast of the island and to Carriacou and

Petite Martinique (CDERA, 2003). In 2004, Grenada was impacted by Hurricane Ivan and eye witness accounts indicate that Soubise in particular, experienced storm surges and wave run-up in excess of 3 m above sea level (Simpson, et al., 2012).

The great majority of settlements and infrastructure in Grenada are located on or near the coast, including government, transportation and commercial facilities. The storm surges also generate coastal erosion risks in low-lying areas and are of particular concern to the primary road that links coastal and interior communities (Simpson, et al., 2012).

Evidence of beach erosion is already present in Grenada (Grande Anse, Marquis Beach, Soubise Beach and Carenage) and further changes in the coastal profile would transform coastal tourism, with implications for destination competitiveness, property values, insurance costs, marketing and wider issues of local employment and economic well-being of thousands of persons (Simpson, et al., 2012).

Adaptation to the Impacts of Observed Climate Change

As a small island developing state Grenada is particularly vulnerable to the impacts of climate change, as evidenced by the impacts of extreme events and the occurrences of increased forest fires, crop loss, water shortages and incidence of pests and diseases occurring in recent years. As such, Grenada recognizes the need to reduce its vulnerability and strengthen the resilience of its land and people to the projected impacts of climate change. It is currently undertaking several projects in this regard, including addressing alternative/sustainable livelihoods and improving benefits of ecosystem services. Grenada’s past and current adaptation actions have been in keeping with a robust National Climate Change Policy and Action Plan (NCCPAP). Grenada is currently undertaking a review of the NCCPAP as part of the National Adaptation Planning (NAP) process. Grenada’s resilience building plan is also in line with regional adaptation strategies.

Grenada’s key economic sectors like agriculture and tourism are extremely vulnerable to the impacts of climate change. All of Grenada`s economic areas including towns and ports are located on the coast, with the single airport on the island being one of the most vulnerable in the region to sea level rise. Any future adaptation plan must take into account the vital nature of these areas and accordingly contain steps to allow them to maintain their functions. Maintaining a healthy natural environment is also imperative as part of Grenada’s efforts to reduce vulnerability to climate change and ecosystem based adaptation to climate change and sea level rise is a priority for Grenada.

Grenada has realized the need to take an integrated approach to adaptation by linking local activities with national policies and sector specific experiences. Mainstreaming climate change adaptation activities into national development planning is a major focus and several actions have been identified to support resilience building at all levels. These include:

1. **Enhancing institutional framework:** establishing an integrated and coordinated approach to addressing climate change can help minimize capacity gaps in the system while ensuring coherence and cohesion at the local and national level. The objective is to evaluate and enhance the existing institutional framework to improve capacity to develop and institute plans for climate change adaptation at the local and national level. Grenada has re-established its National Climate Change Committee which provides overall guidance and support to climate change activities on the Island. Grenada has also began improving its

institutional capacity by selecting climate change focal points in all line ministries and conducting trainings in climate change risk analysis and general as well as sector specific climate change knowledge. Grenada is also undertaking activities to increase its potential to access international climate funding: The National Designated Authority for the Green Climate Fund has been formalized and actions to strengthen it are underway.

2. **Building coastal resilience:** Grenada's economy is very dependent on healthy coastal areas, its beaches, coral reefs and mangroves all provide many ecosystems, social and economic benefits and therefore it is important to protect them from the adverse impacts of climate change. Grenada is in the advanced stages of developing its Integrated Coastal Zone Management Policy and management system with the aim of facilitating integrative planning and management processes with the view to preserving and enhancing coastal ecosystems and ecosystem services while enabling social and economic development. As part of the policy development Grenada had to undertake a detailed mapping of the coastal features to provide a definition of the coast. Grenada has also re-established its beach monitoring program under new terms of reference and stronger institutional backing. Grenada is also undertaking several community ecosystem based adaptation actions including coral restoration, mangrove rehabilitation, all with alternative livelihood implications

3. **Improving water resource management:** The management of water resources, like that of the coastal environment is crucial to the long-term development of Grenada as a nation. The goal is promoting and maintaining equitable and sustainable use of the water sources and their watersheds. In addition, improved capture, storage, distribution and conservation of water increase the adaptive capacity of individuals and communities. Grenada has recently completed a vulnerability assessment of the water sector and developed a national adaptation plan and action plan for the water sector, mapping and water quality testing of informal water sources. Rain water harvesting activities are currently underway in some remote communities to improve water collection and storage.

4. **Building the resilience of communities:** it has become increasingly evident that buy in at the local levels can go a long way in aiding the success of adaptation actions. Grenada is committed to engaging community groups and NGOs in participating in activities geared at building resilience to climate change. A people that is knowledgeable about the expected threats of climate change and the actions that can be taken to reduce their vulnerabilities to these threats can help inform actions and policies that can further build their resilience. There is a need for capacity building at all levels for this approach to be more beneficial for all.

Implementation of further actions to reduce the level of vulnerability is severely constrained by the lack of capacity, human resources, technology, financial resources, data, knowledge and awareness. It is important to make use of existing new and emerging technologies such as early warning systems to reduce the impact of extreme events. Grenada is currently reviewing its technology needs assessments (TNA) and has selected the water, agriculture and tourism as the focal sectors. Water was identified as the most dominant cross-cutting sector. The results of the

TNA will provide the necessary information on technology needs for Grenada to continue its resilience building activities.

Projected Climate Changes and Biophysical Impacts

It is highly likely that future climate changes, including rising temperatures, variable rainfall and increasing drought, more intense tropical storms and hurricanes and sea level rise will have far-reaching biophysical impacts in tri-state Grenada.

Future Air Temperature

Climate model projections of future scenarios are based on both General Circulation Model (GCM) ensemble of 15 models and the Regional Climate Model (RCM), PRECIS, driven by two different GCMs (ECHAM4 and HadCM3) and forced by the A2, A1B and B2 IPCC marker scenarios.

Mean annual temperatures in Grenada are projected to increase, irrespective of the scenario or model used. General Circulation Model (GCM) projections from the 15-model ensemble indicate that Grenada can be expected to warm by 0.7˚C to 2.2˚C by the 2050s and 1˚C to 3.7˚C by the 2080s, relative to the 1970-1999 mean (Simpson, et al., 2012). This is consistent with projections from the IPCC Fifth Assessment Report (AR5), which indicates that the average air temperature in the Caribbean will rise by 1.4°C by 2081-2100 relative to 1986-2005 (IPCC, 2014a).

Regional Climate Model (RCM) projections driven by ECHAM4 and HadCM3 indicate much more rapid increases in temperatures over Grenada compared to the median projections from the GCM ensemble for the A2 scenario (Simpson, et al., 2012). RCM projections indicate increases of 3.2˚C and 2.4˚C in mean annual temperatures by the 2080s when driven by the ECHAM4 and HadCM3 respectively. The GCM ensemble projections for the same period range from 2 to 3.7˚C (Simpson, et al., 2012).

Since the surface of land masses warm more rapidly than ocean due to their lower heat capacity, a more rapid warming over Grenada is seen in the RCM projections forced by the A2 marker scenario compared to the GCMs (Simpson, et al., 2012).

Future Rainfall Patterns

GCM projections of future rainfall for Grenada tend towards decreases in most models (Simpson, et al., 2012). Projected rainfall changes in annual rainfall range from -40 to +7 mm per month (-66% to +12%) by the 2080s across the three emissions scenarios. The overall decreases in annual rainfall projected by GCMs occur largely through decreased rainfall during the months of June to August and September to November.

RCM projections of rainfall for Grenada are strongly influenced by the driving GCM providing boundary conditions (Simpson, et al., 2012). Driven by ECHAM4, RCM projections indicate a large proportional decrease over the months of June to August (-41%) and decreases over the periods of December to February (-21%); and March to May (-15%) resulting in a decrease in total annual rainfall (-22%) (Simpson, et al., 2012). When driven by HadCM3, RCM projections indicate large proportional decreases in rainfall in December to February (-41%) and March to May (-47%) months resulting in a substantial decrease in annual rainfall (-29%) (Simpson, et al., 2012).

These results are consistent with other regional projections performed using PRECIS, which have also indicated drier conditions in the southern Caribbean, with drying occurring in the traditional wet season (June–October) (Whyte et al., 2008; Campbell et al., 2011). Lengthening of seasonal dry periods, and increasing frequency of drought are expected to increase demand for water throughout the region (Cashman et al., 2010).

Future Intensities of Storms and Hurricanes

Projected increases in SST (Simpson, et al., 2012) as well as more recent projections of future increases in windspeed (CCCCC, 2015) all indicate that hurricane intensity, but not necessarily frequency, over the North Tropical Atlantic has the potential to increase in the coming decades. Also, the frequency and intensity of tropical storms and hurricanes will continue to be heavily influenced by the state of the ENSO phenomenon well into the future.

Future Sea Surface Temperature

GCM projections indicate increases in sea-surface temperatures throughout the year (Simpson, et al., 2012). Projected increases range between +0.9˚C and +3.1˚C by the 2080s across all three emissions scenarios. This is supported by the IPCC's AR5 which notes that based on projected temperature increase; there is high confidence that positive SST trends will continue well into the future (IPCC, 2014b).

Future Sea Level Rise

The IPCC (AR5) projects that net sea-level in the Caribbean will rise by 0.5-0.6m by 2081–2100 (relative to 1986–2005) (IPCC, 2014). However, other studies (Rahmstorf, 2007) integrating land ice contributions have proposed a more dramatic increase globally, of up to 1.4 m by the year 2100, which would have severe implications if the regional rate of rise remains consistent with global trends.

Despite the variances in projections, there is fundamental consensuses that 'mean sea level rise will continue during the 21st century' (IPCC, 2013).

Future Storm Surges

Changes to the frequency or magnitude of storm surges experienced at coastal locations in Grenada are likely to occur as a result of the combined effects of several factors:

1. Increased mean sea level in the region, which raises the base sea level over which a given storm surge height is superimposed;
2. Changes in storm surge height, or frequency of occurrence, resulting from changes in the severity or frequency of storms; and
3. Physical characteristics of the region (bathymetry and topography) which determine the sensitivity of the region to storm surge by influencing the height of the storm surge generated by a given storm (Simpson, et al., 2012).

Biophysical Impacts

The biophysical impacts of future climate change and sea level rise on coastal resources are, but not limited to:

- Increased coastal erosion due to sea level rise and the increased frequency and intensity of storm surges and intense rainfalls: continued coastal erosion, exacerbated by SLR would very likely disrupt coastal villages like Gouyave, Grand Mal, Duquesne, Soubise and Marquis;
- Prolonged dry periods, higher temperatures and increased rates of evapotranspiration will also negatively impact the water supply systems of the islands and increasing episodes of drought, based on the SPI (Standard Precipitation index) especially in the dry season would severely affect the calendar of farmers (planting dates…);
- Increasing ocean acidification and the inhibition of primary production processes and disruptions to fisheries;
- Coral bleaching and the loss of fish habitats and tourist activities;
- Destruction of vital coastal ecosystems (mangroves and sea grass) that are not only important fisheries habitats but also facilitate stabilisation of the coast against erosion;
- Increased frequency and intensity of flood events caused by storm-surges intense rainfalls and damages to coastal infrastructures (roads and bridges), beaches for tourism, agricultural lands and crops (nutmeg and cocoa) and the proliferation of mosquito vectors that lead to health problems;
- Saltwater intrusion into low-lying estuaries and aquifers that would affect surface and ground water quality.

Projected Impacts on Socioeconomic Sectors and Recommendations

The socio-economic sectors that would be most sensitive to future climate change and sea level rise are: coastal resources, water resources, agriculture, fisheries and coastal ecosystems, human health, tourism and human settlements and infrastructure.

Coastal Resources

Impacts

Natural habitat destruction is one major issue of concern within the coastal zone of Grenada. For example, the removal of mangrove stands as a source of fuel (charcoal) is reducing the natural physical and biological functionality of this ecosystem. Furthermore, the harvesting of corals over time has resulted in the physical damage to the structure of reefs and the ecosystem function these provide.

The destruction of sea grass beds to promote coastal development and the unsustainable and inappropriate fishing methods/practices are also issues of concern. Over harvesting of specific species of reef fish and shellfish is also contributing to the exploitation of coastal resources. Furthermore, the fisheries resources have been negatively affected by inappropriate fishing activities; especially within the near shore areas of Grenada.

Grenada’s sandy beaches have also experienced changes due to anthropogenic activities. Previously, almost all sands used in the construction, transport and tourism industries in Grenada came from beaches and further exacerbated beach erosion. Presently, sand mining is only authorized at a few sites (Galby Bay, Bacolette beach in St. David’s and the Canals in Mt. Rodney) and the only entity legally allowed to engage in sand-mining is Gravel and Concrete Corporation (GCC). However, GCC has ceased mining since April 2016 and is now promoting the use of imported sand.

Although recently curtailed, the removal of mangroves for hotel, marina or other coastal development, remains a significant threat. In some areas, mangroves are replaced by beaches (built) which may disrupt the natural ecological transition of coastal vegetation. In addition, increased sedimentation along with the introduction of sewage and other wastes from land into the sea has increased pressures on coastal resources.

Other impacts include loss of tourism, recreation and transportation; increased risk of disease outbreaks and loss of cultural assets and historical values.

Recommendations

Grenada is at a nascent stage of planning to expand the current protection of its coastal areas. The initiative to move in this direction has come as a result of the recognition of severe degradation of coastal ecosystems and extensive beach erosion that are caused by both natural and human-induced activities, the loss of valuable coastal infrastructure and the increasing need to protect existing infrastructure. Grenada has realised the need to take an integrated approach to adaptation by linking local activities with national policies and sector specific experiences. Mainstreaming climate change and coastal adaptation activities into national development planning is a major focus and several actions have been identified to support resilience building at all levels.

In order to achieve this, and to maintain the population's wellbeing and sustainably manage the coastal environment and the range of activities that are associated with it, Integrated Coastal Zone Management (ICZM) has been identified as a useful tool (Cicin-Sain and Belfiore, 2005) and an effective means to address climate change impacts and to reduce vulnerability to coastal hazards.

The imperative of ICZM is to strengthen the resilience of Grenada's coasts to adapt to the impacts of global climate change and its associated risks, while enhancing the ability of coastal resources to contribute to national economy and community livelihoods.

A number of measures to address crosscutting issues such as capacity building, education and public awareness, and an institutional and legislative framework are also vital to successful implementation of the ICZM. Grenada is also undertaking several community ecosystem based adaptation actions including coral restoration, mangrove rehabilitation, all with alternative livelihood implications.

Other recommendations would include: conservation of all marine areas, including the establishment of new MPAs and the monitoring of all activities within the coastal zone and increased enforcement and direct implementation of land-use plans and policies, especially related to coastal setback and infrastructure and other facilities within the coastal zone.

Water Resources

Impacts

The major vulnerabilities impacting the water sector in Grenada are the extreme in rainfall patterns. On the one hand, heavy and intense rainfalls cause flooding and sedimentation that affect water quality. On the other, the increase in the occurrence of droughts due to lack of rainfall, especially in the dry season, increase in air temperature and evapotranspiration all lead to shortfalls in water supply and affect key sectors such as tourism and agriculture.

Increasing demand for water based on current supply and demand trends for domestic, commercial and tourism-based consumption are other factors to consider. A lack of essential data to support sustainable water resources management is also of importance.

Recommendations

In consideration of identified climate change impacts on water resources, the following are recommended adaptation strategies to improve the adaptive capacity and resilience of the water sector to climate change:

1. The adoption and implementation of Integrated Water Resources Management;
2. The greater use of other sources of water, namely underground water from aquifers other than surface waters and rainwater harvesting;
3. Improvements to Argo-Hydro-Meteorological Monitoring;
4. Policies that focus on Flood Mitigation and Flood Risk Management;
5. Policies that focus on Drought Mitigation and Drought Risk Management;
6. Improved data collection and controls on Water Supply and Demand Management;
7. Increased Water Infrastructure (reservoirs, tanks and boreholes), Development and Planning;
8. Education and Capacity Building especially in regard to water conservation measures such as the recycling of waste/grey water and the use of drip irrigation in agriculture;
9. Legislation and Regulation regarding water use.

Agriculture

Impacts

Climate change threatens to progressively deteriorate food supply and economic growth in complex ways across tri-state Grenada. The potential for intensifying impacts and vulnerability has contributed to growing concerns about the long-term effects of climate change on the agricultural sector and food security, livelihoods of the poor and other vulnerable populations in Grenada. Understanding how local climate and other environmental variables (e.g. rainfall, temperature, potential evapotranspiration, vegetation and soils) are changing is therefore an absolute imperative.

Despite the agriculture sector’s low contribution to GDP and the reliance on food imports, agriculture is a significant source of local food supply and plays a major role in economic growth and diversification in Grenada.

Grenada is a net importer of food and climate change impacts in supply countries will affect price and availability of food. Local farmers are already feeling the effects of climate change that is affecting domestic food production and food security.

The Government of Grenada has identified the agriculture sector as one of the pillars of the national economy. Despite accounting for 6.2% of Grenada's GDP in 2015, agriculture makes a significant contribution to the livelihoods of many rural people and makes up almost 40% of total land use. The principal exports include nutmeg, cocoa, mace, cinnamon, banana, mango, and avocado.

Grenada’s agricultural sector is highly vulnerable to the existing climate variability and is susceptible to extended periods of drought. The end of century climate projection for tri-state Grenada shows a consistent drying trend across many different models and global warming scenarios. Tropical storms and hurricanes that are expected to be more frequent and more intense following climate change are also a major threat to crop production, especially key export crops such as nutmeg and cocoa. This will in all likelihood affect crop production and a greater reliance on irrigation water use. Also, the thriving tourism sector influences productivity in related sectors such as agriculture.

Recommendations

In order to increase the resilience of the agriculture sub-sector the climate change, the following are some key recommendations:

1. Research and development of new varieties of Grenada's key export crops (nutmeg and cocoa) and into other varieties such as Soursop, Cinnamon, Pimento and other spices and crops that are more suited to the changing climate;
2. The greater use of hurricane proofed greenhouses for the production of vegetables such as tomatoes, peppers, cucumber and lettuce so as to protect against wind and diseases and increase crop yields;
3. The greater use of irrigation water (grey water), especially in the dry season so as to allow year-round agricultural production;
4. Reduce land degradation due to inefficient agricultural practices, such as the land clearing on steep slope, overgrazing (especially in Carriacou and Petite Martinique), poor soil and water conservation practices (including little use of organic matter) and avoidance of farming too close to riverbanks so as to avoid flooding of croplands;
5. Greater adoption and use of CSA (Climate Smart Agriculture) practices such as contour ploughing and planting, intercropping, rationalization of agro-chemicals and crop insurance schemes;
6. Greater support of the Government to the agriculture sector through financial incentives (choice of crops, insurance…).

Fisheries and Coastal Ecosystems

Impacts

Significant impacts from climate change and climate variability are expected to be experienced in the coastal and marine environments of Grenada over the next several decades. As fisheries and coastal ecosystems are part of an integrated social-ecological system, climate change will therefore have interconnected bio-physical and social impacts. These will be all the more significant as climate change and climate variability are expected to exacerbate existing stressors as well as introduce additional adverse impacts on fisheries and coastal ecosystems.

Numerous pathways exist through which climate change can impact fisheries in Grenada (Badjeck et al., 2010). Causal variables of impact include SLR, altered precipitation patterns, varied ocean and coastal processes such as wind velocity, wave action and ocean currents and changes in chemical and physical oceanographic parameters such as pH and water temperature.

Grenada and its dependencies are amongst the most vulnerable due to the high dependence on marine resources, and the high vulnerability of fisherfolk and fisheries infrastructure in the coastal zone. Consequently, effective adaptation measures for the fisheries sector are particularly critical for sustainable livelihoods, improved food security and protection of marine resources.

Recommendations

The following are some of the key recommendations that may be adopted to reduce the impacts of climate change and sea level rise on the Fisheries sub-sector;

1. Continue to Improve Technical Capacity and Institutional Arrangements for ICZM, especially as they relate to coastal habitats;
2. Improve Availability of Ecosystem Data and Strengthen Monitoring of Critical Ecosystems such as mangroves, sea grass beds and coral reefs;
3. Mainstream Climate Change Adaptation (CCA) Into Fisheries Management and Planning;
4. Improve Policies, Regulatory and Institutional Frameworks to Increase the Resilience of important coastal ecosystems;
5. Improve Fisher's Access to Information to strengthen their Resilience to Climate Change Impacts;
6. Enhance Livelihood Diversification in Fishing Communities;
7. Develop and Implement a National Plan for Coastal Ecosystem Based Adaptation;
8. Strengthen and Expand Marine Protected Areas;
9. Expand Coral Restoration Efforts and enhance Reforestation of Mangroves;
10. Enhance adaptive capacity of fishers: early warning systems; sustainable fisheries management; disaster risk preparedness; awareness of climate change impacts; and training in use of assets and equipment;
11. Improve profitability of the sector and safety at sea of fisherfolk.

Human Health

Impacts

Vector-borne diseases (particularly Dengue, Chikungunya and Zika virus) are a primary concern of Grenadian public health officials, due to the difficulty of vector management and the outbreak prone nature of these diseases. An increase in intense rainfalls and temperatures is likely to create favorable mosquito breeding conditions, making the control of these diseases a priority in the health sector. Rodent-borne diseases such as leptospirosis are prone to outbreaks during floods, when sewage can mix with drinking water supplies, increasing the risk of human infection. Moreover, heavy rainfall and hurricanes are often accompanied by an increase in water-borne diseases, when communities using pit latrines are flooded and their water supplies contaminated.

Climate change presents significant risks to human population in developing countries and small island states as Grenada where health burdens are relatively high and the resources to adequately address these burdens tend to be limited. A number of determinants contribute to population vulnerability to injury and disease, and even more so under circumstances of a variable and changing climate (IPCC, 2014).

These determinants may operate in solo, but more often work in interconnected and complex ways:

- Location is one such determinant: increasing temperatures on outdoor workers in areas where temperatures are already high, as well the impact of extreme heat on health of persons living and working in congested, urban areas, increased flooding in coastal low-lying areas from sea level rise, and the impacts of reduced rainfall on rural farming communities and regions that might increase the risks of under-nutrition and water-related diseases;

- Vulnerability tends to be higher in low-income areas and regions, as limited access to resources do not allow for adequate preventative or adaptive measures;
- Vulnerability to disease and injury is also relatively higher in infants, youths and the elderly compared to other age groups, owing to reasons of physiology (mainly in children) and limited mobility and sub-optimal health in the elderly;
- Quality of, and access to public health infrastructure and service deployment are also crucial to determining vulnerability. The quality of other public service provision and infrastructure (water supply, sanitation, electricity, etc.) also plays a role in reducing or contributing to the vulnerability of the population to diseases and injuries.

Recommendations

The following is a list, though not complete, of recommendations that may be adopted and implemented in the health sector of Grenada so as to increase its resilience to climate change:

1. Conduct more research on the complex inter-relationship between climate, vector ecology, and human health;
2. Link data on epidemiology of diseases with climate data (including historical climate data);
3. Evaluate effectiveness of vector control and implement necessary changes;
4. Implement an electronic health information system for improved disease surveillance, monitoring and control;
5. Implement a national information center that is linked to relevant regional centers containing detailed timed information on the incidence and type of diseases and their geographical locations and linked environmental and climatological data;
6. Solidify the institutionalized collaboration and cooperation at both inter- and intra-sectoral levels;
7. Increase the resilience of the health sector by adopting: health information systems; health service delivery; climate resilient and sustainable technologies and infrastructure; leadership and governance and timely and adequate financing and improved surveillance of diseases and vector populations and integrated vector management.

Tourism

Impacts

Grenada's tourism sector is one of the main drivers of economic growth, particularly with the decline in the agricultural sector (Bhola-Paul, 2015). Tourism's significance as a foreign exchange earner, employer and catalyst for investment in Grenada is reflected in the commitments by the government, private sector and communities: for instance, one of the six strategic objectives outlined in Grenada's Growth and Poverty Reduction Strategy, 2014 – 2018, is "Developing Tourism and Hospitality Industries" to help improve the country's competitiveness both regionally and globally (Antoine et al., 2014). The Government of Grenada plans to create conditions for the sustainable prosperity of the people and future generations through, amongst other things, developing "a world class service industry especially in tourism" (Government of Grenada, 2014f); However, the tourism sub-sector of Grenada is very likely to face a variety of vulnerabilities and challenges with climate change and sea level rise in the future. Amongst these expected impacts are:

- Increasing air temperatures may make conditions too hot for certain tourists, especially the elderly that make up a large percentage of tourists;
- Warming in the countries of origin, North America and Europe in particular, may cause more tourists to stay in their home countries in winter, the peak tourist season;
- The expected increase in the number and intensity of tropical storms and hurricanes may deter certain tourists to Grenada, although this threat is limited to the low tourist season;
- Sea level rise may exacerbate coastal erosion and loss of certain beaches and sunning and swimming activities;
- Ocean temperature increase and acidification will cause severe damages to coral reefs that are crucial habitats for fisheries and snorkeling and diving activities;
- On account of the impending threats of sea level rise, more frequent and intense hurricanes, damages to hotels and costal infrastructure (roads and bridges) may affect tourist activities;
- Insurance costs to hotels may also increase and when passed on to tourists, the costs may become prohibitive;
- If tourism is affected other sectors and peoples employed in these sectors (agriculture, fisheries, transport…) may also be affected through loss of employment;
- Airline travel costs may become prohibitably expensive if aircrafts emissions reductions incur additional airline travel costs.

Recommendations

Grenada has produced a number of policy directives, sector-specific plans and projects directed towards increasing resilience to climate change. While these initiatives may not have specifically targeted the tourism sector, they nonetheless recognised the critical importance of tourism to Grenada's economy and highlighted how they could enhance tourism-related activities.

Grenada has recently produced a Master Plan for the Tourism Sector of Grenada, Carriacou and Petite Martinique (1997) and the Grenada Board of Tourism Strategic Plan (2011-2014). Grenada's (1997) Master Plan for the Tourism Sector of Grenada, Carriacou and Petite Martinique recognises climate as one of the primary attractions for visitors.

The following is a list, though not exhaustive, of actions that may increase the resilience of the tourism sector to climate change and sea level rise:

1. Further development of the Grenada Board of Tourism Strategic Plan to provide technical guidance to the Grenada Board of Tourism in its role as the principal agency involved in the development of the tourism industry;
2. The adoption and implementation of the SPCR (Strategic Program for Climate Resilience) of the areas of intervention through investment projects and technical assistance of specific relevance to the tourism sector, such as the "Disaster Vulnerability and Climate Risk Reduction Project" and the "Forest Rehabilitation Project" that proposes a series of activities to rehabilitate degraded forest areas and build the capacity of the Forestry and National Parks Departments;
3. Given the linkages of Grenada's coastal and agricultural resources to ecotourism activities, projects and plans focused on building climate change resilience in these sectors, which provide inputs to tourism activities, should be implemented;

4. Climate-risk profile for the tourism sector: this should investigate the destination's key tourism assets (pull factors) and their vulnerability;
5. Continued diversification of Grenada tourism towards more climate resilient products such as festivals, heritage tourism, community tourism, and eco-based tourism;
6. Since tourism is integrally connected to various sectors and activities, it should therefore be mainstreamed into the climate change adaptation processes related to integrated coastal zone management, land-use planning, water resources management, disaster risk management, environmental health management, and sustainable development;
7. An assessment of Grenada's coastal tourism assets and infrastructure should be undertaken to determine the most appropriate measures to address erosion, storm surges, and SLR;
8. Since Grenada's tourism sector relies heavily on ecosystem services such as sandy beaches, clean and clear waters, diverse fish species, and coastal protection. pilot projects should be developed to encourage the participation of tourists, communities, hotels and tourism operators in ecosystem management;
9. Given that tourism is a highly water intensive sector, efforts by hotels to capture rainwater should be continued, and in some cases enhanced or initiated and incentives should be put in place and strategies adopted to improve water efficiency (e.g. installing low-flow and other water-saving fittings, irrigating lawns with greywater and using micro-irrigations systems, and covering swimming pools when not in use to avoid evaporation;
10. As tourism assets along the coast and inland can be vulnerable to climate risks, enabling policy frameworks and incentives should be in place to encourage the construction of climate-resilient infrastructure and finance mechanisms should also be available for retrofitting tourism assets (e.g. hotels) to be more climate-resilient;
11. Given the impact hazards, many of which are related to climate change, can pose to tourists and destination image, a National Tourism Safety and Security Plan, as well as crises management plans for tourism operators, should be developed and attention should also be given to effective communication strategies, inclusive of media management backstopped by appropriate training and capacity building;
12. Tourism operators and agencies should improve their understanding of available climate finance mechanisms and criteria, as well as their capacity to access such funds to build resilience of the tourism sub-sector to climate change and sea level rise.

Human Settlements and Infrastructure

<u>Impacts</u>

The lives and livelihoods of the people of Grenada will be largely dependent what actions are taken to address the impacts of a changing climate, sea level rise and extreme weather events. The experiences of Hurricanes Ivan and Emily have exposed the risks to which the country is exposed. Successful adaptation programmes should result in the overlap of actions being implemented by individuals, households and the commercial/industrial sector which can either be through government programmes or donor-funded through external agencies.

The vulnerabilities of Grenada's people, communities and infrastructure are shaped by several factors, namely, natural, social, economic and cultural which often interact in various, and sometimes complex ways to create vulnerable circumstances such as:

- Hurricanes and attendant storm surges are most notable in coastal areas where most of the settlements and infrastructure are located;
- Other physical factors such as topography and geology expose sections of the country (the coastal town of Gouyave) to climate-induced secondary hazards such as landslides and flooding, especially during or in the aftermath of extreme rainfall;
- Human activities (agriculture, construction and development, etc.) further contribute to slope destabilisation and landslide risk as significant construction activities occur on very steep slopes (>45°) (GFDRR, 2010), and landslides often impact the road network (Constantine Main Road) and bridges (Lance and Hubble bridges);
- Grenada's relatively dense drainage and steep relief give rise to flash flood events during periods of heavy rainfall, which typically affect settlements and other infrastructure located close to rivers, especially those located near the lower stages of river channels and within coastal areas;
- Intense rainfall associated with tropical storms and hurricanes along with the mountainous terrain expose Grenada to incidents of land slippage and flash flood events: areas which are about 2 m below sea level such as St. Georges, Grenville, Hillsborough and the southwest peninsula of the island;
- Poverty is also a major contributor to vulnerability: poorly constructed homes.

<u>Recommendations</u>
The following is a list, though not complete, of recommendations to increase the resilience of human settlements and infrastructure to climate change and sea level rise and storm surges:

1. Continued improvement on the regulatory and institutional framework as it relates to Government policies for sustainable land management practices and enhancing the structural integrity of infrastructure;
2. Enforcement of the national building code and continued development of legislation through capacity building exercises for the Physical Planning Unit through either increased human resources and/or enhanced technical capabilities is also necessary;
3. The identification of land and infrastructure which are presently vulnerable to the impacts of a changing climate such as the three airports (Dumfries, Maurice Bishop International and Pearls), that are of vital importance to the Tourism sector;
4. Capacity building within the public sector as it relates to data management, risk modelling and climate smart approaches towards sustainable livelihoods development and develop and implement training programmes on climate resilient building practices, guidelines and standards;
5. An action plan to ensure the long-term sustainability for spatial data management should be developed and implemented and this action plan should also consider improving capacity for risk modelling for natural hazards such as sea level rise, storm surges, inland flooding and land slippage.
6. Improve the resilience of key infrastructure assets and implement community adaptation plans: establish a revolving loan fund for home improvement of vulnerable households in the building sector;
7. Furthermore, a disaster management fund should also consider mitigation and preparation activities and not only response and recovery;

8. Collaboration between the Government, communities and civil society should be explored to develop action plans to identify vulnerable infrastructure and develop monitoring and evaluation programmes for the maintenance of drainage systems, watershed management, climate smart agricultural programmes and coastal resources management;
9. Greater use of insurance and risk transfer mechanisms can to reduce the impacts of climate change and extreme weather events on human settlements and infrastructure;
10. One of the main barriers to implementing adaptation measures is the lack of human resources and technical capacity within government ministries and key institutions and these should be addressed;
11. Also, there may not be available financial resources to ensure the delivery of sustainable training and capacity building programmes for staff to ensure the successful implementation of climate change adaptation measures.

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LIST OF ABBREVIATIONS AND ACRONYMS

ACCC............Adaptation to Climate Change in the Caribbean project
ACCRA ....Australia-Caribbean Coral Reef Alliance
ACP..............African, Caribbean and Pacific Group
AOSIS...........Alliance of Small Island States
AusAID.........Australian agency for International Development
AWE.............At Water's Edge
AWS.............Automated Weather Station
BPoA............Barbados Programme of Action
BRCCC..........Building regional Climate Capacity in the Caribbean
BUR..............Biennial Update Report
C&D ....Construction and Demolition (waste)
CANARI ....Caribbean Natural Resources Institute
CAPE ....Caribbean Advanced Proficiency Exam
CARDI ....Caribbean Agricultural Research and Development Institute
CariCOF........Caribbean Climate Outlook Program
CARICOM.....Caribbean Community
CARIWIN......Caribbean Water Initiative
CARPHA.......Caribbean Public Health Agency
CASSALD......China and South-South Scoping assessment for Adaptation, Learning and Development
CBO..............Community-Bases Organisation
CCCAF..........Community Climate Change Adaptation Fund
CCCCC..........Caribbean Community (CARICOM) Climate Change Centre
CCI ....Caribbean Challenge Initiative
CCMS...........Convention on the Conservation of Migratory Species of Wild Animals
CCORAL ....Caribbean Climate Online Risk and Adaptation Tool
CCREEE ....Caribbean Centre for Renewable Energy and Energy Efficiency
CCRIF ....Caribbean Catastrophe Risk Insurance Facility
CCSLC...........Caribbean Certificate of Secondary School Competence
CDB.............. Caribbean Development Bank
CDEMA ....Caribbean Disaster Emergency Management Agency
CDM ....Clean Development Mechanism
CDPMN........Caribbean Drought and Precipitation Monitoring Network
CEHI............. Caribbean Environmental Health Institute
CERMES.......Centre for Resource Management and Environmental Studies
CH_4...............Methane
CHaRIM ....Caribbean Handbook on Risk Information Management
CHENACT.....Caribbean Hotel Energy Efficiency Action Programme
CHTA............Caribbean Hotel and Tourism Association (CHTA)
CIMH ....Caribbean Institute for Meteorology and Hydrology
CMO ....Caribbean Meteorological Organization

CO_2 .... Carbon Dioxide
CO_2e .... Carbon Dioxide Equivalent
COP............. Conference of the Parties
CPACC......... Caribbean Planning for Adaptation to Climate Change project
CSEC .... Caribbean Secondary Education Certificate
CSGM.......... Climate Studies Group Mona
CTCN........... Climate Technology Centre and Network
CTO............. Caribbean Tourism Organisation
CWWA......... Caribbean Water and Wastewater Association
CXC .... Caribbean Examination Council
DEM............ Digital Elevation Model
DFATD .... Department of Foreign Affairs, Trade and Development Canada
DFID............ Department for International Development UK
DRR............. Disaster Risk Reduction
DVRP .... Disaster Vulnerability Reduction Project
ECCB .... Eastern Caribbean Central Bank
ECERA......... Eastern Caribbean Energy Regulatory Authority (project)
ECLAC .... United Nations Economic Commission for Latin America and the Caribbean
ECV .... Essential Climate Variable
EET.............. Energy Efficient Technology
EGTT .... Expert Group on Technology Transfer
EIA .... Environmental Impact Assessment
EU .... European Union
EWISACTs .... Early Warning Information Systems Across Climate Timescales
FAO............. Food and Agriculture Organization of the United Nations
GAA .... Grenada Airports Authority
GCC............. Gravel and Concrete Corporation
GCCA .... Global Climate Change Alliance
GCF .... Green Climate Fund
GCMs.......... General Circulation Models
GCOS .... Global Climate Observing System
GDP .... Gross Domestic Product
GEF .... Global Environment Facility
GFCS .... Global Framework for Climate Services
GFDRR .... Global Facility for Disaster Reduction and Recovery
Gg .... Gigagram
GHG .... Greenhouse Gas
GIS .... Geographic Information System
GIZ .... Deutsche Gesellschaft für Internationale Zusammenarbeit (German Society for International Cooperation)
GLISPA .... Global Island Partnership
GOG............ Government of Grenada

GOOS...........Global Ocean Observing System
GPMU..........Geothermal Energy Project Management
GPRS............Growth and Poverty Reduction Strategy
GRENLEC .....Grenada Electricity Services Ltd.
G-RESCP.......Electricity Sector to support Climate Policy in Grenada initiative
GSWMA.......Grenada Solid Waste Management Authority
GTOS............Global Terrestrial Observing System
GWP-C.........Global Water Partnership – Caribbean (GWP-C)
HDI ....Human Development Index
HDR ....Human Development Report
ICCAS...........Integrated Climate Change Adaptation Strategies
IFRC ....International Federation of Red Cross and Red Crescent Societies
IICA..............Inter-American Institute for Cooperation in Agriculture
INC...............Initial (First) National Communication (to the UNFCCC)
INDC ....Intended Nationally Determined Contribution
INSMET........Instituto de Meteorologia de Cuba
IPCC ....Inter-governmental Panel on Climate Change
IRENA ....International Renewable Energy Agency
IWCAM ....Integrated Water Resources and Coastal Areas Management
IWRM ....Integrated Water Resources Management
JICA..............Japan International Cooperation Agency
KAP ....Knowledge, Attitudes and Practices
kW ....Kilowatt
LDN..............Land Degradation Neutrality
LEAP ....Long-range Energy Alternative Planning
LED ....Light-Emitting Diode
LPG ....Liquid Petroleum Gas
LST ....Land Surface Temperature
MACC ....Mainstreaming Adaptation to Climate Change
MALFFE ....Ministry of Agriculture, Lands, Forestry, Fisheries and the Environment
MBIA............Maurice Bishop International Airport
MDG ....Millennium Development Goals
MEA............. Multilateral Environmental Agreement
MEA.............Multilateral Environmental Agreement
MEHRDE......Ministry of Education, Human Resource Development and Environment
MoHSS.........Ministry of Health and Social Security
MPA.............Marine Protected Area
MRV.............Monitoring, Reporting and Verification
MW ....Megawatt
MWh ....Megawatt-hour
N_2O ....Nitrous Oxide
NaDMA........National Disaster Management Agency

NAP ....Grenada's National Climate Change Adaptation Plan
NAWASA......National Water and Sewerage Authority
NBSAP ....National Biodiversity Strategy and Action Plan
NCB..............National Co-ordinating Body
NCCC ....National Climate Change Committee
NCCPAP ....National Climate Change Policy and Action Plan
NDC ....Nationally Determined Contribution
NDSP............National Sustainable Development Plan 2030
NFP ....National Focal Point
NGO.............Non-Governmental Organisation
NOAA...........National Oceanic and atmospheric Administration US
NREL ....National Renewable Energy Laboratory of the U.S. Department of Energy
NWIS ....National Water Information System
OAS..............Organisation of American States
OECS............Organisation of Eastern Caribbean States
PAHO...........Pan-American Health Organization
PICCAP.........Pacific Islands Climate Change Assistance Program
PPCR .... Pilot Program for Climate Resilience
PRECIS ....Providing Regional Climates for Impact Studies
PV ....Photovoltaic
RCC ....Regional Collaboration Centre (of the UNFCCC)
RCP ....Representative Concentration Pathway
RDVRP ....Regional Disaster Vulnerability Reduction Project
RECC ....Review of the Economics of Climate Change in the Caribbean
RET ....Renewable Energy Technology
RRACCC ....Reduce risks to Human and Natural Assets Resulting from Climate Change
SBSTA ....Subsidiary Body for Scientific and Technological Advice
SDC ....Sustainable Development Council
SDG..............Sustainable Development Goal
SGP ....Small Grants Program
SIDS ....Small Island Developing State(s)
SLR...............Sea Level Rise
SNC ....Second National Communication (to the UNFCCC)
SPCR ....Strategic Program for Climate Resilience
SPI................Standard Precipitation Index
SRO ....Statutory Rules and Orders
TAMCC.........T. A. Marryshow Community College
TEC ....Technology Executive Committee
TNA..............Technology Needs Assessments
UNCCD.........United Nations Convention to Combat Desertification and/or Drought
UNCBD.........United Nations Convention on Biological Diversity
UNDESA.......United Nations Department of Economic and Social Affairs

UNDP .... United Nations Development Programme
UNEP .... United Nations Environment Programme
UNEP-DTU ... United Nations Environment Programme and the Technical University of Denmark Partnership
UNESCO .... United Nations Educational, Scientific and Cultural Organization
UNFCCC .... United Nations Framework Convention on Climate Change
UNIDO .... United Nations Industrial Development Organization
US$ .... US Dollar
USAID .... United States Agency for International Development
UWI .... University of the West Indies
V&A .... Vulnerability and Adaptation
VCA .... Vulnerability and Capacity Assessment
W .... Watt
WAM .... With Additional Measures
WB .... The World Bank
WC .... Wider Caribbean
WEM .... With Existing Measures
WIGOS .... WMO Integrated Global Observing System
WINDREF ..... Windward Islands Research and Education Foundation
WMO .... World Meteorological Organisation
WPM .... With Potential Measures
WtE .... Waste-to-Energy
WTP .... Water Treatment Plant
XCD .... Eastern Caribbean Dollar

CHAPTER 1.
NATIONAL CIRCUMSTANCES

1.1 INTRODUCTION

The information presented within this chapter is linked to the other Sub-components of the national communication. Consequently, all sections and subject areas refer to the national situation in terms of physical, social, economic and policy contexts, and national and regional development priorities as appropriate. Information on the linkages between the activities and policies relating to climate change and those of other Conventions, such as the Convention on Biological Diversity and the Convention on Combating Desertification is also reflected in this chapter. The chapter provides an essential basis for understanding Grenada's current and future vulnerability, its capacity and appropriate response measures for climate change. These measures include options for addressing the country's GHG emissions, as well as adaptation options within the broader context of sustainable development.

The chapter was prepared by collecting all the required data and information from different sources through literature review and engagement with stakeholders, particularly the members of the National Climate Change Committee. Limitations were mostly confined to the inability to present extensive datasets or time series as a result of some data gaps and unavailability of data. The structure of the chapter closely follows that which is recommended in the UNFCCC Guidelines, and is as follows:

1. Physical Characteristics of Grenada
2. Climate
3. The Economy
4. National Infrastructure and Utilities
5. Demographic and Social Contexts
6. Climate Change Policy, Legislation and Institutional Arrangements

1.2 PHYSICAL CHARACTERISTICS

1.2.1 Geography

The sovereign state of Grenada[1] is comprised of three islands, including Grenada, Carriacou and Petite Martinique. The combined land area of all three islands is 345 km^2; with mainland Grenada being the largest at roughly 310 km^2 (34 km long and 18 km wide) and Carriacou and Petite Martinique having land areas of 34 km^2 and nearly 2 km^2, respectively (Government of Grenada, 2013a; Government of Grenada, 2011c). Grenada is the southernmost of the

[1] Hereinafter, the three islands of Grenada, Carriacou and Petite Martinique shall collectively be referred to as the *country of Grenada* or simply, *Grenada* and any reference to the main island of Grenada alone shall refer to is as *mainland Grenada*.

Windward Islands, located at 12.07° North latitude and 61.40° West longitude, between Saint Vincent and the Grenadines to the north and Trinidad and Tobago to the south (Government of Grenada, 2013a). Mainland Grenada is divided into 6 administrative parishes: Saint Patrick, Saint Andrew, Saint David, Saint George, Saint John and Saint Mark (see Figure 1).

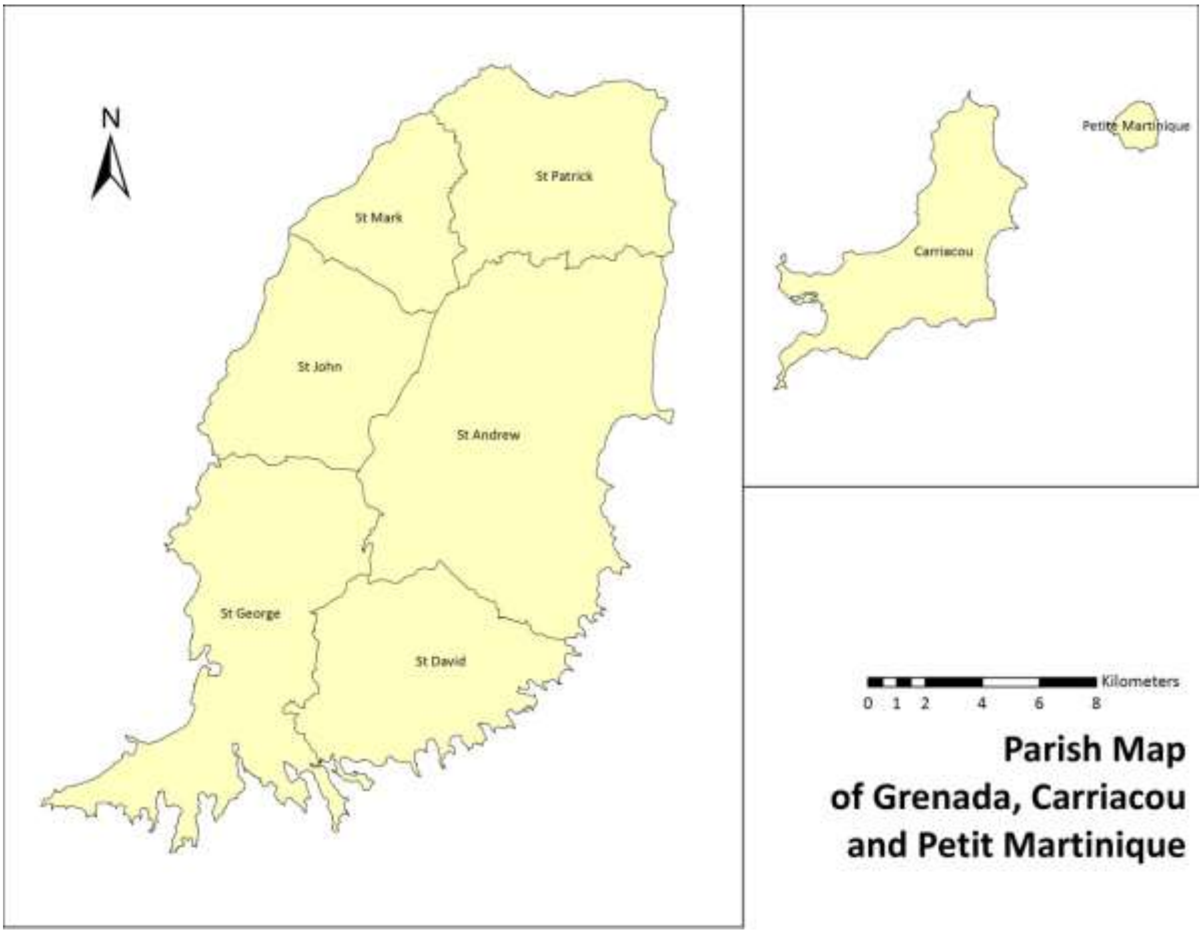

Figure 1-Map of Grenada, including the islands of mainland Grenada, Carriacou and Petite Martinique

The capital city of mainland Grenada is St. George's, which is situated in the southwest of the island. The east coast of mainland Grenada is bounded by the Atlantic Ocean, while the west coast is bordered by the Caribbean Sea.

1.2.2 Topography, Geology and Soils

The topography of mainland Grenada is varied, but is generally steep; seventy one percent of the land has a slope of over 20 degrees (Niles, 2013). The highest point out of all three islands is Mount Saint Catherine, within the central mountain chain on mainland Grenada, which reaches 2,757 ft. in elevation (GFDRR, 2010; see Figure 2). Steep mountain peaks, deep valleys and volcanic craters characterise the centre of mainland Grenada's land mass. The western coast of mainland Grenada is rugged and defined by a series of bays and headlands, in contrast to the eastern coast which consists of rolling plains. The southern part of the island is relatively flat with a number of beaches which have attracted substantial tourism development in the last few decades (Kairi Consultants Ltd., 2008).

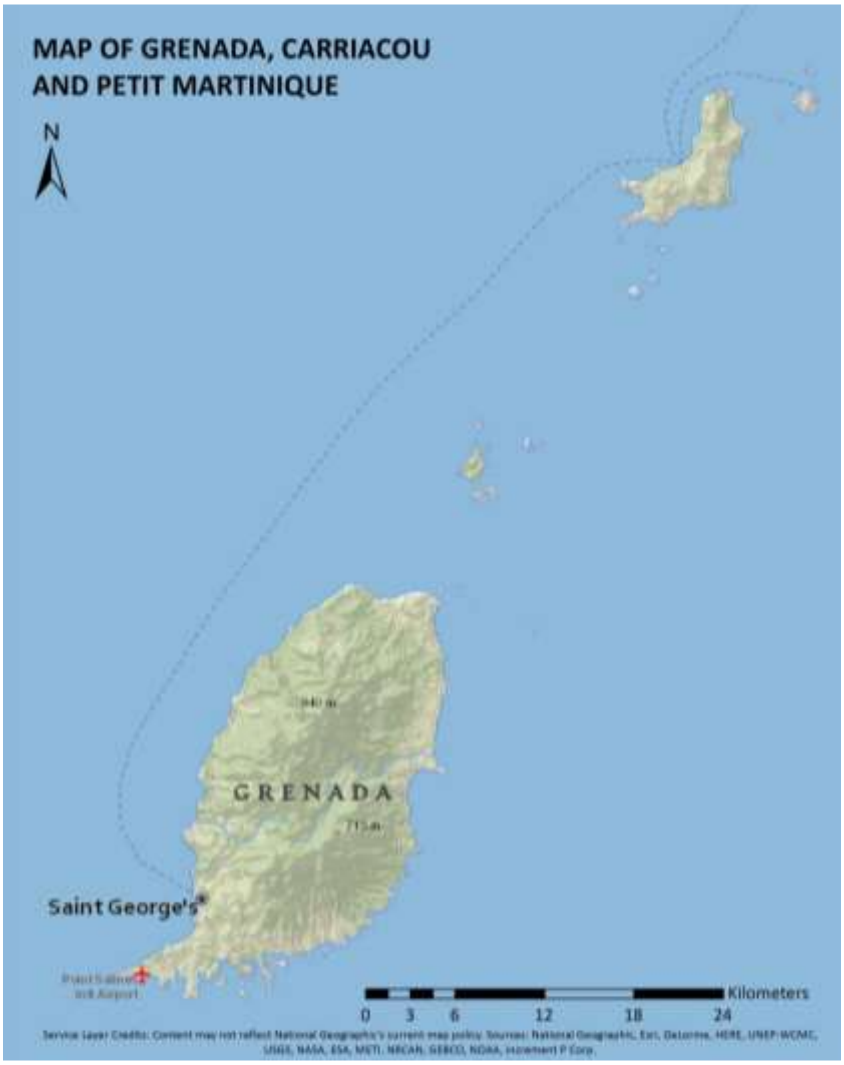

Figure 2-General Relief Map of Grenada

Carriacou's terrain is less hilly than Grenada's; only 50% of the land has slopes greater than 20 degrees and the island's highest point is High North Peak, which rises to 954 ft. in elevation (Niles, 2013).

Petite Martinique's terrain is rugged with 90% of the lands having slopes greater than 20 degrees (Niles, 2013). The island's highest point reaches 756 ft. above sea level (Government of Grenada, 2013b). The east coast of the island is rocky and uninhabited.

All three islands are irregularly shaped, with indented bays that harbour white sand beaches in some areas and mangrove forests in others.

The islands of Grenada are predominantly volcanic in origin and is almost entirely composed of andesite lava (in the centre of the island) and basalt and pyroclastic rocks (in a belt along the rim) (Niles, 2013) However, there are also more isolated deposits of alluvial sediments near streams and rivers, limestone in isolated outcrops and tuffaceous shale in the northwest coast (Government of Grenada, 2000c).

Carriacou and Petite Martinique constitute the exposed peaks of submerged volcanic mountains. There is an active underwater volcano called 'Kick 'em Jenny' located approximately 8 km off the north coast of Grenada. Much of what's known regarding the soils of Grenada stems from the work of Ternon et al., (1989) and Vernon et al., (1959). Topography and climate, especially, are the dominant factors which influence soil formation in Grenada. Clay loams are the dominant type of soil which are found (84.5%), followed by clays (11.6%) and sandy loams (2.9%). Three major types of clay loam comprise the vast majority of these soils: Woburn, Capitol, and Belmont. Together these three types of clay loam constitute nearly 80% of the island's soil. In some places, eruptions of the Soufrière volcano in St. Vincent have added ash to old soils, which serve to replenish nutrients in wetter areas that are prone to weathering and leaching of minerals. The soils of Carriacou and Petite Martinique are primarily made up of Woburn Clay Loam (65.22%) and Limlair Clay (16.03%). However, some agricultural practices have degraded soil quality (Government of Grenada, 2005a).

1.2.3 Hydrology and Drainage

Grenada's wet season traditionally runs from June to December. Mainland Grenada's interior mountains produce an orographic effect which causes a difference in the distribution of rainfall across the land; rainfall is greatest in mountainous areas of high elevation. Average annual rainfall in the interior is approximately 4,000 mm, while the coastal zone receives only 1,000 mm to 1,500 mm in comparison (CEHI, 2007). The northern and southern ends of the island receive the least rainfall and are, consequently, the most arid. Carriacou and Petite Martinique are much drier in comparison to mainland Grenada, owing to their small size and lower elevation and receive an annual average rainfall of approximately 1,000 mm (CEHI, 2007).

Rainfall on mainland Grenada supports surface stream flow and recharges underground aquifers. The land mass is separated into 71 watershed areas and these are comprised of a network of permanent rivers (CEHI, 2007; see Figure 3 and Figure 4). The largest of the watersheds is the Great River watershed which accounts for approximately 15% of mainland Grenada's total area. Most of the surface flow of water originates from high rainfall areas in the central mountains and continues towards the coast in a distinct radial pattern (Environmental Solutions Ltd., 2015). Lakes have formed in several extinct volcanic craters, including Grand Etang (the largest), Lake Antoine and Levera Pond (Government of Grenada, 2011c). Mainland Grenada has an abundance of surface water resources, owing to its numerous rain-fed mountain streams and rivers, and these surface water sources are the primary sources of potable water on the island.

Figure 3-Watersheds on mainland Grenada (Source: produced by author, based on data from the Land Use Division, 2000)

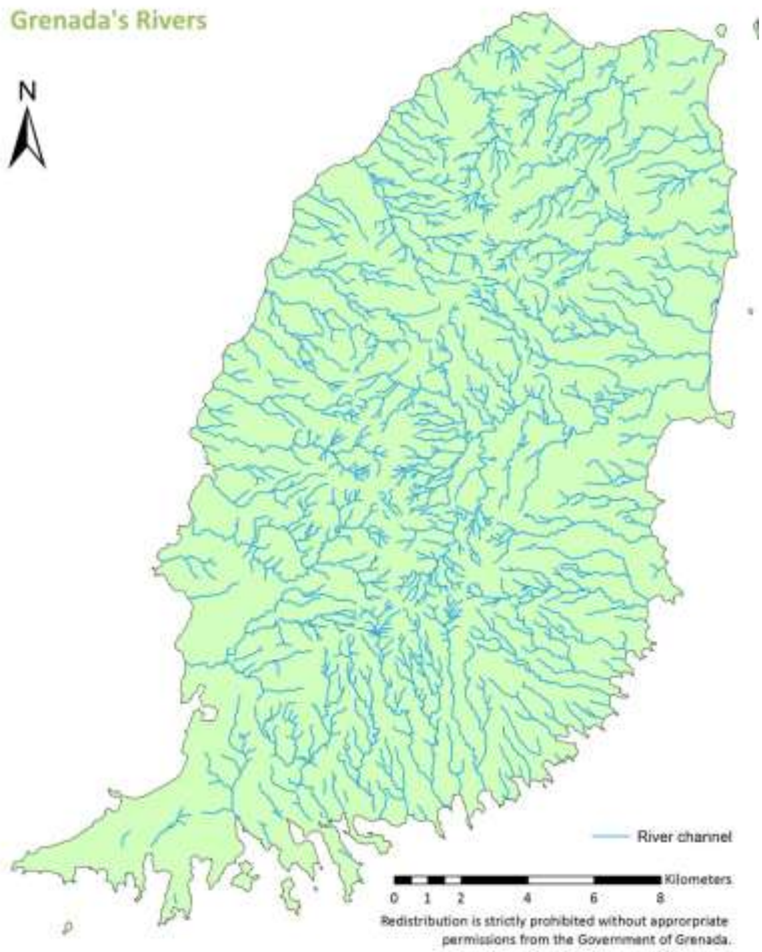

Figure 4-Grenada's Rivers (Source: based on data sourced from the CHaRIM GeoNode)

Grenada's steep slopes and volcanic rock-based soils which have low permeability contribute to drainage infiltration that is low and run-off that is commensurately high. Additionally, the meeting points for many rivers and tributaries occur in coastal and other low-lying areas. This combination of drainage, geology and topography gives rise to very high run-off during intense rainfall events, erosion in steep areas where surface flow rates are rapid, and flooding in moderate to low-lying areas where the water is unable to drain faster than it accumulates (Environmental Solutions Ltd., 2015).

Carriacou and Petite Martinique have mostly streams. Carriacou is separated into 20 distinct watershed units (See Figure 5), while Petite Martinique has no such differentiations (CEHI, 2007). Carriacou, like Grenada, also exhibits a radial drainage pattern where the surface flows originate from the central areas and drain towards the coast. High runoffs can occur in extreme rainfall events owing to the coincidence of geology, topography and drainage factors, and watersheds that are in low-lying areas can experience erosion and flooding. In Petite

Martinique, the drainage pattern follows the natural land form into gullies and ravines and there are no rivers (Environmental Solutions Ltd., 2015).

Figure 5-Watersheds on Carriacou (Source: produced by author; based on data from the Land Use Division, 2000)

1.2.4 Biodiversity and Ecosystems

Despite its relatively small size, Grenada is rich in biodiversity, which provides a number of ecosystem goods and services that support critical sectors of its economy. As part of its efforts to safeguard and enhance this natural capital, Grenada has ratified the United Nations Convention on Biological Diversity (CBD) and regularly reports to the Convention about its activities through the CBD National Focal Point in the Ministry of Education, Human Resource Development and the Environment (Convention on Biological Diversity, n.d.). Additionally, the country recently signed on to the Declaration on the application of Principle 10 of the Rio

Declaration on Environment and Development in Latin America and the Caribbean (ECLAC, 2016). As a signatory, Grenada will undertake to advance the achievement of a regional instrument on the rights of access to environmental information, participation and justice, areas which are enshrined in the Principle 10 of the Rio Declaration on Environment and Development (ECLAC, 2016).

1.2.5 Coastal and Marine Ecosystems

Grenada's coastline is 121 km long and is dotted with beaches, mangrove swamps, lagoons, dry woodlands and cactus shrub. The nearshore marine environment includes coral reefs and seagrass beds. Collectively, these ecosystems are home to 233 marine species, 69 brackish water/marine species and a number of sea birds, as well as four species of sea turtles and humpback whales, intermittently (Government of Grenada, 2009b). The coral reefs, coastal lagoons, including seagrass beds and mangrove areas provide a variety of habitats for species to forage, spawn, hide and recruit. However, Grenada's Fifth National Report to the Convention on Biological Diversity (2014) indicates that these ecosystems are being overexploited for tourism, agriculture, energy and construction purposes resulting in their overuse and in some cases, destruction.

Coral reefs

Mainland Grenada is surrounded by about 12.5 km^2 of coral reefs, which can be found throughout the island (Government of Grenada, 2009b). Both Carriacou and Petite Martinique are also fringed by coral reef systems. Five types of corals form the basis of the reefs around Grenada, including the critically endangered Elkhorn coral, as well as Boulder coral, Finger coral, Mustard coral and Brain coral (Government of Grenada, 2009b). Like many areas in the Caribbean, the health of the reefs in Grenada has declined over the previous decades and surveys completed between 2008 and 2010 indicate that many nearshore reef areas are dominated by algae rather than corals (Anderson et al., 2012). Despite these changes, Grenada's extensive reef system (including the Grenada Bank Reef) is considered an area of ecological significance as it is thought to supply the Northern Caribbean with larval fish and coral (UNDESA, 2012).

Mangroves

A recent study using both remote and field mapping techniques to provide updated information on mangrove forest cover on the islands that constitute Grenada. The study determined that Grenada maintains 298 hectares of total mangroves, a significant area of habitat within the context of the Windward Islands (Moore et al., 2014). Three true mangrove species characterise these forests; the red mangrove, black mangrove and white mangrove; and two mangrove associates are also commonly found – the buttonwood and mangrove fern. Basin mangroves represent the greatest area (181 ha), followed by fringing mangroves (65 ha), while scrub (8 ha) and riverine (1 ha) mangroves contribute the least to total area. Fringing mangroves, which play an important role in shoreline protection, exist in isolated patches. Mangrove forests are mainly distributed along the southern and eastern coasts of the main island of Grenada, as well as three main mangrove areas in Carriacou, on the north and west coasts. Petite Martinique has no mangrove areas.

In 2004, Hurricane Ivan caused extensive damage to Grenada's forests, including its mangrove areas. Mangroves remain under threat of deforestation primarily from housing and tourism developments along the coast.

Seagrass beds

Seagrass beds can be found in the shallow, sheltered waters of Grenada, Carriacou and Petite Martinique. There are approximately 1800 ha of seagrass in Grenada (Aucion, 2013 in Government of Grenada, 2014). The main species of seagrass in the waters of the Grenadines are turtle grass (*Thalassia testudinum*) and manatee grass, which are commonly found throughout the Caribbean. Seagrass beds are concentrated along the eastern and south eastern coast of mainland Grenada, in the area of Telescope and within the reef formation extending from Grenville Bay (Parish of Saint Andrew) to Prickly Bay in the south (Parish of Saint George) (Government of Grenada, 2000a). Similarly, in Carriacou, seagrass beds are primarily found on the eastern and southeastern coasts (Government of Grenada, 2014a).

1.2.6 Forest Ecosystem

Much of Grenada's biodiversity is found in its forests. Survey work undertaken in the 1940's resulted in the identification of six forest communities: Cloud Forest; Rain Forest and Lower Montane Rain Forest; Evergreen and Semi-evergreen Forest; Deciduous Forest and Cactus Scrub; Littoral Woodlands; and Mangrove Woodlands (Beard, 1949). Altogether, these forests cover approximately 50% of the land area (FAO, 2014a).

There are approximately 16,993 hectares of forest in Grenada (FAO, 2014b). The major forested regions in the state include Mount St. Catherine Forest Reserve, Grand Etang Forest Reserve, Levera, Mount Hope/Clabony water catchment, Annandale watershed and Morne Delice on mainland Grenada, as well as the High North Forest Reserve in Carriacou (Government of Grenada, 2014a). There are five forested areas in Grenada which are officially protected: Grand Etang Forest Reserve, Annandale Watershed, Concord Watershed, Mt. St. Catherine State Land and Mt Hope/Clabony Watershed (FAO, 2014b). The largest of these areas is the Grand Etang Forest Reserve, which protects 1,748 hectares of cloud forest, rain forest and lower montane rain forest and plantations from any change in land use and from hunting (Government of Grenada, 2000a; FAO, 2014b).

It has been reported that the forests of Grenada support 450 species of flowering plants and 85 different types of trees (McGregor et al., 1998; Government of Grenada, 2014a). Three endemic plant species are also present: the Grand Etang Fern (*Danaea sp*.), the Cabbage Palm (*Oxeodoxa oleracea*) and the tree species (*Maythenus grenadensis*) (Government of Grenada, 2000a).

Overall, Grenada's terrestrial habitats are home to 22 mammals (three of which are native), 150 species of birds (18 of which are considered threatened or endangered), four amphibian species and a number of invertebrates (Government of Grenada, 2014a). Within each of these groups there are several notable species, including the Lesser Chapman's Murine Opossum, the Greater Chapman Murine Opossum and the Nine Banded Armadillo (which together comprise the only native mammals in Grenada) as well as the endangered Grenada Frog. The dry forests found in the north and south of mainland Grenada are critical habitats to two endemic and endangered birds: the Grenada Hook-billed Kite (*Chondrohierax uncinatusmurus*) and the Grenada Dove (*Leptotila wellsi*) (Government of Grenada, 2000a). Grenada is also home to a few other species of birds which are endemic to the Lesser Antilles, including the Lesser Antillean bullfinch (*Loxigilla noctis*), the Grenada flycatcher (*Myiarchus nugator*), the Scaly-breasted thrasher, (*Margarops fuscus*), and the Lesser Antillean tanager (*Tangara cucullata*) (Government of Grenada, 2014a).

Mainland Grenada once had large expanses of primary forests; however much of the island has been deforested, firstly for conversion to sugarcane and cotton plantations in the 18th century and subsequently for lumber, energy, agriculture and housing purposes (Government of Grenada, 2009b). While a recent report (FAO, 2014) indicates that Grenada's forest cover remained stable from 1990-2010 (occupying 50% of the land area), forested areas still face threats from clearing of land for agricultural production, tourism development, housing settlements, animal tethering, infrastructure and commercial activities. In Carriacou, overgrazing by livestock has made it difficult for natural vegetation to regenerate (FAO, 2014a).

Hurricanes have also caused severe damage to forest resources; Hurricane Ivan, which passed over the island in 2004, destroyed an estimated 90% of forest cover in the Grand Etang Forest Reserve (Williams, 2010). Mangrove forests, especially in the southern part of the island, have been cleared to make way for marinas and tourism facilities. In spite of the losses of forested areas as a result of both natural and man-made events, several recent (from 2009-2015) initiatives in the areas of mangrove restoration and forest replanting and rehabilitation have been undertaken throughout Grenada (Government of Grenada, 2014a). Mangrove replanting is also being undertaken at the community level as a form of ecosystem based adaptation to climate change (Government of Grenada, 2015d). Such replanting efforts have had varying rates of success, with the survival of replanted areas being low to medium in some cases and over 90% in others (Government of Grenada, 2014a).

The legal and policy framework for management of forests in Grenada is comprised of the National Forest Policy (1999, Forest Policy Strategic Plan (2001-2011), the Soil and Water Conservation Ordinance and other Acts; and the Millennium Development Goals (MDGs) and Multilateral Environmental Agreements (MEAs) (FAO, 2014a). Forest reserves in Grenada are controlled by the Forestry Division and the forested crown lands are managed by the Lands and Surveys Division, of the Ministry of Agriculture.

1.2.7 Freshwater Ecosystems

Mainland Grenada is well-endowed with freshwater resources. The land mass is marked by an intricate network of rivers and streams, three volcanic lakes and one man-made lake (Lake Palmiste). In contrast, Carriacou and Petite Martinique are dominated by intermittent streams (CEHI, 2007).

In terms of biodiversity, 17 freshwater species can be found on mainland Grenada, including many fish species, the notable ones being tilapia, yoca, titiree, crevalle jack, mullet, crayfish, zandmey, river coco, guppy and sword tail (Government of Grenada, 2009b). Several species of snails and insects are also associated with freshwater habitats.

A number of issues threaten Grenada's freshwater resources, including improper disposal of domestic waste, overexploitation of species, unsustainable agricultural practices (including the use of weedicides and pesticides), marine saline intrusion, deforestation, introduction of alien invasive species and intense extraction of freshwater for domestic and commercial usage (Government of Grenada, 2009b).

1.2.8 Land Use

Recent data on land use for Grenada is not readily available; however the Government's (2015e) report to the United Nations Convention to Combat Desertification (UNCCD), on their efforts towards implementing the land degradation neutrality concept, provides a snapshot of the state of land use in 2010 and trends over the previous decade. Land-use information for Grenada from this report is presented in Table 1. The biggest change reported over this period was the increase in urban (artificial) areas (by 13.41%). Additionally, the areas of shrubs, grassland, sparsely vegetated areas and wetlands and water bodies decreased by roughly 5%. Croplands and forested areas each decreased by less than 2%. The report also cites that areas of abandoned cropland in Grenada have increased, likely due to neglect. Grenada's Fifth National Report to the Convention on Biodiversity (2014a) attributes this increase in abandoned cropland to the decline of the country's agriculture sector over the last 20 years.

Table 1-Land use in Grenada

Land Use Category	Land Area in Hectares (2000)	Land Area in Hectares (2010)	Net change in area in Hectares (2000-2010)	Percent (%) Change in Area in Hectares (2000-2010)
Forest Land	9,317.0	9,229.96	87.04	-0.93%
Shrubs, grassland and sparsely vegetated areas	1,813.1	1,719.99	93.11	-5.14%
Cropland	18,077.1	17,814.46	262.64	-1.45%
Wetlands and water bodies	262.71	250.02	12.69	-4.83%
Artificial areas	1,864.7	2320.17	250.02	13.41%
Bare land and other areas				
TOTAL	**31,334.6**	**31,334.6**	**705.77**	
				Adapted from: Government of Grenada, 2015e

The Government (2015e) report identified the following as direct drivers of land degradation in Grenada:

- On mainland Grenada, deforestation is occurring mainly in the central area and southwestern end of the island;
- On Carriacou, where livestock rearing is commonplace and animals are left to forage for food during the dry season, soil erosion is occurring as a result of overgrazing;
- Uncontrolled mining of gravel, sand, and other aggregates weakens ecosystems and increases their vulnerability to natural hazards (e.g. hurricanes) and storms. Grenada has experienced problems with unregulated mining of sand, for use in construction; the practice has been identified as a major contributor to beach erosion (Isaac, n.d.).
- Inappropriate agricultural practices are a major cause of land degradation in Grenada; particularly indiscriminate use of synthetic herbicides, pesticides and fertilisers, slash and burn, and planting of shallow rooted crops on steep slopes.
- Climatic events such as hurricane Ivan in 2004 and Emily in 2005 not only severely damaged forests, but also caused extensive erosion on some exposed slopes (Government of Grenada, 2015e).

1.3 CLIMATE

The humid tropical marine climate experienced by Grenada, Carriacou and Petite Martinique is strongly shaped by their location and topography. The climate is influenced by Tropical Atlantic Hurricane activity, the North Atlantic Sub-Tropical High, the North East Trade Winds, and also by weather resulting from the convergence of the North and South East trade winds forming the migrating Inter-Tropical Convergence Zone (ITCZ).

In the Caribbean, inter-annual variations in rainfall and drought incidence are associated with the El Niño Southern Oscillation (ENSO) phenomenon that results in multi-year cycles of rainfall variance. These cycles normally range from 3 – 7 years (the average duration is 5 years), characterized by (a) the *El Nino* period where there are less active Tropical Atlantic Hurricane seasons; followed by (b) the *La Nina* period characterized by more active seasons with stronger storms.

1.3.1 Temperature

In Grenada and its dependencies, observed average annual temperatures do not vary significantly, with a minimum average of 28.3°C and a maximum average of 33.3°C (Government of Grenada, 2015g). The current averages in temperature are higher than those reported in the Initial National Communication (INC) (Government of Grenada, 2000a) and a distinct warming trend is evident (Government of Grenada, 2011c). Average diurnal ranges in observed maximum and minimum temperature are small, tempered by oceanic wind influences.

1.3.2 Rainfall

Grenada experiences most of its rainfall during the Tropical Atlantic Hurricane season which normally lasts from June to December. This same period coincides with the annual 'wet' season for Grenada (Government of Grenada, 2015g). ITCZ activity also influences weather in Grenada when the ITCZ is at its most northern position during the middle months of the year. The dry season, when the least rainfall is generally recorded, occurs during the January to May period.

On mainland Grenada, topography and orographic processes are key factors causing the significant spatial variations in rainfall, with annual averages ranging from approximately 1,000 - 1,500 mm per year in drier coastal locations, to approximately 4,000 mm in the central mountainous areas (Figure 6). Thirteen (13) climatic zones characterize mainland Grenada as a result of these spatial variations in rainfall (Figure 7) (Government of Grenada, 2015g). The dependencies – Carriacou and Petite Martinique – are much smaller and flatter, and thus have no orographic influences on total rainfall. Therefore, lower rainfall figures are generally recorded, and climate tends to be relatively even across both islands (Government of Grenada, 2011c).

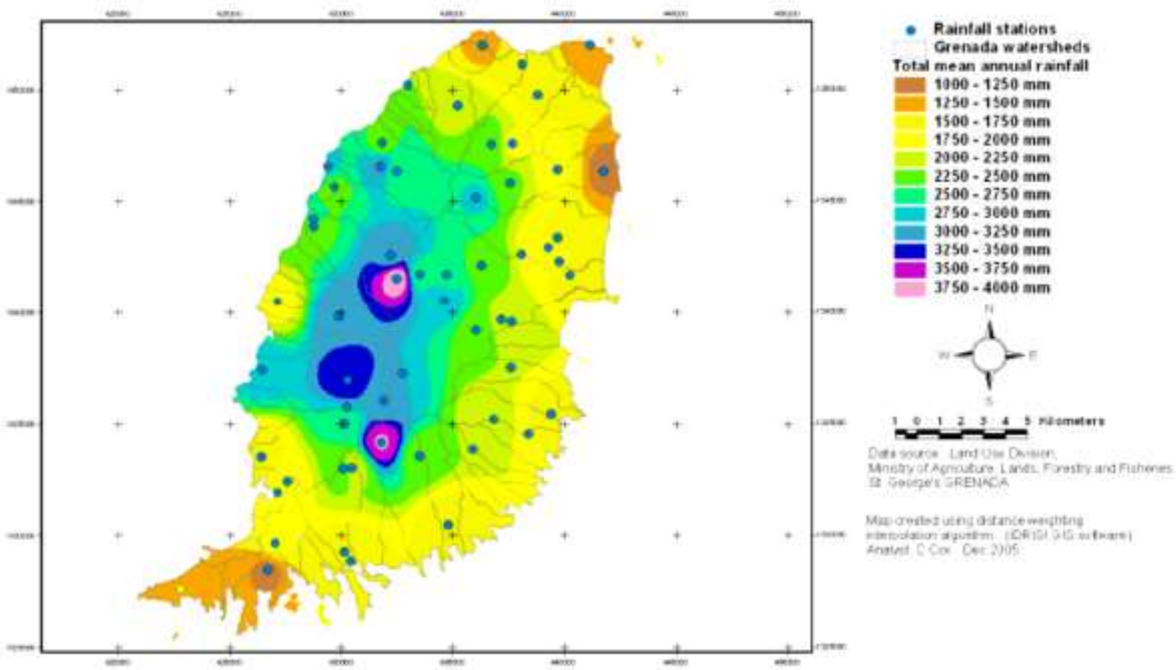

Figure 6-Mean Annual Rainfall for Grenada (Source: CEHI, 2006)

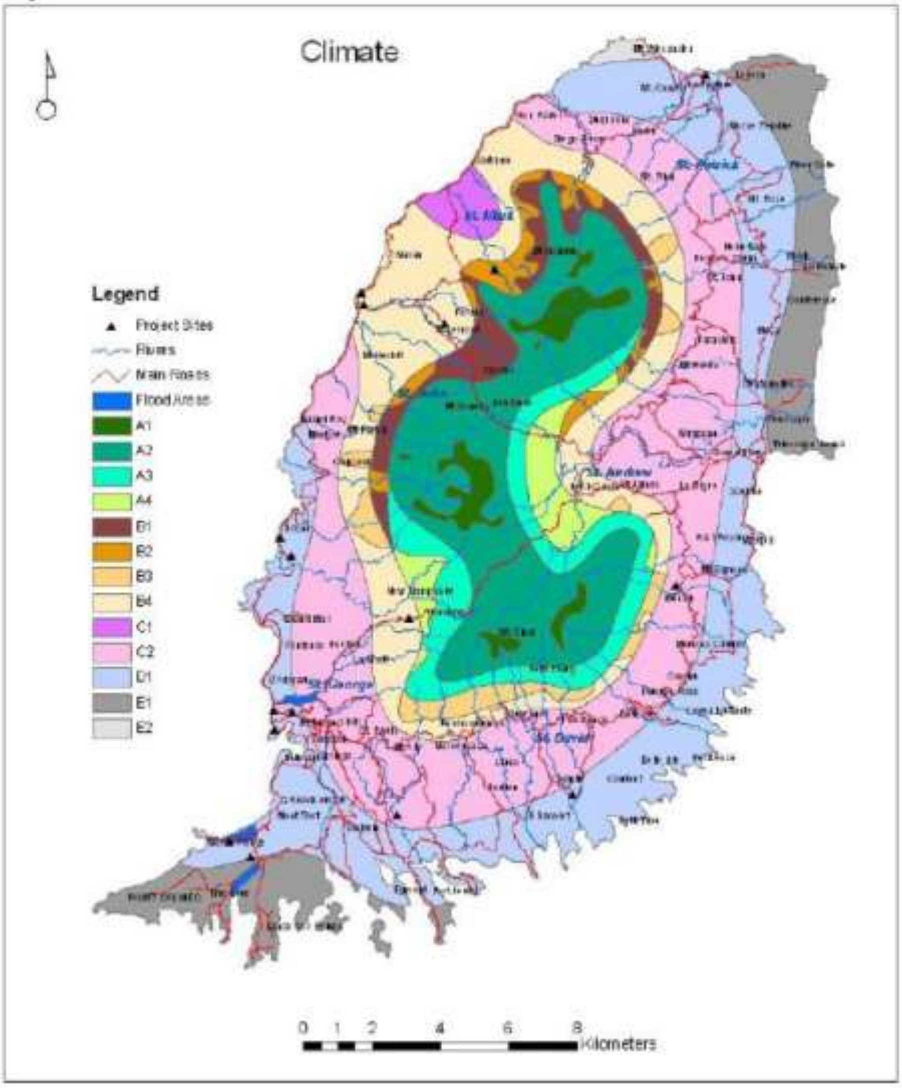

Figure 7-Grenada's Climatic Zones (Source: Government of Grenada, 2015g)

1.3.3 Tropical Storms

Grenada, being closer to the equator, is not directly impacted by many of the intense tropical storm or hurricane events (Figure 8). Prior to the 1990s, the most damaging event was Hurricane Janet in 1955, which resulted in the loss of more than 100 lives and island wide destruction(Government of Grenada, 2000a; Government of Grenada, 2011c).

Figure 8-Output from the NOAA Historical Hurricane Tracks Tool, showing the tracks of named storms whose centres passed over or near to Grenada since 1950.

(NB: tracks shown for tropical depressions are those that further developed into named storms after passing Grenada. Source: (NOAA, 2016))

However, the years following the submission of the INC a drastic turn of events in regard to the potential impacts of climate variability and climate change was observed. Grenada was devastated by Hurricane Ivan in 2004 – perhaps the most famous event on Grenada's recent weather record – a Category 3 hurricane with wind speeds exceeding 120 mph (OECS, 2004). The passage of Hurricane Ivan caused extensive destruction across Grenada's economic and social sectors – notably agriculture, tourism, housing and public infrastructure (education, health and utilities) – and resulted in the loss of 28 lives (OECS, 2004). Only shortly thereafter in 2005, the northern section of Grenada was affected by Hurricane Emily, which caused further destruction especially to the agriculture sector (Government of Grenada, 2011c).

Many areas of mainland Grenada are susceptible to flooding, with some areas being less than 2 m above sea level. These include areas of St. George (e.g. Carenage, Melville Street), Grenville, Hillsborough and the southwest peninsula as they are located on the coast. The country experienced severe flood damage caused by storm surge and high waves as Hurricane Lenny passed across the northern portion of the eastern Caribbean in 1999, causing US $94.3 million in damage, which amounted to 27% of GDP (USAID, 2000; in CARIBSAVE, 2012). Carriacou and Petite Martinique are susceptible to drought conditions, particularly in the dry season because of comparatively low rainfall and low water retention capacity, (Farrell et al., 2010; Government of Grenada, 2011c). A major drought event impacted Grenada over the 2009–2010 period. Although a regional event, the greatest declines in recorded rainfall were observed in Grenada, with some months recording up to 50% below normal rainfall, and the perennially wet interior areas experiencing 1-2 dry months (Farrell et al., 2010). The drought conditions experienced in Grenada were some of the worst during the last 20 years and as a result, vegetables, fruits and root crops were destroyed.

Mainland Grenada's topography and drainage lends to higher risks of localised flash flooding and attendant landslides on and near to steep-sloped areas or locations with streams/rivers.

More so, instances of flooding in Grenada are associated with the impacts of storm surge events on communities and infrastructure in low lying coastal areas (GFDRR, 2010). Flooding from excess rainfall and storm surges are more likely to occur during the wet season, but instances of flooding during the dry season can occur as in 2011 (CDEMA, 2013).

1.4 THE ECONOMY

In the previous two decades, Grenada's economy has switched from being agriculture-based to service-dominated. Over the same period, the country's economy has shown modest growth; with average annual economic growth from 1981-2013 being 3.4% (IDB, 2013). The economy suffered major setbacks from Hurricanes Ivan and Emily and also from recent global economic downturns.

1.4.1 Macro-Economic Performance: Gross Domestic Product

Real GDP is often referred to as "Constant Price" or "Constant Dollar" GDP. Figure 9 shows the pattern of Grenada's Real GDP performance from 1995-2015, with data projected for 2014 and estimated for 2015 (About Money, 2016; the World Bank, n.d.).

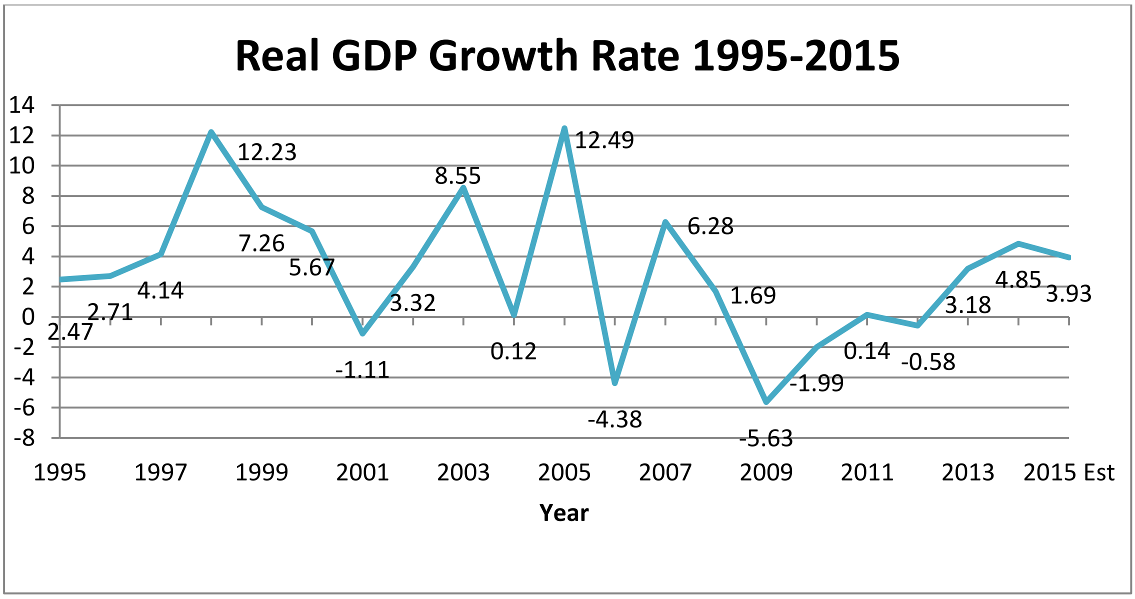

Figure 9-Real GDP Growth Rate 1995-2015; Source: (ECCB, 2016a)

The Grenadian economy has exhibited moderate growth over the last twenty years. In 2015, GDP in constant (2006) prices was estimated at XCD 2,126.27 million, representing an 86% growth from its value in 1995. Average annual economic growth from 1995-2003 was 5%. The impact from the Hurricane Ivan in 2004 was devastating; damage was estimated at US$900 million; exceeding 200% of the country's GDP (Government of Grenada, 2015f). This event was a tremendous setback to the country's economy, and economic growth dropped to 0.12% in 2004, a stark contrast compared to the preceding year's growth rate of over 8% (as reflected in Figure

9). The passage of Hurricane Emily in 2005 also took its toll on the country; damages from this hurricane's impact were estimated at 12.5% of the GDP (Government of Grenada, 2015f). Grenada made a notable recovery from both hurricane events and its economy continued to grow, due to the increased economic activity from the reconstruction and rebuilding programmes, as evidenced by the 12.5% growth rate in 2005. In 2007, the economy was further bolstered by the CWC World Cricket cup events that were hosted in Grenada. The country has not been immune to the recent global economic and financial crisis and it recorded negative growth rates in 2009 (-5.63%) and 2010 (-1.99%).

The Government of Grenada's recent (November, 2015) Budget Statement notes that the country is projected to record a real GDP growth rate of 5.1% in 2016 (Government of Grenada, 2015a). The primary drivers of this growth performance are cited as Construction, Agriculture, Tourism and Education (Government of Grenada, 2015a).

The Grenadian economy has traditionally depended on exports of agricultural commodities – mainly banana and nutmeg; however hurricanes Ivan and Emily proved devastating for industries, whilst the loss of European trade preferences on banana led to the virtual disappearance of the industry (IDB, 2013). Table 2- displays the contribution of various industries to Grenada's GDP in 2013 and projections for 2014. In 1980, Agriculture, Livestock and Forestry contributed 17.16% to Grenada's GDP, however this declined to just 3.97% in 2013, but was projected to grow to 5.82% in 2014 (ECCB, 2016a).

Table 2-Contribution to GDP by industry in Grenada (%) in 2013 and projections for 2014

Industry	2013	2014 (Projected)
Agriculture, Livestock and Forestry	3.97	5.82
Fishing	1.75	1.74
Mining & Quarrying	0.23	0.17
Manufacturing	3.55	3.44
Electricity & Water	4.53	4.34
Construction	7.38	6.21
Wholesale & Retail Trade	7.87	7.8
Hotels & Restaurants	4.44	5.51
Transport, Storage and Communications	13.39	13.55
Financial Intermediation	7.27	6.77
Real Estate, Renting and Business Activities	14.33	13.91
Public Administration, Defence & Compulsory Social Security	8.48	8.09
Education	18.78	18.72
Health and Social Work	2.38	2.26
Other Community, Social & Personal Services	2.09	2.04
Activities of Private Households as Employers	0.94	0.91

Industry	2013	2014 (Projected)
(Source: ECCB, 2016b)		

The service industry now plays a primary role in Grenada's domestic production and is also important for employment. Within this sector, three services dominate: education; real estate, renting and business activities; and transport, storage and communication (IDB, 2013). Altogether, in 2013 these contributed 46.5% to the Grenadian economy. St. George's University School of Medicine is one of the largest employers on the island and makes a significant contribution to the island's economy in the form of salaries, housing, hotel accommodation, recreation, food, construction, goods and services, advertising expenditure and charitable donations.

1.4.2 Trade

Since 2000, Grenada's net trade balance has declined significantly, mainly due to a major rise in total imports, while total exports have remained fairly constant, particularly for the last ten years (Figure 10). Exports of nutmeg, which used to be one of the country's main export commodities dropped drastically after hurricanes Ivan and Emily (in 2004 and 2005) destroyed most of the plantations. The decline in exports of this commodity has been somewhat supplemented by an increase in exports of cocoa and cocoa preparations and more recently, fish (IDB, 2013).

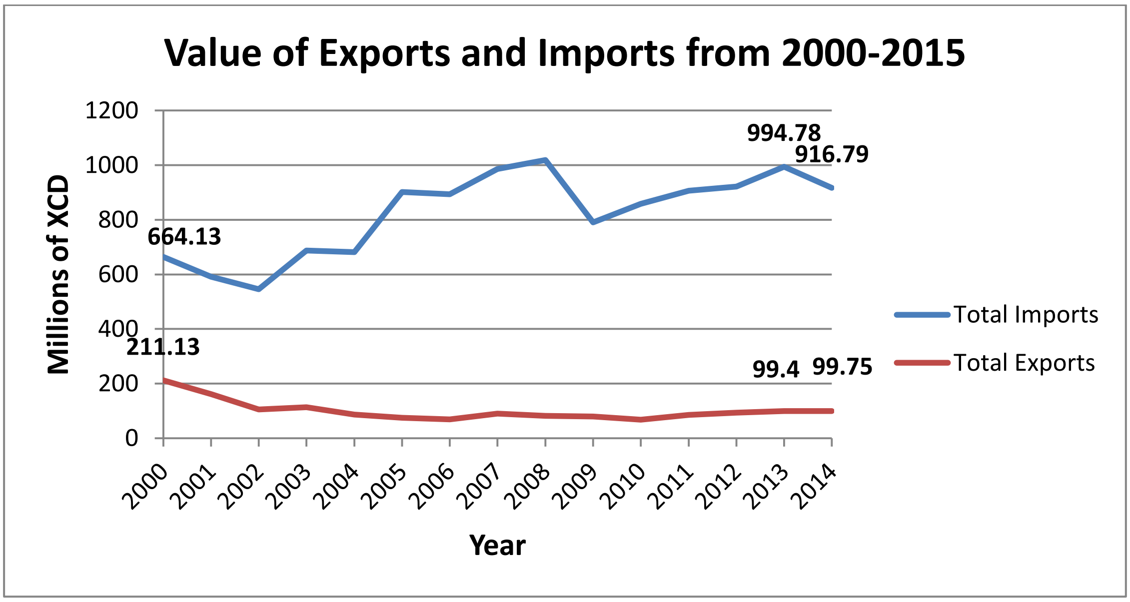

Figure 10-Value of Grenada's Exports and Imports from 2000-2015; Source: (ECCB, 2016b)

In 2014, total exports for Grenada amounted to $99.8 million XCD, while the value of total imports was $916.8 million XCD. Grenada is reliant on imports of fuel and food to power and feed the country; in 2014 Minerals, Fuels and Related Materials, and Food and Live Animals accounted for the largest portion of imports, comprising 25.9% and 22.7% of imports, respectively (see Figure 11). Overall, Grenada is a net importer of food, despite the fact that some of its food products (e.g. fish and spices) are major exports for the country (Government of Grenada, 2013d). In particular, Grenada's livestock industry is not able to completely supply domestic demand for meat and consequently, meat has become a major import commodity for the country (David, 2004). The tariffs applied to most imported goods in Grenada are fairly low, which means that local producers are subject to strong competition from imported products. However, the Government of Grenada has sought to enhance the competitiveness of its export industries through reducing input costs via the provision of concessions to some industries (for example, tourism) to import goods duty-free (IDB, 2013).

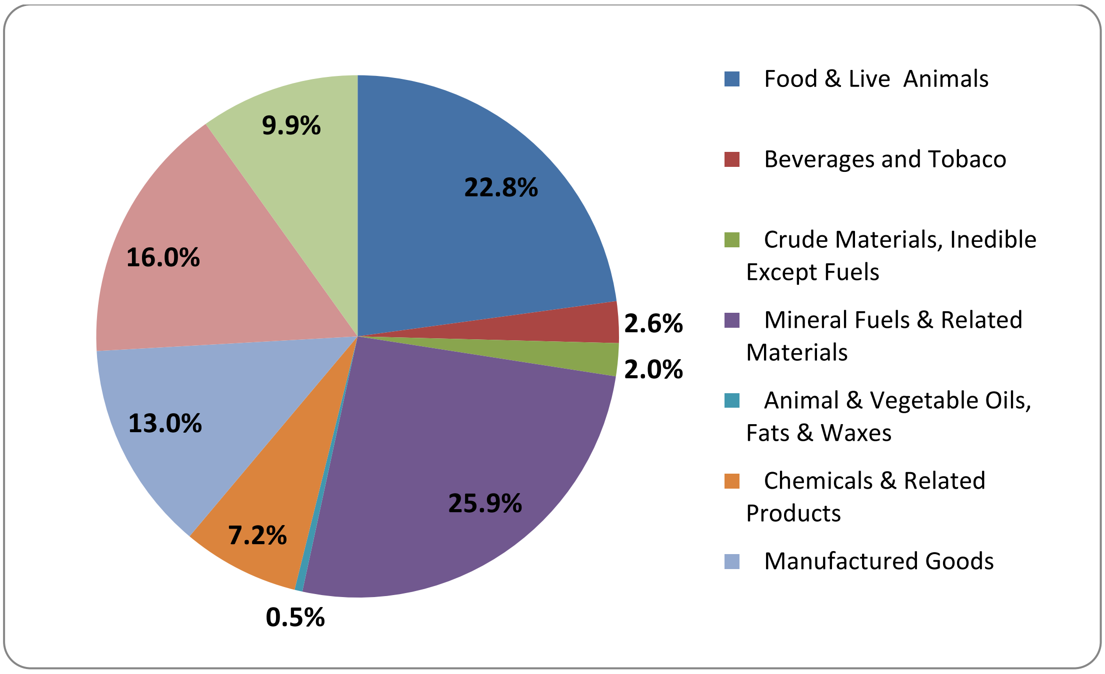

Figure 11-Percent (%) contribution to total imports by various sectors in 2014

In 2014, Agricultural produce and Fisheries were Grenada's primary category of exports, comprising 70% of all exported goods (ECCB, 2016b). Exports of Agricultural commodities and Fisheries nearly doubled from 2006 to 2014, likely bolstered by the continued expansion of Grenada's fishing industry which had an annual average growth rate 7.7% for the period 2005-2013 (ProTrade Consult and International Economics, 2015). The top ten exports for Grenada in 2014 are listed in Table 3. Fish and fish products are Grenada's primary exports, followed by spices (mainly nutmegs), commodities, ships, boats and cocoa and its preparations.

Table 3-List of top 10 products exported by Grenada in 2014

Product	Exported Value in 2014 (1000's USD)
Fish, Crustaceans, molluscs, aquatic invertebrates	7,663
Coffee, tea, mate and spices	6,417
Commodities not elsewhere specified	2,349
Ships, boats and other floating structures	2,199
Cocoa and cocoa preparations	1,587
Paper and paperboard, articles of pulp, paper and board	1,142
Residues, wastes of food industry, animal fodder	1,130
Milling products, malt, starches, inulin, wheat gluten	849
Iron and steel	750
Edible fruit, nuts, peel of citrus fruit, melons	607
(Adapted from ProTrade Consult and International Economics, 2015)	

Growth in Grenada's economy is expected through the developments of its "Ocean Economy", mainly through the continued expansion of tourism and fisheries. In particular, sustainable fishing and aquaculture, renewable marine energy, marine bio-prospecting, marine transport and coastal tourism, amongst others, have been cited as prime opportunities for export diversification, new investments and economic growth (ProTrade Consult and International Economics, 2015).

1.4.3 National Debt

While Grenada's economy showed moderate annual growth in the 1990's, hurricanes Ivan (2004) and Emily (2005) were economic catastrophes. As noted earlier, estimated damages from hurricane Ivan exceeded 200% of the country's GDP (Government of Grenada, 2015f). This massive financial burden prompted a series of actions by the Government in the ensuing years to recover its economy, most notably:

- In 2005, restructuring its commercial debt;
- In 2006, approaching the Paris Club for debt relief which led to rescheduling of its obligations to some of its bilateral creditors and a later (2010) extension on the repayment of medium and long term debt to Paris Club members;
- In 2006, engaging the International Monetary Fund (IMF) to enter into the Poverty Reduction and Growth Facility (PRGF) which ended in 2010, but the country was subsequently approved to receive a new arrangement under the Extended Credit Facility (of about US$13.3 million);
- In 2009, establishing a Debt Management Unit within the Ministry of Finance;
- In March 2013, announcing it would undertake a comprehensive restructuring of the Public Debt; and
- In 2014, receiving approval for an Extended Credit Facility from the IMF in the sum of US$ 21.7 million over a three-year period (Government of Grenada, 2015f).

Grenada remains one of the most heavily indebted small-island developing states in the world. Grenada recorded 2.65 billion XCD in Public Sector Debt in 2015, the highest over the 2010 – 2016 period; and likewise its Debt to GDP ratio climbed to 109% between 2010 and 2014 (Government of Grenada, 2016). The Government of Grenada intends to reduce its debt to 60% of GDP by the 2020. Towards this end, the Government is currently implementing several measures as part of its debt management strategy (Government of Grenada, 2015f):

- Conducting debt analysis of any new debt to be incurred;
- Not incurring any new government guarantees;
- Adopting a risk management framework in the management of its debt portfolio; and
- Ceasing to incur any new external commercial debt.

In spite of fiscal challenges, Grenada has demonstrated tremendous progress in its efforts to reduce the debt burden and improve economic performance generally. The years 2014 and 2015 recorded the highest economic growth statistics within the ECCU, of 7.3% and 6.2% respectively (Government of Grenada, 2016). The IMF recently completed its Sixth Review under the Extended Credit Facility Arrangement for Grenada, and highlighted Grenada's economic growth of 3.9% in 2016 – driven largely by construction and tourism activities, as well as the reduction of Debt to GDP ratio to 83% at the end of 2016 - compared to 108% in 2013 (IMF, 2017).

1.4.4 Employment

Grenada's rate of unemployment has varied only slightly in the last few years (by less than 5%). In 2013, unemployment was 32.5%, dropping to 28.9 % in 2014 before rising slightly to 30.4% in 2015 (Government of Grenada, 2015a; Government of Grenada, 2015c). In 2015, the highest unemployment rate was among persons between the ages of 15 to 24 (Government of Grenada, 2015c) and the slight increase from the year before was credited to a higher labor participation rate as more persons, particularly women, were now seeking employment (Government of Grenada, 2015a). The Government of Grenada's 2014 Labor Force survey found that the wholesale and retail sector was the dominant sector with respect to employment (Government of Grenada, 2015b).

1.4.5 Key Economic Sectors

Tourism

The Tourism sector is extremely important to the economy of Grenada due to its contribution to GDP, employment creation and foreign exchange earnings. In 2014, it is estimated that tourism directly contributed XCD $154.4 Million to the country's economy (World Travel and Tourism Council, 2015). As an island in the Caribbean, Grenada and its dependencies offer a traditional "sun, sand and sea" destination. However, it has recently broadened its tourism offerings through the development of ecotourism, heritage tourism and "edu-tourism". Mainland Grenada has a cruise ship terminal, as well as several marina and yachting facilities.

The number of stay-over visitors has remained relatively stable since 2000 (Figure 12). In 2015, Grenada received 139,393 stay over visitors, an approximate 10% increase from 15 years prior.

The devastation caused by Hurricane Ivan had a major impact on visitor arrivals; as the country experienced a 23% dip in arrivals from 2004-2005. Stay over visitors have been on an upward trend for the last two years; from 2013-2014 there was a marked 18% increase in visitors. This strong performance was attributed to the continued recovery of the American economy and American household incomes and also the first full year of operations of a new resort on the island (Government of Grenada, 2015a). This increasing trend continued from 2014-2015 with a 4% increase in visitor arrivals.

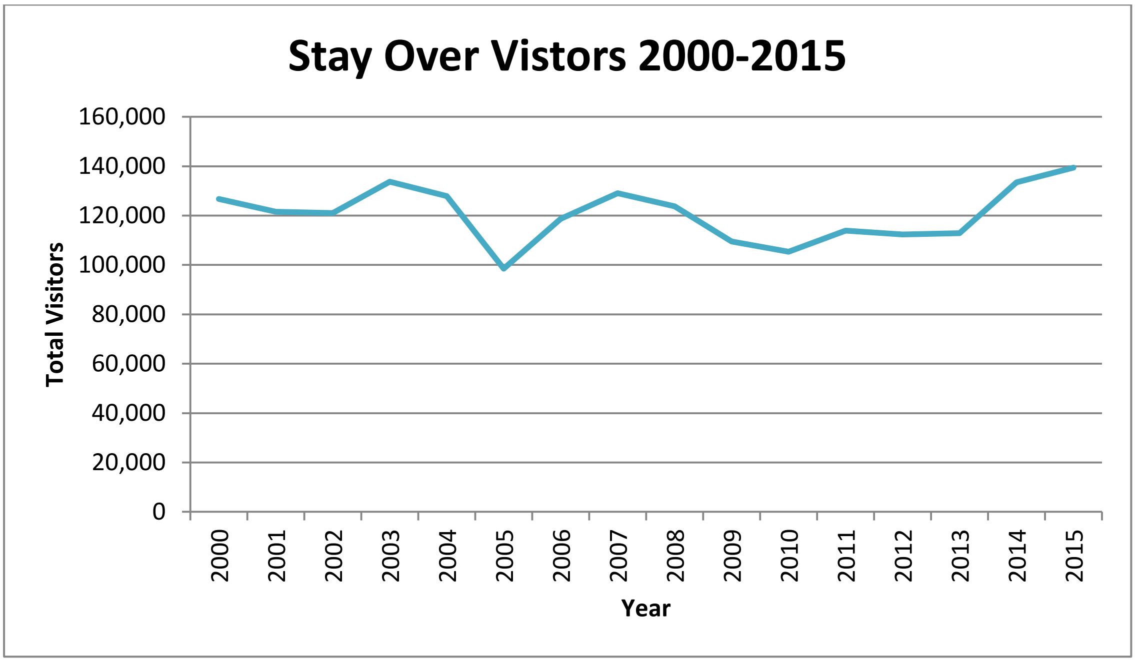

Figure 12-Total Stay-Over Visitors 2000-2015; Source: (ECCB, 2016c)

Figure 13- shows trends in visitor arrivals from different areas of the world to Grenada from 2010-2015. Visitors from the USA have steadily increased in number since 2010 and comprised the largest proportion of stay-over visitors for the last four years, accounting for 32% of visitors in 2015, followed by visitors from other Countries (25%). Mainland Grenada is serviced by both regional and international airlines (e.g. JetBlue, Delta Airlines) and this is expected to assist in the continued increase in visitor arrivals from the USA (Government of Grenada, 2015a).

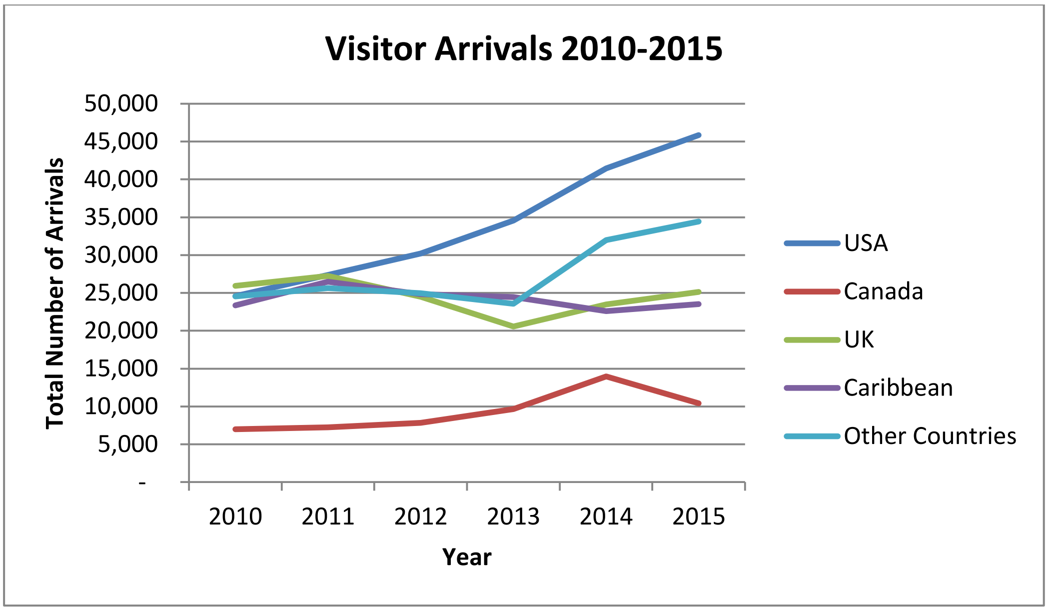

Figure 13-Trends in Visitor arrivals from different areas of the world to Grenada 2010-2015; Source: (ECCB, 2016c)

Agriculture

Agriculture in Grenada at present is characterized by small-scale, family run farms. In 1977, Agriculture (including production of crops, livestock and forestry) contributed 20% to Grenada's GDP, however by the turn of the century this share had fallen to just over 6% (ECCB, 2016a). In 2014 the sector was estimated to account for 5.82% of GDP, mainly due to the predominance of "Other Crops" (all produce except for banana and nutmegs, including fruits, vegetables, ground provisions, cocoa, mace and other spices) (ECCB, 2016a). In 2008, the Agriculture and Fisheries sectors combined contributed nearly 9% to employment (Caribbean Development Bank, 2008). Fisheries and crops were the primary export for Grenada, contributing 69.9% to overall exports in 2014 (ECCB, 2016b).

Grenada is known in the Caribbean as the Spice Island, owing to the historical importance of spices such as nutmeg and mace to the economy. Nutmeg is also integral to the island's culture and was once the main source of livelihoods and economic benefits from the country's rural population (Government of Grenada, 2010). Hurricanes Ivan and Emily destroyed 90% of the nutmeg trees and as a result, Grenada's market share of nutmeg dipped from about 25% of world nutmeg trade in early 2000's to roughly 3% after 2005 and production has not returned to pre-hurricane values (ProTrade Consult and International Economics, 2015). Despite these setbacks, Grenada remains the second largest producer of nutmeg in the world after Indonesia and is also a significant producer of mace, cinnamon, ginger and cloves (see Figure 14 below).

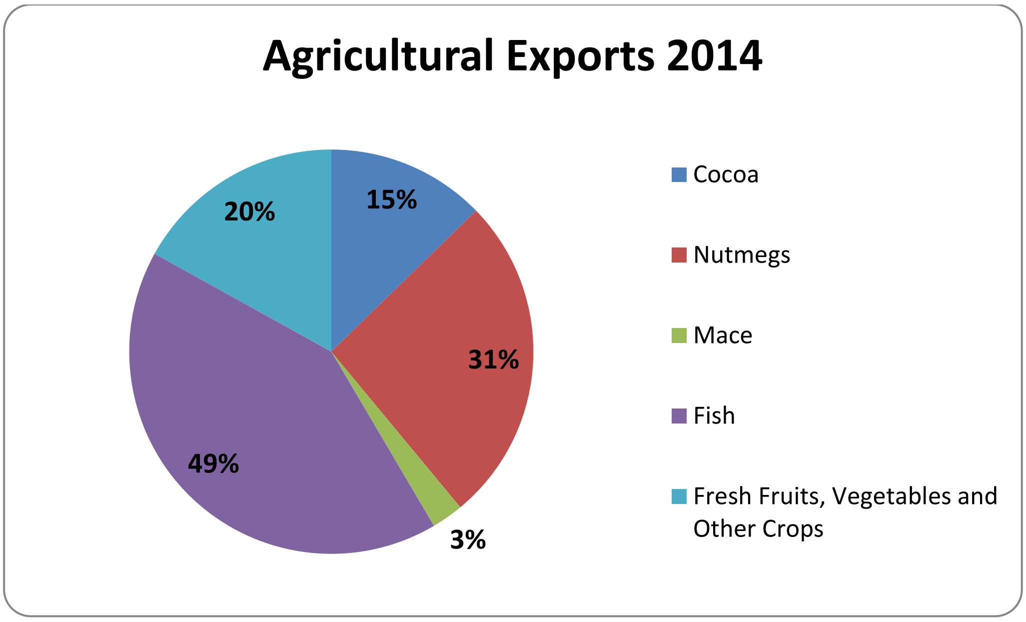

Figure 14-Agriculture Exports 2014; Source: (Government of Grenada, 2015a)

Agriculture is particularly important in fuelling the country's rural economy. The Agro-Processing Subsector is considered as thriving and is now being recognized as a viable means of sustaining families and assisting in achieving overall food security (Government of Grenada, 2011a).

However, the agriculture sector in Grenada still faces a number of challenges, including:

- A struggle to regain its prominence in the production of traditional crops (banana, cocoa and nutmeg) after these industries were decimated by hurricanes in two successive years;
- Inadequate resources to enforce agriculture policies;
- Praedial larceny;
- Limited investments in the sector;
- Obsolete farming systems; and
- Insufficient research and development, disorganized markets, access to credit for producers and the lack of an 'agri-business' approach to farming (Government of Grenada, 2011a).

Fisheries

Grenada has a multi-species fishing industry, with a mix of small and large pelagics, a broad spectrum of demersal species, as well as a few high value commercial species (conch, lobster and certain species of turtle). The industry is dominated by large oceanic pelagic species like tuna, which make up 75% of landings. The overall trend in total fish catch over the last 60 years (1951-2011) has been one of increasing production, with the annual catch in 2012 totalling 2,500 tonnes. Over this same period, a large shift took place in the industry, when the catch of large pelagics (at $US5-10/kg) replaced small pelagics (at $US2-3/kg). These changes have been attributed to the Government's promotion of a switch from demersals to the more valuable long-lining pelagics. As of 2012, the Grenadian fishing industry provided employment to 3,800 persons, 1,500 of which were almost full-time fishermen. The ACP Fish II Programme funded by the European Development Fund was completed in 2014 and provided support to formulate a fisheries and aquaculture policy for Dominica, Grenada, and St. Vincent and the Grenadines (European Commission, 2015). One of the outputs for Grenada was a working document to support the formulation of fisheries policies for Grenada's Fisheries Sector (ACP Fish II, 2012).

In 2014, Grenada's fishing industry projected contribution to GDP was 1.74%; however, fish comprised the largest portion of exports (49%). Grenada benefits from its successful, high value seafood export business; supported primarily by its fresh tuna exports (mainly yellowfin) by air to the USA and its fresh demersal exports by sea to Martinique (ACP Fish II, 2012). Grenada is a net exporter of fish and in total, exports about 600-700 tonnes per year (ACP Fish II, 2012). This has significant positive benefits for the country, including the generation of foreign currency. There are a few key export markets for the country, including the USA (receives 85%), France (receives 8%), Canada (receives 5%) and Barbados (receives just over 2%) (ProTrade Consult and International Economics, 2015).

1.5 NATIONAL INFRASTRUCTURE AND UTILITIES

1.5.1 Energy

The energy landscape in Grenada is dominated by traditional fossil fuels - Diesel, Gasoline, Kerosene and Liquefied Petroleum Gas (LPG) - which account for over 98% of the national energy mix; together with an almost negligible share of renewable sources (CARICOM, 2015b; National Renewable Energy Laboratory, 2015) (Figure 15). Grenada is dependent on imports, chiefly from Venezuela under the PetroCaribe Agreement signed in 2006. These fuels are used primarily for transportation, electricity generation and cooking, and the quantity of local petroleum product consumption has doubled between 2001 and 2008 to 115,874 tonnes of oil equivalent (Government of Grenada, 2011d). The largest consumers of energy are the Small Commercial and Residential sectors, which collectively absorb just over 84% of total national energy resources.

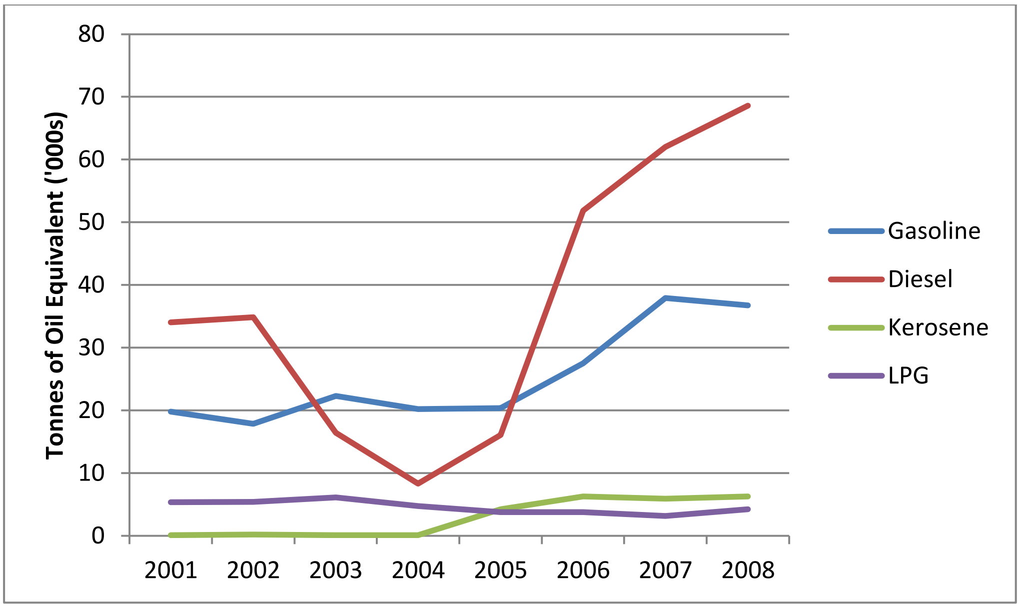

Figure 15-Fossil Fuel Imports 2001 – 2008; Source: (Government of Grenada, 2011d)

Critical questions of energy security over the coming years are a cause for concern, given the economic challenges facing Caribbean countries as Grenada (IRENA, 2012; Emanuel and Gomes, 2014). Local energy trends strongly influenced by international market dynamics, and the international climate change dialogue in recent years, have undoubtedly fuelled the development of a National Energy Policy for Grenada (Government of Grenada, 2011d). The Policy charts the country's pursuit of a sustainable, low carbon development pathway that will, among other goals, realise increasing efficiency in energy use and renewable energy uptake, as well as reductions in energy costs and greenhouse gas emissions (Government of Grenada, 2011d). Further to the National Energy Policy, the more recently published Nationally Determined Contribution (NDC) articulates a national target of a 30% reduction of 2010 GHG emissions by 2025, with a potential reduction of 40% by 2030 (Government of Grenada, 2015d; Emanuel and Gomes, 2014).

The proclamation of these emissions reductions and renewable energy uptake targets has prompted several national initiatives focused on the energy and related sectors, with the assistance of regional and international entities including the OECS, OAS, GIZ and IRENA, amongst others. The Reform of the Electricity Sector to support Climate Policy in Grenada (G-RESCP) funded by the Federal Government of Germany through its International Climate Initiative, is seeking to transform the sector by creating a more enabling legal and regulatory environment. This will be achieved through the enactment of the new Electricity Supply and Public Utilities Regulatory Commission Bills, slated for 2016 (Government of Grenada, 2015a). This would serve to better facilitate the participation of independent power producers in the local energy market as well as the planned renewable energy and energy efficiency developments articulated in national climate and energy policies (Government of Grenada, 2015a; Rothenberger, 2015).

The Government of Grenada is currently pursuing the exploration of offshore hydrocarbon potential in cooperation with Trinidad and Tobago (Government of Grenada, 2015a). Grenada is also exploring the feasibility of renewable energy generation from multiple sources, with recognised potential by developing or exploiting geothermal, solar and wind resources (Government of Grenada, 2011d; (GRENSOL; GrenSol, n.d. and the Grenada Alternative Solar Project (GRASP). Proposed solar energy initiatives for street lighting and government buildings in 2016 (Government of Grenada, 2015a) are also being considered. Waste-to-Energy (WtE) options are also being given consideration as potential energy sources (IRENA, 2012; Rothenberger, 2015).

1.5.2 Electricity

Legislation pertaining to energy in Grenada is largely associated with electricity services, and is provided by the Electricity Supply Act and the Public Utilities Commission Act, both enacted in 1994. However new Electricity Supply and Public Utilities Regulatory Commission laws are in preparation and once enacted, will bestow regulatory responsibilities for Grenada's energy sector to the newly formed Eastern Caribbean Energy Regulatory Authority (ECERA) (OECS, 2015).

Grenada Electricity Services Ltd. (GRENLEC) is the sole utility engaged in generating, transmitting and distributing electricity for public use, and has been accorded exclusive rights for managing these services until 2073 under the 1994 Electricity Supply Act (Government of Grenada, 2011d). Based on 2010/2011 data, GRENLEC has a total generation capacity of approximately 52 MW spread across the tri-island nation, and with a high 99% electrification rate, GRENLEC has provided between 195 and 204 GWh per year over the 2010-2015 period to approximately 46,000 customers (IRENA, 2012; Emanuel and Gomes, 2014). Other actors on the supply side including GrenSol and GRASP focus on providing and connecting photo-voltaic systems for solar energy generation at the household level. Existing stipulations prevent electricity generation outside of GRENLEC's domain to grow beyond 1% of peak demand, which is currently estimated at 30 MW, translating to very limited scope for the expansion of independent power production in Grenada (Government of Grenada, 2011d; Emanuel and Gomes, 2014).

1.5.3 Transport

The transport system in Grenada consists of both international and domestic components, with the chief modalities being transport by air, sea and road. International and domestic air transport in Grenada falls under the purview of the Grenada Airports Authority (GAA). International travel is facilitated by the Maurice Bishop International Airport (MBIA; previously known as the Point Salines International Airport) which was opened in 1984. The airport supports both scheduled and chartered passenger services, as well as cargo and air courier services to and from other Caribbean States, the United States of America, Canada, South America, = the United Kingdom and Germany (MBIA, 2016). Grenada's second airport, Lauriston Airport, is located on the island of Carriacou and processes daily domestic flights between Carriacou and Grenada, as well as the neighbouring Grenadine islands (MBIA, 2016).

Maritime transport is facilitated by several ports across the tri-island state. The chief port of call in Grenada is the Port of St. George's, which accommodates both cargo and cruise vessels. Cruise passengers are received by the Melville Street Cruise Terminal. Other ports include Grenville, Lance Aux Epines (also known as Prickly Bay), St. David's Harbour and Petit Calivigny in Grenada (the latter three being ports of call specifically for yachts); and Tyrrel Bay and Hillsborough in Carriacou (Grenada Ports Authority, 2015).

Grenada's land transport affairs are overseen by the Grenada Transport Board. But, there are no established legal frameworks or Government departments dedicated to the regulation and management of ground transportation in Grenada (Emanuel and Gomes, 2014).

A public transportation system is currently operated by privately owned buses which service a number of routes, and both residents and visitors have options to access private transportation through purchase or rental arrangements. There were an estimated 26,400 registered vehicles between public and private use in 2009 with a historic average increase of approximately 1,200 vehicles per year over the decade prior (Government of Grenada, 2011d). This trend would suggest an estimate count of 33,000 registered currently. Most vehicles currently run on diesel or gasoline (Emanuel and Gomes, 2014).

1.5.4 Water Resources Management

Freshwater production is strongly aligned to the seasonal weather patterns, namely the wet and dry seasons. Potable water on mainland Grenada is drawn from 23 surface and 6 groundwater supply sources on mainland Grenada that provide a maximum of 31,800 m^3/day in the dry season and 54,600 m^3/day in the rainy season (ECLAC, 2011; CEHI 2007).

The demand for water in the dry season is 54,600 m^3/day and in the rainy season it is 45,500 m^3/day (10 mgd) (GEF, 2000, in CEHI 2007). The agriculture and tourism sectors are considered two of the largest consumers of the resource, aside from domestic (residential) usage (ECLAC, 2011). The majority of homes in mainland Grenada have their own piped water supply, with the exception of two villages which use treated spring water during the wet season and government-supplied water trucks in the dry season (Commonwealth Network, 2016).

Both Carriacou and Petite Martinique are completely reliant on rainwater harvesting to meet their needs for potable water, owing to extremely limited natural water capture on these islands. Water is supplied through 33 community rainwater catchments and public buildings such as schools, hospitals and churches have also installed communal cisterns, which number 78 altogether (CEHI, 2007). The Government of Grenada has recently built two reverse osmosis desalination plants on Carriacou to supplement the needs of the sister islands (Government of Grenada, 2015a; Government of Grenada, 2015h).

While access to potable water in Grenada has improved over the last 10 years and has historically been consistent for most parts of the country (Government of Grenada, 2011c), water demand is expected to increase, occasioned by population growth and potential expansion in the tourism and agricultural sectors (ECLAC, 2011).

Further, current climate variability and future climate changes in temperature and rainfall will affect freshwater availability, and Grenada is already feeling these effects. The prolonged drought event over the 2009/2010 period severely affected Grenada. Water production in Grenada was estimated to be 65% below normal during this drought period (Farrell et al., 2010; Government of Grenada, 2011c). The proximity of many of mainland Grenada's and Carriacou's potable water wells to the coastline is also a major concern, particularly in respect to rising sea levels and saline intrusion (UNDESA, 2012). Very little information is available about the quality of freshwater sources in Grenada and there are no formal environmental monitoring programmes in place to assess the health of watersheds (UNDESA, 2012). Water resource management activities in Grenada are co-ordinated chiefly by the state-owned National Water and Sewerage Authority (NAWASA), the Ministry of Agriculture, Lands, Forestry and Fisheries (Land Use and Forestry Divisions), and the Ministry of Health (Environmental Health Department). The respective responsibilities of these primary stakeholders are outlined in Table 4.

Table 4-Primary stakeholders responsible for the management of water resources

Agency	Summary of Responsibility	Legislation, Policies & Plans Related to Responsibilities
NAWASA	• Capture, treatment and supply of drinking water, and sanitary disposal of sewage • In conjunction with the Ministry of Health, NAWASA is responsible for monitoring the quality of freshwater and implements a regular programme of sampling and bacteriological analyses of treated waters	• National Water and Sewerage Authority Act • National Water and Sewerage Authority Sewerage Regulations • National Water and Sewerage Authority Water Services Regulations • Draft National Water Policy
Forestry Division	• Protection of water catchment areas	• Forest, Soil and Water Conservation Act • National Parks and Protected Areas Act • Environmental Policy and Management Strategy for Grenada • Forest Policy • Draft Integrated Watershed Management Model Plan
Land Use Division –	• Provision of water for agricultural purposes (handled	• Crown Lands Act

Agency	Summary of Responsibility	Legislation, Policies & Plans Related to Responsibilities
Irrigation Management Unit	separate to the domestic supply operations), and development of irrigation infrastructure for agricultural lands within the Ministry of Agriculture's domain	• Land Settlement Act
Physical Planning Unit	• Guiding and integrating water resource infrastructure planning within national planning and development processes	• Physical Planning and Development Control Act • Grenada's Building Code • National Physical Development Plan • Draft Integrated Physical Development and Environmental Management Plan for Carriacou and Petite Martinique
Environmental Health Department	• Potable water quality monitoring • Works closely with NAWASA to ensure compliance with international drinking water safety standards • Periodic monitoring of non-NAWASA managed freshwater sources (rural springs) and sanitary surveys of catchment areas	• Public Health Act • Water Quality Act
(Sources: CEHI, 2007; ECLAC, 2011; Environmental Solutions Ltd., 2015; FAO, 2015)		

Additionally, several other actors play a supporting role in water resource management: 10 public sector agencies and 40 or more associated climate and water-related legislative acts, policies or plans such as the National Water Policy, the National Water and Sewerage Authority Act (1990) and the Grenada Water Quality Act (Environmental Solutions Ltd., 2015).

NAWASA is responsible for various water catchment, intake, treatment and distribution-related infrastructure across mainland Grenada, which includes 19 tanks, 11 boreholes (largely located in the southern section of the island) and 23 treatment plants, along with an extensive network of water distribution pipelines. Additional water infrastructure includes reservoirs and filter plants that are collectively maintained and monitored by NAWASA and used for potable water supply and irrigation purposes (ECLAC, 2011; Environmental Solutions Ltd., 2015).

Within recent years, Grenada has made a concerted effort towards the implementation of Integrated Water Resources Management (IWRM). The pursuit of IWRM in Grenada was initiated by activities conducted under the Integrated Water Resources and Coastal Areas Management (IWCAM) project[2], culminating in the development of a "National Road Map Toward Integrated Water Resources Management Planning for Grenada" (2007) which proposes a path forward to achieve IWRM principles at the national level (CEHI, 2007).

Under the Caribbean Water Initiative (CARIWIN), a pioneering National Water Information System (NWIS) to act as a central repository for hydrological and other water management data was developed and implemented in Grenada. Amongst other outcomes, the IWCAM project and national review activities highlighted the deficiencies in water management data availability and access that hindered planning and decision-making efforts. The NWIS was officially launched at the beginning of 2009 and is currently under the care of the Ministry of Agriculture, with several other collaborators from the public and private sectors (St-Jacques et al., 2010).

1.5.5 Waste Management

Currently housed within the Ministry of Health and Social Security, the Grenada Solid Waste Management Authority was established by the Grenada Solid Waste Management Authority Act (1995), and is responsible for co-ordinating national solid waste management activities which include collection (which is fully privatised), treatment and disposal (Rothenberger, 2015). Other legislative and policy developments post-1995 include the Solid Waste Management Act of 2001 and an Integrated Solid Waste Management Strategy in 2003 (PAHO, 2004; Rothenberger, 2015).

Grenada generates approximately 40,000 tonnes of solid waste per year, and this amount is expected to increase to 56,000 tonnes over the next 25 years based on projections by the Solid Waste Project Grenada Phase 2. Based on data collected in 2009, the largest constituents of waste going into Grenada's landfill site at Perseverance included organic waste, site cleaning waste, plastics, paper, cardboard and construction and demolition (C&D) waste. Waste sources include domestic or residential sources which are serviced by compactor trucks for collection and delivery to the landfill; plus larger non-domestic sources such as the agriculture (commercial farms, slaughterhouses), tourism (hotels, restaurants, cruise ships) and industrial sectors, some of which are serviced through separate collection arrangements (Rothenberger, 2015).

Solid waste separation, streaming and recovery are limited. Concerns regarding the sustainability of the landfill as the sole means of waste disposal in Grenada were raised in 2004 (PAHO, 2004). As a result, attention is currently being paid to the feasibility of Waste-to-Energy options for Grenada as immediate solid waste management alternatives, while simultaneously adding new constituents to the national energy mix (Rothenberger, 2015).

[2] The Integrated Water Resources and Coastal Areas Management project was implemented in select Caribbean territories (including Grenada) by the Caribbean Environmental Health Institute (CEHI) and the Global Environment Facility (GEF).

Data on total liquid waste production is limited. The containment of liquid waste is challenging, and the potential impacts on the environment (terrestrial, but especially marine) are widely conceded as wastewater is currently discharged into the sea (referred to as "marine treatment") (Rothenberger, 2015). Local enterprises have also recognised some of the potential benefits from liquid waste recovery, and there are ongoing efforts to reuse or recycle liquid waste by converting it to biodiesel, animal feed and soap products.

Grenada's Nationally Determined Contribution (NDC) report (Government of Grenada, 2015d) suggests that greenhouse gas emissions from the waste sector account for approximately 10% of the national emissions profile (mainly resulting from methane production by the landfill). In efforts to reduce the amount of methane released by the landfill, the introduction of engineering-assisted capture of the gas has been proposed, which could potentially reduce landfill-associated methane emissions by 90%. The captured gas would then be used for electricity generation (Government of Grenada, 2015d).

1.6 DEMOGRAPHIC AND SOCIAL DEVELOPMENT CONTEXTS

Grenada continues to place within the 'High Human Development' category of the United Nations Human Development Report (HDR), based on the results of successive reports over the 2010-2014 period. With a Human Development Index (HDI) value of 0.750 in the most recent HDR (2015; based on 2014 data), Grenada ranks at #79 out of a total of 188 countries - three places up from its 2014 report ranking (see Table 5) (UNDP, 2015).

Table 5-Human Development Rankings and Indices for Select CARICOM Countries and Regional Groupings

Country / Region	Ranking	HDI value
Bahamas	55	0.790
Barbados	57	0.785
Antigua & Barbuda	58	0.783
Trinidad and Tobago	64	0.772
St. Kitts and Nevis	77	0.752
GRENADA	**79**	**0.750**
Average for Latin America and the Caribbean (33) Countries		0.748
Average for Countries in the "High Human Development" Category		0.744
Saint Lucia	89	0.729
Dominica	94	0.724
St. Vincent and the Grenadines	97	0.720
Jamaica	99	0.719

Belize	101	0.715
Average for All Countries		0.711
Average for Developing Countries		0.660
Average for Small Island Developing States		0.660
Guyana	124	0.636

Source: (UNDP, 2015)

1.6.1 Population

Grenada's total population was estimated to be 109,374 in 2014, up from 106,669 recorded in 2011 when the Population and Housing Census was conducted (Government of Grenada, 2015e); implying a current population density of approximately 317 persons per square kilometre. Census data also indicated a near-equal gender ratio in 2011 (50.5% of the population were males) (Government of Grenada, 2015a). The population figure is projected to increase to approximately 112,000 by 2018 based on a 0.6% population growth rate per annum (Government of Grenada, 2015a).

Most of the population is concentrated on the mainland of Grenada, with approximately 10% residing in Carriacou and Petite Martinique collectively (Government of Grenada, 2011c). Grenada is considered to have a youthful population, although the population numbers of the elderly are also gradually increasing (CARICOM, 2009a) (see Figure 16). Approximately 40% of the population is classed as urban area residents (UNDP, 2015). The population is predominantly Black, with smaller proportions of Mixed, East Indian and Caucasian members (Government of Grenada, 2009a).

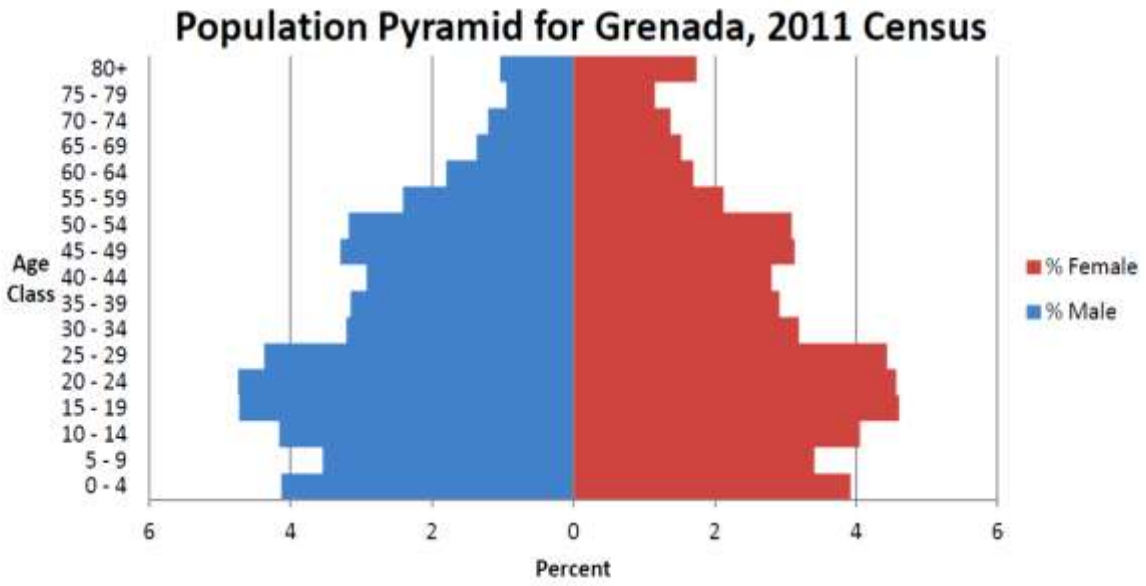

Figure 16-Population Pyramid for Grenada, based on 2011 Census Data: Source: Central Statistics Office; (Government of Grenada, 2015a)

Data on housing and housing structures suggest that wooden and concrete/brick structures were the most common, with a greater percentage of wooden houses being inhabited by the poor, and conversely the concrete structures by the "better-off" (Kairi Consultants Ltd., 2008). This correlation in living conditions and socio-economic status implies greater vulnerability for poor persons or families living in wooden dwellings, which are structurally weaker and more prone to damage from high wind and excess rainfall. In 2004 with the passage of Hurricane Ivan, 79% of Grenada's entire housing stock was affected. But units that were less structurally sound were most affected and these were more likely to have been inhabited by the poor (OECS, 2004; The World Bank, 2005).

1.6.2 Health

The Ministry of Health and Social Security is responsible for policy development, management and administration of Grenada's Health Sector, and is currently comprised of 14 departments: namely General Administration; Planning; Epidemiology and Information; Central Medical Store; Registrar Generals Division (Births, Deaths and Marriages); Nursing; Mental Health; Environmental Health; Health Promotion; National Infectious Disease Control Unit; Hospitals; Dental Health; Pharmacy and Information Technology (Ministry of Health, 2016). Other private entities and non-governmental associations also exist which provide health services and contribute to national health and well-being (Hatt, et al., 2012).

There are currently seven hospitals in operation, four of which are public-owned (Government of Grenada, 2013c). Additionally, there are also six district health centres and 30 medical stations located across the country (Ministry of Health, 2016). Other key public health services include those provided by the Environmental Health Division, which include vector monitoring and control, food safety investigation, water quality, waste management, monitoring, investigation, control and evaluation of the spread of infectious diseases as well as controlling the spread of hazardous materials (Ministry of Health, 2016).

Since the submission of the INC, data for many of Grenada's health indicators have shown improvement in the quality of life and health across the country, and are relatively consistent with trends exhibited by more advanced developing states:

- In 2013, the crude birth rate stood at 16.9 and the crude death rate at 7.6. Both rates have been in flux in the years prior, but not to any significant extent. The rate of natural increase has ranged between 8.4 and 9.7 (CARICOM, 2015c);
- Average life expectancy at birth rose from 73 in 2008 to 76 years in 2013. Female life expectancy remains higher than that for males, which was recorded at 74 years in 2013, compared to 79 years for females. The gap in life expectancy of males and females has varied between 4-6 years over the 2008-2013 period (CARICOM, 2015c);
- A slight decline in the total fertility rate[3] has been observed recently. The rate was 2.1 in 2013 (CARICOM, 2015c) compared to average 2.4 births per female reported over the 2000/2005 period (UNDP, 2015);
- Conversely however, the data suggest a notably increasing trend in infant mortality rates which rose from 5 deaths per 1,000 live births in 2008 to 17.4 per 1,000 in 2013 (CARICOM, 2015c);
- The maternal mortality rate was reported as 54.4 in 2013 (CARICOM, 2015c). Adult mortality in males and females was recorded at 120 and 194 per 1,000 people respectively (UNDP, 2015);
- In 2011, approximately 73.5% of households in Grenada had piped water, and 61.8% had access to flush toilets (CDB, 2014);

The Ministry of Health and Social Security carries out surveillance on a number of communicable diseases, such as Acute Respiratory Infections, Gastroenteritis, Undifferentiated Fever, Conjunctivitis, Chicken Pox, food-borne illnesses, sexually transmitted infections and vector-borne diseases (e.g. Malaria, Dengue Fever and Leptospirosis). These are further discussed in section on Human Health.

1.6.3 Education

Grenada's education system largely takes after that of the British, and education is free for children between the ages of 5 and 16 years (Government of Grenada, 2009a). Several public schools are in operation at the Preschool, Primary and Secondary education levels, in addition to three Tertiary institutions – namely St. George's University, the University of the West Indies

[3] The *Total Fertility Rate* is defined as the "number of children that would be born to a woman if she were to live to the end of her child-bearing years and bear children at each age in accordance with prevailing age-specific fertility rates." (UNDP, 2015)

Open Campus and the T. A. Marryshow Community College (Government of Grenada, 2009a; MOEHRD, 2014).

Participation in the formal education system has expanded significantly over the last five to six years. The net school enrolment ratios at both the primary and secondary levels of education increased from 68% in 2009 to over 90% in just three years (CDB, 2014), Grenada achieved Universal Secondary Education in September 2012 (MOEHRD, 2014), and more recently a 6.7% increase in overall enrolment was recorded between 2014 and 2015 (Government of Grenada, 2015a). The 2014 HDR also reports that expected years of schooling[4] in Grenada currently stands at 15.8 years, and the average number of schooling years[5] reported is 8.6 years (UNDP, 2015).

The Ministry of Education, Human Resource Development and the Environment in Grenada is in charge of the development of the formal education system; although it is noted that churches also play a key role as many schools are associated with the different religious denominations (MOEHRD, 2014). Supporting instruments for education development in Grenada include the Strategic Plan for Educational Enhancement and Development (SPEED II; 2005 – 2006; the OECS Education Sector Strategy (2012 – 2021) and an Education Action Plan 2014.

The education sector is also important within the context of climate change and disaster management, as a number of schools also serve as storm/hurricane shelters in different communities, the remaining shelters being mostly community centres (22%) and church buildings (27%) (Government of Grenada, 2014d).

1.6.4 Gender

Gender visibility and mainstreaming efforts in Grenada are shaped by its commitments to several international and regional conventions that speak to gender and universal human rights. Landmark gender-focused agreements to which Grenada is now party include the Convention on the Elimination of All Forms of Discrimination Against Women (CEDAW; ratified in 1990), the Beijing Declaration and Platform for Action coming out of the Fourth World Conference on Women; and the hemispheric Inter-American Convention on the Prevention, Punishment, and Eradication of Violence against Women (Convention of Belem do Para; ratified in 2000) (Government of Grenada, 2014c).

At the national level, Grenada's Domestic Violence Act (2001), the Child Protection Act (2008) and the Criminal Code of the Revised Laws of Grenada provide legal basis for protection and

[4] *Expected Years of Schooling* in the HDR is defined as the "number of years of schooling that a child of school entrance age can expect to receive if prevailing patterns of age-specific enrolment rates persist throughout the child's life" (UNDP, 2015).

[5] *Mean Years of Schooling* in the HDR is defined as the "average number of years of education received by people ages 25 and older, converted from education attainment levels using official durations of each level" (UNDP, 2015).

sanction of gender- and child-related conflicts. Most recently, the development of a *Gender Equality Policy and Action Plan (GEPAP)* was spearheaded in Grenada, which seeks to be a central medium for guiding and facilitating gender-sensitive and gender-responsive actions across all sectors (Baksh, 2014).

Additionally, the current Growth and Poverty Reduction Strategy (GPRS 2014 - 2018) has outlined Gender Equity[6] as a priority area for action under its second thematic focus of "Developing Competitiveness and Equity", with strategic objectives that aim to further mainstream gender and devise policy interventions that support this theme. The pursuit of gender equity is also captured in the legislative reform to address the disadvantages that both married and unmarried women face in respect of entitlements and benefits (Antoine et al., 2014).

Gender programming is carried out primarily by the Gender and Family Affairs Division within the Ministry of Social Development and Housing. The Domestic Violence Unit and Social Services Division also play key roles in respect of the protection of women and children in particular. Other non-governmental and civil society actors (e.g. the Grenada National Organisation of Women) also contribute significantly to Grenada's gender programming, and complement public policy and programme development with advocacy and action (Government of Grenada, 2014c).

Coinciding with the development of the GEPAP, the Caribbean Development Bank (CDB) recently commissioned and published a Country Gender Assessment for Grenada (Baksh, 2014) as part of its Gender Equality Policy and Operational Strategy (GEPOS.

Overall, while Grenada has made measurable progress in anchoring gender issues within the development process, a number of critical gaps still persist, and more support is required to improve existing legislation, governance and institutional arrangements to effect further progress (Baksh, 2014).

1.6.5 Poverty

In spite of development progress, poverty is still very present across Grenada. The last Country Poverty Assessment conducted for Grenada over the 2007/2008 period (Kairi Consultants Ltd., 2008) revealed a poverty rate of 37.7% and an indigence (extreme poverty) rate of 2.4%. When combined with the percentage of persons considered vulnerable (living above the poverty line, but vulnerable to becoming poor), just over half of the population was classified as either poor or vulnerable. Other key findings presented in the assessment report included the following:

[6] The phrase *Gender Equity* is presented here based on its presentation/use in the GPRS, whereas Gender *Equality* is used in the title of the GEPAP and the CDB's Gender Equality Policy and Operational Strategy, the latter described in following paragraphs.

- St. George's and St. Mark, as the two most populated parishes, also recorded the highest percentages of the poor;
- Likewise, the Services, Construction, and Agriculture and Fisheries sectors having the largest percentages of employees in that order, also exhibit the highest percentages of working poor persons;
- Two-thirds of the poor at the time of the assessment were aged 24 or younger, likely as members of poor households with a relative high number of children and youth;
- There was a slightly higher percentage of poor males (~40% of all males), compared to females (~36% of all females);
- 65% of poor persons were employed at the time of the assessment, suggesting that they are not earning enough to lift them above the poverty line, and/or they are members of poor households that cannot be sustained over the poverty line with the household's collective income;
- 31.5% of employed (approximately 35,722) persons were living below the poverty line, likewise half of the unemployed portion of the labour force (Kairi Consultants Ltd., 2008).

The 2008 poverty rate increased from 32.1% reported in the 1998 assessment. This increase is substantiated within the context of successive natural and economic events that severely impacted the country since the earlier assessment, including the impact of the 2001 terrorist attacks in the US on tourism and world travel; Hurricanes Ivan (2004) and Emily (2005); and the Global Economic Recession that started in 2008. Conversely, the current indigence rate represents a significant decrease from the 1998 assessment findings (12.9%) (Kairi Consultants Ltd., 2008).

1.7 CLIMATE CHANGE: POLICY, LEGISLATION AND INSTITUTIONAL ARRANGEMENTS

Significant strides have been made by the Government of Grenada in pursuing climate change adaptation and mitigation options as a result of its commitment to international and regional actions to reduce climate change and its impacts.

1.7.1 Grenada and the United Nations Framework Convention on Climate Change (UNFCCC)

Grenada, like other SIDS, is classed as a Non-Annex I country. As such, it is not legally bound to reach any specific targets in GHG emission reduction, but it has made recent commitments to reduce GHG emissions by 30% of 2010 levels by 2025 (Government of Grenada, 2015d).

Grenada was as one of 177 countries that had signed, and one of 17 countries that had ratified the Paris Agreement upon its opening for signature. The Paris Agreement officially entered into force on 4 November, 2016 (UNFCCC, 2016d).

Grenada has not, to date, submitted any Biennial Update Reports (BURs) to the UNFCCC. However, in preparation for COP21, the Government of Grenada prepared and submitted[7] its Nationally Determined Contribution (NDC) report to the UNFCCC, providing an account of indigenous sources and sinks of greenhouse gases, and proposals for emissions reduction – in contribution to the achievement of the Convention's objective (Government of Grenada, 2015d).

Under the new Paris Agreement, each Party to the Convention will be required to submit its first Nationally Determined Contribution (NDC) upon submission of instruments to ratify, accept, approve or accede to the Agreement, to which Grenada has complied (UNFCCC, 2016a; UNFCCC, 2016b).

Grenada is also the host country for one of five Regional Collaboration Centres (RCCs), established across the world by the UNFCCC in efforts to further engage what are considered under-represented countries and regions within Clean Development Mechanism (CDM) activities of the Convention.

1.7.2 Other International Activities and Commitments Related to Climate Change

Grenada is party to all three (3) of the Rio Conventions on the environment which are intrinsically linked: 1) the aforementioned UNFCCC, 2) the United Nations Convention on Biological Diversity (UNCBD), ratified by Grenada in 1994; and 3) the Convention to Combat Desertification and/or Drought (UNCCD) ratified in 1997. A summary of the status of other Multilateral Environmental Agreements (MEAs) and activities are presented below.

1.7.3 The United Nations International Strategy for Disaster Reduction (UNISDR) and the Hyogo Framework for Action (HFA)

Further to the adoption of the International Strategy for Disaster Reduction in 1999 by the UN General Assembly, the Hyogo Framework for Action (HFA) 2005-2015 was established at the World Conference on Disaster Reduction held in Kobe, Hyogo, Japan in 2005 (UNISDR, 2005). The Action Plan is a non-binding instrument, and articulates three Strategic Goals that speak to policy and programming; institutional capacity building and the design and implementation of disaster risk reduction interventions at national and local levels, along with specific Priority Actions which are as follows:

[7] The official date of submission is registered as 30 September, 2015. This date of submission was prior to the signing of the Paris Agreement, and the document was then referred to as the Intended Nationally Determined Contribution.

1. Ensuring that disaster risk reduction is a national and a local priority with a strong institutional basis for implementation.
2. Identifying, assessing and monitoring disaster risks and enhancing early warning.
3. Using knowledge, innovation and education to build a culture of safety and resilience at all levels.
4. Reducing the underlying risk factors.
5. Strengthening disaster preparedness for effective response at all levels (UNISDR, 2005).

In its National Progress Report on HFA implementation, reference is made to Grenada's substantial progress against most of the Priority Actions outlined above, but the country still faces challenges with legal, institutional and policy arrangements, financial resources and operational capacities that hinder disaster risk reduction efforts (Government of Grenada, 2013e).

More recently, the Sendai Framework for Disaster Risk Reduction 2015-2030 was created and adopted by the Third UN World Conference on Disaster Risk Reduction in 2015 in Sendai, Japan, to succeed the HFA in guiding efforts to achieve global disaster risk reduction and resilience (UNISDR, n.d.-b).

1.7.4 Alliance of Small Island States

Grenada is one of 44 member and observer countries comprising the Alliance of Small Island States (AOSIS), established in 1990, and characterised as "a coalition of small-island and low-lying coastal countries that share similar development challenges and concerns about the environment, especially their vulnerability to the adverse effects of global climate change". The Government of Grenada, having Member status with the Alliance has served as chair of AOSIS over the 2006 – 2011 period (AOSIS, 2015).

1.7.5 Other Multilateral Environmental Agreements (MEAs)

Other MEAs ratified by Grenada encourage environmental preservation and monitoring which have spin-off benefits (both direct and indirect) for climate change adaptation and mitigation. Table 6 below lists some of the MEAs already ratified by Grenada or under consideration.

Table 6-Multilateral Environmental Agreements Ratified or Being Considered

Multilateral Environmental Agreement	Status
Montreal Protocol on Substances that Deplete the Ozone Layer	Acceded on March 31, 1993
Nagoya Protocol to the Convention on Biological Diversity	Signed December 22, 2001 Ratification pending
Cartagena Protocol on Biosafety to the Convention on Biological Diversity	Signed May 24, 2000 Ratified February 5, 2004
The Protocol Concerning Specially Protected Areas and Wildlife (SPAW Protocol)	Acceded
The Protocol Concerning Pollution from Land-Based Sources and Activities (LBS Protocol)	Acceded
The Convention on Wetlands (Ramsar Convention)	Acceded September 22, 2012 One Ramsar site declared
The Basel Convention on the Transboundary Movement of Hazardous Waste and their Disposal	Ratification Pending
Rotterdam Convention	Ratification Pending
Stockholm Convention on Persistent Organic Pollutants	Ratification Pending
Convention on the Conservation of Migratory Species of Wild Animals (CMS); or the Bonn Convention	Ratification Pending

Source: (Government of Grenada, 2014a; UNEP, 2017)

1.7.6 Regional Drivers of National Climate Change Programming

The Global Conference on the Sustainable Development of Small Island Developing States (SIDS) held in 1994 and the proceeding Barbados Programme of Action (BPoA) document were major international actions also placing emphasis on climate change impacts and adaptation, for SIDS which are considerably more vulnerable.

Grenada and several other CARICOM Member States were beneficiaries of the CPACC project. Specifically, Grenada participated in each of the four (4) project components and was one of three sites for a Coastal Vulnerability and Risk Assessment Pilot Project which investigated the potential impacts of sea level rise (SLR) on portions of Grenada's coastline, including estimates of beach loss and impacts on adjacent physical infrastructure and natural resources.

In recognition of the need for a sustained, co-ordinated regional approach to address the challenges of climate change, the *Caribbean Community Climate Change Centre* (CCCCC) Centre was legally established in 2001 by CARICOM, and became fully functional in 2004. The Government of Grenada is one of the CARICOM Member State governments to have representation on the Board of Directors of the CCCCC (CCCCC, 2016).

Grenada has been a beneficiary of a series of projects and tools developed and/or implemented by the Centre, namely the Mainstreaming Adaptation to Climate Change Project (MACC) and most recently the EU-funded Global Climate Change Alliance (GCCA) programme which sponsored a localised Vulnerability and Capacity Assessment and a National Adaptation Strategy and Action Plan for the Water Resources sector in Grenada.

In 2009, CARICOM Heads of Government produced and signed the *Liliendaal Declaration on Climate Change and Development* as another collective commitment to tackle climate change across the region (CARICOM, 2009b).

Grenada assumed the chairmanship - lasting two years - of the Small States Forum of the World Bank, a grouping of 49 small countries across the world. The Government of Grenada understands its role in this forum as an advocate for SIDS to strengthen international relations so as to access official development assistance and securing resources to fight climate change.

At the Sub-Regional level, the OECS has also contributed to climate change programming: the Environment and Sustainable Development Unit (ESDU). The *St. George's Declaration of Principles for Environmental Sustainability in the OECS* was developed in 2001 by the ESDU and has responsibility for the Environment from across OECS Member States (OECS, 2007).

Most recently, the OECS has implemented a more climate change-focused, five-year USAID-funded project entitled *Reduce Risks to Human and Natural Assets Resulting from Climate Change* (RRACC). The project (2011-2015) built adaptive capacity for climate change across the OECS Member States and focused on four component areas: improving the enabling environment to better facilitate adaptation, implementing interventions in freshwater and coastal management, building institutional capacity particularly within the public sector, and building public awareness (OECS, n.d.).

Furthermore, Grenada is chairing the Council of Environmental Ministers Meeting of the OECS in 2017 until the end of 2018.

Other key stakeholders and actors that influence regional climate change programming include the Caribbean Institute of Meteorology and Hydrology (CIMH); the Caribbean Disaster Emergency Management Agency (CDEMA), and other regional sectoral institutions (e.g. Caribbean Environmental Health Institute (CEHI) and Caribbean Agricultural Research and Development Institute (CARDI)). Other private sector and civil society organisations working at the regional level include the Caribbean Red Cross Society under the International Federation of Red Cross and Red Crescent Societies (IFRC), the Global Water Partnership – Caribbean (GWP-C), and the Caribbean Hotel and Tourism Association (CHTA).

1.7.7 National Policy and Legislation Relevant to Climate Change

National Climate Change Policy

Under the Integrated Climate Change Adaptation Strategies (ICCAS) initiative, Grenada has produced a Draft National Climate Change Policy 2017-2021 which is currently in the Final Draft stage, and is expected to be approved by Cabinet this year. Building on the previous version of the climate change policy, this updated/revised will be a crucial instrument for guiding and monitoring the progress of Grenada's national climate change programme within the near term. The policy revision process is being conducted in parallel with the development of Grenada's National Climate Change Adaptation Plan (NAP) 2017-2021, which is also in its Final Draft stage.

The preceding *National Climate Change Policy and Action Plan (NCCPAP) 2007 – 2011,* guided climate change activities at the national level in Grenada over the last decade (Government of Grenada, 2007). The Policy, published in 2007, affirms a vision of "*an empowered Grenadian population capable of managing the risks from climate change, at the individual, community and national levels"* and sought to set the stage for an "organised long term response to climate change" (Government of Grenada, 2007). Eight (8) strategies were outlined to achieve this objective, presented in the Policy as follows:

1. Climate-proofing present and future national development activities by requiring a climate risk analysis of all ongoing and new development initiatives
2. Strengthening the collection, analysis and use of climate-related data and impacts;
3. Building local human capacity to assess and respond to climate change, including through the access and use of appropriate technologies;
4. Reducing greenhouse gas emissions through increased energy efficiency and the use of renewable energy;
5. Eliminating unsustainable livelihood and development practices that increase climate change vulnerabilities;
6. Sustained public awareness and education programming;
7. Foreign policy advocacy for international action on climate change;
8. Joint Implementation and networking with OECS and CARICOM partners and other SIDS.

Ongoing simultaneously with the NCCPAP review and update, is the development of a National Climate Change Adaptation Plan (NAP) – both processes spearheaded by the Environment Division with support from GIZ. The NAP seeks to address issues of climate resilience and adaptation on mainland Grenada, Carriacou and Petite Martinique, and has thus far encompassed an extensive, multi-sectoral review and stock-take of the vulnerabilities, risks, adaptation capacities and responses that characterize Grenada and how these may change under future climate scenarios.

Grenada's Growth and Poverty Reduction Strategy (2014-2018)

Grenada's most recent Growth and Poverty Reduction Strategy (GPRS) 2014 – 2018, is currently the country's overarching development strategy document, which accentuates "pro-poor growth" and the "new economy" as its principal premises "guiding national actions and interventions at the macro-economic, sector and institutional levels over the next five years"(Antoine et al, 2014). In this vein, the GPRS outlines four thematic areas of focus: (1) Building Resilience; (2) Developing Competitiveness with Equity; (3) Reducing Vulnerability and (4) Strengthening Governance and Security (Antoine et al., 2014).

National Disaster Risk Reduction and Management

Despite the gap in legislation, a National Disaster Management Plan was originally established in 1985, and subsequently revised in 2005 following the passage of Hurricane Ivan (Government of

Grenada, 2005b), and again in 2011 with assistance from CDEMA's Co-ordinating Unit (CDEMA CU) as part of the Disaster Risk Management Sub-Regional Programme for the Caribbean under the ACP-EU Natural Disaster Facility (Government of Grenada, 2011b).

The structure of the 2011 Draft Plan sets out specific hazard and phase plans, responsibilities and expectations of the constituents of the National Disaster Organisation (NaDMO): the Grenada National Disaster Management Advisory Council (NaDMAC), the National Disaster Management Agency (NaDMA) and the network of national, district and community/village disaster management committees (Government of Grenada, 2011b).

Other Legislation, Policies and Plans

Since the INC (2000), a number of executive policies and plans have been developed with specific references to the implications of climate change, and climate change adaptation and mitigation across multiple sectors. These are provided in Table 7 below.

Table 7-National Policies and Plans with Relevance to Climate Change

Policy / Plan / Strategy	Year
Draft National Climate Change Policy 2017 - 2021	2017
Draft National Climate Change Adaptation Plan 2017 - 2021	2017
Coastal Zone Management Policy	2015
Comprehensive Disaster Management Policy	2015
National Adaptation Strategy and Action Plan for the Water Sector	2015
Grenada Protected Area System Plan – Part 2	2014
Grenada Vision 2030 (GREENADA)	2012
Grenada Strategic (Investment) Policy Framework	2011
National Energy Policy	2011
Grenada Disaster Vulnerability Reduction Project and Resettlement Policy Framework	2011
Grenada Strategic Program for Climate Resilience	2011
Grenada Protected Area System Plan – Part 1	2009
National Water Policy (Draft)	2007
National Development Strategy for Grenada	2007
National Environmental Policy and Management Strategy	2005
National Waste Management Strategy	2003
National Physical Development Plan	2003
Forest Policy and Action Plan	2000
National Biodiversity Strategy and Action Plan (updated in 2014)	2000
Legislation	**Year**

Physical Planning and Development Control Act	2002
Waste Management Act	2001
National Parks and Protected Areas Act	1990
Fisheries Act	1986
Public Health Act	1958
(Sources: Felician & Joseph-Brown, 2014; Murray, 2015; Nachman, et al., 2015)	

1.7.8 Institutional Arrangements for Climate Change

Climate change programming in Grenada managed and coordinated by the Ministry of Education, Human Resource Development and the Environment (MEHRDE). This Ministry, along with the Ministry of Agriculture, Lands, Forestry and Fisheries (MALFF), serve as the NFP for a number of the regional and international Multilateral Environmental Agreements (MEAs) to which Grenada is party.

A *National Climate Change Committee* (NCCC) which was initially established in Grenada in 2001 (Felician and Joseph-Brown, 2014), and re-established in 2014, is currently providing oversight to a number of ongoing initiatives via its four working groups: Mitigation, Adaptation, Finance and Sustainable Development, and International Negotiations and Relations (Murray, 2015).

The National Disaster Management Plan consists of several National Disaster Management Committees with responsibility for specific areas deemed critical to disaster management, namely: Public Information and Education; Damage and Needs Assessment; Transport and Road Clearance; Shelter Management; Health Services; Emergency Telecommunications; Disaster Relief Management; Public Utilities, Rehabilitation and Reconstruction; Search and Rescue - Land and Sea; Welfare and Voluntary Services; Security Services; Evacuation; Earthquakes, Volcanic Eruptions, Floods and Landslides; Marine Pollution and Oil Spills; and Hazardous Materials and Hazardous Wastes (Government of Grenada, 2011b).

The draft Comprehensive Disaster Management Policy takes a proactive approach to disaster management and incorporates considerations of climate change adaptation, as well as the needs of the most vulnerable. It also considers harmonization with the existing policy framework.

1.7.9 Financing National Climate Change Programming

A key limitation in the advancement of climate change programming across Caribbean SIDS is access to adequate and sustained financing. While some countries have, and continue to dedicate a portion of their GDP to climate change activities, this is very limited and has to be justified against other national development priorities which may be considered more urgent in the short term.

By nature of its vulnerability to climate change, the Caribbean region has received assistance from a range of regional and international development partners to address vulnerability challenges. These partners have provided direct financing in the form of grants, loans or combined grant-loan mechanisms, technical assistance to fill existing gaps, and complementary support for resource and capacity development in efforts to minimise reliance on external providers which can significantly add to programme costs. Recent and notable financing and technical assistance initiatives, along with the funding and implementing agencies, are outlined below:

At the Global Level:

- The Pilot Program for Climate Resilience (PPCR), by the World Bank; which was subsequently followed by:
    - The Strategic Program for Climate Resilience (SPCR);
    - The Disaster Vulnerability Reduction Project (DVRP);
- the Programme for Integrated Climate Change Adaptation Strategies (ICCAS), by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ; German Society for International Cooperation) and the United Nations Development Programme (UNDP);
- Building Capacity for Coastal Ecosystem-based Adaptation in Small Island Developing States (SIDS) (UNEP).

At the Regional Level:

- Mainstreaming Adaptation to Climate Change (MACC);
- Community Alerts Project: An effective implementation in the Caribbean through integrated Early Warning Systems (UNDP);
- the Caribbean Disaster Management Project (CDMP), implemented by the Caribbean Disaster Emergency Management Agency (CDEMA);
- the Caribbean Risk Management Initiative (CRMI), completed by the United Nations Development Programme (UNDP);
- The Reduce Risks to Human and Natural Assets Resulting from Climate Change (RRACC) Project, funded by USAID and implemented by the OECS Secretariat;
- The Global Climate Change Alliance Project supported by the ACP-EU (EU-GCCA).

At the National Level:

- Vulnerability and Capacity Assessment of the Chemin Watershed area and a National Adaptation Strategy and Action Plan for the Water Sector (EU-GCCA/CCCCC);
- Preserving Nature. Protecting Lives (The Nature Conservancy and the Grenada Red Cross Society), noting the Vulnerability and Capacity Assessments (VCAs) conducted in Marquis, Soubise, Grenville and Telescope;
- Implementing a Ridge to Reef Approach to Protecting Biodiversity and Ecosystem Functions within and around Protected Area Systems in Grenada (UNDP/GEF);
- Assistance to Improve Local Agricultural Emergency Preparedness (FAO).

1.8 PROGRESS SINCE THE INITIAL NATIONAL COMMUNICATION

Since the Initial National Communication and premised on the recommendations contained therein, Grenada has made tremendous progress and has achieved notable successes under its growing climate change portfolio, principally including the establishment of a National Climate Change Policy and Action Plan and a National Climate Change Committee, a National Energy Policy that promotes a thrust towards the meaningful integration of renewable energy across Grenada, and the development and implementation of a series of national and sub-national adaptation and mitigation interventions such as the projects sponsored under the Pilot Program for Climate Resilience (PPCR).

The Second National Communication (SNC) report is now timely. It represents another major milestone for Grenada in respect of its national climate change programming, and its continued commitment as a Non-Annex I Party to the UNFCCC. The Second National Communication will comprehensively capture what has taken place in Grenada since the submission of the Initial National Communication, and will focus on those sectors that have strong linkages or implications in respect of climate change vulnerability, adaptation, and mitigation: namely the coastal sector; the water sector; the agricultural sector; the tourism sector; the health sector; the social sector and human settlements; and industrial sectors that are considered key players in respect of GHG emissions and mitigation: energy, transport, waste and other industrial processes and product use.

The National Communication report is recognised as one of the principal tools for bringing climate change concerns to the attention of policy makers at the national level through highlighting and disseminating climate change concerns; fostering wide stakeholder engagement; and highlighting human, technical and financial needs to adequately respond to climate change at the national level. Grenada's SNC will therefore present information that will provide positive benefits for Grenada beyond complying with its UNFCCC commitments.

There are recognised opportunities to reduce GHG emissions and develop new markets that are likely to thrive in future climate change scenarios and provide increased economic resilience to potential climate changes. Assessing vulnerabilities, promoting adaptation and mitigation strategies and policies, and identifying new financing opportunities and markets for Grenada could help the country secure a more stable economic base in the future. New climate investment and financing mechanisms have been launched leading up to, and including the advent of the Paris Agreement (e.g. the Green Climate Fund), and Grenada can be well-positioned to capitalise on these through meeting its international reporting obligations.

Additionally, the Government of Grenada, in conjunction with other national and international partners, is in the process of completing the country's National Climate Change Adaptation Plan (NAP) and reviewing the existing National Climate Change Policy (NCCP) with the intention of producing a revised policy output. Also ongoing is a Climate Change Technological Needs Assessment (TNA), work towards the implementation of Grenada's National Determined Contributions (NDC), and the activities that fall under the purview of the Pilot Program for Climate Resilience (PPCR).

The outputs and outcomes of these processes have been integral to the preparation of Grenada's SNC, with the development of synergies in implementation across the ongoing activities, and productive co-ordination across local stakeholders and key policy drivers to ensure consistency in the messages that are delivered by these processes.

CHAPTER 2.
NATIONAL INVENTORY OF GREENHOUSE GASES

2.1 INTRODUCTION

This chapter provides a technical description of the methodology used to compile the greenhouse gas (GHG) inventory for Grenada for the years 2000 to 2014. All non-Annex I Parties[8] are required to submit a national inventory of anthropogenic emissions by source, and removals by sink, of all greenhouse gases as part of their national communications.

Consistent with the 2006 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories[9], estimates of emissions and removals by sinks for the following sectors have been developed:

- Energy (including transport)
- Industrial Processes and Product Use
- Waste
- Agriculture, Forestry and Other Land Use (AFOLU)

The following direct GHGs have been considered: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and the Fluorinated Gases (HFCs, PFCs and SF_6). It has not been possible to estimate the emissions of indirect GHGs (non-methane volatile organic compounds (NMVOC), nitrogen oxides (NOx), sulphur dioxide (SO_2) and the reasons for this are provided in the subsequent sector sections.

Within the sectors, emission estimates are calculated within Common Reporting Format (CRF) sub-categories as defined by the 2006 IPCC reporting guidelines[9]. This enables analysis of emissions within specific sub-categories, where possible. The methodologies set out in the 2006 IPCC reporting guidelines are classified accordance to Tier 1, Tier 2 and Tier 3. Each Tier represents an improvement in the detail of the methodology employed and integration of country specific activity data or emission factors. Due to limited data availability, in all cases a Tier 1 methodology has been used. This provides the most basic level of emissions estimates, applying default emission factors to activity data.

All emission estimates were calculated using templates designed in commercial spreadsheet software. These templates function according to the same underlying methodologies implemented in the IPCC worksheets and software that accompany the 2006 IPCC Guidelines. An exception is the waste emission estimates, which also uses the IPCC FOC model in select cases. Further detail on the development of the templates used can be found in **Error! Reference ource not found.**. All emission estimates have been subject to rigorous QAQC procedures to

[8] Grenada is a Non-Annex I Party under the United Nations Framework Convention on Climate Change.

[9] http://www.ipcc-nggip.iges.or.jp/public/2006gl/

ensure all the data presented conforms to the QAQC principles of TCCCA (Transparency, Consistency, Comparability, Completeness and Accuracy), described in the Guidelines.

- **Transparent** assumptions, data sources and methods are provided to facilitate replication and assessment of the validity of the outcomes by users. Transparency is fundamental to the success of the process for the communication and consideration of information.
- Data is **consistent** and ensures internal coherence in all elements.
- Where possible data are **comparable** across different entities (e.g. stakeholders). In the case of emissions, the allocation of different source/sink categories should follow an agreed and defined nomenclature.
- **Completeness** is ensured and gaps highlighted. The data and analysis covers all elements expected within the sectoral/geographical/timeframe defined.
- Our approaches strive to be **accurate** in the sense that they are systematically neither over nor under estimating as far as can be judged, and that uncertainties are reduced as far as practicable and defined.

In this manner, it is intended that the templates developed and the emission estimates produced provide a good basis for the continuation of the inventory in future updates.

A number of techniques are available to help assess and prioritise resources within an inventory, these techniques include key category analysis (KCA) and an assessment of uncertainties. For details about both techniques, please see **Error! Reference source not found.**

2.2 ENERGY

The energy sector includes two major combustion related activities: stationary combustion and transport / mobile combustion. Each of these activities includes various sources that emit Greenhouse Gas (GHG) emissions.

To estimate emissions of the indirect GHGs, detailed process information such as the combustion conditions, size and age of the combustion technology, operational practices and emission controls is required. Therefore, only the direct GHG emissions have been estimated.

Non-Annex 1 parties are encouraged to estimate and report CO2 emissions using both the Sectoral and Reference approaches and explain any large differences between the approaches. The sectoral approach uses fuel consumption statistics by fuel consumption and economic sector, whereas the reference approach uses a basic energy balance sheet. For this inventory, only a sectoral approach has been undertaken. A reference approach was not able to be completed due to lack of an energy balance.

Table 8 displays all CRF categories contained within the energy sector, accompanied by notation on which categories have been estimated and those categories for which sources exist, but they are not estimated (NE), due to a lack of activity data. It should be noted that the CRF categories displayed below can be expanded according to the detail of the activity data available.

Table 8-Overview of emission estimates from the energy sector.

Source	IPCC 2006	GHGs	Status	Explanation
Main Activity Electricity and Heat Production	1A1a	CO_2, CH_4, N_2O	Estimated	
Combustion in manufacturing industries and construction	1A2	CO_2, CH_4, N_2O	Estimated	
Road transportation	1A3b	CO_2, CH_4, N_2O	Estimated	
Commercial/ institutional combustion	1A4a	CO_2, CH_4, N_2O	Estimated	
Residential combustion	1A4b	CO_2, CH_4, N_2O	Estimated	
Agriculture/Forestry/fishing	1A4c	CO_2, CH_4, N_2O	Estimated	
Domestic aviation	1A3a	CO_2, CH_4, N_2O	Estimated	
Domestic shipping	1A3d	CO_2, CH_4, N_2O	Estimated	
International aviation	Memo item	CO_2, CH_4, N_2O	Estimated	
International shipping	Memo item	CO_2, CH_4, N_2O	NE	No data available

Detailed energy data was supplied by the Ministry of Finance and Energy, which covered the years 2006 to 2014 inclusively. This provided useful information on the type of fuels combusted in Grenada. Due to the coverage of this dataset and the implications this poses in terms of time series consistency, other datasets were also sourced and used where appropriate. The majority of the additional required activity data was sourced from the United Nation's (UN) Energy Statistics Database[10]. This provides fuel consumption data, split according to application.

Emissions of carbon dioxide (CO_2) from the energy industries and the transport sector are the most important sources making up the energy inventory. Other sources are emissions from manufacturing and construction industries, commercial and residential combustion, and emissions from fishing, forestry and agriculture. Estimates of methane (CH_4) and nitrous oxide (N_2O) emissions are also made for all source sectors.

2.2.1 Methodology

A summary of the methodology for each source is provided below. Refer to the accompanying calculation worksheets in Annex I for detailed information on the methodologies used in estimating GHG emissions from the energy sector.

[10] http://data.un.org/Browse.aspx?d=EDATA

Category 1A1a – Main Activity Electricity and Heat Production

Grenada generates all of its power for public electricity[11] from the combustion of gas/diesel oil. The amount of fuel consumed has been obtained from UN Energy Statistics. This source was used due to a full time series being available.

Category 1A2 – Stationary combustion in manufacturing industries and construction

LPG, motor gasoline, gas/diesel oil and bagasse are combusted within the manufacturing industries and construction sector. Activity data for this category is sourced from UN Energy Statistics.

In line with IPCC 2006 Guidelines[2], emissions of CO_2 resulting from the combustion of biomass (bagasse) are not included in the inventory total; however, emissions of CH_4 and N_2O from this source are included.

Category 1A3a – Domestic aviation

Aviation gasoline and jet fuel consumed by domestic aviation was provided by the Ministry of Finance and Energy. However, it is unclear whether this should in fact all be allocated to domestic aviation or whether in fact some of this is international. As a response, the aviation industry in Grenada was investigated, concluding that it is likely, due to the aircrafts used for domestic flights, that domestic flights only operate using aviation gasoline. Hence, it assumed all jet fuel should be allocated to international flights. This assumption is consistent with the EMEP EEA 2016 Guidebook[12], which also uses this assumption as the basis for emission calculations. However, the only airline which operates domestically, SVG AIR, also provides short haul international flights to surrounding Caribbean nations. These flights are conducted using similar small aircrafts, also likely to operate on aviation gasoline. Hence there is a need to further discern the international and domestic components accounted for within the aviation gasoline figures supplied. In order to derive this split, a bottom up estimate of fuel use for domestic flights was estimated using data on the aircraft's fuel consumption and flight route. SVG AIR uses a BN-2 Islander aircraft for all domestic flights to Carriacou and Union Island, utilising a circular route from Grenada, resulting in 3 flights per day[13]. As Union Island is classified as outside of Grenada's territory, the only flight that can be described as domestic out of these 3 daily journeys is the return journey from Carriacou to Grenada. Fuel consumption for this aircraft was assumed equal to the fuel consumption for a similar BN-2 Islander aircraft, currently in service with Logan Air[14]. The distance of the flight path was estimated enabling the calculation of annual fuel consumed by domestic flights. Once calculated, Tier 1 emission factors for

[11] http://www.grenlec.com/ResourceCentre/Generation.aspx

[12] http://www.eea.europa.eu/publications/emep-eea-guidebook-2016

[13] Personal communication, SVG AIR, 27/02/2017

[14] http://www.loganair.co.uk/loganair/aircraft

aviation gasoline were applied. These emission factors are calculated to account for landing and take-off cycles, in addition to cruising.

It is recommended that a more accurate methodology, for estimating the amount of fuel used for domestic aviation relative to international, is undertaken in future inventory compilations.

Category 1A3b – Road transportation

Activity data for the road transport sector consists of petrol and diesel consumption. This data has been sourced directly from UN energy statistics for all years.

Category 1A3c – Domestic navigation and fishing

Fuel consumed in maritime navigation was provided by the Ministry of Finance and Energy for the period 2006 – 2014. Gap filling was employed to complete the time series. However, it is unclear how much of the fuel is used for domestic purposes and how much for international purposes. A number of comparisons were employed in order to verify the nature of the fuel figures supplied. The details of the inventories presented in the national communications of other Caribbean Islands were not detailed enough to enable any comparison specific to domestic navigation. Therefore, emissions arising from domestic navigation in Malta were sourced[15]. Malta was chosen because it is an island state and like Grenada consists of 2 principal islands. Population and GDP data were used to scale emissions to enable a comparison, the result of which verified that the fuel figures supplied are likely to account or be comparative to the fuel used for domestic purposes. Emissions were calculated via the application of fuel based emissions factors for gasoline and diesel consumed in navigation. It is recommended that clarification is sought on the domestic / international split and that this information is incorporated into subsequent inventories.

Category 1A4a – Commercial / institutional combustion

Activity data for this category consists of gas/diesel oil and LPG. This data has been sourced from UN Energy Statistics. Whilst a full-time series was available for the consumption of LPG; gas/diesel oil data was only available from 2008 onwards and therefore gap filling was deployed for earlier years.

Category 1A4b – Residential combustion

Activity data in the stationary residential combustion sector consists of kerosene, LPG, petrol, kerosene, charcoal and wood. This data was sourced from UN energy statistics, due to a complete dataset being available.

[15] http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/9492.php

Again, in line with IPCC 2006 Guidelines, emissions of CO_2 resulting from the combustion of biomass (wood) are not included in the inventory total; however, emissions of CH_4 and N_2O from this source are included.

Category 1A4c – Agriculture/forestry/fishing

According to the energy balance supplied by the Ministry of Finance and Energy, only gas/diesel oil is combusted within this category. Activity data was sourced from UN energy statistics, due to a complete dataset being available. However, when reviewing the time series, a large drop in fuel consumption by two orders of magnitude can be observed from 2008 onwards and then in 2011 and 2012 the activity is zero. Following discussion at the May 2017 workshop, it has been determined that the data for 2008, 2009, 2010, 2013 and 2014 is most likely a unit conversion error, and an adjustment factor of a 100, was applied in order to improve the accuracy of the estimate. For 2011 and 2012, gap filling was applied as it was agreed that it was not realistic to be zero for these years.

Memo items – International transport

International bunker fuels include both shipping and civil aviation from international transport activities. Currently only emissions from international aviation have been estimated. Aviation gasoline and jet fuel consumed by domestic aviation was provided by the Ministry of Finance and Energy. However, it wasn't clear whether this data specifically referred to domestic aviation or in fact was an aggregate figure accounting for international flights in addition to domestic. Via profiling the aviation industry in Grenada, it was determined that jet fuel is unlikely to be used for domestic purposes and hence should be allocated to international aviation. In addition, a bottom up estimate of aviation gasoline consumed by domestic flights was calculated and subtracted from the figures supplied, thus deriving the amount of gasoline thought to be consumed for short-haul international flights. Emissions factors specific to each fuel type were applied in order to calculate emissions. These factors are calculated to take into account both landing and take-off cycles, in addition to cruising.

It is recommended that better data is obtained on the domestic / international split for both aviation and shipping. In line with IPCC Guidelines, emissions arising from international aviation are reported as a memo item.

2.2.2 Energy GHG Emission Estimate Summary

Table 9 below provides GHG emission estimates for the energy sector. CO_2 is the dominant GHG from the energy sector contributing over 99% to the overall total in 2014.

Table 9-Estimated Emissions by Pollutant 2000-2014 (Gg CO_2e)

Year	CO_2	CH_4	N_2O
2000	207.5	2.1	3.2
2001	216.7	2.2	3.3
2002	226.4	2.3	3.5
2003	238.7	2.4	3.7

Year	CO_2	CH_4	N_2O
2004	232.2	2.4	3.6
2005	243.4	2.5	3.7
2006	251.4	2.6	3.9
2007	264.9	2.6	4.0
2008	280.1	2.5	3.8
2009	277.8	2.5	3.9
2010	289.0	2.6	4.1
2011	275.0	2.6	3.7
2012	295.9	2.6	3.8
2013	335.0	2.6	4.0
2014	278.9	2.7	4.0

Figure 17 and Table 10 provide the estimated emissions by source category. Emissions from the energy industries comprise nearly half of the 2014 total (45%), with the transport sector contributing the remaining majority (41%). Commercial and residential combustion contributes 12% to the 2014 total and manufacturing and construction contributes the remaining 2%.

The time series (Figure 17) shows a trend of increasing emissions, with a peak in 2013. This was caused by a substantial increase in the amount of diesel combusted in the energy industry sector in this year. As noted previously, this data is subject to change following clarification of the split between domestic and international aviation and shipping.

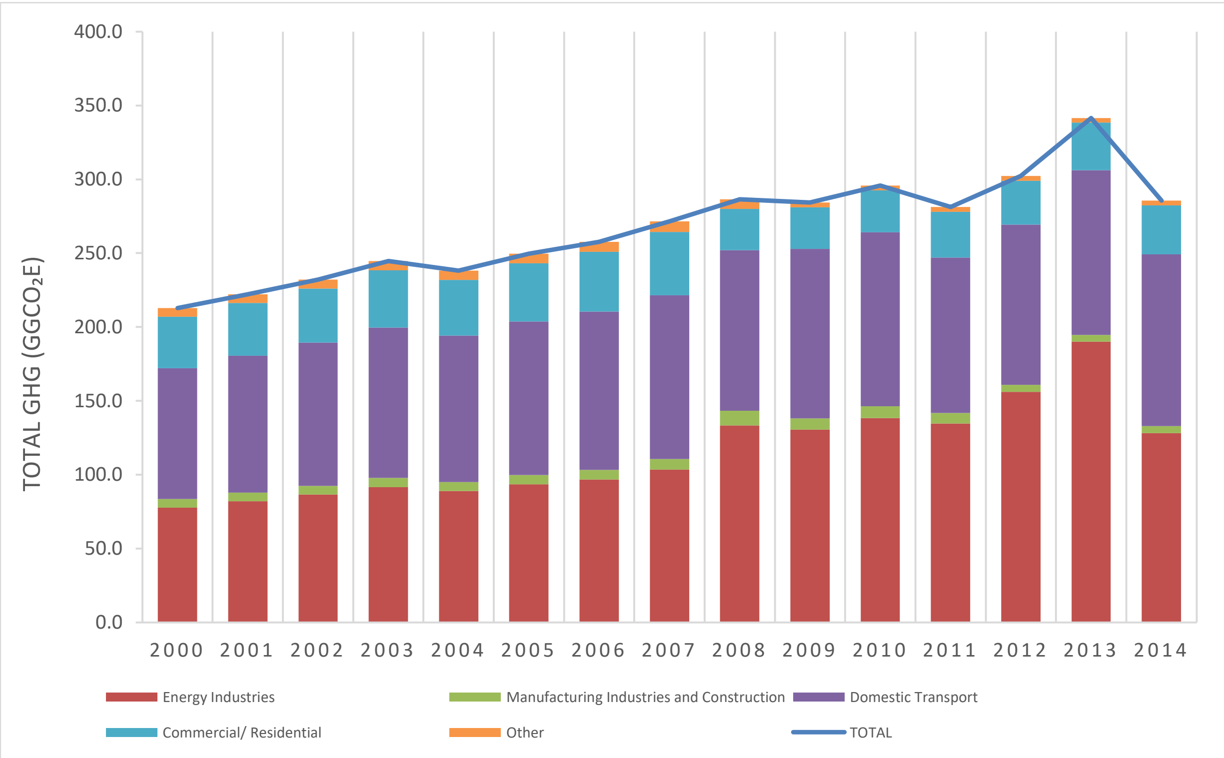

Figure 17-Time series displaying emissions from the Energy Sector.

Table 10-GHG emissions by source category 2000 - 2014 (Gg CO2e)

Year	Energy Industries	Manufacturing Industries and Construction	Domestic Transport	Commercial/ Residential	Other	TOTAL
2000	77.7	5.8	88.7	34.7	5.9	**212.8**
2001	82.0	5.8	92.7	35.7	5.9	**222.2**
2002	86.6	5.9	96.9	36.7	6.0	**232.2**
2003	91.6	6.2	101.9	38.7	6.4	**244.8**
2004	88.9	6.1	99.2	37.7	6.2	**238.1**
2005	93.6	6.3	103.8	39.4	6.5	**249.6**
2006	96.8	6.5	107.1	40.7	6.7	**257.8**
2007	103.6	7.0	111.1	42.9	7.1	**271.5**
2008	133.3	9.9	108.8	27.9	6.4	**286.4**
2009	130.6	7.6	114.6	28.2	3.2	**284.2**
2010	138.4	8.0	117.8	28.4	3.2	**295.7**
2011	134.7	7.2	105.3	30.9	3.2	**281.3**
2012	156.1	4.7	108.5	29.8	3.2	**302.3**
2013	190.2	4.5	111.4	32.2	3.2	**341.6**
2014	128.3	4.6	116.2	33.2	3.2	**285.5**

Note: the sum of the component parts may not exactly add up to the total due to rounding.

2.2.3 Recommendations for the Energy Sector

The activity data provided for energy consumption is currently not of high enough completeness to allow for estimates to be made based on country-specific data. Professional judgement and international default values have been used where data has been lacking and extrapolations have been made based on past data to complete the time series. The recommendations provided in Table 11 below focus on obtaining fuel consumption data sets that are readily available for future inventory compilations.

Table 11-Recommendations for the Energy Sector

No.	Improvement Issue	Priority Rating
1	Fuel consumption data Fuel consumption data across the time series (in this case 2000 to 2014) is required to make accurate emission estimates across the energy sector. This would be preferential compared to using data from UN statistics. The following is required: - An annual official energy balance (this would allow estimates to be compiled using the Tier 1 reference approach). - Fuel consumption by sector and type of fuel for the years being	Very High

No.	Improvement Issue	Priority Rating
	assessed. This has been provided for the year 2006 onwards, but is not fully complete	
2	Fuel consumption data - Obtain a detailed split of fuel consumption for both international and domestic aviation and maritime navigation. This may be included in the above improvement issue.	High
3	Fuel consumption data - Information on fuel consumption by plant (for each electricity plant and each industry) for the years being assessed - Fuel analysis information showing average energy and carbon content of fuels.	Medium
4	Emission factors - Tier 1 emission factors have been used throughout. Detailed information on the characteristics of the energy industries – e.g the technologies used, the age of the transport fleet and the use of catalytic converters would enable more accurate estimates to be made.	Medium

2.3 INDUSTRIAL PROCESSES

Industry in Grenada includes processes that give rise to direct and indirect GHGs. This includes food and drink manufacture, chiefly sugar (producing non-methane volatile organic compounds [NMVOC] from fermentation and food production processes). There is no evidence of primary ferrous, non-ferrous metal production, chemical production or cement/clinker production in Grenada of significance.

In addition to the large manufacturing processes, emissions from the use of fluorinated gases (HFC and SF_6) used in refrigeration, air conditioning, fire equipment, aerosols and some foams are included in the industrial processes sector. Globally, emissions of these gases have increased dramatically since 1995 as a result of them being used to substitute chlorofluorocarbons (CFCs) banned by the Montreal Protocol[16].

The following sections outline the data that was used to compile the GHG inventory for the industrial processes sector.

Table 12 provides an overview of the source that has been estimated in the industrial processes sector. Where there are sources known to exist, that have not been estimated (NE), these are also highlighted.

Table 12-Overview of emission estimates from the industrial processes sector.

Source	IPCC 2006	GHGs	Status	Explanation
Consumption of F-gases	2F	HFCs, SF_6	Estimated	
Food and beverages industry	2H2	CO_2, CH_4	NE	There is data to suggest Grenada is a significant producer of a variety of sugars, liquors, nutmeg, and cocoa, however no detailed production data is available. Nor is there sufficient export and import data to derive estimates of production.

This sector is subject to a lack of data. As a result, emissions were estimated via scaling factors derived from surrogate datasets produced for other Countries. Whilst this isn't an accepted methodology according to the 2006 IPCC reporting guidelines, it is sufficient for the purposes of the SNC, provided this is recognised as non-compliant with the guidelines and a focal point for development in future emission estimates.

2.3.1 Methodology

A summary of the methodology for each source is provided below.

[16] United Nations Environmental Programme: The Montreal Protocol on Substances that Deplete the Ozone Layer, as either adjusted and/or amended in London 1990, Copenhagen 1992, Vienna 1995, Montreal 1997, Beijing 1999

Category 2F – Consumption of F-Gases

Due to the lack of data on the imports/exports and content of HFCs in appliances, estimates have been derived by assuming the same emissions per capita as Malta. Emissions data was sourced from Malta's 2016 national inventory report[15]. Population data was sourced from the World Bank for both Malta and Grenada[17]. Malta was selected as it had its own estimates of HFCs from its Annex I reporting to the UNFCCC, and despite Grenada being classed as Non-Annex I, was considered similar in climate, population and economic output. This approach assumes that the rate of HFCs lost and the species of HFCs are the same as in Malta and the quantity and size of appliances is relative to the population. There is therefore much uncertainty in the emission estimates.

As with the estimates of HFCs above, a lack of the necessary data has meant that emission estimates for SF_6 in electrical equipment have also been derived by assuming the same emissions per capita as Malta.

2.3.2 Industrial Process GHG Emission Estimate Summary

Figure 18 and Table 13 below provide GHG emission estimates for the industrial process sector[18].

The consumption of F-gases increased by over 4,000% across the time series. The substantial increase within this sector is due to the use of such gases as replacements for ozone depleting substances and to the greater utilization of these gases in refrigeration equipment.

[17] http://data.worldbank.org/indicator/SP.POP.TOTL

[18] Whilst data on the imports of total HFCs was provided by the Environment Division, unfortunately it was not possible to use this data to estimate emissions. The following additional information would be required: (1) A breakdown by different type of HFCs owing to their different global warming potentials and (2) information on the exports and imports of products containing HFCs.

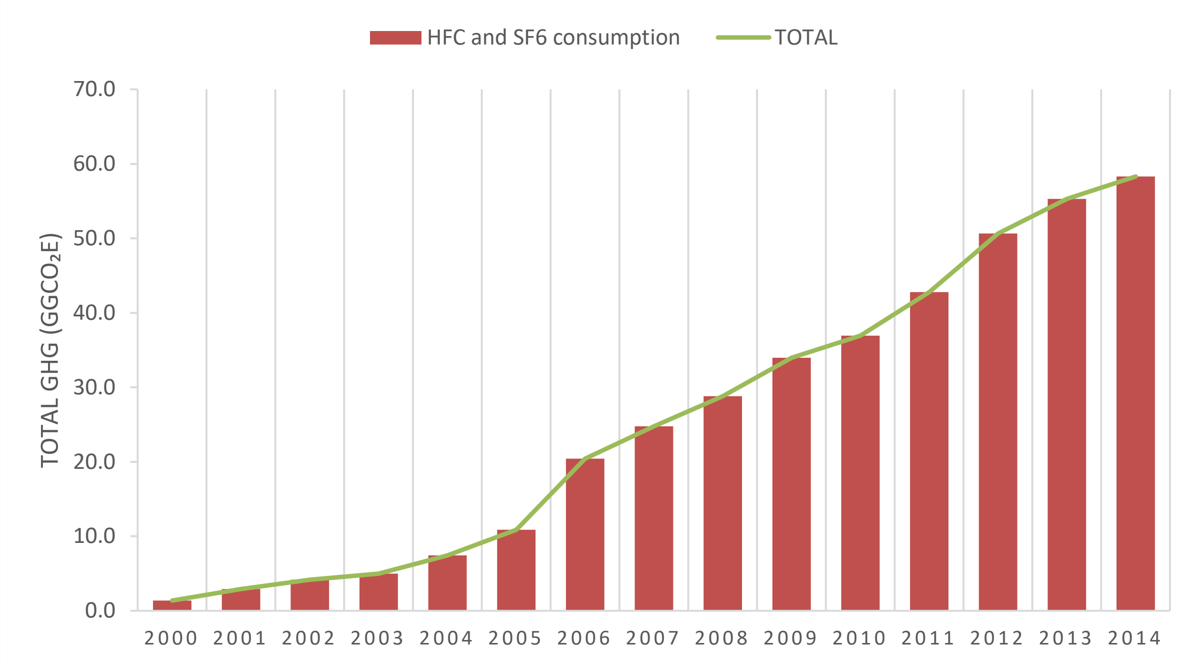

Figure 18-Time series displaying emissions from the industrial processes sector.

Table 13-Estimated Emissions 2000-2014 (Gg CO_2e)

Year	HFC and SF_6 consumption	TOTAL
2000	1.4	**1.4**
2001	2.9	**2.9**
2002	4.2	**4.2**
2003	5.0	**5.0**
2004	7.4	**7.4**
2005	10.9	**10.9**
2006	20.4	**20.4**
2007	24.7	**24.7**
2008	28.8	**28.8**
2009	34.0	**34.0**
2010	36.9	**36.9**
2011	42.8	**42.8**
2012	50.6	**50.6**
2013	55.3	**55.3**
2014	58.3	**58.3**

Note: the sum of the component parts may not exactly add up to the total due to rounding.

2.3.3 Recommendations for the Industrial Processes Sector

The following recommendations (Table 14) are made, so that improved estimates can be made for the industrial processes sector.

Table 14-Recommendations for the Industrial Processes Sector

No.	Improvement Issue	Priority Rating
1	F-gas emission estimates To improve the estimates of HFCs and SF_6 emissions, the amount used for recharging appliances and any quantities lost in disposal or destruction of gases would be beneficial and improve the estimates provided here.	Medium
2	Use of F-Gases in Electronics There may be emissions from the use of F-Gases in the electronics industry in cleaning and purging equipment. It is recommended that Grenada investigate possible sources and imports of PFCs for the electrical equipment industry.	Medium

2.4 AGRICULTURE, FORESTRY AND OTHER LAND USE

The agricultural sector accounted for 9.6% of the labour force in 2013[15] and therefore this is an important sector. Between 2010 and 2014, the agricultural sector's contribution to total national GDP averaged 5%, with the main agricultural contributor originating in crop production (2.8% of total GDP). Livestock and forestry combined only contribute 0.7% of the total GDP across the same time period[19].

The island of Grenada and its territories are continuing to recover from the devastation by hurricanes which severely damaged the agriculture sector in 2004 and 2005. Agricultural exports are nutmeg, mace, cocoa, bananas, other fruits and vegetables[20].

Table 15 below displays all IPCC categories within the agriculture, forestry and other land use sector, together with information on which categories have been estimated and those categories for which sources exist, but cannot be estimated (NE).

Table 15-Overview of emissions from Agriculture, Forestry and Other Land Use

Source	IPCC 2006	GHGs	Status
Enteric fermentation	3A1	CH_4	Estimated
Manure management	3A2	CH_4, N_2O	Estimated
Direct N_2O emissions from managed soils	3C4	N_2O	Estimated
Indirect N_2O emissions from managed soils	3C5	N_2O	Estimated

[19] http://agricarib.org/images/docs/COUNTRIES_GRENADA_National_Agriculture_Plan_Final_Aug25_2015_Final_Edit_(002).pdf

[20] http://www.cardi.org/country-offices/grenada/

Emissions from biomass burning in croplands	3C1b	CH_4, N_2O	Estimated
Forestland remaining forestland	3B1a	CO_2	Estimated
Emissions from biomass burning in forestland	3C1a	CH_4, N_2O	Estimated

2.4.1 Methodology

A summary of the methodology for each source is provided below.

Category 3A1 – Enteric fermentation

The methodology for enteric fermentation relies on the supply of activity data detailing the livestock population. This was sourced from the FAOSTAT database[21], which estimates livestock for Grenada according to the following categories: dairy cattle, non-dairy cattle, goats, horses, mules, sheep, breeding swine and market swine. Default methane emission factors for each livestock category, were sourced from the 2006 IPCC guidelines. The default emission factors applied are representative of Latin America, and hence are considered representative of Grenada.

Category 3A2 – Manure management

Activity data for manure management, similarly to enteric fermentation, consists of livestock data sourced from the FAOSTAT database[27]. Default emission factors, relating to Latin America, were applied to derive CH_4 emissions and are specific to the average temperature of Grenada. Direct N_2O emissions occur via combined nitrification and denitrification of nitrogen contained in the manure. The emission of N_2O from manure during storage and treatment depends on the nitrogen and carbon content of manure, and on the duration of the storage and type of treatment. Nitrification (the oxidation of ammonia nitrogen to nitrate nitrogen) is a necessary prerequisite for the emission of N_2O from stored animal manures. Emissions are estimated following Tier 1 method of IPCC 2006 Guidelines, by multiplying the number of animals of each category by the default emission factor in IPCC. Default emission factors are those for Latin America, and are deemed most appropriate relative to the emission factors available. The emission factors used account for the following manure management systems; lagoon, liquid/slurry, solid storage, drylots, pit storage, PRP (pasture range and paddock), daily spreading, poultry manure and deep bedding, with the percentage optimisation by livestock category supplied by the 2006 IPCC guidelines.

Category 3C4 – Direct N_2O emissions from managed soils

Activity data for this category consists of the amount of nutrients added to soils: manure, urine and dung form grazing animals and crop residues. Amount of nitrogen in manure applied to soils comes from the estimates of manure management systems (developed in category 3A2); nitrogen from grazing animals is estimated using default values for excretion and pasture, range

[21] http://www.fao.org/faostat/en/#data/QA

and paddock practices and nitrogen in crop residues is sourced from the FAOSTAT database[26], that presents data for maize and dry beans. Default emissions factors from the IPCC 2006 Guidelines were applied to derive N_2O emissions.

Category 3C5 – Indirect N_2O emissions from managed soils

There are two paths for indirect emissions: atmospheric deposition and leaching and runoff. Activity data for atmospheric deposition consists of the amount of nitrogen volatilised from manure applied to soils and urine and dung from grazing animals; for leaching and run-off, nitrogen in crop residues is also considered. Default fractions of N volatilised as NO_x and NH_3 and lost through leaching and runoff together with default emissions factors from the IPCC 2006 Guidelines were applied to derive N_2O emissions.

Category 3B1a – Forestland remaining forestland

Activity data for this category consists of the area and carbon stocks data compiled by countries in the 2015 FAO[22] Global Forest Resource Assessment[23], available by country. For forestland area, data for 2001 has been assumed across the time series, due to issues with data quality. For growing stock, values were sourced for 2003, 2005 and 2010. Expert judgement and interpolation has been used to complete the necessary time series. A Tier 1 approach has been utilised, using the stock difference method, by combining a range of default conversion factors sourced from the IPCC 2006 Guidelines.

Category 3C1a – Biomass burning in forestland

Biomass combustion due to wildfires is a source of the following GHG gases: CO_2, N_2O and CH_4. CO_2 is accounted for since the CO_2 emissions and removals for the biomass pool are not assumed equivalent in the reporting year. The total amount of dry forest matter burnt is directly sourced from the FAOSTAT database[26]. The default emission factor for 'tropical forests', from the 2006 IPCC Guidelines was applied to the total amount of dry matter burnt to derive emissions for both N_2O and CH_4.

Category 3C1b – Emissions from biomass burning in croplands

The methodology for this category relies on activity data regarding the amount of dry biomass matter burned annually; this was sourced from the FAOSTAT database[26]. Two types of crops are burnt in Grenada, according to this data: maize (corn) and sugar cane. Default emission factors for both CH_4 and N_2O, from the 2006 IPCC Guidelines, were applied to derive emissions.

2.4.2 Agriculture GHG Emission Estimates Summary

[22] FAO is the Food and Agriculture Organisation of the United Nations

[23] http://www.fao.org/forest-resources-assessment/en/

Figure 19 and Table 16 below provide GHG emission estimates for the agricultural sector. Emissions from agriculture are dominated by livestock, contributing 71% of the total agricultural emissions in 2014. Out of this livestock component, more emissions originate from enteric fermentation than the management of manure.

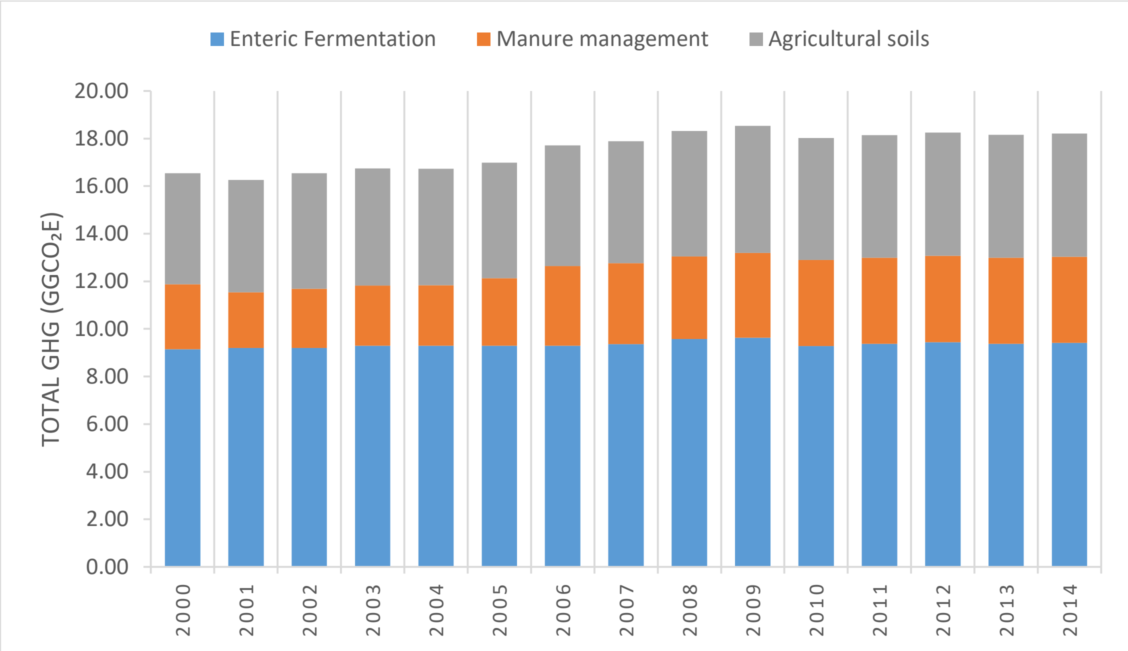

Figure 19-Time series of emission estimates for the agricultural sector.

Table 16-Estimated Emissions 2000-2014 (Gg CO_2e)

Year	Livestock	Managed soils	TOTAL
2000	11.9	4.7	**16.6**
2001	11.5	4.7	**16.3**
2002	11.7	4.9	**16.6**
2003	11.8	5.0	**16.8**
2004	11.8	4.9	**16.8**
2005	12.1	4.9	**17.0**
2006	12.6	5.1	**17.8**
2007	12.8	5.2	**17.9**
2008	13.0	5.3	**18.4**
2009	13.2	5.4	**18.6**
2010	12.9	5.2	**18.1**
2011	13.0	5.2	**18.2**
2012	13.1	5.2	**18.3**
2013	13.0	5.2	**18.2**
2014	13.0	5.2	**18.3**

Note: the sum of the component parts may not exactly add up to the total due to rounding.

The emission estimates show a slight increase over the time period. This is primarily due to increases in the numbers of non-dairy cattle, sheep and pigs. The uncertainty associated with these estimates is high due to international data sources being used, which do not provide any detailed characterisation. Similarly, the emission factors are based on international defaults and include a variety of underlying assumptions.

2.4.3 Recommendations for the Agricultural Sector

The following recommendations (Table 17) are made so that improved estimates can be made for the agriculture sector.

Table 17-Recommendations for the Agriculture Sector

No.	Improvement Issue	Priority Rating
1	Livestock Data It is recommended that a livestock census is undertaken. This should ideally be at least every 5 years, and annual data would be estimated from this.	High
2	Methane emission factors for cattle Currently it is assumed that methane emission factors for manure management can be represented by an average Latin American EF. This should be reviewed by local agriculture experts and amended as necessary.	High
5	Nitrogen inputs to soils It is recommended (if relevant) that data regarding the use of synthetic fertilizers is obtained	High
3	Manure management Currently it is assumed that manure management N_2O emission factors can be represented by Latin American practices. This should be reviewed by local agriculture experts and amended as necessary.	Medium
4	N Excretion Rates Currently it is assumed that N excretion rates for all animal categories is represented by Latin American livestock characteristics. If possible, country specific N excretion rates should be used for swine and cattle, to allow a Tier 2 method to be used.	Medium

2.4.4 Forestry and Other Land Use GHG Emission Estimates

Figure 20 and Table 18 below provide GHG emission estimates for the forestry and other land use sector.

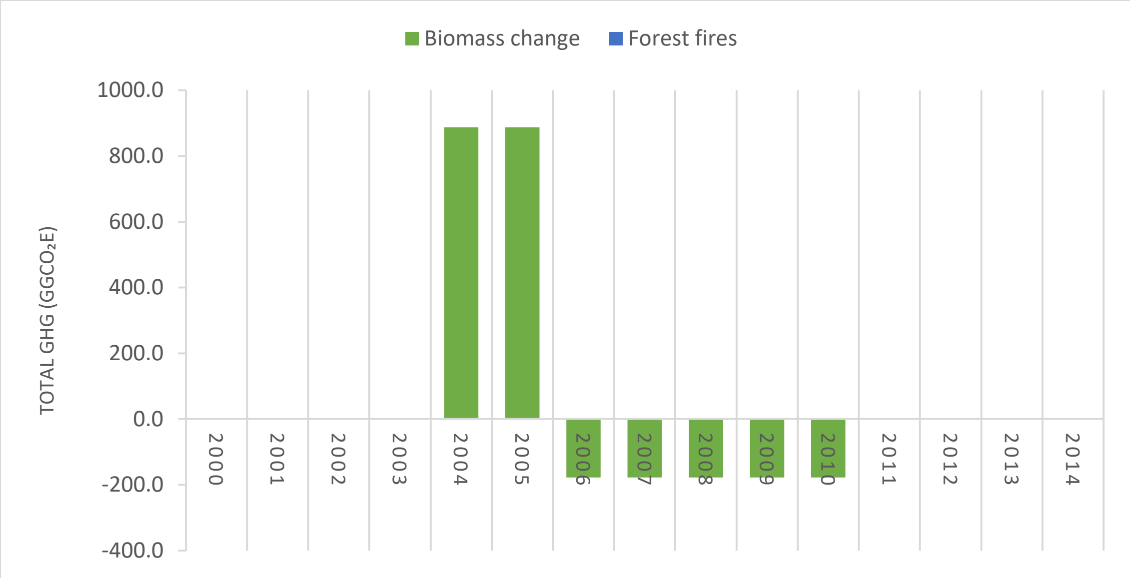

Figure 20-Time series displaying emissions or sinks from forestry and other land use[24]

Table 18-Estimated Emissions 2000-2014 (Gg CO_2e)

Year	Biomass change	Forest fires	Total
2000	0.0	0.15	**0.2**
2001	0.0	0.00	**0.0**
2002	0.0	0.00	**0.0**
2003	0.0	0.00	**0.0**
2004	887.1	0.00	**887.1**
2005	887.1	0.00	**887.1**
2006	-177.4	0.00	**-177.4**
2007	-177.4	2.10	**-175.3**
2008	-177.4	0.00	**-177.4**
2009	-177.4	0.00	**-177.4**
2010	-177.4	0.00	**-177.4**
2011	0.0	0.00	**0.0**
2012	0.0	0.00	**0.0**
2013	0.0	0.00	**0.0**
2014	0.0	0.00	**0.0**

Note: the sum of the component parts may not exactly add up to the total due to rounding

The emissions estimates show three different periods:

- Two periods with no carbon change in forestland, due to the growing stock value being kept constant;

[24] Note emissions from forest fires are not visible due to them contributing a very small amount of GHG emissions

- 2004 and 2005: high emissions, due to Hurricanes Ivan (2004) and Emily (2005), that caused severe damage to the forests. However, this damage has not changed the amount of land cover classified as forest
- The land use and forest cover change has therefore been assumed constant[25].
- 2005-2010 shows a constant annual absorption, due to recovery of biomass in forestland after the hurricanes.

2.4.5 Recommendations for the Forestry and Other Land Use Sector

The following recommendations (Table 19) are made so that improved estimates can be made for the forestry and other land use sector.

Table 19-Recommendations for the forestry and other land use sector

No.	Improvement Issue	Priority Rating
1	Land cover data It is recommended that land cover data is collected on a routine basis, so that this data can feed into the GHG inventory. This should consist of estimates of initial and final land use areas (Thousand Hectares) as well as the total area of land that is unchanged by category for each year of the inventory: • Forest land (unmanaged); • Forest land (managed) including the type of tree, and the age class if possible; • Grassland (rough grazing); • Grassland (improved); • Cropland; • Wetlands; • Settlements; and • Other land.	High
2	Growing stock in forestland It is recommended that growing stock information is collected on a routine basis, so that this data can feed into the GHG inventory, reducing the need to use expert judgement.	High

[25] FAO, 2015. Global Forest Resources Assessment 2015, Country report: Grenada.

2.5 WASTE

Emissions of GHGs from the waste sector in Grenada occur from solid waste disposal on land and waste water handling.

The following sections outline the data that was collected and used to compile the GHG inventory for the waste sector. The data sources are also discussed.

Table 20 below, displays all IPCC categories within the waste sector, alongside information on which categories have been estimated and those categories for which sources exist, but cannot be estimated (NE).

Table 20-Overview of emission estimates from the waste sector

Source	IPCC 2006	GHGs	Status	Explanation
Solid waste disposal	4A	CH_4	Estimated	
Biological treatment	4B	CH_4, N_2O	NE	Sources suggest composting occurs in both residential and industrial contexts, however no activity data is available
Waste incineration	4C1	CO_2, CH_4, N_2O	NE	There is data to suggest incineration of clinical waste at two hospitals occurs, however no activity data is available.
Domestic wastewater treatment	4D1	CH_4, N_2O	Estimated	
Industrial wastewater treatment	4D2	CH_4, N_2O	IE (included elsewhere)	Included in the above category, due to application of co-discharge factors.

2.5.1 Methodology

A summary of the methodology for each source is provided below.

Category 4A – Solid waste disposal

Grenada has two landfills that have been operational since 2001 to handle waste, replacing open-dump sites. To enable the calculation of emissions, the IPCC waste model was utilised.

Country specific waste composition data was sourced from Grenada's National Waste strategy, alongside waste per capita values for both municipal and industrial waste[26]. To create waste generation estimates, population data was sourced the World Bank[27]. The classification of the landfills was adapted from 2001 onwards, to account for the transition from open-dump sites, to engineered landfills. It was assumed no flaring or methane recovery takes place at either of these landfills. Methane generation rates by waste composition have been selected by 'moist and wet tropical' criteria.

Category 4B – Biological treatment

Composting in the hotel sector was identified according to a scoping study into waste to energy plants[28]. In addition, composting is encouraged by the Grenada Solid Waste Management Authority (GSWMA), the national body for waste collection and disposal[29]. However, due to a lack of data, no estimates have been made for this sector.

Category 4C – Waste incineration

Incineration of clinical waste was identified to occur at both the Princess Alice and St George's hospital[30]. No data however was available to enable emission estimates to be made. Any emissions from these activities, however, are thought to be insignificant.

Category 4D1 – Domestic wastewater treatment

Activity data for this category can be split according to whether it is required to estimate CH_4 emissions or N_2O emissions. For the former, activity data consists of population data sourced from the World Bank[32], and data referring to the relative utilization of disposal routes (e.g. latrines), sourced from the Grenada's National Waste Management Strategy[31]. The methodology relies on the use of a default Biochemical Oxygen Demand factor, in order to determine the organically degradable component within waste water, and default emission factors for each disposal/treatment route identified. Key activity data for the estimation of N_2O emissions consists of country specific protein per capita data sourced from FAOSTAT[31].

Category 4D2 – Industrial wastewater treatment

No activity data is currently available, hence default factors to account for protein and organic material in the discharge of industrial wastewaters, in addition to domestic wastewaters, have been applied in the methodology for 4D1, in accordance with the IPCC guidelines.

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[26] http://www.gswma.com/download/National_Waste_Management_Strategy_Grenada.pdf

[27] http://data.worldbank.org/indicator/SP.POP.TOTL

[28] http://sea.sidsdock.org/download/wte_expo_library/Waste-to-Energy_Potential_Grenada_150316.pdf

[29] http://www.gswma.com/faqs.htm

[30] http://www.caribank.org/uploads/2015/02/BD94_14_SolidWasteManagement_Grenada.pdf

[31] http://www.fao.org/faostat/en/#search/protein

2.5.2 Waste GHG emission estimates

Figure 21 and Table 21 below provide GHG emission estimates for the waste sector. Landfill emissions and emissions from wastewaters contribute nearly equally to the annual total.

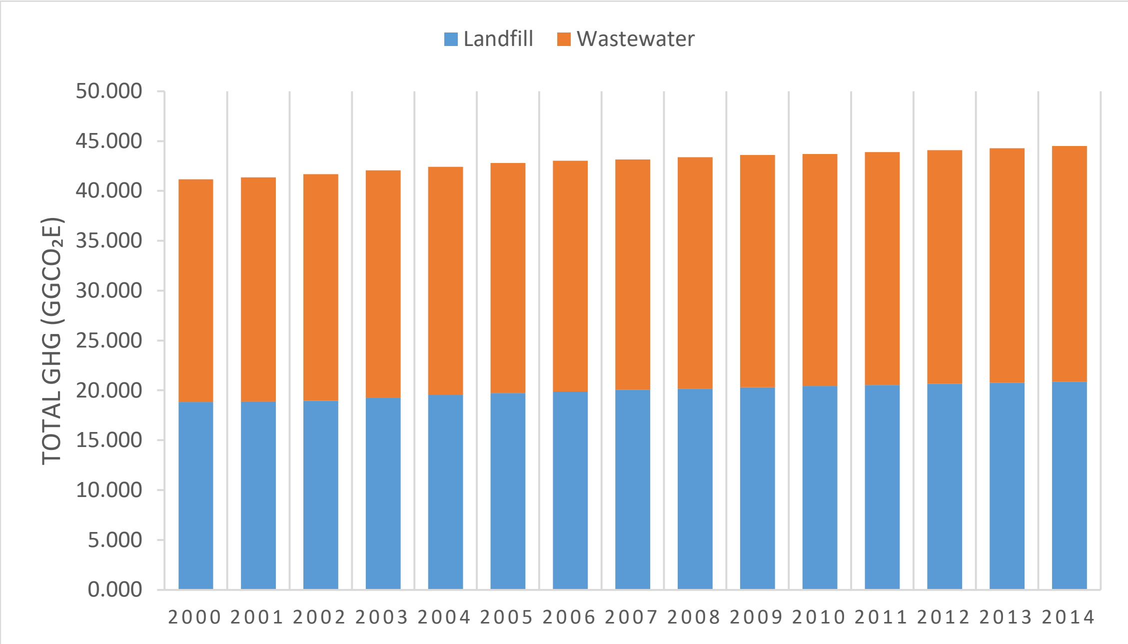


Figure 21-Time series displaying emissions estimates from the waste sector

Table 21-Estimated Emissions 2000-2014 (Gg CO_2e)

Year	Landfill	Waste water	TOTAL
2000	18.8	22.3	**41.2**
2001	18.9	22.5	**41.4**
2002	19.0	22.7	**41.7**
2003	19.3	22.8	**42.1**
2004	19.5	22.9	**42.4**
2005	19.7	23.1	**42.8**
2006	19.9	23.1	**43.0**
2007	20.0	23.1	**43.2**
2008	20.2	23.2	**43.4**
2009	20.3	23.3	**43.6**
2010	20.4	23.3	**43.7**
2011	20.5	23.4	**43.9**
2012	20.6	23.4	**44.1**
2013	20.7	23.5	**44.3**
2014	20.9	23.6	**44.5**

Note: the sum of the component parts may not exactly add up to the total due to rounding

2.5.3 Recommendations for the Waste sector

The following recommendations (Table 22) are made so that improved estimates can be made for the waste sector.

Table 22-Recommendations for the Waste Sector

No.	Improvement Issue	Priority Rating
1	Waste characterisation Waste characterisation data is available for 2009 and the same split has been assumed for other years. It is recommended that this data is collected at least every 5 years. This would allow for more reliable data on the composition of waste generation to go into the inventory calculations.	High
2	Waste generation Waste generation rates have been obtained from various Grenada literature sources. It is recommended that this data is collected annually, so that any change over time can be reflected in the emission estimates.	High
3	Wastewater treatment No data was made available on the wastewater treatment type used in Grenada for domestic and industrial/commercial wastewater. This information should be made readily available for future compilations.	High
4	Tier 1 emission factors The Tier 1 emission factors have been used based on Caribbean regional values for emissions from landfill in the IPCC Waste Model. Also, a number of Tier 1 emission factors based on international data sets have been used in estimating emissions from wastewater, an example being the degradable organic component of residential wastewater, where the default guidebook value for the Latin America region has been applied due to a lack of local/regional data. Studies to determine local/regional values would improve the accuracy of estimates. The following is a list of Tier 1 emission factors used in the wastewater, which could benefit from location specific data being used instead: • Caribbean default values for landfill emissions; • Wastewater generation from industrial processes; and • Degradable organic component of residential and industrial/commercial wastewater.	Medium

2.6 SUMMARY AND RECOMMENDATIONS

Figure 22 and Table 23 provide the estimated overall GHG emissions arising from Grenada annually between 2000 and 2014 in terms of CO_2 equivalent. The inclusion of AFOLU sinks and emissions within the total creates a sporadic trend, with peaks occurring in 2004 and 2005. When this element is ignored, it is possible to see a gradual increase across the time series, with a slight peak in 2013, primarily due to changes within the energy sector.

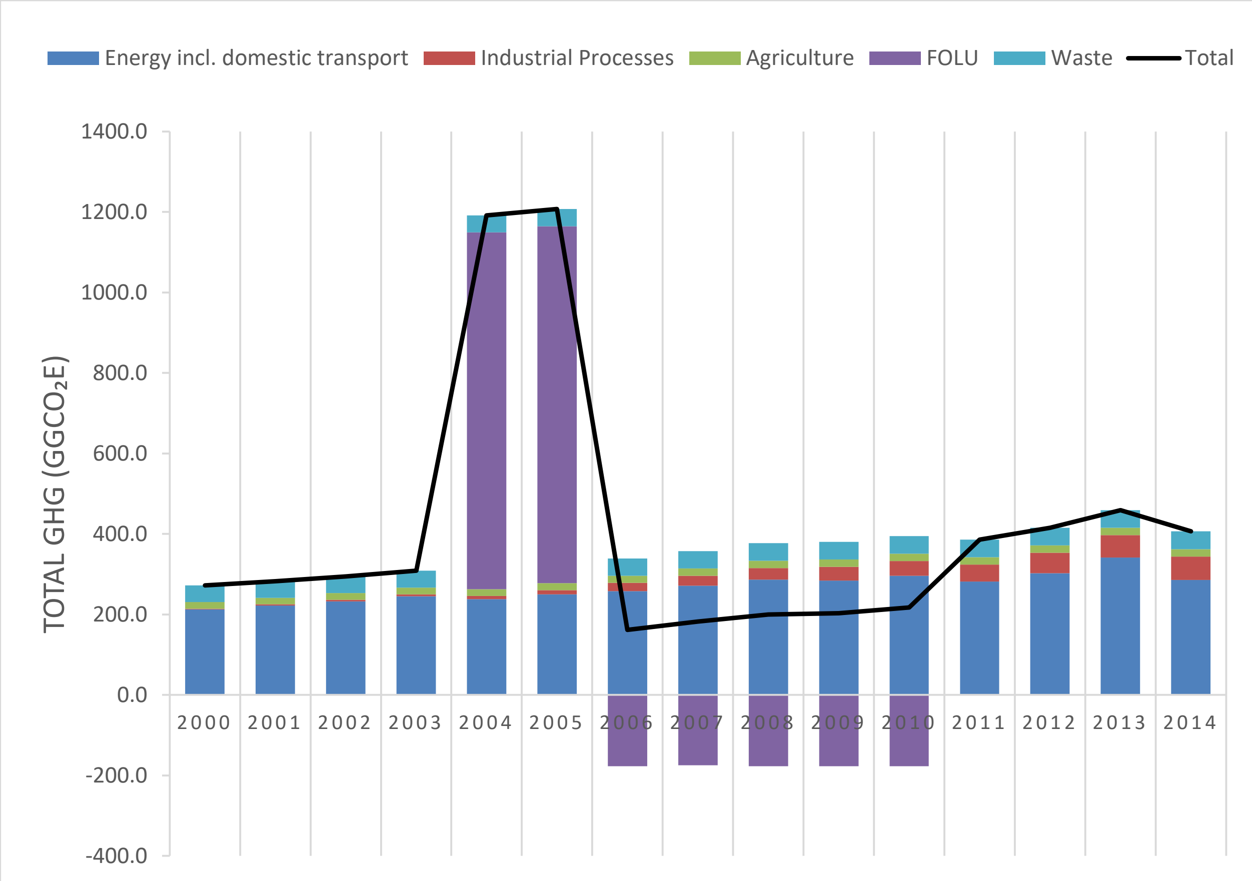


Figure 22-Time series displaying emissions from all sectors

Table 23-Total estimated GHG emissions for Grenada (Gg CO_2e)

Year	Energy incl. domestic transport	Industrial Processes	Agriculture	Forestry and Other Land Use	Waste	Total
2000	212.8	1.4	16.6	0.2	41.2	**272.1**
2001	222.2	2.9	16.3	0.0	41.4	**282.8**
2002	232.2	4.2	16.6	0.0	41.7	**294.6**
2003	244.8	5.0	16.8	0.0	42.1	**308.6**
2004	238.1	7.4	16.8	887.1	42.4	**1191.8**

2005	249.6	10.9	17.0	887.1	42.8	**1207.4**
2006	257.8	20.4	17.8	-177.4	43.0	**161.6**
2007	271.5	24.7	17.9	-175.3	43.2	**182.1**
2008	286.4	28.8	18.4	-177.4	43.4	**199.5**
2009	284.2	34.0	18.6	-177.4	43.6	**203.0**
2010	295.7	36.9	18.1	-177.4	43.7	**216.9**
2011	281.3	42.8	18.2	0.0	43.9	**386.1**
2012	302.3	50.6	18.3	0.0	44.1	**415.3**
2013	341.6	55.3	18.2	0.0	44.3	**459.3**
2014	285.5	58.3	18.3	0.0	44.5	**406.6**

The total estimated emissions in 2014 were estimated to be 406 Gg CO_2e. This total can be further split into the 5 sectors, as seen in Figure 23 below. Immediately evident is the influence of energy sector, with 70% of emissions arising from this sector in 2014. Industrial processes follows, comprising 14% of emissions; however this sector should be approached with caution due to the potential uncertainty as a result of the methodology used (Figure 23).

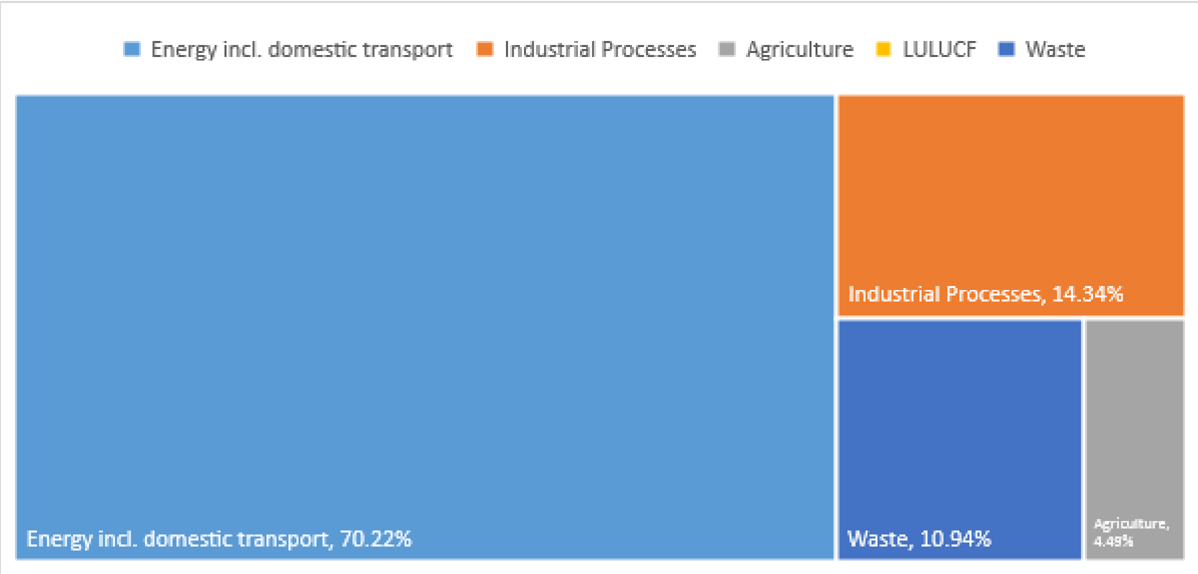


Figure 23-Treemap displaying the emissions (CO_2e) from all sectors in 2014

2.6.1 Comparison with Initial National Communication Report

Figure 24 below presents a comparison between the GHG inventory presented in the Initial National Communication report[32], which provides estimates for 1994 only, and the GHG emissions estimates for 2000 presented in this report. Immediately evident is the change in emissions from the waste sector. The emission estimates for waste presented in the first

[32] http://unfccc.int/essential_background/library/items/3599.php?rec=j&priref=2734#beg

communication report are likely to be subject to a calculation error, with the report claiming 0.71 tonnes of methane per capita. This is an astronomical number; for comparison, this is 15 times the UK waste methane per capita estimate for the same year. This error aside, the emission estimates are comparative for other sectors, with increases in the energy sector between 1994 and 2000 similar to the increases seen between 2000 and 2014.

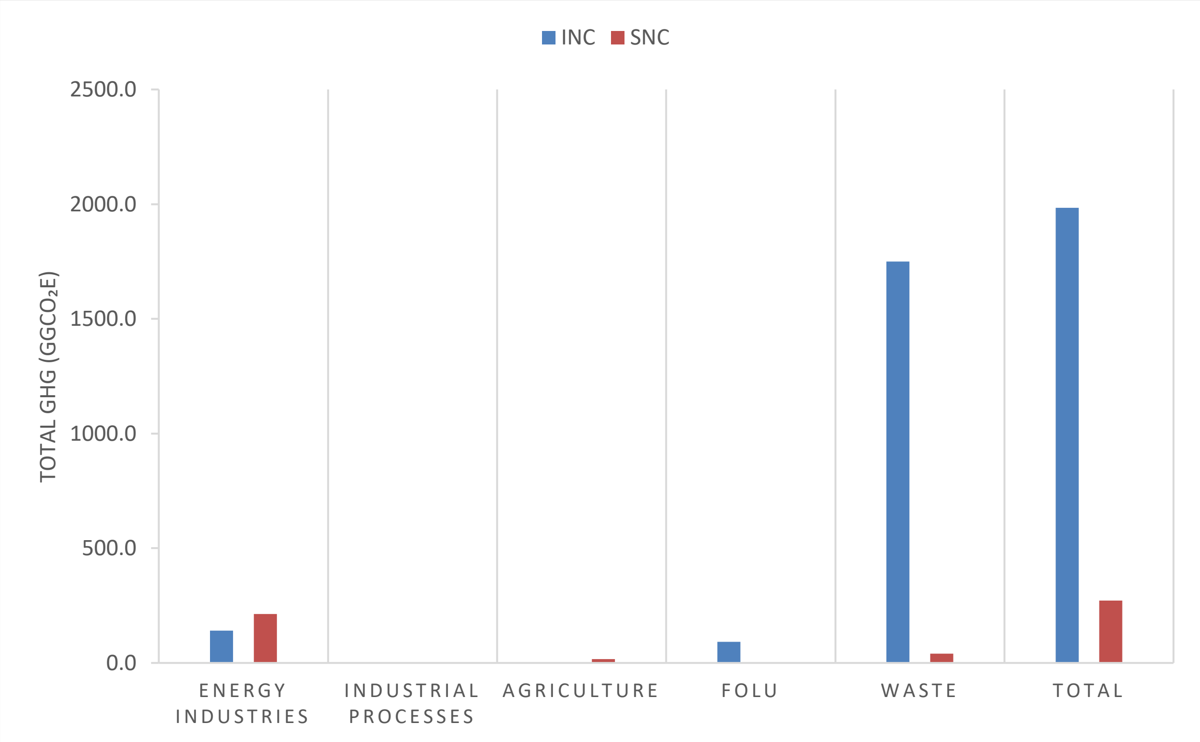


Figure 24-Comparison of emission inventories presented in this report and the Initial National Communication report.

2.6.2 Overall Recommendations

A large number of emission estimates were based on activity data from UN Statistics and surrogate datasets. It is therefore recommended that in order to improve the accuracy of the estimates that the Government Agencies work together to collate the required data for future inventory calculations. A full list of agencies and their potential roles is provided in Table 24, which reflects the research into potential data providers; however, without a detailed understanding of each of these agencies, defining the nature of their role in GHG inventory compilation and collaborations between them cannot be firmly determined.

Collaboration between different agencies is intended to be facilitated via the creation of an online portal. This online portal serves as a platform for defining different roles within the inventory, with an emphasis on the creation of data providers, in addition to compilation experts. Via the online platform it is intended that data sources can be added and referenced to specific individuals within the inventory system, improving the understanding and availability of country specific data sources, whilst strengthening the institutional arrangements. Engagement with this platform therefore could allow for further improvements and the effective implementation of the recommendations detailed within this report.

Table 24-Agencies within Grenada and their potential responsibilities within a GHG Inventory system.

Name of agency /stakeholder	Potential responsibility
Ministry of Finance and Energy	Providing an annual fuel balance and sectoral breakdown by sector
Ministry of Agriculture, Forestry and Fisheries	Undertaking an agricultural census every 5 years to ascertain the number of livestock and fertilizer use. In addition, a survey of land cover on a routine basis
The National Water and Sewerage Authority (NAWASA)	Collection of data required for wastewater emission calculations.
Grenada Solid Waste Management Authority (GSWMA)	Collection of data required for solid waste disposal and waste incineration (other than the sources identified in this report).
Princess Alice Hospital	Provision of waste incineration data to GSWMA
St George's Hospital	Provision of waste incineration data to GSWMA
Ministry of Finance and Energy	Collection of fuel use statistics in the energy sector.
Grenada Chamber of Industry & Commerce	Collection of food production statistics (e.g. sugars, nutmeg).
Grenada Tourism Authority	Provide assistance to the Ministry of Finance and Energy on the allocation of fuel between domestic and international aviation.
Grenada Ports Authority	Provide assistance to the Ministry of Finance and Energy on the allocation of fuel between domestic and international navigation.

CHAPTER 3.
MEASURES TO FACILITATE ADEQUATE ADAPTATION TO CLIMATE CHANGE

3.1 CURRENT AND FUTURE CLIMATE AND SEA LEVELS

This section presents current and future climate and sea level, including storm surges, scenarios and adaptation measures for key sectors including coastal resources, water, agriculture, tourism, human health and human settlements and insurance.

3.1.1 Existing and Future Climates in the Caribbean

The availability of data is usually the greatest limitation in impact and adaptation assessment studies. The assessment relied on existing, secondary sources. Projections and scenarios from a few key documents were incorporated into the discussion of trends and future climate projections for Grenada:

1) Future climate scenarios were drawn from research carried out by Oxford University and the University of the West Indies for the preparation of the CARIBSAVE Climate Change Risk Atlas (CCCRA) and the Full Risk Profile for Grenada, completed in 2012 (Simpson, et al., 2012). The climate change information used in the Risk Atlas for Grenada was derived from a combination of recently observed climate data sources, and climate model projections of future scenarios using both a General Circulation Model (GCM) ensemble of 15 models and the Regional Climate Model (RCM), PRECIS, driven by two different GCMs (ECHAM4 and HadCM3.

2) The projections included herein are based on the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4) standard 'marker' scenarios – A2 (a 'high' emissions scenario), A1B (a 'medium' emissions scenario) and B1 (a 'low' emissions scenario). Climate projections are examined under all three scenarios from the multi-model GCM ensemble, but results from the regional models are only available for scenario A2 (Simpson et al., 2012)[33].

3) Outputs produced by the Climate Studies Group Mona (CSGM) under the EU-GCCA project implemented by the CCCCC., namely the Vulnerability and Capacity Assessment (VCA) for the Chemin Watershed, and the National Adaptation Strategy and Action Plan (NASAP) for the Water Resources Sector are used.

Findings from the above documents were supplemented by information from recent and relevant publications in scientific journals related to climate change; historical global and

[33] More recent scenarios are now available, based on the new Representative Concentration Pathways (RCPs) adopted by and published within the IPCC's Fifth Assessment Report (AR5). At the time of producing this report, the AR4-based scenarios were used based on the availability of modelled data and outputs, and to ensure consistency with Grenada's National Climate Change Adaptation Plan (NAP) which also references the AR4 scenarios.

regional trends in climate elements and future climate projections. Altogether, these studies allowed for some comparative conclusions to be drawn.

3.1.2 Rising Air Temperatures

Grenada, Carriacou and Petite Martinique are characterized by a humid tropical, marine climate. The country's climate is modulated by the Tropical Atlantic Hurricane activity, North East Trade Winds, the north Atlantic subtropical high, and the weather resulting from the convergence of the North and South East trade winds at the Inter-Tropical Convergence Zone (ITCZ). Variations in the islands' landscapes (mainly topography) also contribute to slight spatial differences in rainfall and temperature. As a result of these factors, the climate is characterised by high and relatively unchanging temperatures year-round, as well as a wet and dry season.

The temperature profile of Grenada includes a period of Northern hemisphere summer warming which begins in April, followed by a period of winter cooling, beginning in December (CCCCC, 2015). The annual average temperature ranges from a low of 28.3°C to a maximum average of 33.3°C (Government of Grenada, 2015). Decadal trends in monthly temperature recordings from the Maurice Bishop International Airport show that temperatures have risen steadily over time, with the 2000s being the hottest decade on record (See Figure 25) (CCCCC, 2015).

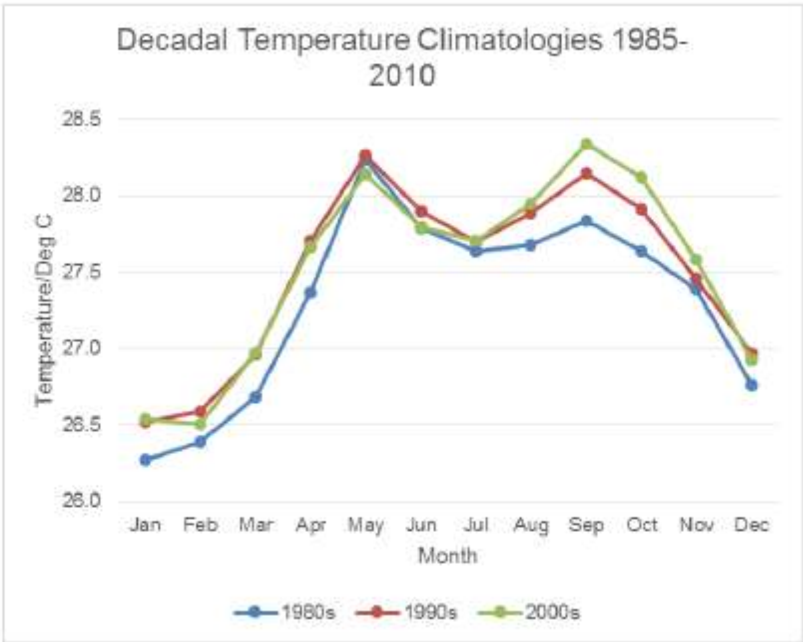


Figure 25-Average monthly temperature by decade for the 1980s, 1990s and 2000s at the Maurice Bishop International Airport - Source: (CCCCC, 2015)

Mean annual temperatures in Grenada are projected to increase, irrespective of the scenario or model used. General Circulation Model (GCM) projections from a 15-model ensemble indicate that Grenada can be expected to warm by 0.7˚C to 2.2˚C by the 2050s and 1˚C to 3.7˚C by the 2080s, relative to the 1970-1999 mean (Simpson, et al., 2012). This is consistent with projections from the IPCC Fifth Assessment Report (AR5), which indicates that the average air temperature in the Caribbean will rise by 1.4°C by 2081-2100 relative to 1986-2005 (IPCC, 2014a).

Regional Climate Model (RCM) projections driven by ECHAM4 and HadCM3 indicate much more rapid increases in temperatures over Grenada compared to the median projections from the GCM ensemble for the A2 scenario (Simpson, et al., 2012). RCM projections indicate increases of 3.2˚C and 2.4˚C in mean annual temperatures by the 2080s when driven by the ECHAM4 and HadCM3 respectively. The GCM ensemble projections for the same period range from 2 to 3.7˚C (Simpson, et al., 2012).

Since the surface of land masses warm more rapidly than ocean due to their lower heat capacity, a more rapid warming over Grenada is seen in the RCM projections compared to the GCMs (Simpson, et al., 2012).

3.1.3 Changing Rainfall Patterns

Grenada experiences most of its rainfall during the Atlantic Hurricane season which runs from June-December each year (Figure 26) (Government of Grenada, 2015). Monthly rainfall observations at the Maurice Bishop International Airport indicate that the island of Grenada receives a total of 116 cm of rainfall per year (CCCCC, 2015).

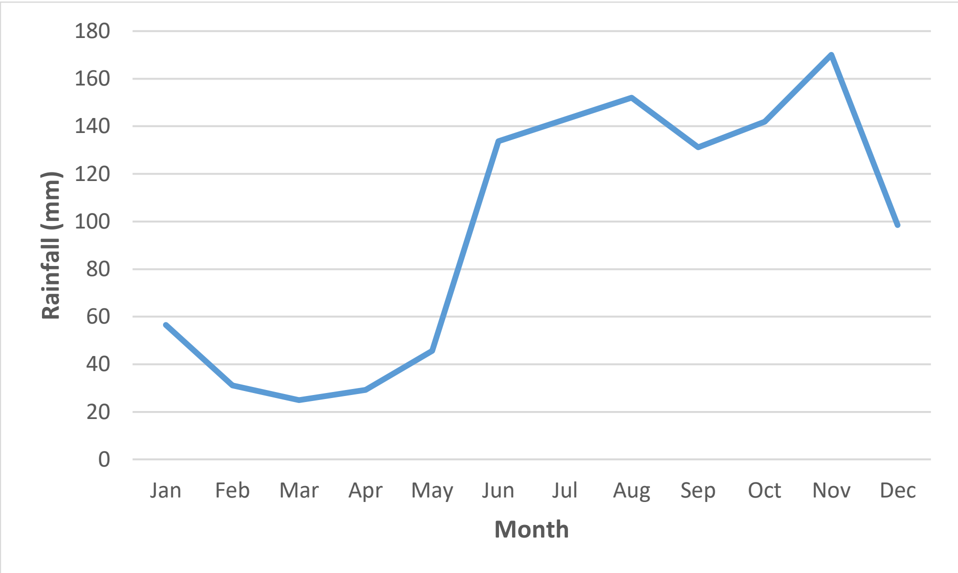


Figure 26-Monthly rainfall recorded at the Maurice Bishop International Airport in Grenada (Data from CCCCC, 2015)

Decadal rainfall observations from the Maurice Bishop International Airport were analysed in a recent report (CCCCC, 2015). Based on this report (see Figure 26), the authors noted that while overall, the rainfall pattern of early season months and late wet season months has remained the same, there has been a change in the amount of rainfall observed throughout the year, especially during the late wet season. There has also been a fluctuation in the number and timing of rainfall peaks throughout the year. In addition, the 1990's have been the driest decade since 1986, as monthly rainfall was below 14 cm for the majority of the rainy season (CCCCC, 2015).

During the late 2000's, Grenada was impacted by severe drought conditions which affected a number of areas of the country's economy. The 2009-2010 drought began in October, 2009 ended in March 2010 (Trotman & Farrell, 2010). Total annual rainfall recorded for 2009 at Point Saline Airport was the lowest in 24 years of records (Trotman & Farrell, 2010). While Carriacou and Petite Martinique generally receive lower levels of rainfall and can experience severe drought conditions during the dry season (Government of Grenada, 2000), during the 2009-2010 drought, conditions in Carriacou, were particularly severe; the majority of the rainwater cisterns that supply water to critical institutions and the public dried out and water had to be barged from Grenada to meet the needs of residents (Trotman & Farrell, 2010) (see Figure 27).

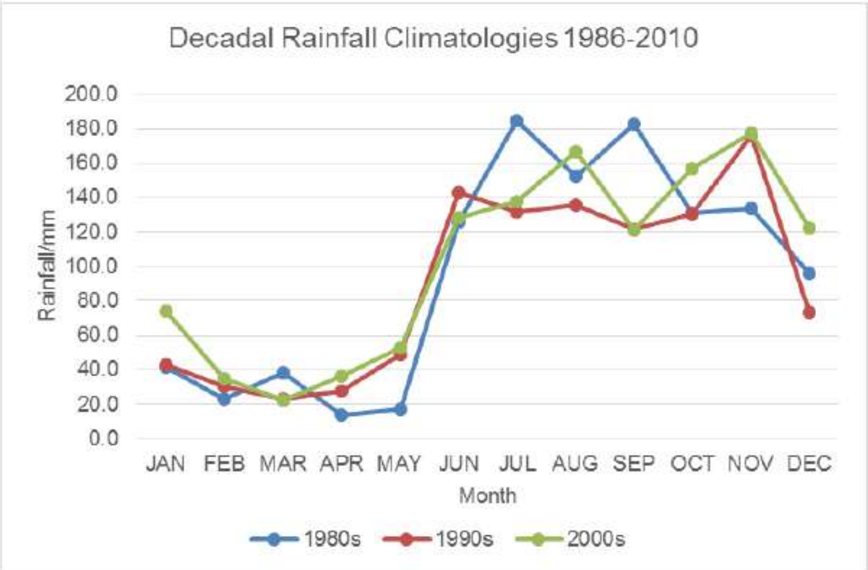


Figure 27-Average monthly rainfall by decade for the 1980s, 1990s, and 2000s at the Maurice Bishop International Airport

GCM projections of future rainfall for Grenada tend towards decreases in most models (Simpson, et al., 2012). Projected rainfall changes in annual rainfall range from -40 to +7 mm per month (-66% to +12%) by the 2080s across the three emissions scenarios. The overall decreases in annual rainfall projected by GCMs occur largely through decreased rainfall during the months of June to August and September to November.

RCM projections of rainfall for Grenada are strongly influenced by the driving GCM providing boundary conditions (Simpson, et al., 2012). Driven by ECHAM4, RCM projections indicate a large proportional decrease over the months of June to August (-41%) and decreases over the periods of December to February (-21%); and March to May (-15%) resulting in a decrease in total annual rainfall (-22%) (Simpson, et al., 2012). When driven by HadCM3, RCM projections indicate large proportional decreases in rainfall in December to February (-41%) and March to May (-47%) months resulting in a substantial decrease in annual rainfall (-29%) (Simpson, et al., 2012).

These results are consistent with other regional projections performed using PRECIS, which have also indicated drier conditions in the southern Caribbean, with drying occurring in the traditional wet season (June–October) (Whyte et al., 2008; Campbell et al., 2011). Lengthening of seasonal dry periods, and increasing frequency of drought are expected to increase demand for water throughout the region (Cashman et al., 2010).

3.1.4 Increased Sea Surface Temperatures

Sea surface temperature (SST) has significantly warmed during the past 30 years over 70% of the world's coastline with the average rate of rise being 0.18 ± 0.16°C per decade (IPCC, 2014b). A recent study by Antuña-Marrero et al., (2015) examined the magnitude of long-term SST trends in the Wider Caribbean (WC) and the Antilles. The authors found that annual mean SST trends combining the sub-periods 1906–1969 and 1972–2005 are 1.32±0.41°C per century for the Antilles and 1.08±0.32°C per century for the WC. However, for the same regions during the sub-period 1972–2005, the corresponding trends are 1.41±0.68 °C per century and 1.18±0.49 °C per century, illustrating the warming intensification during the last four decades.

GCM projections from the CCCRA indicate increases in sea-surface temperatures throughout the year (Simpson, et al., 2012). Projected increases range between +0.9˚C and +3.1˚C by the 2080s across all three emissions scenarios. The range of projections under any single emissions scenario spans roughly around 1.0 to 1.5˚C. This is supported by the IPCC's AR5 which notes that based on projected temperature increase; there is high confidence that positive SST trends will continue (IPCC, 2014b).

3.1.5 Greater Intensity of Tropical Cyclones

Detection of long-term changes in tropical cyclone activity has been hindered by a number of issues with historical records; with heterogeneity introduced by changing technology and methodology being the major issue (Kunkel, et al., 2013).

A recent report by the Caribbean Community Climate Change Centre (CCCCC, 2015) examined current trends in tropical cyclone activity for Grenada. The report indicates that over the period 1856 to 2012 there has been an increase in the number of hurricanes passing within a 100-km radius of Grenada. The report also notes a period of increased hurricane activity beginning in the year 2000 and that there was a sharp increase in the number of more intense storms (Category 4 and 5 hurricanes) starting in 2002. From 1950 to 2014, Grenada was impacted by three hurricanes that passed within 50 Km of St. Georges; Hurricane Janet (1955), Hurricane Ivan (2004) and Hurricane Emily (2005). The CCCCC (2015) report also notes that between 1950 and 2014 the islands of Petite Martinique and Carriacou have only been impacted by two hurricanes that passed within a radius of 50km of and the islands of Petite Martinique and Carriacou have not been impacted by a hurricane in the last 60 years.

The IPCC, has concluded that the frequency and intensity of the strongest tropical cyclones in the North Atlantic have increased since the 1970s (IPCC, 2014b) and other studies also indicate an increase in the annual number of tropical storms over the last 30 years (Simpson, et al., 2012).

Observed and projected increases in SST (Simpson, et al., 2012) as well as more recent projections of future increases in windspeed (CCCCC, 2015) all indicate that hurricane intensity, but not necessarily frequency, over the North Tropical Atlantic has the potential to increase in the coming decade.

In the Caribbean, inter-annual variations in rainfall and drought incidence are associated with the El Niño Southern Oscillation (ENSO) phenomenon. These cycles normally range from 3 – 7 years and are characterised by the *El Nino* period, where there are less active Tropical Atlantic Hurricane seasons and by the *La Nina* period of more active seasons with stronger storms. The IPCC notes that the ENSO phenomenon will remain a major mode of tropical variability in the future and that ENSO-related precipitation variability in the region will likely intensify (IPCC, 2013). As such, the frequency and intensity of tropical storms and hurricanes will continue to be heavily influenced by the state of the ENSO phenomenon.

3.1.6 Sea Level Rise

From 1901 to 2010, global mean sea level rose by 0.19m and the rate of rise since the 1850s was larger than the average rate during the previous 2,000 years (IPCC, 2013). Global mean SLR is projected to continue during the 21st century, with the rate of rise being greater than observed in recent decades and not uniform across regions (IPCC, 2013). Observations from tidal gauges which are deployed across the Caribbean basin indicate that regional SLR is relatively consistent with global trends (Table 25).

Table 25-Sea level rise rates at observation stations surrounding the Caribbean Basin Source: (Simpson, et al., 2012)

Tidal Gauge Station	Observed trend (mm yr^{-1})	Observation period
Bermuda	2.04 (+/- 0.47)	1932-2006
San Juan, Puerto Rico	1.65 (+/- 0.52)	1962-2006
Guantanamo Bay, Cuba	1.64 (+/- 0.80)	1973-1971
Miami Beach, Florida	2.39 (+/1 0.43)	1931-1981
Vaca Key, Florida	2.78 (+/- 0.60)	1971-2006

The AR5 projects that net sea-level in the Caribbean will rise by 0.5-0.6m by 2081–2100 (relative to 1986–2005) (IPCC, 2014). However, Rahmstorf (2007), by integrating land ice contributions has proposed a more dramatic increase globally, of up to 1.4 m by the year 2100, which would have severe implications if the regional rate of rise remains consistent with global trends.

Despite the variances in projections, there is fundamental consensus that "mean sea level rise will continue during the 21st century" (IPCC, 2013).

3.1.7 Storm Surges

Grenada has historically been impacted by storm surges which are associated with weather events such as tropical storms and hurricanes. The storm surge produced by Hurricane Lenny in 1999 caused extensive damage to infrastructure along the west coast of the island and to Carriacou and Petite Martinique (CDERA, 2003). In 2004, Grenada was impacted by Hurricane Ivan and eye witness accounts indicate that Soubise in particular, experienced storm surges and wave run-up in excess of 3 m above sea level (Simpson, et al., 2012).

The great majority of settlements and infrastructure in Grenada are located on or near the coast, including government, transportation and commercial facilities. The storm surges generate coastal erosion risks in low-lying areas and are of particular concern on the primary road that links coastal and interior communities (Simpson, et al., 2012).

Evidence of beach erosion is already present in Grenada and further changes in the coastal profile would transform coastal tourism, with implications for destination competitiveness, property values, insurance costs, marketing and wider issues of local employment and economic well-being of thousands of persons (Simpson, et al., 2012).

The CCCRA risk profile for Grenada (2012) notes that changes to the frequency or magnitude of storm surges experienced at coastal locations in Grenada are likely to occur as a result of the combined effects of several factors:

1. Increased mean sea level in the region, which raises the base sea level over which a given storm surge height is superimposed
2. Changes in storm surge height, or frequency of occurrence, resulting from changes in the severity or frequency of storms
3. Physical characteristics of the region (bathymetry and topography) which determine the sensitivity of the region to storm surge by influencing the height of the storm surge generated by a given storm.

3.2 COASTAL RESOURCES

This Chapter provides an overview of the existing physical conditions around the coast of Grenada and its territories and the socio-economic stresses and the likely impacts of climate change and sea level rise. In view of future scenarios of climate change and sea level rise, possible adaptation strategies and measures are then identified.

3.2.1 Methodology

Overview and Approach

The impacts of climate change and sea level rise on coastal areas can be divided into two broad categories: biophysical and socio-economic impacts. Biophysical impacts include (IPCC, 2005):

- Increased coastal erosion;
- Inhibition of primary production processes;
- Increased flood frequency;
- Increased intensity of flood events caused by storm-surges;
- Saltwater intrusion into estuaries and aquifers;
- Changes in the quality of surface water and groundwater characteristics;
- Changes in the distribution of pathogenic micro-organisms; and
- Increase in sea surface temperatures (SST).

Economic and social impacts include:

- Increasing number of homes lost and coastal habitats;
- Increased risk of flooding and the number of lives potentially lost;
- Damage to buildings and other infrastructure, and coastal protection;
- Increased risk of disease outbreaks;
- Loss of resources that cannot be replaced;
- Loss of tourism, recreation and transportation;
- Loss of cultural assets and historical values; and
- Impacts on inland fisheries and agriculture due to declining quality of soil and water as a result of saltwater intrusion.

This chapter builds on previous studies carried out by the Caribbean Planning for the Adaptation to Climate Change (CPACC) project followed by the Adapting to Climate Change in the Caribbean (ACCC) and then most recently by the Mainstreaming Adaptation to Climate Change (MACC) project.

The approach involves a review all available published reports/documents that relate to coastal resources in Grenada, especially the impact of climate projections on coastal biophysical features and the built infrastructure as detailed in Grenada's National ICZM Policy (2016). The section has therefore integrated the socioeconomic and biophysical aspects of vulnerability to climate change in Grenada, and focuses on the following:

- Vulnerability of key habitats and economic sectors;
- Evaluation of adaptation efforts and activities; and
- Recommendations for improving adaptation efforts.

Uncertainties Associated with the Coastal Zone

It is important to recognise that there are uncertainties involved with predicting the impacts of climate change and variability and other associated phenomena such as SLR. In relation to coastal resources, uncertainties can arise from not only climatic factors but also non-climatic factors including:

- Those related to accuracy of data and measurements, assumptions used in climate modelling and even the prediction of the contributions of bio-physical relationships involved in climate change and coastal changes;
- Uncertainty arising from natural and anthropogenic variability and uncertainties associated with global climate change projections and their local validity (Mimura, et al., 2007).
- There are uncertainties surrounding regional projections of climate change, particularly precipitation (see Current and Future Climate and Sea Levels);
- Uncertainty in the magnitude of climate change impacts and the extent and timing of climate change;
- Uncertainty as to the social and economic forces that contribute towards development and sustainability of coastal systems; and
- Uncertainty as to what future public policy and other initiatives may do to affect the extent of climate impacts on the country's natural environment as well as on coastal development. This is particularly significant considering the vulnerability of coastal areas.

The task of assessing impacts of climate change on the coastal zone becomes more difficult due to the paucity of existing data on the various issues confronting the coastal zone of Grenada.

Major Non Climate Specific Threats and Issues Affecting Coastal Resources

Natural habitat destruction is one major issue of concern within the coastal zone of Grenada. For example, the removal of mangrove stands as a source of fuel (charcoal) is reducing the natural physical and biological functionality of this ecosystem. Additionally, reefs were historically harvested to create lime however in recent times they face additional numerous threats from land based sources of pollution, physical damage such as from anchors and dredging. Consequently, the harvesting of corals over time has resulted in the physical damage to the structure of reefs and the ecosystem function these provide.

The destruction of sea grass beds to promote coastal development and the unsustainable and inappropriate fishing methods/practices are issues of concern.

Over harvesting of specific species of reef fish and shellfish is also contributing to the exploitation of coastal resources: spear fishing that constitutes a form of livelihood security for many coastal communities is often undertaken within the nearshore. Spear fishing is illegal within MPAs with the exception of the lionfish culling programme.

Grenada's sandy beaches have also experienced changes due to anthropogenic activities. Sand-mining was a major problem that has become illegal since 2010 under the Beach Protection Act. Previously, almost all sands used in the construction, transport and tourism industries in Grenada came from beaches and further exacerbated beach erosion. Presently, sand mining is only authorized at a few sites (Galby Bay, Bacolette beach in St. David's and the Canals in Mt. Rodney) and the only entity legally allowed to engage in sand-mining is Gravel and Concrete Corporation (GCC), which is the statutory body for construction material supplies. However, GCC has ceased mining since April, 2016 and is now promoting the use of imported sand.

The removal of mangroves for hotel, marina or other coastal development, remains a significant threat due to lack of enforcement. In some areas, mangroves are replaced by (built) beaches which may disrupt the natural ecological transition of coastal vegetation. In addition, increased sedimentation along with the introduction of sewage and other wastes from land into the sea has increased pressures on coastal resources. Furthermore, the fisheries resources have been negatively affected by inappropriate fishing activities; especially within the near shore areas of Grenada (see Table 26).

Table 26-Coastal Stresses and their Sources (Government of Grenada, 2011)

Stress Source	Major Stresses
Terrestrial - based Uses	**Tourism / Marina Development** • Ecosystems used at overcapacity • Mass coastal infrastructure built too close to coastline • Damage to beaches, mangroves, sea grass, coral reefs • Improper sewage and other waste disposal **Settlement** • Coastal infrastructure built close to coastline • Effluents: sewage and other waste disposal (chemicals) • Pollution from manufacturing and other industries • Solid waste disposal **Agriculture** • Sedimentation from poor land management practices • Fertilizer runoff
Marine-based Uses	**Tourism related** • Occasional sewage and other waste disposal • Occasional oil spills **Fishing** • Poor fishing practices (spear fishing, nets and traps set directly on beach) • Commercial vessels causing traffic in shallow areas) • Oil spills

Institutional Arrangements for Coastal Resource Issues

With regard to the management of regulation of activities relating to the coastal zone, Table 27 identifies those organizations that are granted responsibility for addressing, regulating, or responding (legally or without a formal mandate) to some of the issues identified previously.

Table 27-Coastal Issues and Government Agency Responsible for Management

Issues	Area	Government Agency Responsible
Policy and Legislation	Coastal zone	Environment Division - Ministry of Education, Human Resources and the Environment
Coastal Development	Review of coastal development projects (through EIAs)	Environment Division; and Physical Planning Unit - Ministry of Communications, Works, Physical Development, Public Utilities, ICT and Community Development. However, the Physical Planning Unit can request other partners to be involved in EIA review.
Water Quality	Watershed management	Forestry Division – Ministry of Agriculture, Forestry and Fisheries
	Water quality standard	Environmental Health Department - Ministry of Health; and National Water and Sewage Authority
Shoreline erosion / mining		Ministry of Communications, Works, Physical Development, Public Utilities, ICT and Community Development
Public Access	Coastal zone	Physical Planning Unit - Ministry of Communications, Works, Physical Development, Public Utilities, ICT and Community Development; and the Environment Division
Natural / Living Resource Protection	Beach dunes	Environment Division - Ministry of Education, Human Resources and the Environment
	Mangroves and wetlands	Forestry Division (MAFF)
	Coastal lagoons	Fisheries Division (MAFF)
	Sea-grass beds	Fisheries Division (MAFF)
	Coral reefs	Fisheries Division (MAFF)
Coastal Hazards	Natural (hurricanes, tsunamis, etc.)	National Disaster Management Agency (NaDMA); and Ministry of Communications, Works, Physical Development, Public Utilities, ICT and Community Development
	Anthropogenic (oil spills, etc.)	Ministry of Communications, Works, Physical Development, Public Utilities, ICT and Community Development; NaDMA; Fisheries Division (MALFFE); and Grenada Ports Authority; Coast Guard

Adapted from (Government of Grenada, 2011; CCCCC, 2015)

3.2.2 Climate Change and Sea Level Rise Impacts Assessment

Impact Assessment: Parameters of Relevance

Grenada is already experiencing some of the effects of climate variability through damages from severe weather systems and other extreme events, as well as more subtle changes in temperatures and rainfall patterns. Climate change projections for Grenada predict an increase in average annual temperature, reduced average annual rainfall, the potential for an increase in the intensity of tropical storms and increased SST (Simpson, et al., 2012; CCCCC, 2015).

SLR poses one of the most widely recognized climate change-driven threats to low-lying coastal areas (Nurse, et al., 2014). This is particularly important in small islands as Grenada where the majority of human communities and infrastructure is located in the coastal zone. Likewise, storm surges deriving from hurricanes and tropical storms generate coastal erosion risks in low-lying areas that result in extensive damage (CDERA, 2003).

Sea Level rise

From 1901 to 2010, global mean sea level rose by 0.19 m and global mean SLR is projected to continue during the 21st century (IPCC, 2014a). Net sea-level in the Caribbean is projected to rise by 0.5-0.6 m by 2081–2100 (relative to 1986–2005) (IPCC, 2014b). However, Rahmstorf, 2007 has proposed a more dramatic SLR increase globally, based on land ice contributions, of up to 1.4 m by the year 2100, which would have severe implications for the coastal zone of Grenada.

Detailed coastal profile surveying was undertaken at Grand Anse, Marquis, Soubise and Carenage as part of CARIBSAVE Climate Change Risk Atlas (CCCRA) project and were documented in the Full Risk Profile for Grenada, completed in 2012 (Simpson, et al., 2012). The results of these surveys indicate that 1 m SLR places 73% of Grenada's major tourism resorts at risk, increasing to 86% at risk with 2 m SLR (see Table 28).

Table 28-Impacts associated with 1 m and 2 m SLR and 50 m and 100 m beach erosion in Grenada (Adapted from (Simpson, et al., 2012)

		Tourism Attractions		Transportation Infrastructure		
		Major Tourism Resorts	Sea Turtle Nesting Sites	Airport Lands	Major Road Networks	Seaport Lands
SLR	1.0 m	73%	44%	50%	4%	40%
	2.0 m	86%	60%	-	6%	
Erosion	50 m	95%	100%	-	-	
	100 m	100%	-	-		

Table 29 highlights the potential loss of beach area at four resorts in mainland Grenada under several SLR scenarios. The greatest total land and beach loss due to SLR is projected to occur in Grand Anse (See Figure 28) including at the Allamanda Beach Resort, Coyaba Beach Hotel, Spice Island Resort and Flamboyant Hotel (Simpson, et al., 2012).

Table 29-Beach Area Losses at Four Beaches in Grenada (Adapted from (Simpson, et al., 2012)

	Grand Anse		Marquis Beach		Soubise Beach	
SLR Scenario (m)	Beach Area Lost to SLR (m^2)	Beach Area Lost to SLR (m^2)	Beach Area Lost to SLR (m^2)	Beach Area Lost to SLR (m^2)	Beach Area Lost to SLR (m^2)	Beach Area Lost to SLR (m^2)
0.5	2,148	4%	4,077	100%	3,169	100%

1.0	10,097	22%	-	-	14	-
2.0	29,584	77%	-	-	-	-
3.0	12,680	100%	-	-	-	-

Figure 28-Beach loss at Grand Anse Beach under a 1 m SLR scenario; Source: (Simpson, et al., 2012)

The Maurice Bishop International Airport of Grenada is considered to be the most vulnerable CARICOM airport in the event of a 1 m rise in sea level, since it is likely that there will be a complete inundation of the runway. In addition, under a mid-range scenario, an estimated 3% of agricultural lands could be lost and could incur annual costs of USD $4 million in 2050. An additional 10% loss could be brought on by a 1 in 100 year storm surge event under the same scenario (Charles, 2014)

It is projected that SLR would also likely result in the loss in mainland Grenada of 11 % and 18 % of tourist resorts under 1 and 2- m rise respectively. The rebuilding of these resorts could cost between 14% and 34% of GDP in 2080 under medium or high SLR scenarios (Simpson, et al., 2012).

SLR may also harm turtle nesting sites and other important coastal habitats: climate change may reduce the availability of nesting beaches by a combination of (i) SLR; (ii) coastal squeeze, where natural beaches cannot recede due to human coastal developments in the way (Fish, et al., 2008) and (iii) coastal erosion due to increased frequency and severity of storms (Fuentes et al., 2012). In the simplest case scenario, SLR would mean a typical nesting beach would be inundated, reducing the net area available for egg laying and successful incubation (The Nature Conservancy, 2016).

Natural Hazards

Landslides

Landslides are a common event in Grenada, with much of the impact experienced along the coastal roadway network. Grenada's mountainous terrain, coupled with its volcanic geomorphology, promotes an increased risk of landslides, particularly where slopes are cut to accommodate construction. With little flat land available for construction (except for within the lower lying coastal areas), much of Grenada's housing stock is found on steeply sloping hillsides. Structures built without adequate design or quality controls are at greatest risk. Landslides are usually associated with periods of prolonged rainfall which occurs during the rainy season from June to December.

Hurricanes

Tropical storms and hurricanes of varying intensities have impacted Grenada and its dependencies, based on records dating back to 1856 (See Table 30), but with very little information on the impacts – damages, costs and the like - of the event.

Table 30 summarises the tropical storms and hurricanes for which recorded information is available. One of the significant features of the data is the time of year during which these events affect the country. The data shows that 50% (17) of the recorded events took place in September or later, and that a further 30% (11) took place in August. The historical record also shows that Grenada is susceptible to late season storms (in October and November) and this should be taken into account in the development of national disaster management plans.

Though its location at the southern tip of the Antillean chain makes landfall from hurricanes rare, the country has experienced substantial damage during these encounters, as exampled by Hurricane Janet (1955). In the last decade there have been at least two storm systems that affected Grenada. In 2004, Hurricane Ivan made landfall as a Category 3 hurricane with sustained winds of 120 mph. A total of 39 persons were killed and the gross costs of the damage were estimated at twice the GDP of the country at the time (US$889 million) which represented losses amounting to 212% of the GDP of Grenada (Binger et al., 2007). The nutmeg industry, the country's main export crop was extensively affected and still faces significant recovery challenges. The following year (2005) brought the effects of Hurricane Emily to the island, which further retarded recovery, particularly in the face of inadequate insurance coverage.

The IPCC, has concluded that the frequency and intensity of the strongest tropical cyclones in the North Atlantic have increased since the 1970s (IPCC, 2014c), although it is not yet certain whether this heightened storm activity in the North Atlantic represents a long-term climate change signal or a shorter-term inter-decadal variability (Simpson, et al., 2012).

Table 30-Dates and Categories of Hurricanes that have affected Grenada in the past

Date	Wind (max speed)	Hurricane Category	Hurricane Name
14 August 1856	81	1	Not named
22 Sept 1877	81	1	Not named
2 Sept 1878	92	2	Not named
16 August 1886	109	2	Not named
20 July 1887	69	Tropical Storm	Not named
12 October 1891	40	Tropical Storm	Not named
7 October 1892	40	Tropical Storm	Not named
15 October 1895	58	Tropical Storm	Not named
28 November 1896	52	Tropical Storm	Not named
9 October 1897	46	Tropical Storm	Not named
20 August 1901	52	Tropical Storm	Not named
7 Sept 1905	58	Tropical Storm	Not named
1 August 1918	40	Tropical Storm	Not named
23 August 1918	75	1	Not named
3 August 1928	40	Tropical Storm	Not named
6 Sept 1931	40	Tropical Storm	Not named
12 August 1933	40	Tropical Storm	Not named
17 August 1933	4o	Tropical Storm	Not named
17 Sept 1933	46	Tropical Storm	Not named
10 August 1938	52	Tropical Storm	Not named
24 July 1944	52	Tropical Storm	Not named
6 October 1954	86	1	Hazel
22 Sept 1955	115	3	Janet
20 July 1961	61	Tropical Storm	Anna
1 October 1063	127	3	Flora
11 August 1978	52	Tropical Storm	Cora
8 September 1986	58	Tropical Storm	Danielle
14 October 1988	52	Tropical Storm	Joan
25 July 1990	58	Tropical Storm	Arthur
December 1999	135	Hurricane	Lenny
1 October 2000	40	Tropical Storm	Joyce
24 Sept 2002	58	Tropical Storm	Lili
15 August 2004	45	Tropical Storm	Earl
7 September 2004	115	3	Ivan
8 July 2005	90	1	Emily
1 Sept 2007	40	Tropical Storm	Felix
29 Sept 2016	65	Tropical Storm	Matthew

Aside from damage to infrastructure, tropical storms and hurricanes can cause extensive damage to coastal ecosystems. The coral reefs around Grenada and Carriacou were badly affected by storm surge activity generated by Hurricane Lenny in 1999 and Ivan's landfall in 2004, which destroyed large areas of live coral (Government of Grenada, 2010). The loss of these reefs, which provide important nursery habitats for many fish species, will have had significant impacts on the biodiversity and resilience of Grenada's coastal ecosystems.

Coastal Flood Risk (storm surges)

Coastal flood risk in Grenada is largely associated with storm surges in low lying coastal areas. Flash flooding from mountain streams coupled with storm surge events are the primary causes of flood events and the effects are generally limited to communities located in the coastal margins along stream passages. Among the areas of particular risk to storm surges is the country capital, St. Georges, which also supports the country's principal port and hence supply link for inter-island trade. Some parts of the main commercial centre of St. George's and the tourist areas in the southwest peninsula are especially susceptible to flooding during periods of high seas and heavy precipitation. Significant flood events, although somewhat rare in Grenada, in November 1975 Grenada experienced its most catastrophic flood event which resulted in USD $4.7 million in losses (Government of Grenada, 2011).

Flood maps recently produced under the Caribbean Handbook on Risk Information Management (CHARiM) project (Jetten, 2016) illustrate the potential flood hazard of all the catchments and locations on the island where flooding may occur, including coastal areas (watersheds). These flood risk maps (CHARiM) show the potential for floods in the major valleys (See Figure 29).

A flood vulnerability analysis for mainland Grenada conducted by Weis et al (2016) modelled flood vulnerability under a number of different scenarios and the analysis highlights the same coastal areas as being vulnerable to flooding from storms both at present day sea level and storms under future sea level scenarios: the south eastern coastal areas, the Grenville Bay area on the central east coast of the main island of Grenada.

Figure 29-Flood hazard along the east coast of Grenada (Source: Jetten, 2016)

The flood modelling study by Weis et al (2016) found that flood related vulnerability is often not driven by the same factors for all areas of Grenada. For example, the vulnerability of Grenville Bay to a 100 year flood is driven by relatively high exposure and relatively low adaptive capacity, with relatively high to very high sensitivity also contributing to vulnerability along the southern coast of the bay. By comparison, the vulnerability of St. George's is driven by exposure and medium to high sensitivity, while its adaptive capacity is relatively high to very high (Weis, et al., 2016).

Figure 30 shows an analysis from Weis, et al. (2016) of the vulnerability of mainland Grenada (separated into different districts) to four different flooding scenarios: a) a 100 year storm under present day sea level, b) a Hurricane Lenny type storm under present day sea level, c) a Hurricane Lenny type storm with 1 m of SLR and d) a Hurricane Lenny type storm with 2 m SLR . The analysis shows a flood hazard for Carriacou from the same report (Figure 31). The analysis results are for the region of a–c St. George's and d–f Grenville Bay displaying the Vulnerability Index, Sensitivity Sub-Index, and Adaptive Capacity Sub-Index respectively along with water depths of the 100 year flood scenario as a representative Exposure layer.

These analyses (Figure 30 and Figure 31) show a strong pattern of exposure to flooding from storms along the east coast of the mainland Grenada and Carriacou. Climate change could have serious adverse impacts on communities and infrastructure in these areas, from flood inundation, especially during storm surges. This is because the east coast of mainland Grenada is likely to experience more exposure from hurricanes as these storm systems typically move across the Atlantic Ocean in an east north-eastwardly direction. Also, the east coast of mainland Grenada, being at comparatively lower lying elevations than the west coast, has relatively more features at risk to flooding. The experience from several hurricanes is instructive in this respect.

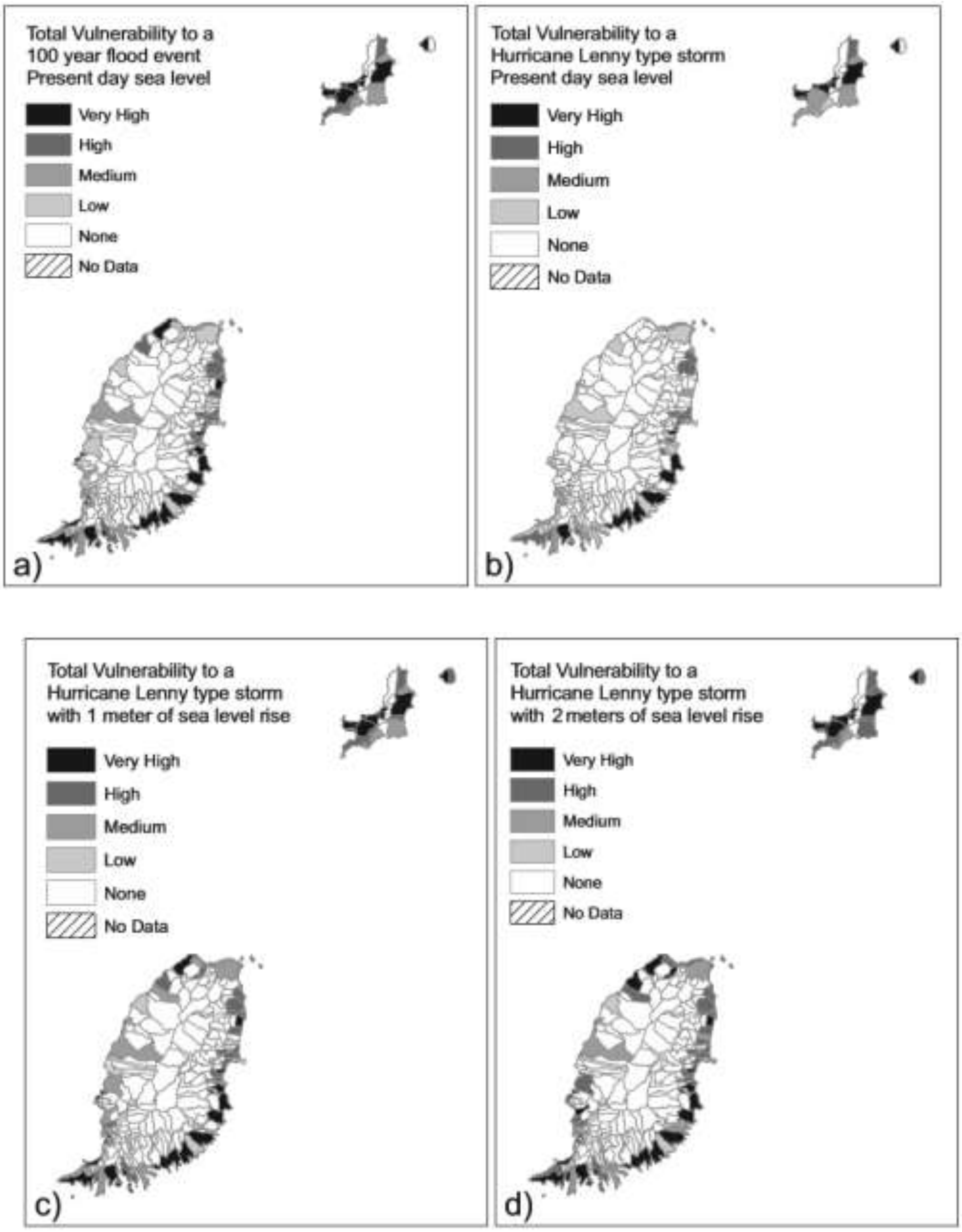


Figure 30-Total Vulnerability to a Hurricane Lenny type storm Source: (Weis, et al., 2016)

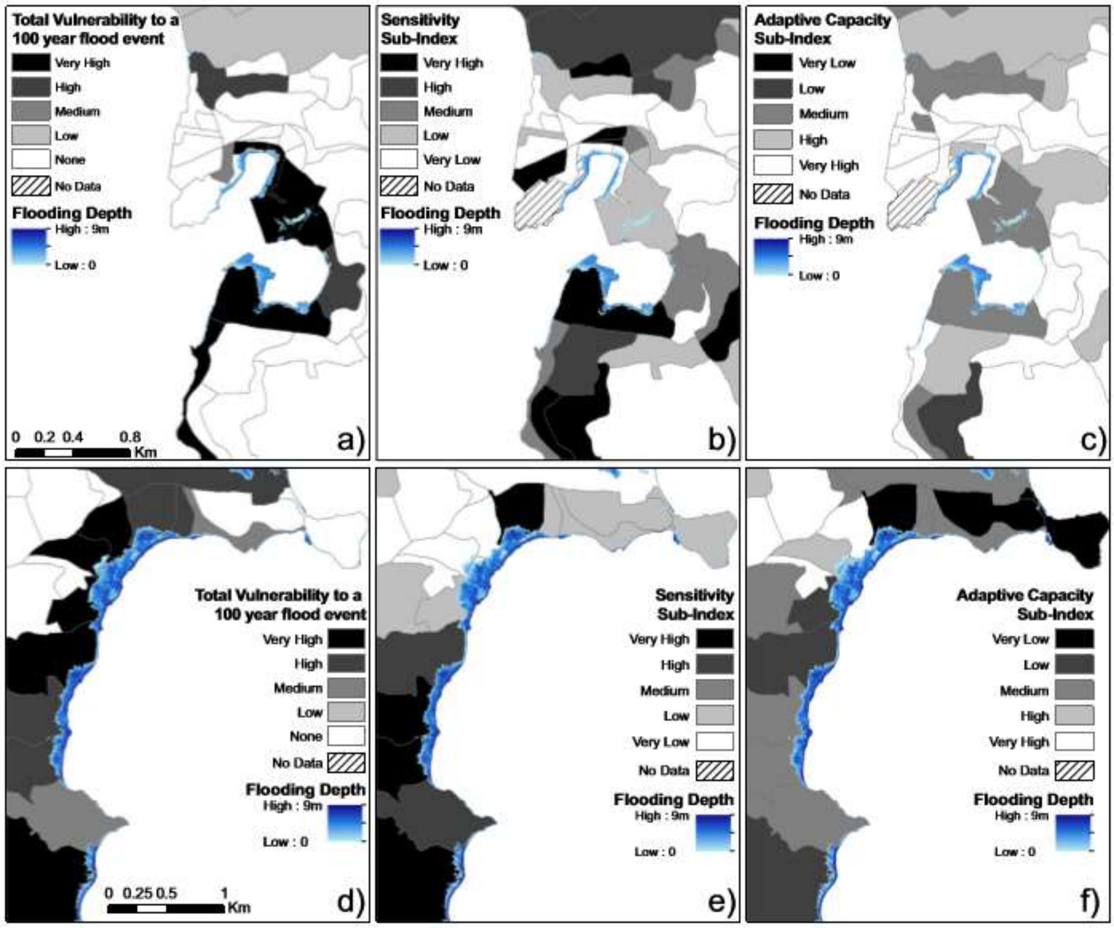


Figure 31-Flood hazard map for Carriacou Source: (Weis, et al., 2016)

Coastal erosion

Although coastal erosion is most pronounced along the east coast of mainland Grenada, coastal erosion occurs in other high energy areas and in some low energy areas on the south of the island. These coastal erosion problems also exist at various coastal areas in Carriacou and Petite Martinique. Continued coastal erosion, exacerbated by SLR would very likely disrupt coastal villages like Gouyave, Grand Mal, Duquesne, Soubise and Marquis. Many roads in the coastal communities and other unsettled areas are built at sea level and below sea level in some cases. Roads in these areas could experience flooding, become impassable during high tides and be severely damaged during storm surges.

The Government of Grenada's (2011) Strategic Program on Climate Resilience provides an overview of some of the anthropogenic causes of shoreline erosion in Grenada. It notes that for several years, mining operations removed sand along the east coast of mainland Grenada to use as construction aggregate which compromised the beach's ability to protect the coast. As a result of this practice, many areas along the east coast are badly degraded, with some locations having completely lost their beaches. The loss of the beach as a protective barrier has threatened the integrity of some roads, which necessitated the construction of a sea wall. In addition, salt water intrusion in some areas has impacted coastal agriculture and coastal species.

As climate change is projected to bring increasing sea levels and the potential for more frequent, intense storm events that are often associated with storm surge, current coastal erosion problems in Grenada are likely to be exacerbated.

Changes in Precipitation

Grenada experiences most of its rainfall during its wet season from June-December (Government of Grenada, 2015b); as much as 65% of the annual rainfall may occur during this period (Day, et al., 2015). Carriacou and Petite Martinique typically receive lower levels of rainfall than mainland Grenada and experience drought conditions on a regular basis. Climate change modelling studies for Grenada have projected reductions in average annual rainfall in the coming decades (Simpson, et al., 2012; CCCCC, 2015). Furthermore, these same reports indicate that hurricane intensity over the North Tropical Atlantic is likely to increase in the coming decades. Heavy rainfall events associated with storms and hurricanes are likely to increase freshwater runoff and the amount of sediments and nutrients entering nearshore waters, which could adversely impact sensitive coral reef and seagrass communities.

Increased Sea Surface Temperatures

Sea surface temperature (SST) has significantly warmed during the past 30 years over 70% of the world's coastline with the average rate of rise being 0.18 ± 0.16°C per decade (IPCC, 2014c). Grenada is already experiencing increases in SST: between 1960 and 2006, increases in SST ranged from 0.05°C to 0.08°C per decade (Simpson, et al., 2012). Projections from the CCCRA using a global climate model indicate that there will continue to be increases in SST throughout the year, ranging from +0.9˚C and +3.1˚C by the 2080s. Continued increases in SST will likely have impacts on all nearshore marine habitats, but coral reefs are particularly sensitive to changes in temperature and likely to be severely impacted.

3.2.3 Impact Assessment: Coastal Habitats

Grenada's shoreline is about 121 km long with a diverse range of geomorphological landforms and associated ecosystems, including mangrove swamps, coral reefs, sea grass beds, beaches, lagoons and cactus scrub (See Figure 32 and Figure 33) (Government of Grenada, 2011). These marine and coastal ecosystems are important sources of livelihoods for significant segments of the population. They also provide protection during storms and adverse weather events. Grenada's economy is very dependent on healthy coastal areas; beaches, coral reefs and mangroves all provide many social and economic benefits. As a member of the Small Island Developing States (SIDS), Grenada became instrumental in the establishment of the Caribbean Challenge Initiative (CCI) and pledged to protect at least 25% of its near-shore marine and coastal environment by 2020. With the Cabinet's approval in 2015, Grenada has an Integrated Coastal Zone Management Policy and management system in effect with the aim of facilitating integrative planning and management processes with the view to preserving and enhancing coastal ecosystems and ecosystem services while enabling social and economic development.

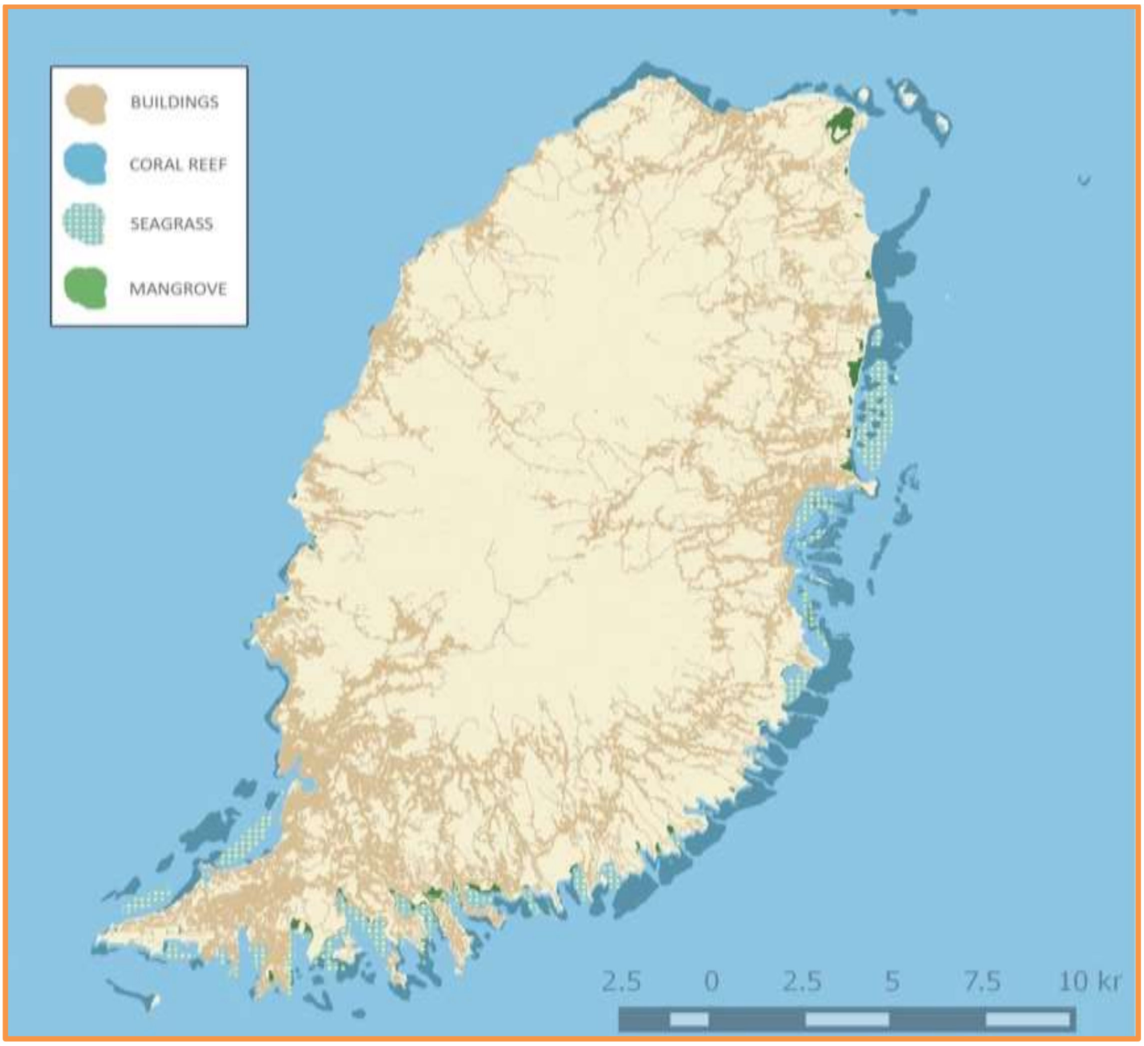


Figure 32-Coastal Ecosystems of mainland Grenada (Day, Van Proosdij, Campbell, Lee, Baker, & Thomas, 2015)

Figure 33-Coastal Ecosystems of Carriacou (Day, Van Proosdij, Campbell, Lee, Baker, & Thomas, 2015)

Coral reefs

Coral reefs occur mainly along the northeast and south coasts of mainland Grenada with large fringing reefs also to be found on the east coast of Carriacou and Petite Martinique. The most diverse reefs on mainland Grenada are located at Moliniere reef, with reefs on Saline and White Islands possessing equally diverse biodiversity. Five types of corals form the basis of the reefs around Grenada, including the critically endangered Elkhorn coral, as well as Boulder coral, Finger coral, Mustard coral and Brain coral (Government of Grenada, 2009b). Grenada, like many other Caribbean countries, has suffered significant loss of coral reefs over the previous decades and the state of reef systems off mainland Grenada and Carriacou now range from heavily stressed to pristine, with the majority being classified as moderately stressed (Day, et al., 2015). A more detailed account of climate change impacts on coral reefs is presented in Section “Fisheries and Coastal Ecosystems”.

Seagrass

Seagrass beds are located mostly in shallow, sheltered areas throughout the coastal waters of Grenada, Carriacou and Petite Martinique. The species of seagrass found in Grenada include (but are not limited to) turtle grass *(Thalassia testudinum)* and manatee grass *(Syringodium filiforme)* (Marchesi, 2014). Seagrass beds trap and stabilize sediment, resulting in better water clarity and light penetration, which are necessary conditions for coral reefs to flourish. The extensive root system of seagrass beds limits erosion by holding the sand substrate together, preventing extensive shifting of sand during storms. Seagrass also provides important habitat and refuge from predators for juvenile reef fish. Furthermore, green sea turtles, several herbivorous fish, echinoderms, molluscs, and birds feed on the seagrass.

Four main anthropogenic activities have been identified as negatively impacting the health of seagrass beds in Grenada, Carriacou and Petite Martinique:

- Anchoring of boats and yachts in seagrass areas (there are only a few established mooring systems);
- Poor fishing practices particularly the use of destructive gears like trammel nets, anchors and chains;
- Sand mining for construction and dredging; and
- Land clearing, deforestation, run-off from cultivated lands, sewage and grey water resulting in effluent, eutrophication and siltation (UNDESA, 2012); (Government of Grenada, 2011).

The potential threats to seagrasses from climate change, including rising sea levels, are changing tidal regimes, sediment hypoxia (reduced supply of oxygen) and anoxia (lack of oxygen), ultraviolet radiation damage, increases in SSTs, nutrient enrichment and eutrophication and increased storm and flooding events (Bjork et al., 2009).

Littoral Forests

Littoral forests in Grenada, unlike mangroves, grow on sandy ground above sea level. The beach forests, which are dominated by almond and sea grapes, are of fundamental importance to the coastal area because of the services they provide in shoreline stabilisation. Other services provided include mitigation of storm damage, reduced sedimentation and reduced run-off (UNDESA, 2012).

Coastal development and deforestation, litter and pollution from inland sources as well as storm surges and wave action are all current threats to littoral forests (Day, et al., 2015). For example, Hurricanes Ivan and Emily devastated the littoral woodlands of Grenada (Marchesi, 2014),

Mangroves

A recent study by Moore et al., (2015) mapped a total of 298 hectares of mangroves within the tri-island state of Grenada, Carriacou and Petite Martinique and found that most of these resources occur along the southern and eastern coasts on the main island of Grenada (181 hectares), as well as three core areas distributed throughout Carriacou (106 hectares). Petite Martinique no longer has mangrove areas and the rest of the Grenadine islands have cumulatively an additional 11 hectares (Moore et al., 2015). Significant mangrove areas on mainland Grenada include Levera Pond, Conference Bay, La Sagesse, and the Bays and Islands from Woburn to Westerhall Bay. Important mangrove systems in Carriacou include Petite Carenage Bay, Saline Island, Tyrrel Bay, and Lauriston Point.

While exact data on the loss of mangroves is lacking, interviews and meetings with users of the mangrove areas indicate that a large portion face major anthropogenic threats through clearing and removal for coastal development, over-exploitation of fish, and pollution from inland sources (chemical and solid waste). Mangrove areas in Levera and Conference/Telescope and in Carriacou are known to be used for charcoal production, construction purposes, cattle grazing, and crabbing (UNDESA, 2012). Grenada's fringing mangroves are vulnerable to several climate change impacts: storm surges cut into barrier beaches and increase tidal action and flood duration. For instance, Hurricane Ivan in 2004 impacted most mangrove patches on the islands of Grenada, resulting in a range of effects from defoliation, the felling of trees, as well as the complete levelling of full mangrove forests (Moore et al, 2015).

Forest officials have reported over 50% restoration of mangrove communities particularly on mainland Grenada. This increase is due to efforts including:

- The Community Based Restoration and Management of the Mangrove of Woburn Bay MPA project which started in 2009, funded by GEF-SGP (Barbados and the OECS) and the Nature Conservancy (Eastern Caribbean Program). The project was implemented by the Grenada Fund for Conservation in partnership with the Woburn Woodlands Development Organization (WWDO) and the Government of Grenada (GFC, 2016).
- At the Water's Edge (AWE), another community-focused mangrove restoration initiative focused on four specific coastal areas: Telescope, Marquis, Grenville and Soubise, all part of the Greater Grenville Area. AWE is being implemented by the Grenada Fund for Conservation; the Nature Conservancy and the Government of Grenada (GFC, 2016).
- The Restoration and Community Co-management of Mangroves (RECCOMM) Project which commenced in 2015, spearheaded by the Forestry and Environment Divisions of the Government of Grenada under the ICCAS project with support from GIZ and the Grenada Fund for Conservation. The initiative completed the replantation of deforested communities so as to enhance the coastal protection ecosystem service provided by the mangroves.

CASE EXAMPLE

The Tyrell Bay Mangroves are the single largest mangrove ecosystem on the island of Carriacou. The mangroves ecosystem forms a protected lagoon which functions as a nursery habitat for several species of marine organisms important to both the fisheries and tourism subsectors. Within the lagoon, the roots of the red mangroves which are the dominant within the system are populated with two species (i.e. mangrove oyster and flat oyster) of naturally occurring oysters. Historically, members of the adjacent communities have utilised the mangrove system to secure fuel, construction materials and food. The mangrove lagoon has also been used as a safe haven for vessels during tropical storms as the mangroves form a protective windbreak; thereby, reducing the impact of the wind on the vessels and minimising damage. The establishment of the Sandy Island-Oyster Bed Marine Protected Area prohibited the harvesting of both the mangroves and oysters until a sustainable harvest and management plan could be established for these resources. However, the mangroves in this area are still facing heavy pressure from ongoing development which has removed mangroves in the area in the recent past.

Adapted from (Marchesi, 2014)

Beaches

Beaches are widespread along the coastline of Grenada and the other islands. Typically they are located in small pockets within bays and have widths varying from 14m to 45m (Government of Grenada, 2011). The longest and most well-known is Grand Anse which is 2.7 km long. Dramatic changes can occur to beach profiles during a storm or hurricane event and although recovery occurs subsequently. For example, when Hurricane Lenny passed through the northern Caribbean region in 1999, several of the beaches on mainland Grenada, Carriacou and Petite Martinique were severely eroded by the resulting storm surge activity (NSTC, 2003). In the months and years after the hurricane the beaches recovered, but often not to pre-hurricane levels (NSTC, 2003).

Beach erosion is also exacerbated by anthropogenic influences such as sand mining for construction, coastal development, recreational activities and tourism activities (UNDESA, 2012).

Coastal Lagoons and Estuaries

The numerous rivers of Grenada discharge into coastal ecosystems through coastal lagoons which are unique habitats in themselves. Coastal lagoons are areas of brackish water in constant connection and interchange with the sea. Grenada has 71 watersheds, each of which has a river that ends in a lagoon as it flows into the sea (Government of Grenada, 2014a).

Common flora includes *terocarpus sp.*, almond, silk cotton, mangroves and herbaceous trees (Marchesi, 2014). These estuaries help in regulating the flow of water and nutrients into the marine environment and provide tremendous opportunities for eco-tourism and education.

Accelerated SLR could lead to the breach of natural coastal barriers and result in inundation of lagoons, increasing salinity and potentially altering the species composition. A major climate-related threat to the coastal freshwater resources in Grenada is saline intrusion associated with SLR (Government of Grenada, 2011). The tri-island nation relies mainly on surface water sources and rainwater catchment; however annual rainfall over Grenada is projected to decrease and droughts may become more frequent (Simpson, et al., 2012; CCCCC, 2015), which may lead to an increased need and utilization of vulnerable groundwater resources.

Marine Protected Areas (MPA)

Grenada currently has three declared marine protected areas, including the Moliniere/Beausejour Marine Protected Area on the west coast of mainland Grenada, the Woburn/Clarkes Court Bay on the south coast of mainland Grenada and the SIOBMPA located on the island of Carriacou. Grenada also has one Ramsar site called, Levera, which is approximately 750 ha of land and sea area.

In addition to the currently there are plans to add other MPAs (see Table 31) (Day, et al., 2015).

Table 31-Existing and Proposed Marine Protected Areas in Grenada

Official Name	Legal Status	Location (Island)	Terrestrial Area (ha)	Marine Area (ha)	Total Areas (ha)
Sandy Island/Oyster Bed	Legally established; operating with management plan	Carriacou	100	780	880
Moliniere / Beausejour	Legally established; operating with management plan	Grenada	0	300	300
Woburn / Clarks Court bay	Legally established; operating with management plan	Grenada	0	600	600
Grand Anse	In planning	Grenada	0	1,500	1,500
Gouyave	In planning	Grenada	0	N/A	N/A

Adapted from: (Government of Grenada, 2014b)

The Sandy Island-Oyster Bed Marine Protected Area (SIOBMPA) is the largest MPA within Grenada's MPA System consisting of roughly 780 ha of protected marine area stretching from Hillsborough Bay in the North to Tyrell Bay in the south (Figure 34). The SIOBMPA which is flanked by the coastal communities of Lauriston, L'Esterre and Harvey vale, provide the vast majority of their livelihoods through fishing and tourism.

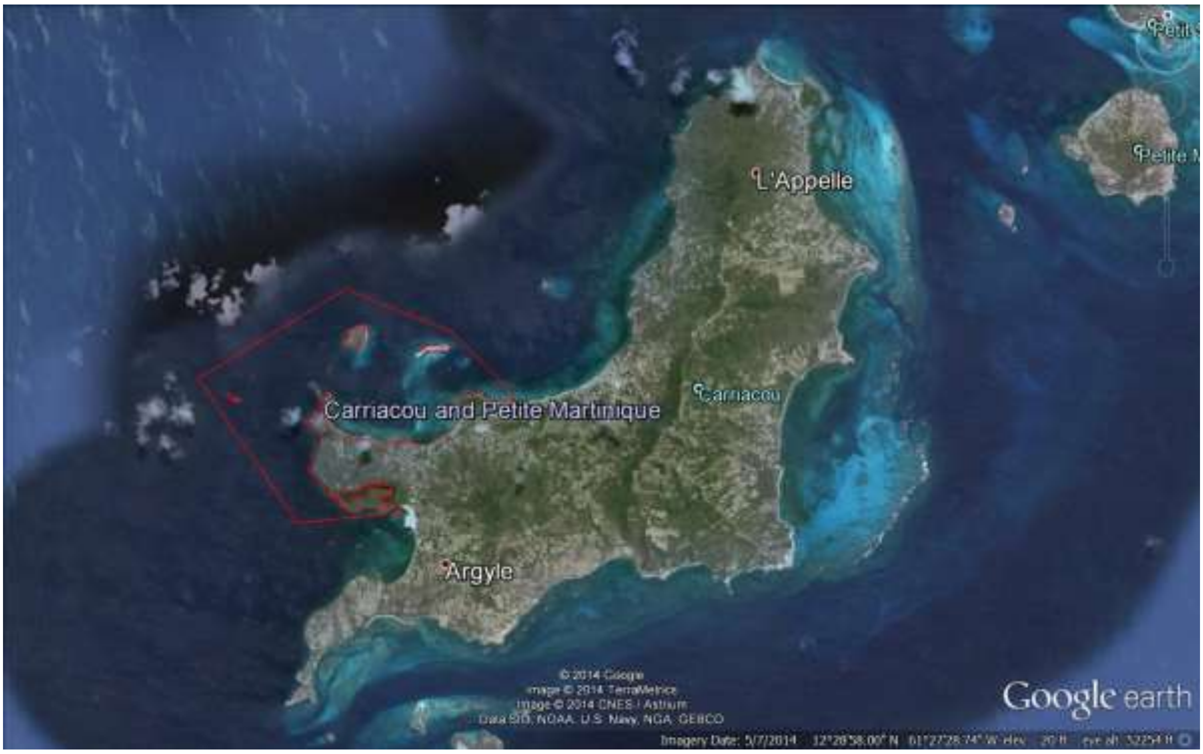


Figure 34-Map of the Sandy Island Oyster Bed Marine Protected Area, Carriacou Source: (C-FISH, 2014)

The marine environment within the SIOBMPA is under threats from a number of anthropogenic impacts including overfishing, mangrove destruction through illegal disposal waste (e.g. whitegoods, vessels and garbage) and coral and seagrass bed destruction due to indiscriminate anchoring of vessels.

MPAs can regulate human activities and reduce the associated pressures, thereby supporting the conservation of biodiversity and ecosystems services (Simon et al., 2016).

Implementing the current MPA Policy and Action Plan;

- In Carriacou, implementing actions ranked as “high priority” in Sandy Island Oyster Bed MPA Action Plan (e.g. develop a zoning plan for the MPA that includes “no take” areas and other areas that permit non - destructive fishing practices, maintaining mooring buoys, removing derelict vessels and other debris);
- Providing infrastructure support for the management and enforcement at new and existing MPA sites through the addition of mooring buoys, patrol boats and field offices for rangers;
- Adopting the ‘Ridge to Reef’ approach in Moliniere/Beausejour and other watersheds adjacent to MPAs; and
- Eliminating inappropriate disposal of solid waste in coastal areas or watersheds which could impact protected areas.

3.2.4 Socio-economic Impacts Assessment

Economy

All of Grenada's major economic areas including towns and ports are located on the coast, with the single airport on the island being one of the most vulnerable in the region to SLR. Hurricane Ivan, the strongest storm to hit Grenada, caused a drop in the growth of the country's economy from +5.7% to -1.4%. Further, Ivan caused an estimated 2.2 billion euros in damage to the infrastructure and environment of Grenada (CCCCC, 2009). Unsustainable livelihood and development practices are increasing Grenada's vulnerability to climate change impacts. These include uncontrolled/poorly managed exploration of the coral reefs by divers and tourists, sand mining on the beaches, mangrove harvesting for firewood, and the use of sensitive land and marine areas for developmental purposes, without putting proper safeguards in place (Government of Grenada, 2011).

Energy

Considerations into the feasibility of offshore renewable energy investments in the face of climate change need to be made in Grenada. Important also would be implementing safeguards of offshore renewable energy infrastructure against future impacts from climate change (Gill, 2005; Burkett, 2011; Schaeffer, et al., 2012).

Coastal Land Use and Ownership

Most of Grenada's coastal land is privately-owned, often with smallholdings being passed down within families over many generations (Murray, 2015). Land use planning and forest management is made difficult by abandoned land or fragmented and informal land tenancy which hinders land acquisitions for renewable energy as well as comprehensive forestry management.

3.2.5 Adaptation Strategies for the Coastal Resources Sector

Adaptation measures to climate change and SLR along the coastal zone should include but not limited to the following:

- Conservation of all marine areas, including the establishment of new MPAs and the monitoring of all activities within the coastal zone;
- Increased enforcement and direct implementation of land-use plans and policies, especially related to coastal setback and infrastructure and other facilities within the coastal zone; and
- Utilisation of alternative fresh water sources for future needs.

Based on the above, the following recommendations are presented for serious consideration, especially by policy makers:

- Further increasing the coastal research capacity of Grenada;
- Greater harmonisation of actions among agencies involved with coastal zone management: this should possibly involve the implementation of the Coastal Zone Policy Framework for Grenada; and

- Appropriate education and training of the relevant personnel (from resource user to the general public) to cope with the impacts of climate change and SLR. This could be complemented by a comprehensive public awareness programme.

The following are some ongoing and planned initiatives that help to build resilience in coastal areas.

Integrated Coastal Zone Management Policy for Grenada

Grenada is at a nascent stage of planning to expand the current protection of its coastal areas. The initiative to move in this direction has come as a result of the recognition of severe degradation of coastal ecosystems, extensive beach erosion that is caused by both natural and human-induced activities, the loss of valuable coastal infrastructure and the increasing need to protect existing infrastructure. Grenada has realised the need to take an integrated approach to adaptation by linking local activities with national policies and sector specific experiences. Mainstreaming climate change and coastal adaptation activities into national development planning is a major focus and several actions have been identified to support resilience building at all levels.

In order to achieve this, and to maintain the population's wellbeing and sustainably manage the coastal environment and the range of activities that are associated with it, Integrated Coastal Zone Management (ICZM) has been identified as a useful tool (Cicin-Sain and Belfiore, 2005). It has also been found to be an effective means to address climate change impacts and to reduce vulnerability to coastal hazards.

The imperative of ICZM is to strengthen the resilience of Grenada's coasts to adapt to the impacts of global climate change and its associated risks, while enhancing the ability of coastal resources to contribute to national economy and community livelihoods.

The degradation of specific ecosystems is driven by global climate change and an ever-increasing coastal population. In Grenada, further stresses on a potentially sustainable coastal zone are associated with the following:

- Limited technical capacity for coastal zone management;
- Fragmented data and information collection for sound decision-making;
- Insufficient clarity with respect to coastal and marine processes; and
- A lack of widespread targeted public education and awareness that helps to control individual actions and behaviour in coastal areas.

A number of measures to address crosscutting issues such as capacity building, education and public awareness, and an institutional and legislative framework are also vital to successful implementation of the ICZM. Consequently, achieving the objectives of both the National Climate Change Policy and the National ICZM Policy (2016) inevitably requires the need to revise specific sectoral policies and plans in order to integrate and contextualise the climate change issue in the relevant sectoral policy.

As part of the ICZM Policy, Grenada has re-established its beach monitoring programme under new terms of reference and stronger institutional backing. Grenada is also undertaking several community ecosystem based adaptation actions including coral restoration, mangrove rehabilitation, all with alternative livelihood implications.

Strategic Adaptation Programmes and Projects

Grenada has produced, and is in the process of, implementing a number of policy directives and projects directed towards increasing resilience to climate change, several of which are of relevance to coastal areas, including: Grenada Strategic Program for Climate Resilience (SPCR) (Government of Grenada, 2011); National Climate Change Policy and Action Plan (Government of Grenada, 2007); Grenada (Draft) National Water Policy (2007); Grenada Coastal Zone Management Policy (2015) and Grenada Protected Area System Plan – Part 1; Grenada Disaster Vulnerability Reduction Project and Resettlement Policy Framework (2011).

The adaptation measures included within these projects range from coastal zone rehabilitation, and flood and landslides mitigation, to potential resettlement of inhabitants of zones at risk. In November 2014, Grenada completed its UNISDR (United Nations Office for Disaster Risk Reduction) country profile, which provides a comprehensive overview of the state of disaster risk reduction, including climate change resilience.

Strategic Program for Climate Resilience

The Grenada Strategic (Investment) Program for Climate Resilience (SPCR) is the key component of the Pilot Program for Climate Resilience (PPCR), developed by the Ministry of Finance, Planning, Economy, Energy and Co-operatives in cooperation with and with financial assistance of the World Bank.

The SPCR proposes a comprehensive package of infrastructure projects and technical assistance activities to be financed under the PPCR. It first identifies the key challenges related to climate change vulnerability:

- Key infrastructure in the country is vulnerable to significant loss and damage from extreme weather events, SLR and storm surges;
- Key natural resources like forests, beaches, soil and water have been damaged and threatened;
- Lack of systems, expertise and facilities to collect, store and analyze relevant information and data on topics related to climate change;
- Inadequate knowledge and awareness of potential impact of climate change and lack of technical skills to address them;
- Policies, laws, rules and regulations related to climate change and disaster risk reduction need strengthening and the capacity to enforce these revised regulations need enhancement; and
- Planning for a coordinated response to climate change and disaster risk reduction activities need improvement.

Integrated Climate Change Adaptation Strategies

The integration and mainstreaming of adaptation measures into national planning takes place under the Grenada Integrated Climate Change Adaptation Strategies Project (ICCAS), funded by the German government's International Climate Initiative (IKI) and implemented by GIZ, UNDP and the Government of Grenada. The project's main goal is to increase resilience of vulnerable communities and ecosystems to climate change risks in Grenada through integrated adaptation approaches. It aims at raising awareness about climate change adaptation and shifting public behavior towards more sustainable habits. Initiatives developed under the ICCAS project include drafting of the Integrated Coastal Zone Management Policy and Coastal Zone Management Roadmap. The ICCAS Project has also adapted the 'Caribbean Climate Online Risk and Adaptation Tool' for Grenada which allows public and private sector entrepreneurs to estimate whether climate change will have a negative impact on their proposed activities, projects or policies. A National Adaptation Plan has also been drafted under the ICCAS Project which has a specific section on coastal adaptation measures.

Grenada Disaster Vulnerability Reduction Project and Resettlement Policy Framework

Funded by the World Bank, the project aims to reduce vulnerability of human and physical assets to natural hazards. It entails a range of civil works which would consist of new construction and rehabilitation of existing infrastructure in order to reduce their vulnerability to natural hazards and climate change. The investments include a suite of civil works activities designed to improve resilience to disaster events and adapt to impacts relating to climate change.

The project consists of four components:

- Component 1 - Prevention and Adaptation Investments
- Component 2 - Regional Platforms for Hazard and Risk Evaluation, and Applications for Improved Decision making and Building Practices
- Component 3 - Emergency Response Contingent Credit
- Component 4 - Project Management and Implementation Support

Green Buffers

The benefits to coastal communities that are provided by mangrove forests ("green buffers") are well documented. Mangroves act as a buffer from storms and flooding, absorbing impacts from waves, and help guard against coastal erosion, in addition to providing critical fish habitat. A 2006 meta-analysis of wetlands valuation studies around the world found that the average annual value of mangroves is just over $2,800 per hectare. Another study estimated that the annual economic value of mangroves due to the products from this ecosystem to be $200,000 - $900,000 per hectare (Wells et al. 2006).

Mangrove restoration programmes can take two general approaches: direct planting of propagules, or transplanting of saplings (McLeod and Salm, 2006). Factors influencing the success of programmes include species selection, seed/propagule quality, nursery quality and management, site preparation, and transplantation techniques. Ideally, natural revegetation can be taken advantage of through secondary succession.

On mainland Grenada, mangrove restoration efforts are taking place in the South, along the East Coast and in the North. These restoration programmes allincorporate elements of community co-management, alternative livelihoods and building awareness around the sustainable use of mangroves. In Carriacou and Petite Martinique, there should be parallel efforts to replant lost mangrove areas island-wide.

Coastal forest restoration

Coastal reforestation projects in Grenada are recommended as they can make use of either natural secondary forests or planting and plantations (Lamb et al, 2005). When working with natural secondary forests, methods can include: protection and management of natural regrowth, or enrichment with key species. When working with planting and plantations, the methods employed will depend on the programme objectives (Lamb et al, 2005). Options to restore biodiversity include: restoration planting using a number of short-lived nurse trees, planting a large number of species from later successional stages, or direct seeding.

Tree planting programmes should be designed to encourage participation of stakeholders (schools and other community groups/organizations) in urban and rural areas and to create incentives for tree planting on private lands. Grenada's Forestry Department could distribute tree seedlings to communities to enhance efforts. At the same time, efforts will be needed to sstrengthen the Forestry Department's extension services to controls indiscriminate cutting of trees.

Coral Restoration and Nurseries

Coral restoration is increasingly recognised as a promising strategy for adaptation to climate change in the Caribbean (Bowden-Kerby , 2001; Young et al., 2012; Rinkevich, 2014; Bowden-Kerby and Carne, 2012).

A recent review found that coral reefs are able to provide highly effective coastal protection, dissipating over 80% of incoming wave energy (Ferrario, et al., 2014). Therefore, rehabilitation of coral reefs is likely to have a positive impact on these systems' ability to mitigate some of the adverse impacts of climate change, particularly the risk posed by the prospect of more frequent, intense storm events.

Grenada has recently (2015) initiated a programme of coastal ecosystem-based adaptation (EBA), in partnership with the United Nations Environment Programme (UNEP). This activity, funded by the European Union, has developed a national strategy for EBA and has initiated two pilot projects for the restoration of coral reefs in Grand Anse and Carriacou which could be scaled up and replicated in other areas and involve local communities. The Fisheries Division through the Grenada Marine Protected Area (GMPA) system is in the process of implementing a comprehensive community based coral reef monitoring and restoration programme both within and outside MPAs.

Building Resilient Coastal Communities

Civil society organisations are playing a leading role in the conservation, restoration and management of coastal ecosystems in Grenada. But there is a need for improved engagement and enforcement mechanisms for civil society formal involvement. There is also need for capacity building among civil society organisations, community groups and staff of government departments involved in coastal resource management.

Building Codes and Standards for the Coast

The majority of Grenada's critical infrastructures (government, health, commercial and transportation facilities) are located on or near the coast. These coastal assets already face pressures from natural forces and human activities such as beach sand removal and inappropriate construction of shoreline structures. The impacts of climate change, in particular SLR, will magnify these pressures.

The development and enforcement of appropriate Building Codes is another strategy to strengthen a country's ability to withstand hazards. In Grenada, legislation to guide building construction was introduced in 2002 with provisions for countering the impacts of tropical cyclones and earthquakes (Government of Grenada, 2011). The Physical Planning Unit (PPU) of the Ministry of Finance has the responsibility for implementation of the Physical Planning Act 2016 which includes updated Building Code regulations, but may be constrained in its ability to implement the code as it does not have the capacity to do so.

3.3 WATER RESOURCES

3.3.1 Methodology

The impacts of climate change across various sectors in Grenada were determined as part of a multi-disciplinary, participatory approach. The following methodology was employed to determine the impacts of climate change on the island's water resources:

- Consultations with public (pertinent Ministries) and private sector stakeholders and civil society associated with community/development organisations involved with Grenada's water sector and related sectors.
- Review of existing reports on Grenada's water resources and water sector, including those dealing with water availability, water demand and supply, and water use by the tourism, agricultural and industrial sectors.
- Review of climate change reports, data and other information for Grenada and the Eastern Caribbean.
- Review of available rainfall and other hydro meteorological data for Grenada.
- Review of existing legislation, policy and regulations related to water resources management.
- Review of Grenada's institutional frameworks related to water and environmental management.
- A cross-sectoral situational analysis of Grenada's water resources in light of trends in water use and availability, and anticipated climate change impacts on the sector.

3.3.2 Climate Impacts Assessment

Rainfall

During the Northern Hemisphere summer, the equatorial trough migrates northwards and Grenada is affected by the inter-tropical front (ITCZ). Intense rainfall during the wet season is caused by storms generated along this inter-tropical front, in addition to convectional thunderstorms usually occurring in the afternoons. The wet season usually spans the months of June to December, while the dry season usually falls in January to May. The main rainy season delivers approximately 75% of total annual rainfall, while approximately 16% of rainfall is received during the dry period at the start of the year. Rainfall observations at the Maurice Bishop International Airport indicate that the island receives a total of 116 cm of rainfall per year.

The major types of precipitation which affect the island are localised convection (thunderstorm activity) and orographic lift caused by the inland mountains that lead to high torrential rainfall as evidenced in Figure 35.

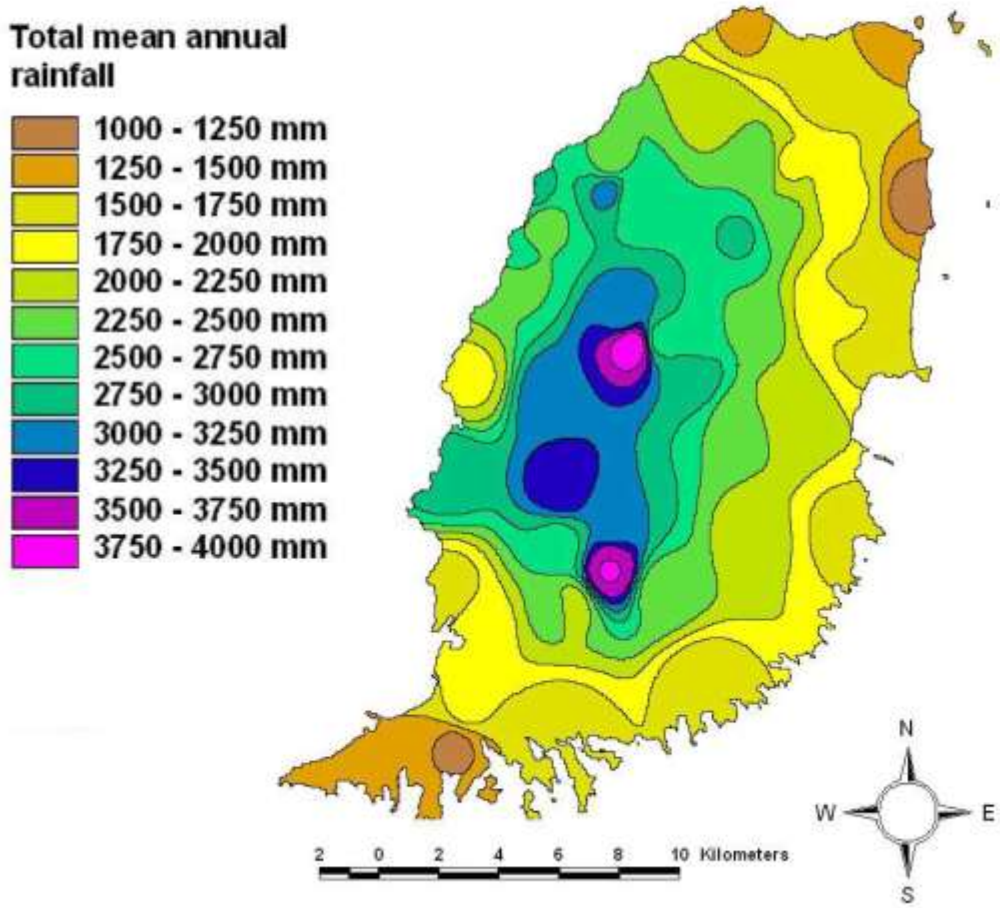


Figure 35-Spatial variation of Rainfall in Grenada (Adapted from NASAP 2015)

Eighty-five percent (85%) of the land in Grenada is occupied by forest and other vegetation, including agricultural crops and other tree crops such as the nutmeg and cocoa trees (UNFCCC 2014). There is a more significant spatial distribution of rainfall on Grenada than on the Carriacou and Petite Martinique because of the forests located within the mountainous regions on the main island of Grenada. Rainfall has been estimated to be nearly four times higher in these higher elevation regions than on the coast (GoG 2007).

Grenada has 71 watersheds occupied by many permanent rivers while Carriacou has 21 watersheds with intermittent streams and Petite Martinique has only two watersheds (GoG 2007) (Figure 36). Surface water from 23 permanent streams and rivers supplies most of the country's potable water together with six ground water sources located primarily on the north coast (GoG 2011, FAO 2014). The National Water and Sewage Treatment Authority (NAWASA) is the major entity responsible for the distribution of the potable water supply. NAWASA does not distribute water for agricultural or recreational purposes; this water is provided by rainwater harvesting and rivers (UNDESA 2012). Carriacou's and Petite Martinique's only source of potable water is obtained through rainwater harvesting and cisterns, which leaves these islands more vulnerable to drought during the dry season (GoG 2011). There has been little documentation of the water quality in Grenada (UNDESA 2012).

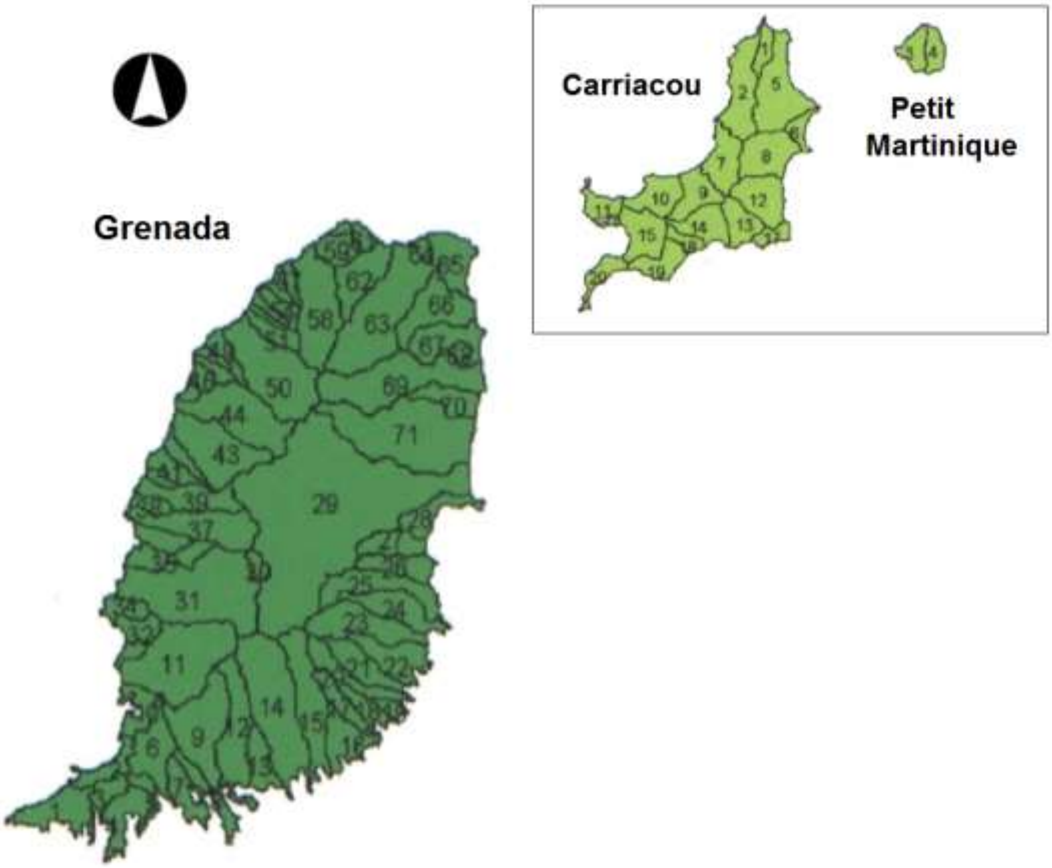


Figure 36-Surface Catchments of Grenada, Carriacou and Petite Martinique (Adapted from NASAP 2015)

The Great River is the largest watershed in Grenada and is located in the central highlands of the country. This watershed has an area of 11,303 acres and occupies 14.6% of the total area of Grenada and it receives most of the rainfall for the country. Given the geology of the catchment, which consist of impervious geology (andesitic rock, pyroclastic flows, scoria and ash), infiltration is significantly limited and the geology along with steep terrain contribute to significant surface runoff. Within the Great River watershed, the location of water storage systems (dams) is significant to Grenada's water resources: it is a potentially suitable location for large-scale storm water harvesting (SWH) for potable and non-potable water supply to sustainably militate against drought.

The NASAP- 2015 reported that all of the watersheds are affected by anthropogenic activities which pose a major threat to watershed management and results from a combination of the following activities:

- Encroachment by farmers;
- Use of agro-chemicals (fertilizers, pesticides, weedicides);

- Siltation of rivers and dams;
- Inadequate land use practices;
- Pollution;
- Land tenure rights;
- Unplanned developments;
- Lack of control of forest clearance.

Watersheds of SIDS such as Grenada which suffer degradation from unsustainable land management practices because of agriculture and/or urbanisation are heavily impacted after the passage of a tropical storm or hurricane. This can lead to significant erosion and landslides in the upper reaches of catchments, and flash flooding in the downstream, typically urbanised areas. Silt and debris-laden storm flows often choke the water intake infrastructure, while landslides often cause breakages in water distribution lines, forcing supply interruptions to many communities for weeks, and in some cases months.

The most prominent hurricanes to date included the damage from passage of Hurricane Ivan in 2004 (Category 3) and Hurricane Emily in 2005 (Category 1) and their impacts on the vegetation are still evident (NADMA, 2005; UNDP, 2004). Reports of increased river flows following heavy downpours after the hurricanes could be the result of deforested watersheds having reduced retention capacity causing significant increases in runoff (NASAP-2015).

Increasing drought conditions have resulted in forest fires in several watersheds, for e.g. during the drought of 2009. This is further exacerbated by the changing biodiversity within the watersheds. Bamboo has spread across the island thereby changing how much surface water is infiltrated. The shallow root system of bamboo encourages surface runoff instead of percolation into the soils which in turn affects the water supply. This is more visible in the forest reserve and has now become predominant in some other watersheds (NASAP-2015).

Geology

As a result of its soil type and geomorphology—in particular the presence of non-porous, impermeable soils—Grenada is prone to high levels of surface runoff and therefore pluvial and fluvial flooding. NASAP-Grenada 2015 reported that the vulnerability to flooding and landslides are higher for watersheds of medium to low elevation. The islands main rock types are andesitic lava, pyroclastic rocks and basalt. The island’s geological map shows that more than 60% of the island is composed of reworked volcanics as shown in Figure 37 below.

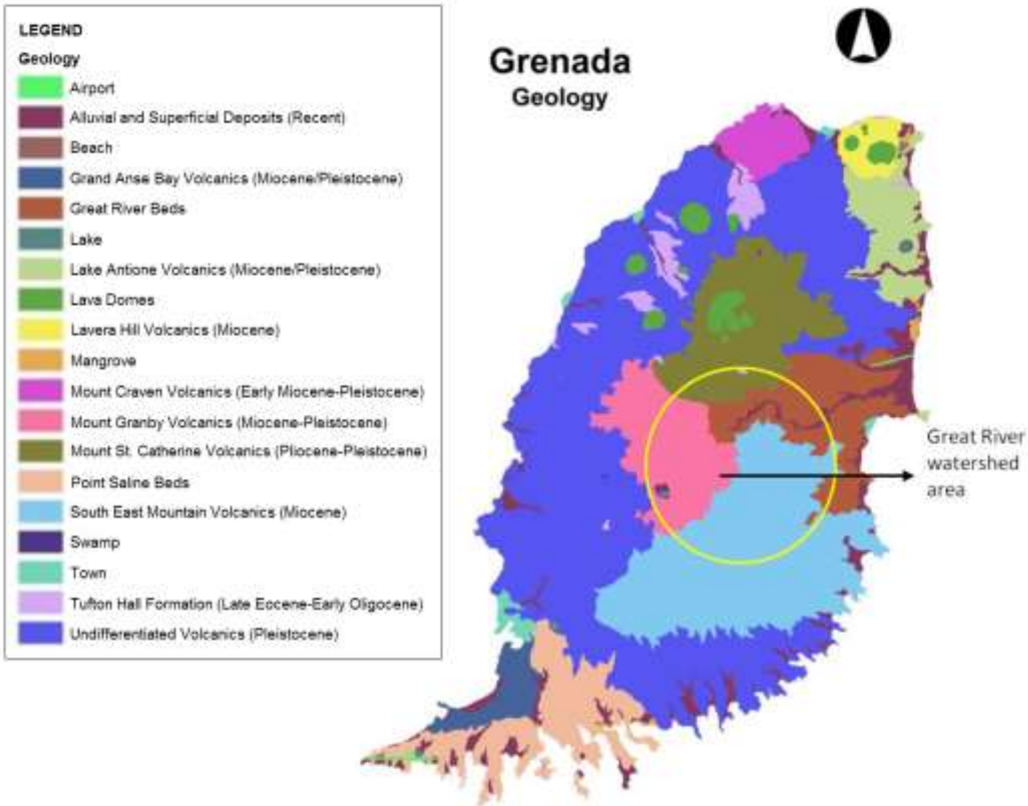


Figure 37-Geology of Grenada (Adapted from NASAP 2015)

The Geology map of Grenada indicates the geology is composed of pyroclastic basalts, andesitic lavas and reworked volcanics, scoria and ash. The Great River watershed falls in the area of volcanic summit (see Figure 37 above) and is composed of reworked volcanic ash, pyroclastic flows and basalts. These rock types are the main reason for the impervious nature of the sub-surface which leads to greater surface runoff and hence the higher density of drainage channels and greater source of surface water systems (NASAP-2015).

The dominant rock types are (NASAP-2015):

1. Mount Craven Volcanics (Early Miocene to Pleistocene) occupying the central section of the island, high rainfall zone and covering parts of the Great River watershed;
2. Undefined reworked Volcanics (Pleistocene) covering approximately 60% of the island extending from north to south, south east;
3. South East Mountain Volcanics (Miocene);
4. Mouth St Catherine Volcanics (Pliocene to Pleistocene) lying in the northern section of the island and coinciding with areas of protected Rainforest zone.

Soils

The soils map of Grenada (1994) indicates that the subsurface of the island is predominantly composed of volcanic rocks, and its soils are dominated by clay loams (84.5%), along with clays (11.6%) and sandy loams (2.9%). Climate and topography are the most important factors in determining soil type. Challenges in the agricultural sector tend to arise from the shallowness, high erosion potential and low moisture retention capacity of the clay loams which are present in most of the country (NASAP-2015).

The dominant soil types in Grenada are defined and described as follows (NASAP, 2015):

- Capital Clay Loam (13,354 ha) – fine textured good drainage reddish soils;
- Belmont Clay Loam (6,479 ha) – fine textured moderately well to well drainage brownish soils of variable depth;
- Woburn Clay Loam (8,276 ha) – fine to medium textured well to excessively drained dark brown to grey moderately deep soil;
- Other Clay Soils – very deep soils drowned from alluvial or colluvial deposits on mainly flat to undulating land;
- Other Soil types – consist of loamy sand and sandy loams that are medium to coarse textured well-drained soils. (NASAP 2015).

Land Use

The 2009 Grenada land use map (see Figure 38 and Figure 39 below) demonstrates that vegetated cover and agriculture are the dominant features across the island. As a result of the islands topography, most of the urbanised areas are located in the coastal zone.

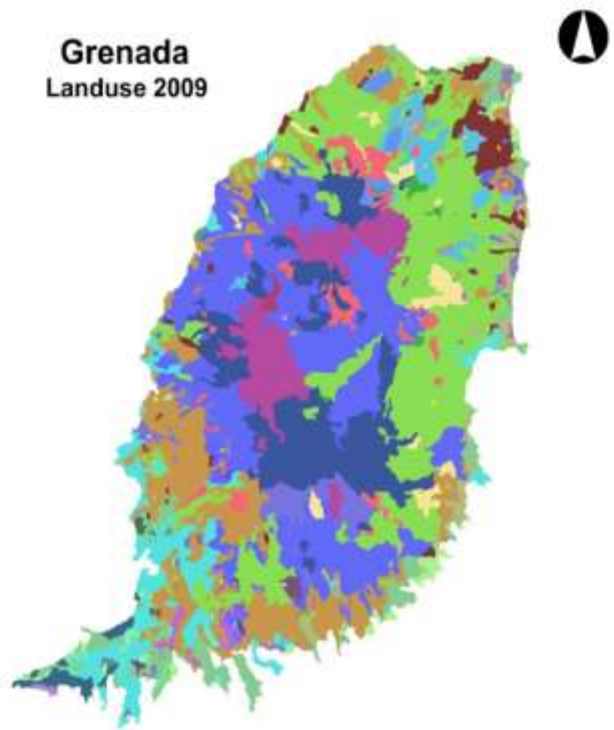


Figure 38-Grenada Land Use (Adapted from NASAP 2015)

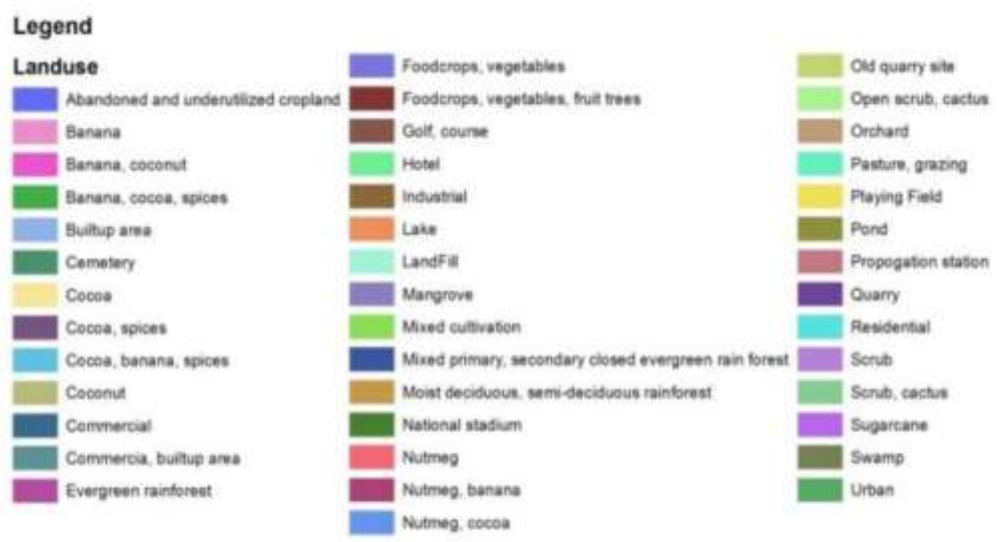


Figure 39-Interpretive Legend of Grenada Land Use Map (Adapted from NASAP 2015)

Agriculture is the main type of land use for the island covering approximately 70% of its area followed by forests and abandoned lands. This is mainly in the northern and south-central sections of Grenada in the Great River, Pearls and Tivoli watersheds (see Figure 38 and Figure 39 above). The urbanised areas of the island are primarily located on the south west coast in the parish of St. George and covering the Chemin, Grand Anse, St. George and Richmond watersheds. The Great River watershed comprises mainly abandoned cultivation, mixed cultivation (agriculture) and forest cover (mainly deciduous). The forests in Grenada are mainly moist, deciduous rainforests with some places having scrub and cacti. (see Figure 40 below).

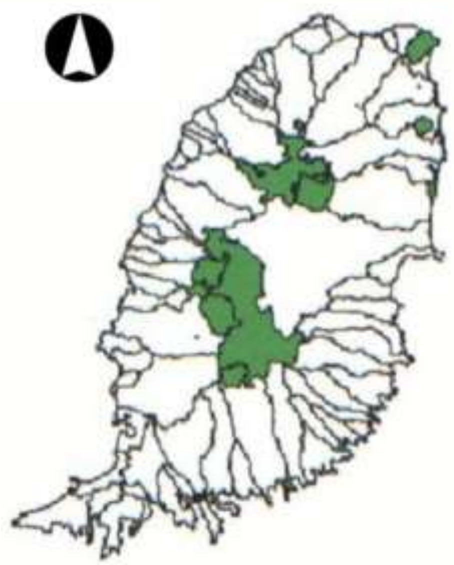


Figure 40-Surface Catchment Map of Grenada Showing Protected Areas (Adapted from NASAP 2015)

Water Resources Availability

Grenada relies heavily on surface water from its river systems. At present, 23 surface and 6 groundwater potable water supplies yield some 54,600 m^3/day (12 mgd) in the rainy season and a maximum of 31,800 m^3/day (7 mgd) in the dry season (GoG 2007). Table 32 (below) shows the primary types of water sources, their locations and their type (tank, treatment plants or reservoirs). In total, there are 19 tanks, 11 boreholes and 23 treatment plants. All of these sources are maintained and monitored by NAWASA and used for potable water supply, as well as, for irrigation. The boreholes are confined to the southern, coastal aquifer of the island. The majority of water catchments are around the Grand Etang and in areas that have the highest rainfall due to elevation. High rainfall in the mountains, paired with impervious geology allows a higher number of streams to transport rain water to tanks and reservoirs. Apres Toute, Blaize, Clozier/Mt. Felix, Fountain, Morne Longue and Union all have spring sources while, Chemin #1, Woodlands #1 and 2, Baillies Bacolet #1 and 2 and Carriacou have borehole sources (see Table 32 below).

Table 32-List of Storage, Water Sources and Types (Adapted from NASAP 2015)

Tanks	Boreholes	Treatment Plants	Remaining Types	Names
Airport	Woodlands 1	Petite Etang	Reservoir	Mt. Rose
Worburn	Woodlands 2	Apres Tout	Filter Plant	Dougaldston
Jean Anglais	Bailie's Bacolet 2	Pomme Rose	Spring	Cllozier
Las Pastora	Bailie's Bacolet 1	Mamma Cannes	Reservoir	Tifton Hall
Petite Espreance	La Sagesse	Munich	Filter Plant	Brandon Hall
D'Arbeau	Baile's Bacolet 3	Bellevue	Spring	Morne Longue
Observatory	3 Chemin Valley	Spring Gardens	Spring	Tufton Hall
S. Hilliar	4 Chemin Valley	Annadale	Dam	Grand Etang
Carriere	5 Chemin Valley	Mirabeau	P Filter	Perdmontemps
Tivoli	1 Chemin Valley	Peggy's Whim	Dam	Spring Gardens
Hermitage		Mt. Reuil		
Lower P Whim		Union		
Rose Hill		Treatment Plant		
Fountain/Castle Hill		Concord		
Samaritan		Clozier		
Baldwin		Guapo		
Black Forest		Blaize		
Morne Jaloux		Radix		
Woburn		Bon Accord		
		Les Avocates		
		Mardigras		

Grenada's steep terrain, especially within the centre of the island, has created difficulty in laying piped networks. Most of the water distribution networks are found near to the coast or in gently sloping areas elsewhere on the island.

Water Supply and Demand

Supply and demand data are limited or non-existent for much of the island. Grenada's population has shown little increase over the last decade (see Table 33). However, despite this trend, there has been a marked increase in the demand for additional water supply sources within the country over the same period.

Table 33-Grenada Population Statistics (x1000)

Year	2005[1]	2007[2]	2009[3]	2011[4]	2013[5]	2015[6]	2030[6]	2050[6]
Population (x1,000)	103	106	104	105	106	107	112	110

1. *United Nations, Department of Economic and Social Affairs, Population Division (2005): World Population Prospectus: The 2004 Revision.*
2. *United Nations, Department of Economic and Social Affairs, Population Division (2007): World Population Prospectus: The 2006 Revision.*
3. *United Nations, Department of Economic and Social Affairs, Population Division (2009): World Population Prospectus: The 2008 Revision.*
4. *United Nations, Department of Economic and Social Affairs, Population Division (2011): World Population Prospectus: The 2010 Revision.*
5. *United Nations, Department of Economic and Social Affairs, Population Division (2013): World Population Prospectus: The 2012 Revision.*
6. *United Nations, Department of Economic and Social Affairs, Population Division (2015): World Population Prospectus: The 2015 Revision.*

Over the last two decades, the number water supply sources in use per parish have increased at a significantly higher rate than the parish population (NASAP). Figure 41 shows the change in parish population versus the number of water sources over the 1991 to 2011 period.

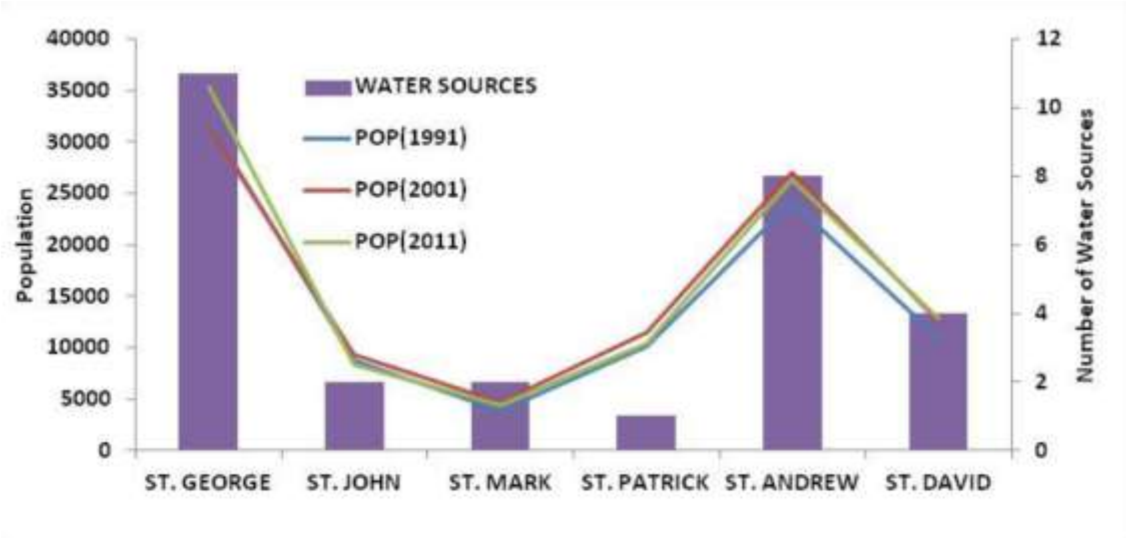
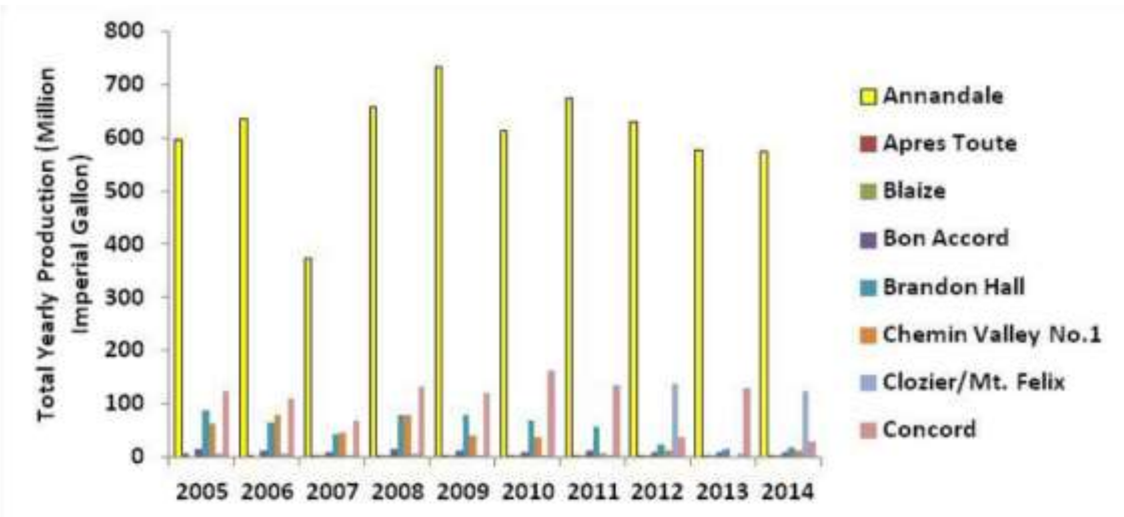


Figure 41-Graph of the Population of Each Parish from 1991-2011 alongside the Number of Water Sources Per Parish (NASAP-2015)

As present, there is not sufficient data to determine water usage per land use classification or water consumption per capita. However, the current trend would suggest that demand for water and the need for additional water supply sources will continue to increase in tandem with overall socio-economic development and improved access to water, even despite little to no increase in population.

Based on the data received by the consultants of the NASAP-2015, annual analysis of the water sources shows that although Annandale has consistently recorded the highest yield, there was a decline in its production over the last decade, particularly from 2007 to 2010. The 2010 decline is as a result of the 2009 drought, however, the reason for the 2007 decrease remains unknown. A similar pattern emerged for both for Mirabeau and Peggy's Whim (see Figure 42 below).



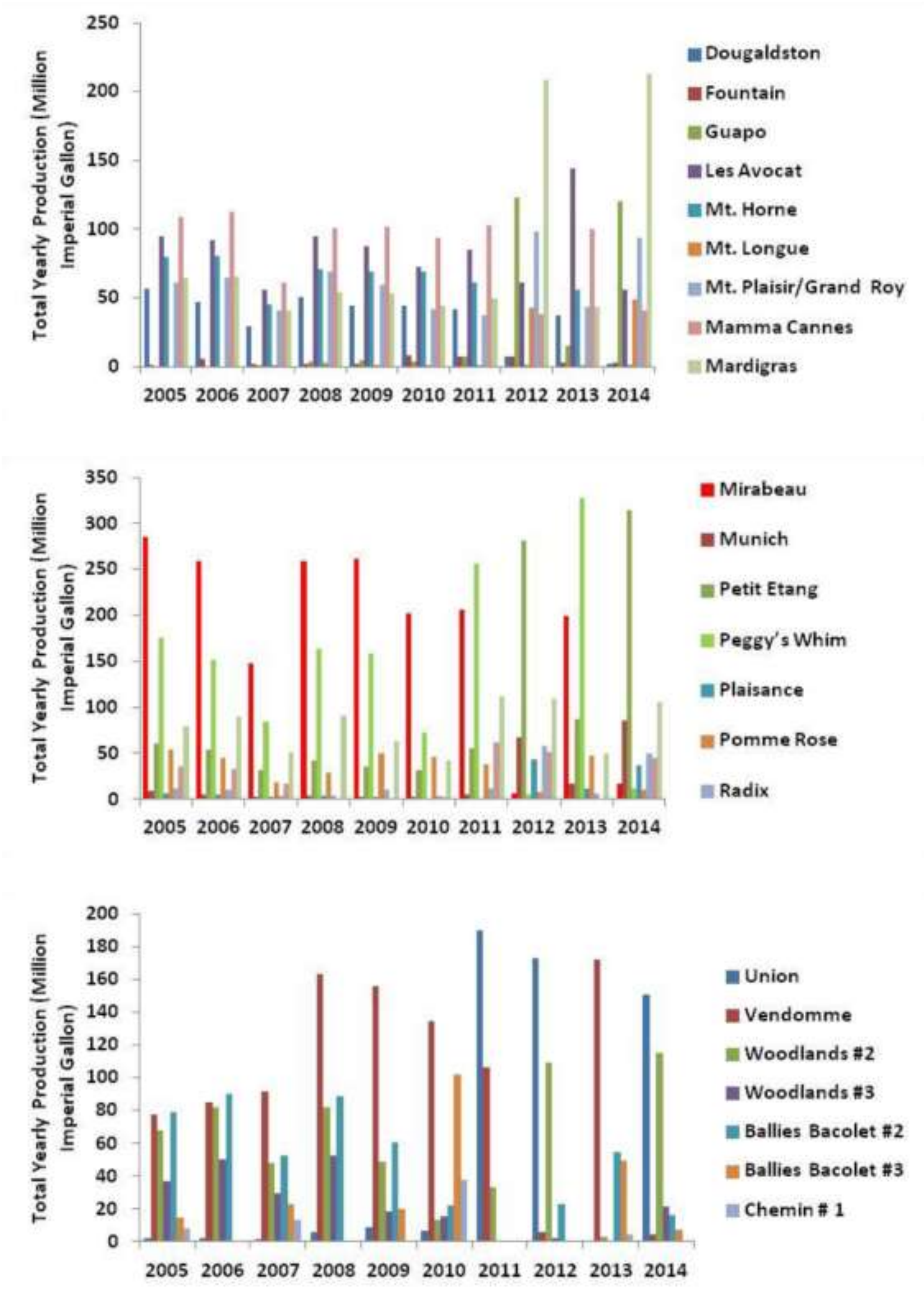


Figure 42-Total Annual Production for All Water Sources in Grenada (Adapted from NASAP-2015)

In summary, the type of water supply source (spring/river/groundwater well) in Grenada often changes within each parish based on population, and therefore demand. Figure 43 below shows that a decadal analysis of the types of sources of water can be seen to be increasing based on the population growth in the different parishes.

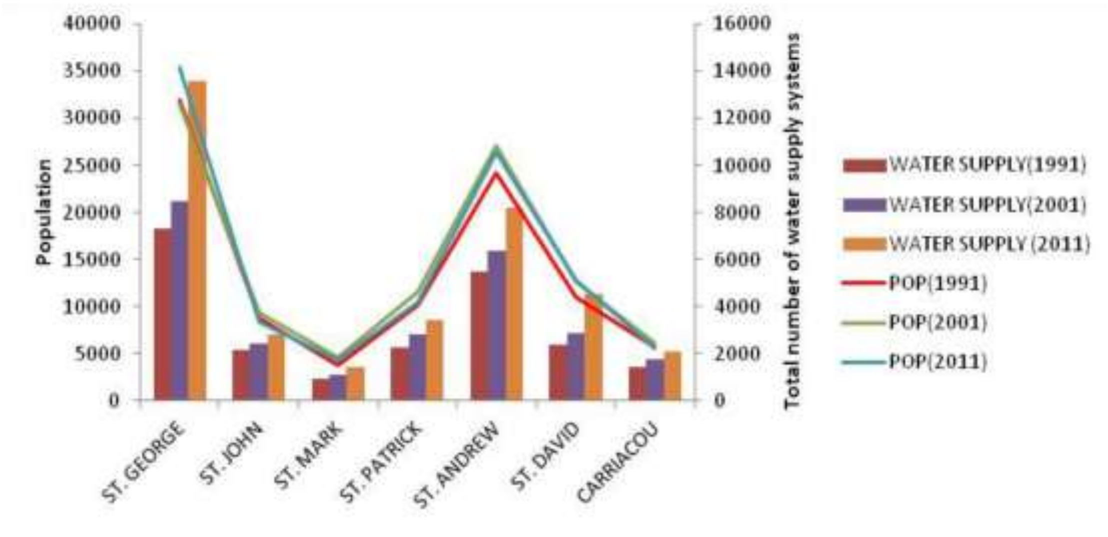


Figure 43-Graph Depicting the Decadal Changes in Types of Water Sources Based on the Needs of the Population (Adapted from NASAP-2015)

The main factors increasing water demand in Grenada are urbanisation and improvements in the standard of living of households (UN DESA 2012). The three main sectors of consumption are water for agriculture, domestic and tourism sectors.

It is projected that new tourism projects will require 825 m^3/day for 1,000 rooms and 60,000 m^3/day for the maintenance of the hotel and the golf courses over the next 15 years. Current production and consumption usage data indicated that this would put a significant strain on the existing supply system.

It is evident that NAWASA would need to explore further groundwater and surface water sources in order to meet the demands of the domestic, agriculture and tourism sectors. It can also be inferred that exploitation of the groundwater will need to be investigated in the inner parts of the country as over exploitation of groundwater wells near the coast can increase saltwater intrusion.

In consideration of reducing the risk of such contamination, it is recommended that NAWASA carry out the following tasks:

1) Map the saltwater-freshwater interface when new wells are being drilled as the interface fluctuates during pumping and aquifer recharge;
2) Monitor the vertical movement of the potentiometric surface of both saltwater and freshwater;
3) Reduce pumping rates during times of drought or prolonged periods of lower rainfall, and increase storage in higher elevations;
4) Undertake continuous water quality sampling, coupled with rainfall and water demand analysis, to identify when pumping rates should be reduced or increased; and

5) Incorporate the use of a groundwater model to assist in the decision-making process for groundwater management and saltwater intrusion mitigation.

In the event that groundwater is sourced from wells further inland, it is recommended that reservoirs be constructed to facilitate the storage of water at these higher elevations. This will allow for water to be distributed to lower-elevation areas under gravity, which will in turn lead to reduced pumping costs related to distribution.

Water Sector Vulnerabilities

Vulnerabilities impacting the water sector include the following:

- The increase in the occurrence of floods and droughts due to projected climate change impacts on precipitation, temperature, cyclone activity and evapotranspiration through increasing temperatures;
- Increasing demand for water based on current supply and demand trends; and
- A lack of essential data to support sustainable water resources management.

Cyclone Activity

The IPCC AR5 Report notes that evidence suggests a virtually certain increase in the frequency and intensity of the strongest cyclones in the Atlantic since the 1970s (Wu et al.; 2008). The historical trend suggests an increase in the number of hurricanes making landfall in Grenada. The 10-year running mean indicates a period of increased hurricane activity beginning in the year 2000. There is a sharp increase in the number of Category 4 and 5 hurricanes starting in 2002, signifying an increase in the more intense storms. With increased intensification of hurricanes, the island is expected to experience severe intense short-duration rainfalls. Prolonged dry periods, higher temperatures and increased rates of evapotranspiration will also negatively impact the water supply systems of the islands.

Droughts

Grenada has experienced three major droughts in recent decades: in 1995; over the 2009/2010 period and the 2011/2012 period. The more recent events created the driest periods in the nation's recorded history. In particular, during the 2009/2010 event, the northern parts of the island were the hardest hit, with the main water production centres experiencing reductions of up to 65% (Grenada-Pilot Program for Climate Resilience (PPCR), 2011; UNDESA, 2012). As a general rule, the northern parts of the island and the island of Carriacou are the most vulnerable to drought, with prolonged dry spells adversely affecting both livestock production and the yield of irrigation crops (PPCR, 2011; CARIBSAVE, 2012).

The Caribbean Drought and Precipitation Monitoring Network (CDPMN) through the Caribbean Water Initiative based at the Caribbean Institute for Meteorology and Hydrology has forecasted droughts lasting between 3 and 6 months normal, below normal and above normal rainfalls.

Figure 44 below illustrates the drought index (SPI) from the Caribbean Drought and Precipitation Network for the three-month period January to March 2016. It indicates normal to below normal rainfall was experienced in the eastern Caribbean: Grenada is forecasted to be extremely dry.

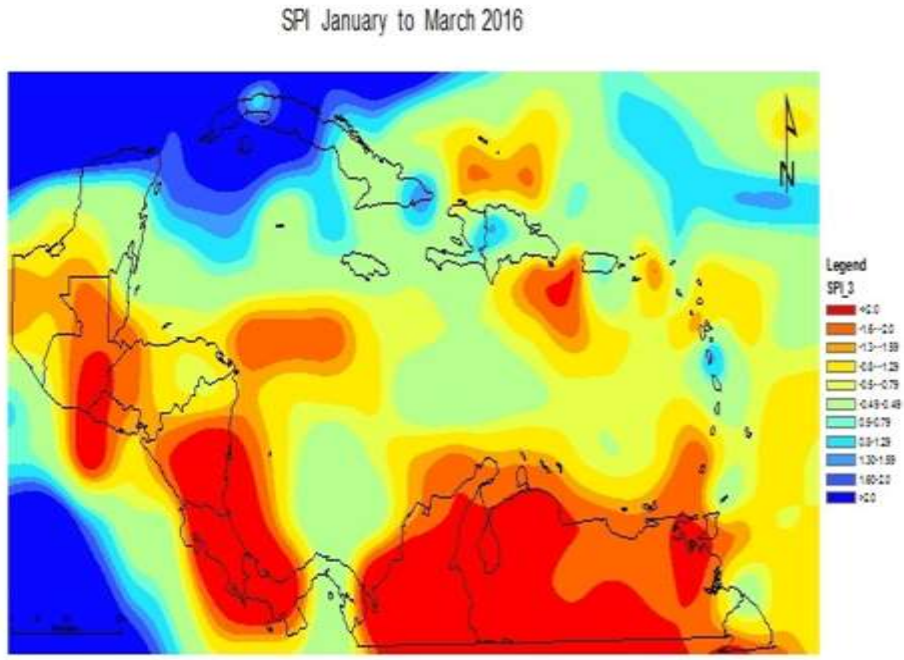


Figure 44-January to March 2016 CDPM - RCC CIMH outlook

While in comparison, Figure 45 below shows that for the October to December 2016, the three-month period, mixed conditions were experienced in the eastern Caribbean islands: Grenada, Antigua and St. Maarten were normal.

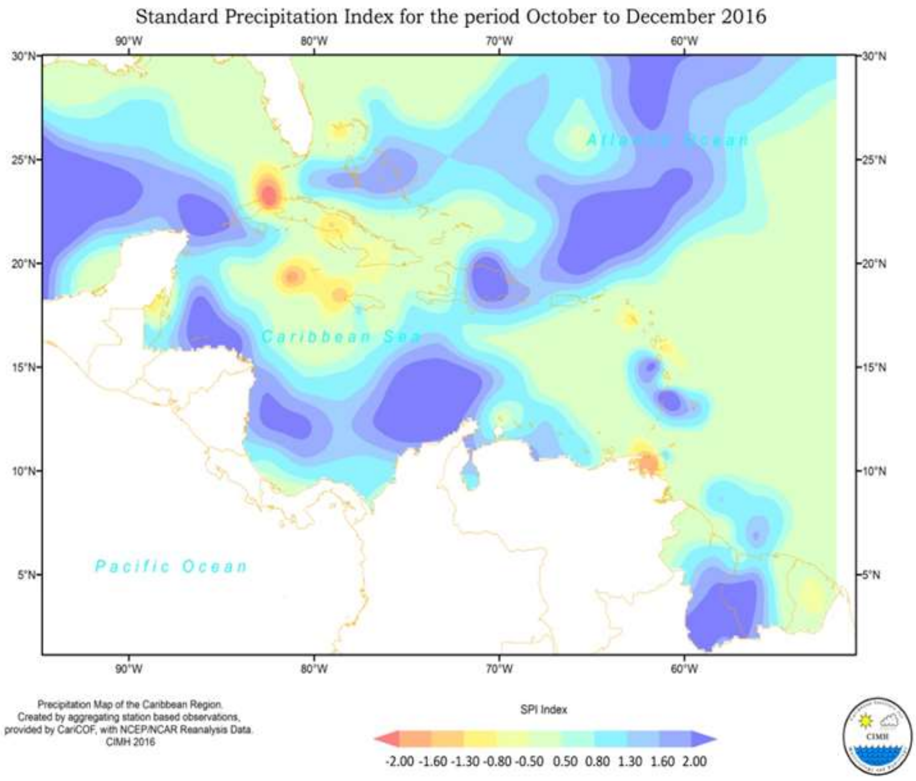


Figure 45-Standard Precipitation Index (SPI), October to December, 2016

The comparison of these projections along with the outputs from the GCM Climate projections completed in Grenada's NASAP indicates that the island will most likely be experiencing extended drier periods.

Floods

Within Grenada, many communities and much of the agricultural lands are located along the coastal flood plains. During the onset of extreme rainfalls, these areas flood, sometimes triggering landslides and causing great danger to communities.

Usually, this phenomenon occurs from extreme rainfall events during the onset of hurricanes/ tropical storms. Grenada does not have an extensive hurricane history due to its location in the southernmost region of the hurricane belt. However, it has been affected by several tropical storms including Hurricane Ivan, 2004, Hurricane Flora, 1963, Hurricane Janet, 1955 and one unnamed storm in 1921. During hurricanes and major flood events, water supply can be affected through a number of sources. According to Peters (2010), Hurricane Ivan significantly affected Grenada's water resources in the following ways:

- Damage to roads which limits access to water supply infrastructure;
- Damage to underground infrastructure, including water distribution pipes;
- Loss of power at pumping stations thereby increasing the time to restore services;
- Degradation of the water producing watersheds;
- Siltation of water intakes; and
- Damage to treatment facilities.

The draft Grenada National Flood Hazard Map Methodology and Validation 2016 (CHARim) report stated that flooding circumstances can be aggravated by planning decisions or human behaviour such as:

- The blockage of drainage channels by refuse, sedimentation and/or debris, many of which cannot be breached by the force of surface runoff, for example:
    - The blockage of channels by refuse, particularly in heavily urbanised areas;
    - The blockage of channels by debris and refuse at bridge crossings;
    - The blockage of coastal outfalls by sand and other sediments.
- Poor maintenance and cleaning of drainage channels - dilapidated drainage structures that are inefficient and less able to carry flood loads;
- The unconscientious diversion of channels to circumvent developed areas, leading to unnatural bends and flow paths that cannot handle extreme discharges;
- The inadequate carrying capacity of under-designed open channels, culverts and bridge clearances, leading to blockages, overflows and the folding of surrounding and upstream areas;
- The unconscientious increase in the percentage of impermeable area due to new development, which reduces the infiltration capacity of a given watershed, thereby leading to the generation of increased surface runoff during rainfall events; and
- Individuals extending their housing infrastructure into the river channel flood plain, thus narrowing the potential flow path and reducing the carrying capacity of such channels.

Summary of Existing Climate Impacts on Water Sector

The following list presents a summary of existing identified climate change impacts on Grenada's water sector:

- Grenada has experienced fluctuations in rainfall levels in past decades. But there has also been a steady increase in supply sources and connections due to ongoing water infrastructure improvements;
- Annual mean, maximum and minimum temperatures at the Maurice Bishop International Airport exhibit a statistically significant warming trend and the higher the temperatures increase the rate of evaporation from rivers, streams, dams and other water bodies, eventually resulting in reduced water levels;
- As per Chatenoux and Wolf (2013), Grenada shows a mean sea level rise of 2.9 mm/yr from 1950 to 2000. Increase in sea level would lead to a commensurate increase in coastal inundation in coastal towns such as Greenville. As for water quality it would imply an increase in the salinity of the well waters of the Chemin, which could eventually lead to closure of the wells, thereby increasing the stress on surface water supply sources.
- Extreme drought and flood conditions are also expected to impact the agricultural sector causing damage to soil and infrastructure and loss of crops and livestock due to both flooding and extended dry periods.

Legislative Review

Noted Weaknesses within the Existing Legal Framework

The NASAP 2015 report concluded that the existing sectorial, disjointed system for water management needs to be replaced by a central coordinating agency which will be responsible for the management of water resources in a holistic manner. This would ensure that due consideration is given to the various conflicting uses of water, thereby resulting in more pragmatic allocation. Successful models already exist in the Caribbean (Jamaica and Saint Lucia) and provide a template which can be tailored to meet Grenada's needs.

Additionally, attaining the goal of implementing IWRM in Grenada will involve four fundamental and required elements:

- A holistic and comprehensive national policy and plan for the management of water resources which consider the current and projected impacts of climate change on water resources;
- Development of the legal and regulatory framework for the management of water resources which considers the current and projected impacts of climate change on water resources;
- Improving and where necessary developing the institutional and administrative framework for water resources management;
- Enhancing the capacity and capability for the management of water resources.

Challenges within the current legal policy and legislation

The challenges highlighted by previous study (NASAP-2015) indicated after much consultation with stakeholders in Grenada that the following are obstacles:

- A severe lack of good water governance;
- Multiple institutions, each with their own piece of legislation and mandate, none of which is broad or deep enough;
- The separation of agencies responsible for managing water quantity from those responsible for monitoring and managing water quality;
- Poorly defined responsibilities for departments/section;
- Overlap of responsibilities, resulting in duplication;
- Cost trade-off between the pollution control and water supply treatment in the same watershed is not evaluated, thus the national investment policies and programmes do not reflect the interrelationships between quality and quantity.
- Lack of effective integration and coordination hampered by:
    - The absence of sound and comprehensive national policies on water resources;
    - The multiplicity of institutions that deal with the management of the resources;
    - The multiplicity of laws, each dealing with separate aspects of the management of the resources, thus encouraging compartmentalization;
    - Institutionally divided approach to dealing with environment and development;
    - Poor management of the dynamics of water supply and demand;
    - Inadequate legal and regulatory frameworks for managing the resources;

The (NASAP-2015) report also highlighted some of the reasons why legislation is not implemented, which include the following:

- A lack of political will;
- A lack of technical and financial resources;
- A lack of commitment by the Ministry or Minister;
- Legislation not being on the legislation time table approved by the Attorney General;
- Change in Government or of Government policy;
- Inadequate drafting instructions; and
- A lack of communication between technical personnel and the Permanent Secretaries of relevant Ministries.

Policy, legislative, inter-agency cooperation and institutional recommendations were provided by the Grenada NASAP-2015 report. These are as follows:

Policy Recommendations

Policy recommendations include:

- Implementation of a National Water Policy;
- Implementation of a National Climate Change Policy and Action Plan;
- Cabinet approval for a National Hazard Mitigation Policy;
- Cabinet approval of a National Waste Management Strategy;

Legislative Recommendations

Legislative recommendations include:

- Enforce Regulations for controlling water quality;
- Enforce Regulations to establish standards and specifications for effluent discharges into receiving surface, underground or coastal waters;
- Finalize and enact draft Public Health Act;
- Finalize and enact draft Environmental Management Policy;
- Prepare and finalize Pollution Regulations;
- Finalize and enact draft Protected Areas Forestry and Wildlife Act.

Inter-agency and Inter-sectoral Co-operation

Although NAWASA has primary responsibility for water management, the role of public health (water quality monitoring), the Forestry Division (Watersheds/forest reserves) and the Physical Planning Unit (environmental issues generally) are also of critical importance in the water-sector. Thus, inter-agency collaboration will be of key importance in the effective implementation of critical issues in the natural resources sector (NASAP-2015).

Institutional Recommendations

A variety of mechanisms will be necessary to strengthen the institutional framework. These include (NSASAP-2015):

- Strengthen the mechanisms for greater enforcement of existing legislation, through the provision of the necessary support from relevant government agencies;
- Establish training programmes for enforcement offices in all agencies;
- Establish inter-agency collaboration among agencies for enforcement of legislation; and
- Strengthen the mechanisms for the EIA process including inter-agency collaboration for evaluating and monitoring EIAs.

Summary of Legislative Review

Grenada has been proactive in formulating a Drought Early Warning and Information Systems (DEWIS) Committee and incorporates land use personnel from the following agencies:

- Ministry of Agriculture (Lead Agency);
- Meteorological Services;
- Farmers' representatives;
- Fire Department of the Royal Grenada Police Force;
- Media Representative;
- Government Information Systems;
- Grenada Chamber of Commerce;
- National Water and Sewerage Authority; and
- National Disaster Management Agency.

The scope of work of the Committee is to ensure institutional synergies for the collection, analysis and dissemination of hydrological, meteorological and other forms of drought-related public information as well as the coordination of any necessary action (NASAP-2015).

The Chemin Watershed: Case Study

The water resources of Grenada's Chemin Watershed are uniquely vulnerable to the effects of climate change. This critical watershed of the island has already seen increased flooding and extended periods of drought in recent years, and is expected to see worsening effects in the coming years due to climate change impacts on water. For this reason, this report places special emphasis on the Chemin Watershed and its vulnerability and potential adaptation to climate change.

Topography and Land Use

The Chemin watershed is located in the south-western part of the island and ranges from 0 m to 500 m in elevation and is the most densely populated part of the island. Although it is predominantly forested with woodlands in the upper reaches of the catchment, Chemin also comprises major agricultural production in the central and lower south-western locations of the island (Figure 46).

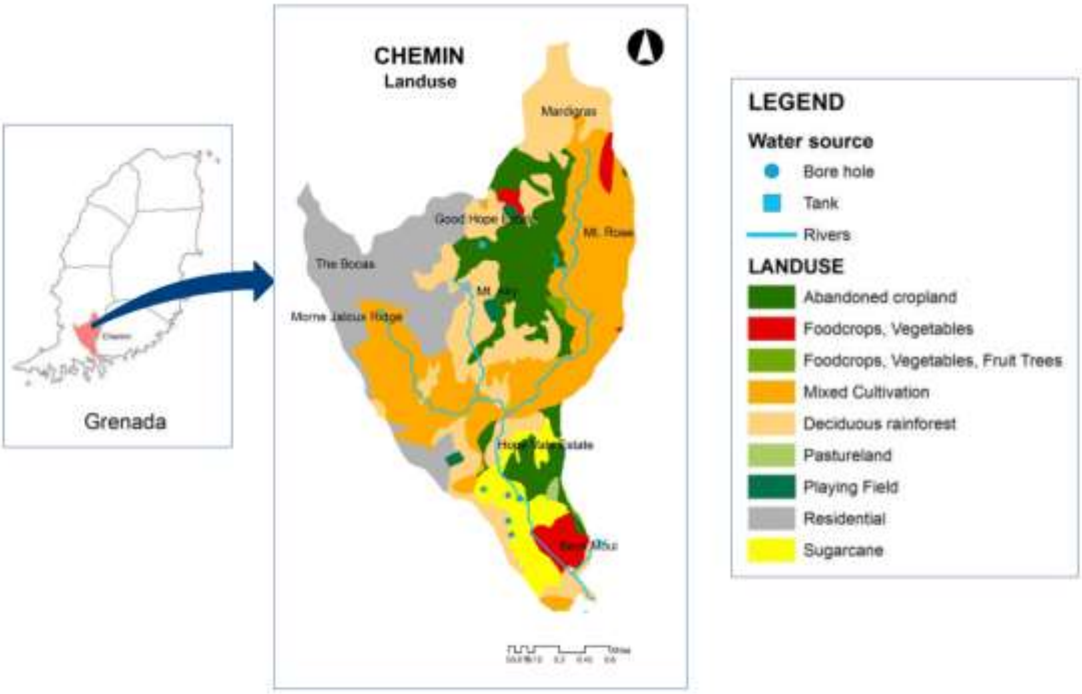


Figure 46-Chemin Watershed within Grenada and the Land Use map of Chemin (Adapted from VCA-Chemin 2015)

Water Resources of Chemin

The Chemin watershed experiences the lowest rainfall on the island, with the main River Chemin flowing from the northeast section of the watershed and it two tributaries converge into the main river within the central parts of the watershed and it flows out to sea at Woburn Bay. Mean annual rainfall for the catchment is 2000 mm with an average yield of 1648 m3/day produced from 6 boreholes. This catchment is the source of major groundwater recharge of approximately 2,407,920 m^3 per year. Because of the geological composition of the island, runoff tends to be greater than infiltration due to the impermeable soils. The hilly nature of the watershed coupled with extreme but variable rainfall events makes the watershed vulnerable to flooding and landslides.

The Chemin River provides a major surface water source for the catchment and is linked to the Mardigras Treatment plant and the Baldwin tank. Both are located in the Hope Vale Estate situated near the mouth of the river. The aquifers in the catchment are coastal and are comprised of Point Saline limestone beds and Plains clay loam (alluvial deposit). The low elevations of the watershed present significant challenges due to a combination of factors, including:

1. Because the aquifer is contiguous with the coast and experiences high groundwater abstraction rates, saline intrusion negatively impacts both the quality of water and mechanical equipment used in its extraction and distribution; and

2. The low elevations of the catchment and the locations of groundwater extraction wells near the coast, it is expensive to pump water uphill to many parts of the community.

Summary of Existing Climate Impact Assessment –Chemin Watershed

Based on the results of the Vulnerability and Capacity Assessment for the Chemin Watershed (VCA-Chemin, 2015), the following limited an exhaustive analysis of the watershed:

- Only monthly rainfall totals were received from the CARDI station located within the Chemin watershed;
- No data on water quality, demand and consumption was available;
- There was limited quantitative data on related health issues;
- There were no data that defined the contribution of the watershed to the economy;
- Some sparse socio-economic data, though available, was difficult to extract.

The Chemin Watershed has several specific issues and threats related to the water sector. These are discussed in the table below (Table 34).

Table 34-Chemin Watershed Water Sector Issues and Impacts (Adapted from VCA Chemin, 2015)

Issues/Threats	Current Impacts
Farming along the banks of the Chemin River	Regular flooding of the farms and loss of crops, irrigation systems and pumps. (It should be noted that due to the close proximity of extraction pumps to farms, there is potential for there to be an increase in the concentration of agricultural contaminants in water within this semi-closed system.)
Blockage of the river channel by trees and sedimentation	Frequent overflow of the river during high intensity and/or long duration rainfall events.
Heavy dependence on water sourced from the river by NAWASA and farmers	During the dry season farmers rely heavily on NAWASA. However, water from NAWASA is expensive. During extreme drought conditions farmers do not have access to alternatives.
Changes in the timing and length of wet and dry seasons attributed to climate variability and change	Dry seasons are becoming prolonged and wet seasons are becoming unpredictable with higher intensity storms.
Poor water quality	The Madriga Water Treatment Plant, which serves two parishes, has issues with water colour and taste, primarily during the dry season. This problem has been readily noted by residents and agro-processing facilities in the area.

The Chemin Watershed is also sensitive to several climate related conditions that are currently placing stress on the water sector. A summary of the main threats follows:

1. Floods - The alluvial fan of the Chemin River has been noted to flood at least once per year due to heavy rainfall caused by storms and hurricanes resulting in significant loss and destruction to crops, livestock and irrigation equipment;
2. Rainfall - Extreme rainfall (NASAP 2015) demonstrates that the texture, porosity and composition of the soils in the Chemin Watershed make some sections of it more prone to flooding. The soils are classified as high moderate to high runoff potential and comprise 20-40% clay (mainly clay loam, clay and sandy clay);
3. Drought - An increasingly longer dry season and shorter wet season is being observed in the Chemin Watershed and this has had serious implications primarily for farmers since they depend heavily on the Chemin River for irrigation water.
4. Temperature and evapotranspiration – The annual mean temperature for Grenada along with the evapotranspiration are expected to increase and this will also place further stresses on the water resources of the catchment.
5. Saline Intrusion- The boreholes in the Chemin Watershed, are currently being affected by saline intrusion. This has resulted in an increasing reliance on surface water (Chemin River) and the Mardigras plant. With further increases in sea level due to climate change this could result in the eventual closure of the coastal wells thereby putting further pressure on the surface flows of the Chemin River.
6. The trend for the Chemin Watershed is for a warmer and drier climate. Flooding may become infrequent and drought more common. This along with sea level rise and its impacts on the boreholes will mean that surface waters will be severely stressed. Communities within the Chemin Watershed, along with farmers, will have to start employing rain water harvesting to reduce their vulnerabilities to climate change.

3.3.3 Social Impacts Assessment

Summary of Social Impacts

It is well established that Grenada is already experiencing the impact of climate change on its water resources, including damage and loss from severe weather systems, and impacts on the availability of water caused by increases in temperature, reduced rainfall totals, and increasingly long dry periods between rainfall events.

Water shortages and flooding both have the potential to negatively impact the country’s social development through a number of mechanisms, including:

- Impacts on the country’s major sectors, including agriculture and tourism;
- Damage to property and infrastructure due to flooding and other hydro meteorological hazards; and
- Impacts on social norms, constructs and institutions due to disaster.

At present, Grenada’s sustained socio-economic development is affected by to limited hydro meteorological data, poor legislative and intuitional frameworks for water resources management, and inadequate water supply and drainage infrastructure.

Gender and Water

With respect to drought and water availability in particular, the central role played by women in the collection and allocation of water at the household and community level is well established.

According to UNDP (2012) integrating gender into drought management is supported by the following considerations, as outlined in the Hyogo Framework for Action:

- A gender perspective should be integrated into all relevant policies, plans and decision-making processes, including those related to risk assessment, early warning, information management, and education and training; and
- Disaster-prone developing countries, especially SIDS like Grenada require particular attention in view of their higher vulnerability and risk levels.

When addressing the social impact of these events, therefore, the unique challenges of gender roles and inequality must be fully considered and include:

- A typical higher level of poverty;
- Extensive responsibilities in caring for children, younger siblings and elderly relatives;
- Extensive household responsibilities activities related to the use of water, including cooking, cleaning, bathing children, younger siblings and elderly relatives, and gardening;
- The prevalence of homes headed by single females;
- Underrepresentation in relevant decision-making and planning activities;
- A lack of access to land and resources; and
- A disproportionately high vulnerability to violence, abuse and coerced transactional sex in exchange for water.

The Caribbean Water Initiative (CARIWIN) project, (2006-2012) identified that when it comes to the domain of water, there are very segregated roles for women, men, and children. During times of water scarcity or drought, when water must be accessed from community faucets, water trucks, irrigation ditches, rivers and wells, women's responsibilities in sourcing and allocating water for domestic use tend to be significantly increased.

Figure 47 below highlights three underlying factors which place women and girls at a unique disadvantage before, during and after disasters in SIDS like Grenada.

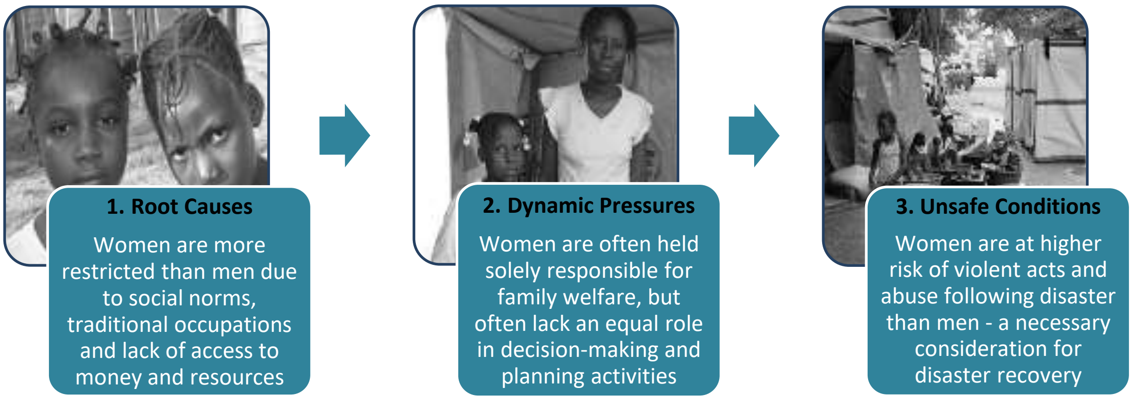


Figure 47-Underlying Factors Which Affect Women and Girls Before, During and After Disaster in SIDS (Adapted from: IJDH, 2010; UNDP, 2012)

3.3.4 Recommended Adaptation Strategies for the Water Resources Sector

In consideration of identified climate change impacts on water resources, this section lists recommended strategies to improve the adaptive capacity and resilience of the water sector to climate change. Notably, the strategies recommended recognise the importance of robust and reliable hydro meteorological data for effective water resources management, and as such there is considerable focus on the collection, management and effective use of such data to inform policy and planning at the national and watershed level. Emphasis is also placed on the need for a collaborative, multi-disciplinary approach to water resources climate change adaptation, requiring the participation and co-operation of multiple public bodies, private sector stakeholders, water sector professionals and community members.

Water resources climate change adaptation strategies are disaggregated into the following categories:

1. Integrated Water Resources Management;
2. Agro-Hydro-Meteorological Monitoring;
3. Flood Mitigation and Flood Risk Management;
4. Drought Mitigation and Drought Risk Management;
5. Water Supply and Demand Management;
6. Infrastructure, Development and Planning;
7. Education and Capacity Building; and
8. Legislation and Regulation.

Integrated Water Resources Management

Table 35 below lists water resources climate change adaptation strategies under the Integrated Water Resources Management (IWRM) guidelines.

Table 35-Adaptation Strategies for Water Resources Management – Integrated Water Resources Management

Strategy	Objectives	Activities
1.1 Development of a water resources master plan which embodies the principles of the Integrated Water Resources Management (IWRM) approach.	To articulate a national vision for water resources management. To incorporate the principles of IWRM into national water resources planning and management. To account for the projected effects of climate change on water resources over the short, medium and long terms. To account for the projected effects of population change on water resources over the short, medium and long terms. To account for the projected effects of industry and other changes in economic activity on water resources over the short, medium and long terms.	Review and update the existing water resources management plans and reports. Incorporate the projected effects of changes in change, population, the national economy in the plan. Prepare draft water resources master plan. Engage in consultations with relevant stakeholders. Implement the new plan.
1.2 Execution of a national water resources quantification study, including: 1) an assessment of how the quantity of these resources is expected to change over time due to various factors; and 2) an assessment of the economic value of Grenada's water resources.	To estimate the quantity of Grenada's water resources, including surface water, coastal/marine waters and groundwater. To determine how said quantity is expected to change over time based on changes in climate, population and industry. To estimate the economic value of Grenada's water resources.	Engage consultant/s. Review and assess rainfall and surface and groundwater flow data. Review and assess water quality data. Assess current and projected fresh water supply and demand. Estimate the current and future quantity of available

		water resources. Estimate the economic value of Grenada's water resources.
1.3 Implementation of a national water quality monitoring programme for surface, coastal/marine and groundwater	To determine the quality of surface, coastal/marine and groundwater resources. To determine the impact of water quality on the value of water resources.	Engage consultant/s. Collect and analyze water quality samples. Monitor surface water quality via satellite imagery. Produce report on water quality for surface, coastal/marine and groundwater resources.
1.4 The development of IWRM policy papers for each of the following relevant industries, agencies and organisations: • Water utilities • Drainage authorities • Ministries and departments of agriculture • Coastal zone management departments • Private contractors involved in the development and/or maintenance of water resources infrastructure • Private contractors and consultant involved in water resources planning and management • Organisations and businesses who are high-volume users of water resources,	To educate relevant industries, agencies and organisations on IWRM, its principles, and its benefits. To help relevant industries, agencies and organisations to incorporate IWRM principles into their policies and day-to-day operations.	Engage consultant/s. Draft IWRM policy papers for each relevant industry, agency and organisation. Engage in consultations with selected representatives from said industries, agencies and organisations. Finalise IWRM policy papers. Execute workshop to introduce and launch policy papers. This workshop is to be attended by representatives from target industries, agencies and organisations. Distribute policy papers.

including those in the agricultural, manufacturing and tourism sectors.		

Agro-Hydro-Meteorological Monitoring

Table 36 below lists water resources climate change adaptation strategies in the Agro-Hydro-Meteorological Monitoring category.

Table 36-Adaptation Strategies for Water Resources Management – Agro-Hydro-Meteorological Monitoring

Strategy	Objectives	Activities
2.1 The deployment and installation of a catchment-based tipping bucket rain gauge network on a national scale. (Such rain gauge stations should be equipped with temperature, wind and humidity gauges to monitor evaporation.)	To collect reliable rainfall total and intensity data. To reduce reliance on centralized airport gauges, thereby increasing the redundancy of data sources. To improve the resolution of reliable rainfall intensity data at the catchment level and on a national scale. To create data which can be used for: water resources quantification studies, water supply forecasting, drought projections and mitigation, and flood modelling and flood risk assessment. To facilitate the above activities on a catchment-by-catchment basis, which is the prescribed methodology under the IWRM approach.	Develop a deployment plan for the rain gauges. (This activity should be carried out in conjunction with the development of deployment plans for other relevant gauging networks, namely surface water and groundwater gauging networks.) Develop a data management plan for the rain gauges. (This activity should be carried out in conjunction with the development of data management plans for other relevant gauging networks, namely surface water and groundwater gauge networks.) Procure tipping bucket rain gauges. (Gauges must have telemetry capability in order to facilitate data collection in real time.)

		Deploy rain gauges. Collect rainfall data in real time via telemetry, and store in database.
2.2 The deployment and installation of a catchment-based network of surface water flow gauges in the following environments: – Rivers, gullies and streams – Constructed and natural channels – Lagoons and detentions ponds and basins. (Such gauge stations should provide flow/water level data with a minute-by-minute temporal resolution to facilitate the development and validation of hydraulic and hydrologic models, including flood models.)	To collect reliable surface flow data. To facilitate the correlation of surface flow and rainfall data. To create data which can be used for: water resources quantification studies, water supply forecasting, drought projections and mitigation, and flood modelling and flood risk assessment. To facilitate, in particular, the validation of hydraulic and hydrologic models (including flood models). To facilitate the above activities on a catchment-by-catchment basis, which is the prescribed methodology under the IWRM approach.	Develop a deployment plan for surface water flow gauging network. (This activity should be carried out in conjunction with the development of deployment plans for other relevant gauging networks, namely rain gauge and groundwater gauging networks.) Develop a data management plan for surface water flow gauging network. (This activity should be carried out in conjunction with the development of data management plans for other relevant gauging networks, namely rain gauge and groundwater gauge networks.) Procure flow gauges. (Gauges must have telemetry capability in order to facilitate data collection in real time.) Deploy flow gauges. Collect surface flow data in real time via telemetry, and store in database.
2.3 The implementation of a groundwater flow, salinity and quality testing programme at the national scale.	To collect reliable groundwater flow and quality data. To facilitate the monitoring of groundwater salinization and the development of appropriate mitigation plans.	Develop a testing plan for groundwater gauging network. Develop a data management plan for groundwater data. (This activity should be carried out in conjunction with the development of data

	To create data which can be used for: water resources quantification studies, water supply forecasting, and drought projections and mitigation.	management plans for other relevant gauging networks, namely rain gauge and surface flow gauge networks.) Procure groundwater gauges. Deploy gauges. Collect groundwater data, and store in database.
2.4 The deployment and installation of a network of tidal gauges at the national scale.	To facilitate the monitoring of sea-level rise. To facilitate the development of coupled inland and coastal flood models. To create data which can be used for: seal-level and tidal monitoring, and coastal flood modelling and coastal flood risk assessment.	Develop a deployment plan for tidal gauging network. (This activity should be carried out in conjunction with the development of deployment plans for other relevant gauging networks, namely rain gauge and surface flow gauge networks.) Develop a data management plan for tidal gauging network. (This activity should be carried out in conjunction with the development of data management plans for other relevant gauging networks, namely rain gauge and surface flow gauge networks.) Procure tidal gauges. (Gauges must have telemetry capability in order to facilitate data collection in real time.) Deploy tidal gauges. Collect tidal data in real time via telemetry, and store in database.
2.5 The development of a data management framework for hydro meteorological data across	To create a single, common language for metadata creation and data	Engage GIS/data management consultant. Engage in consultations with

public sector bodies.	management. To facilitate more efficient data sharing and management across agencies and departments. To facilitate greater ease of data processing and treatment across agencies and departments.	relevant public sector bodies. Create draft data management framework. Solicit feedback from relevant public sector bodies and test framework as part of a participatory workshop. Implement data management framework.

Flood Mitigation and Flood Risk Management

Table 37 below lists water resources climate change adaptation strategies in the Flood Mitigation and Flood Risk Management category.

Table 37-Adaptation Strategies for Water Resources Management – Flood Mitigation and Flood Risk Management

Strategy	Objectives	Activities
3.1 The systematic collection of rainfall, surface flow and tidal data, and the development of a national database to house said data. (See Strategies 2.1, 2.2 and 2.4 above.)	To develop a robust and reliable database of hydro meteorological data to support drought risk reduction and management. To provide the data necessary to carry out effective flood mitigation and flood risk assessment. (Also see Strategies 2.1, 2.2 and 2.4 above.)	(See Strategies 2.1, 2.2 and 2.4 above.)
3.2 Execution of a national flood modelling, flood risk assessment and flood hazard mapping programme (for urban, fluvial and coastal flooding). (This will rely on data	To determine flood risk and flood extents for events of various recurrence probabilities and for a range of future climate scenarios. To create flood hazard maps for events of various	Engage consultant/s. Assess current hydro meteorological data availability relevant to flood modelling and management. Assess current climate models.

collected as part of Strategies 2.1, 2.2 and 2.4 above.)	recurrence probabilities and for a range of future climate scenarios. To determine the risks posed by flooding to critical infrastructure, including emergency, transportation, energy and telecommunications infrastructure. To determine the risks posed by flooding to critical industries and their infrastructure. To determine the risks posed by flooding to vulnerable communities. To facilitate the creation of flood evacuation routes and flood rescue plans at the national and district level.	Collect additional data as required. Build and test urban, fluvial and coastal flood models. Validate models against measured data in the field. Produce flood hazard maps. Produce report on national flood modelling, flood risk assessment and flood hazard mapping programme.
3.3 Implementation of flood early warning systems (EWS) for flood-prone areas identified as part of the execution of the above strategy. (This will rely on data collected as part of Strategies 2.1, 2.2 and 2.4 above.)	To improve the preparedness for and response to floods in flood-prone areas.	Engage consultant. Prioritise at-risk areas and develop EWS strategy Procure EWS equipment and instrumentation. Development and test EWS.
3.4 Development of flood response and recovery plans for flood-prone areas. (This will rely on data collected as part of Strategies 2.1, 2.2 and 2.4 above.)	To improve the response to and recovery from floods in flood-prone areas.	Assess the results of national flood modelling, flood risk assessment and flood hazard mapping programme. Determine flood evacuation routes. Develop plans for the removal

		of flood waters after extreme events. Develop clean-up plans for severe flooding. Finalise comprehensive flood response and recovery plans.
3.5 Inclusion of flood risk reduction measures as part of the national development process, including the drafting and enforcement of legislation: 1) restricting development in flood-prone areas; 2) requiring the preservation of drainage reserves; and 3) limiting the percentage of impermeable area created during new development.	To facilitate the inclusion of flood risk reduction measures the national development planning process. To restrict unconscientious development in flood-prone areas (see point 1). To restrict the filling and/or blocking of natural drainage channels and retention/detention basins, thereby limiting the flood risk impact of new development (see point 2). To reduce the amount of surface runoff produced by new development projects, thereby limiting the flood risk impact of new development (see point 3).	Engage consultant/s. Assess the results of national flood modelling, flood risk assessment and flood hazard mapping programme. Prepare draft legislation. Finalise legislation through a consultative process. Facilitate training for enforcement officers. Enforce legislation.
3.6 Carry out a national assessment of socio-economic vulnerability to flooding.	To determine the relative vulnerability of various communities to flooding. To facilitate comprehensive flood risk and impact assessment on a national scale.	Engage consultant/s. Carry out assessment via GIS data review, survey questionnaires and public consultations. Produce report on socio-economic vulnerability to flooding.

Drought Mitigation and Drought Risk Management

Table 38 below lists water resources climate change adaptation strategies in the Drought Mitigation and Drought Risk Management category.

Table 38-Adaptation Strategies for Water Resources Management – Drought Mitigation and Drought Risk Management

Strategy	Objectives	Activities
4.1 The systematic collection of rainfall, surface flow and groundwater data. (See strategies 2.1, 2.2 and 2.3 above.)	To develop a robust and reliable database of hydro meteorological data to support drought risk reduction and management. To provide the data necessary to carry out effective drought mitigation and flood risk assessment. (See also Strategies 2.1, 2.2 and 2.3 above.)	(See Strategies 2.1, 2.2 and 2.3 above.)
4.2 The inclusion of projections from the Caribbean Drought and Precipitation Monitoring Network (CDPMN) in the decision-making process for drought mitigation and drought risk management.	To incorporate useful information from the Caribbean Institute for Meteorology and Hydrology's (CIMH) CDPMN water resources decision making. To facilitate effective planning and management.	Engage CIMH. Facilitate the training of technical staff in the interpretation of data, and the translation of information into effective drought management actions. Include projections in drought mitigation and drought risk management on a systematic basis.
4.3 Execution of a national groundwater study. (This will rely on data collected as part of Strategies 2.1, 2.2 and 2.3 above.) (This strategy is to be execution in conjunction with Strategies 1.2 and 1.3	To determine the quantity of available groundwater resources, and how this quantity is likely to change over time due to climate change and changes in fresh water demand. To map the saltwater-freshwater interface at strategic locations, particularly	Engage consultant/s. Assess current hydro meteorological data availability relevant to the groundwater study. Assess current climate models. Collect additional data as

above.)	at and in the vicinity of wells near to the coast. To determine threshold pumping rates at key wells, with a view to reducing the incidence and severity of saltwater intrusion. To develop a long-term plan for the exploration and exploitation of new groundwater extraction points. To develop a groundwater model to assist in the decision-making process for groundwater management and saltwater intrusion mitigation.	required. Build and test groundwater model/s. Validate model/s against measured data in the field. Produce diagrammatic outputs, including groundwater contours, saltwater-freshwater interface maps, maps of the potentiometric surface of both saline water and freshwater, etc. Produce report on national groundwater study.
4.4 The exploration of groundwater extraction points at higher elevations. (This strategy is to be execution in conjunction with Strategy 2.3 above.)	To increase the water supply. To increase the redundancy of the water supply network. To reduce the incidence and severity of saltwater intrusion.	Engage consultant/s. Procure groundwater gauges. Deploy gauges. Collect groundwater data, and store in database. Assess and prioritize new extraction points. Develop plan for the exploitation of new groundwater extraction points.
4.5 The exploration of storm water, rainwater and greywater harvesting and reuse as an alternative means of potable and non-potable water supply augmentation.	To ascertain the suitability and potential yield of these alternatives, non-traditional sources, with the view to reducing demand on existing water sources.	Engage consultant/s. Assess the potential of storm water, rainwater and greywater harvesting and reuse for water supply augmentation, including for potable and non-potable reuse. Assess, in particular, the potential yield of these

		approaches. Engage in consultations with potential users, including the general public and the hospitality, tourism and food sectors in particular. Incorporate the concerns of potential users into the overall strategy. Develop appropriate water quality standards and quality control measures. Produce report on the potential exploitation of storm water and wastewater harvesting reuse for water supply augmentation.
4.6 The exploration of wastewater harvesting and reuse as an alternative means of non-potable water supply augmentation.	To ascertain the suitability and potential yield of wastewater harvesting for non-potable agricultural reuse in particular, with the view to reducing demand on existing sources used for farming.	Engage consultant/s. Assess the potential of wastewater harvesting and reuse for non-potable agricultural use. Assess, in particular, the potential yield of this approach. Engage in consultations with potential primary users, including farmers. Engage in consultations with potential consumers of food crops produced by the proposed means, including the general public, and the hospitality, tourism and food sectors in particular. Incorporate the concerns of

		potential users and consumers into the overall strategy. Develop appropriate water quality standards and quality control measures. Produce report on the potential exploitation of storm water and wastewater harvesting reuse for water supply augmentation

Water Supply and Demand Management

Table 39 below lists water resources climate change adaptation strategies in the Water Supply and Demand Management category.

Table 39-Adaptation Strategies for Water Resources Management – Water Supply and Demand Management

Strategy	Objectives	Activities
5.1 Implementation of a national education-centered water demand management programme focused on the reduction of water wastage and overall water usage in all sectors. (See Strategy 7.1 below.)	(See Strategy 7.1 below.)	(See Strategy 7.1 below.)
5.2 Installation of 'smart' water meters for water for high-volume users of water resources, including those in the agricultural, manufacturing and tourism sectors.	To monitor, in real time, the use of fresh water resources by high-volume users. To determine the impact of high-volume users on overall water supply. To facilitate the development of strategies for water conservation.	Publish tender notice for meters. Engage tenderers/suppliers. Produce meters install meters. Collect data.
5.3 Installation of 'smart'	To monitor, in real time, the	Publish tender notice for

water meters at the individual customer level, along distribution lines, and on storage infrastructure.	use and transportation of fresh water resources. To determine the relative use of water resources by district, industry and socio-economic grouping. To facilitate the development of strategies for water conservation.	meters. Engage tenderers/suppliers. Produce meters install meters. Collect data.
5.4 Incentivising the use of water-efficient fixtures on residential, commercial and industrial properties. (See also Strategy 7.1 below.)	To reduce the use and therefore overall demand for water resources. To serve as a complementary strategy to, and therefore work in tandem with, Strategy 5.1/7.1.	(See Strategy 7.1 below.)
5.5 Execution of a national fresh water demand forecasting project, disaggregated by metering district and industry.	To determine the future use of fresh water resources in the country's various metering districts and by its various industries. To facilitate effective planning for future fresh water resources demand.	Engage consultant/s. Assess the results of national water resources quantification study. Estimate future water supply under a range of climate and economic scenarios. Assess projection trends for population growth and economic activity. Estimate future water usage under a range of population growth and economic scenarios. Produce report on future national fresh water demand.

Infrastructure, Development and Planning

Table 40 below lists water resources climate change adaptation strategies in the Infrastructure, Development and Planning category.

Table 40-Adaptation Strategies for Water Resources Management – Infrastructure, Development and Planning

Strategy	Objectives	Activities
6.1 The strategic construction of storm water retention and detention structures	To reduce the volume of surface runoff generated from rainfall and therefore the incidence flooding during high-intensity storms. To reduce the storm water load on downstream drainage networks, particularly in heavily-populated urban environments. To reduce the impact of contaminated surface water flows on receiving coastal environments.	Engage consultant/s. Assess the results of national flood modelling, flood risk assessment and flood hazard mapping programme. Strategically locate storm water retention and detention structures. Carry out preliminary designs of structures. Carry out environmental impact assessment for the proposed works. Carry out detailed designs of structures. Publish tender for the construction of structures. Construct structures. Routinely monitor water levels, flow and water quality at structures.
6.2 The drafting and enforcement of legislation: 1) restricting development in flood-prone areas; 2) requiring the preservation of drainage reserves; and 3) limiting the percentage of	(See Strategy 3.5 above.)	(See Strategy 3.5 above.)

impermeable area created during new development.		
6.3 Revision of building codes to require the storage of a certain percentage of surface runoff on-site for new and existing development.	To reduce the volume of surface runoff generated from rainfall and therefore the incidence flooding during high-intensity storms. To reduce the storm water load on downstream drainage networks, particularly in heavily-populated urban environments. To reduce the impact of contaminated surface water flows on receiving coastal environments.	Engage consultant/s. Review existing building codes relative to drainage and flood management. Assess the results of national flood modelling, flood risk assessment and flood hazard mapping programme. Determine the percentage surface runoff to be retained on-site for new and existing development, based on the relative flood risk within reach catchment area. Revise building codes.

Education and Capacity Building

Table 41 below lists water resources climate change adaptation strategies in the Education and Capacity Building category.

Table 41-Adaptation Strategies for Water Resources Management – Education and Capacity Building

Strategy	Objectives	Activities
7.1 Execution of a national public education and awareness-building programme to reduce water wastage and overall water usage.	To educate the public on the value of water. To educate the public on strategies to reduce the overall use and wastage of water, including on residential, commercial and industrial properties. To positively influence public	Select a focus group and determine existing public perception/knowledge of water resources and water availability/scarcity. Ascertain gaps in perception/knowledge. Develop and execute educational programme.

	water usage behaviour. To educate the public on the applications and benefits of water-efficient fixtures, and thereby incentivise their use on residential, commercial and industrial properties. To reduce the use and therefore overall demand for water resources.	Assess the impact of the programme through consultations with focus group.
7.2 Execution of a national public education programme to build public awareness of the projected effects of climate change on water resources, including fresh water availability, water quality and flood risk.	To educate the public on climate change and its projected impacts on water resources. To positively influence public water usage behaviour. To reduce the use and therefore overall demand for water resources.	Select a focus group and determine existing public perception/knowledge of climate change and its project impacts on water availability, water quality and flood risk. Ascertain gaps in perception/knowledge. Develop and execute educational programme. Assess the impact of the programme through consultations with focus group.
7.3 Execution of a national training programme for farmers, focused on IWRM.	To share knowledge on IWRM. To educate on the harmful impacts of excessive chemical usage on receiving water quality and public health. To promote and facilitate livelihoods adaptation. To promote water conservation in farming practice. To reduce the negative impacts of farming on water resources.	Engage in consultations with farmers. Determine existing perception/knowledge of IWRM and ascertain gaps in knowledge. Develop and execute training programme. Assess the impact of the programme through follow-up consultations.

7.4 Execution of a national training programme on IWRM for technical professionals in the construction, engineering, architecture, planning, water resources management fields.	To share knowledge on IWRM. To promote and facilitate water-sensitive and flood-resilient development planning. To reduce the negative impacts of construction and development on water resources.	Engage in consultations with technical professionals. Determine existing perception/knowledge of IWRM and ascertain gaps in knowledge. Develop and execute training programme. Assess the impact of the programme through follow-up consultations.
7.5 The updating of job descriptions across the water resource managements-related fields within the public sector.	To assess the human resources capacity in the water resources management field across the public sector. To reduce duplication of effort across the public sector, particularly in water resources management. To improve efficacy and efficiency across the sector.	Carry out a situational analysis of current water resources management human resources within the public sector. Assess the capacity of these professionals to address current and projected challenges in water resources management. Identify areas of duplication of effort. Combine and/or separate roles as appropriate to improve efficacy and efficiency.

Legislation and Regulation

Table 42 below lists water resources climate change adaptation strategies in the Legislation and Regulation category.

Table 42-Adaptation Strategies for Water Resources Management – Legislation and Regulation

Strategy	Objectives	Activities
8.1 The drafting and enforcement of legislation requiring the sharing of	To avoid duplication of effort and expenditure in data collection and management by	Engage consultant/s.

environmental data across public sector agencies.	Government. To facilitate a collaborative, multidisciplinary approach to data management across Government. To facilitate the creation of cross-agency databases for environmental and natural resources management.	Prepare draft legislation. Finalise legislation through a consultative process. Facilitate training for enforcement officers. Enforce legislation.
8.2 The drafting and enforcement of legislation: 1) restricting development in flood-prone areas; 2) requiring the preservation of drainage reserves; and 3) limiting the percentage of impermeable area created during new development.	(See strategy 3.5 above.)	(See strategy 3.5 above.)
8.3 The drafting and enforcement of legislation defining standards for drinking and recreational/bathing water quality.	To protect consumers and users from harmful contaminants and toxins in water.	Engage consultant/s. Assess the results of the national water quality monitoring programme. Prepare draft legislation. Finalise legislation through a consultative process. Facilitate training for enforcement officers. Enforce legislation.
8.4 The drafting and enforcement of legislation defining standards for wastewater and industrial effluent quality.	To protect receiving surface, sub-surface and coastal waters from contamination. To protect aquatic flora and fauna in receiving environments. To protect recreational users	Engage consultant/s. Assess the results of the national water quality monitoring programme. Prepare draft legislation. Finalise legislation through a consultative process.

	of at-risk coastal waters.	Facilitate training for enforcement officers. Enforce legislation.
8.5 The drafting and enforcement of legislation requiring the development of a water resources master plan every ten years.	To update the national water resources management strategy in consideration of the impact of changes in climate, population and physical infrastructure development, as well as in light of the anticipated development of new approaches and methods for water resources management.	(See strategy 1.1 above.)
8.6 Drafting and execution of legislation of a national water resources quantification study every ten years.	To update national knowledge on the quantity, quality and value of available water resources.	(See strategy 1.2 above.)
	To periodically update national knowledge on flood risk in consideration of the impact of changes in climate and physical infrastructure development.	(See strategy 3.2 above.)

3.4 AGRICULTURE

3.4.1 Methodology

This section relies on high spatial resolution environmental data to characterize climate impacts and secondary information to highlight climate conditions and their impacts on agriculture in Grenada. The use of high spatial resolution environmental data was dictated by the unavailability of high quality and long-term weather station observations. Throughout this section, the term “estimate” is prescribed to all gridded data in order to not confuse actual weather station data with modelled or satellite-derived data. However, for these purposes, gridded estimates represent observed conditions very well.

Rainfall estimates for the island of Grenada are derived from the Climate Hazards Group Infrared Precipitation with Station data (CHIRPS). CHIRPS spans all longitudes from 50^0 S to 50^0 N and is available at daily resolution from 1981 to present with a 0.05 degree spatial resolution. Monthly averages, monthly climatologies, monthly anomalies, and annual totals are all aggregated from daily CHIRPS rainfall data. Monthly climatologies are calculated by averaging all days for each month while monthly anomalies are calculated by subtracting the monthly climatology from the monthly total. Seasonal totals (February-April and June-August), annual totals and 12-month running rainfall means along with seasonal trends are all calculated from the monthly rainfall aggregate. Monthly rainfall boxplots are developed to analyse interannual rainfall comparisons. Interdecadal rainfall variability is analysed through calculating a 10-year running mean. Twelve (12) pixels from the CHIRPS dataset cantered over Grenada were used for the rainfall analysis.

The Standardized Precipitation Index (SPI), a rainfall derived drought index, is calculated from CHIRPS monthly rainfall estimates throughout the 1981-2016 study period. Both the SPI-3 (SPI calculated at a 3-month rainfall timescale) and the SPI-7 (SPI calculated at a 7-month rainfall timescale) are used to assess drought at different time scales and for different hydrologic applications.

The primary source for temperature and soil moisture analysis is derived from the Modern Era Retrospective-Analysis for Research and Applications (MERRA) from NASA. MERRA monthly temperature and soil diagnostic products are available at a 0.5 x 0.66 degree spatial resolution and span from 1979 to present. Like rainfall aggregates described above, similar temporal time scales are aggregated from the monthly scale to analyse interannual variability, monthly anomalies, trends, and seasonality.

Again, due to the limitation of available station data, PE is analysed from the NOAA NCEP-NCAR CDAS-1 MONTHLY diagnostic reanalysis gridded product. The spatial resolution for PE in this study is 1.875 degrees, which extends beyond the limits of Grenada, but can still be used to analyse the atmospheric moisture demands. The seasonal cycle, monthly anomalies, and 12-month running averages are calculated from the monthly PE time series in the same manner as rainfall.

The NASA Aqua-MODIS satellite provides derived Normalized Difference Vegetation Indices (NDVI), a proxy for vegetation productivity that measures chlorophyll content, at a 250-meter spatial resolution. Individual NDVI grids are mapped at monthly scales and are also aggregated to the seasonal scale to describe seasonal differences in chlorophyll activity. The seasonal cycle of NDVI, or the NDVI monthly climatology, is calculated from the monthly scale by following the same procedure as rainfall described above. Aqua-MODIS-derived NDVI is available at a 16-day temporal resolution, known as a granule. Two granules per month are averaged to calculate the monthly NDVI average. Approximately 5,000 pixels from the Aqua-MODIS derived NDVI were used in the vegetation analysis.

3.4.2 Climate Impacts Assessment

Overview

Climate change threatens to progressively deteriorate food supply and economic growth in complex ways across Grenada and the wider Caribbean. The potential for intensifying impacts and vulnerability has contributed to growing concerns about the long-term effects of climate change on the agricultural sector food security, livelihoods of the poor and other vulnerable populations in Grenada. In Carriacou, the agriculture sector is small (3.8% of Agriculture GDP). The sector depends on rainwater catchment techniques during the wet season to irrigate the farms. However during the dry seasons, farmers generally do not operate due to insufficient water supply. Understanding how local climate and other environmental variables (e.g. rainfall, temperature, potential evapotranspiration, vegetation and soils) are changing is therefore an absolute imperative.

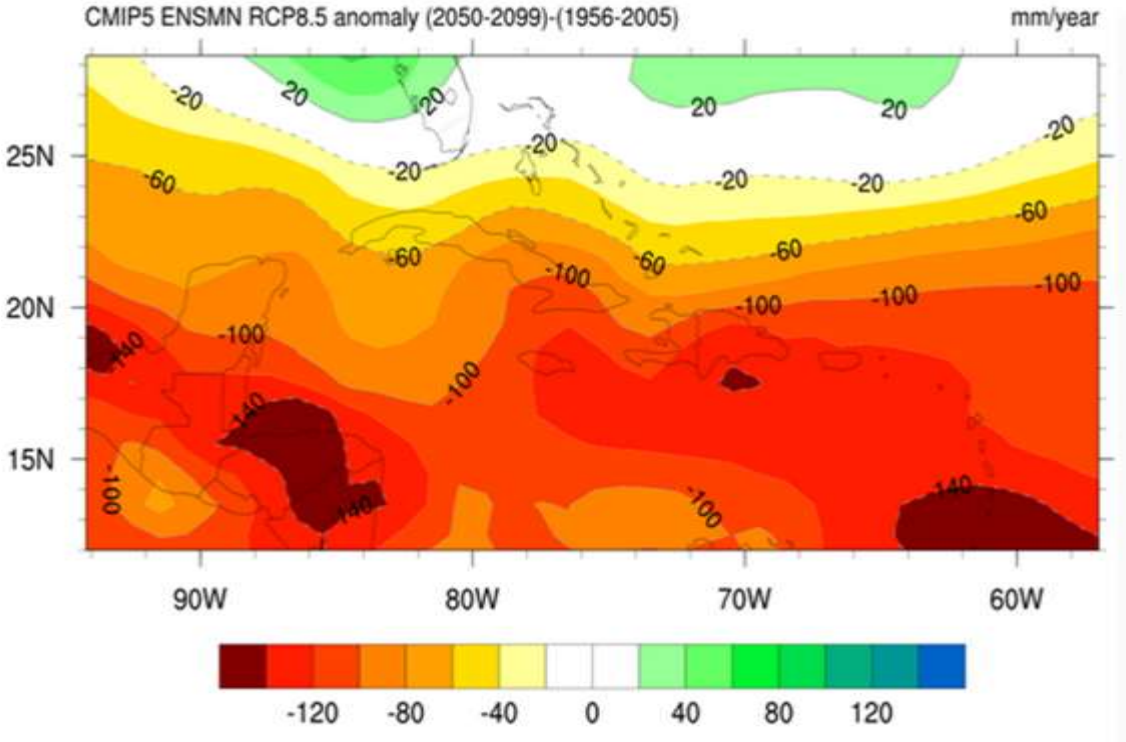


Figure 48-End of century projected rainfall anomaly outlook in units of mm/year.

The projected annual rainfall throughout the Caribbean, based on an ensemble of global climate models (The Coupled Model Intercomparison Project Phase 5, CMIP 5), is forecasted to be drier than normal by the end of the 21st century (up to 140 mm less than current annual averages near Grenada) (Figure 48). However, the majority of projected annual decrease in rainfall, about 50%, is expected to occur during the wet season when the projected decrease in seasonal rainfall is expected to be 60 mm (Figure 49) Annual and seasonal projected trends for the Caribbean basin averaged rainfall are illustrated in Figure 50. It is apparent that the annual drying will be most felt during the normally wet months.

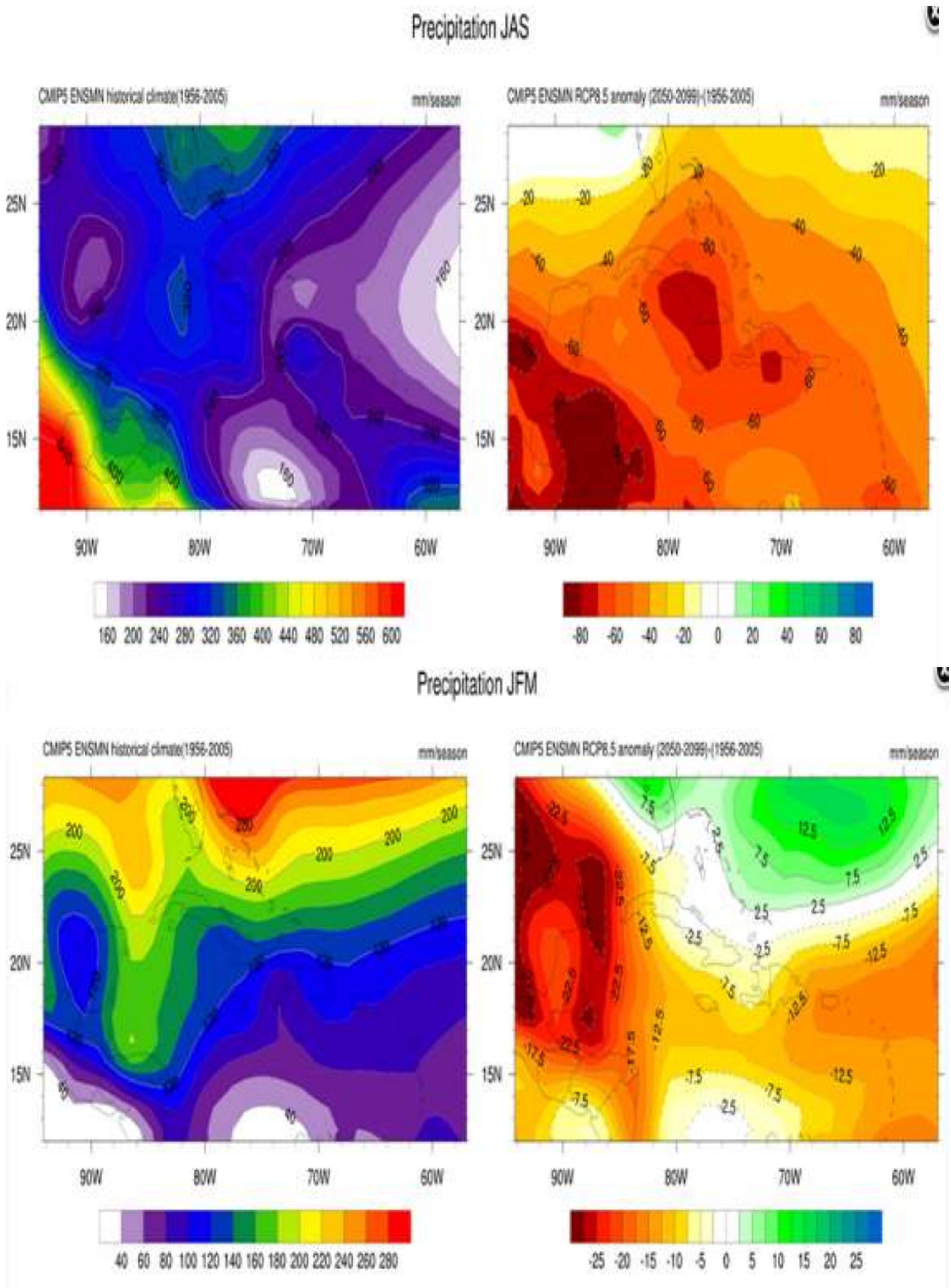


Figure 49-Climatology of dry season rainfall (top left) (January-March) and the projected end of century anomalies (top right) with corresponding wet season (July-Sept) (bottom).

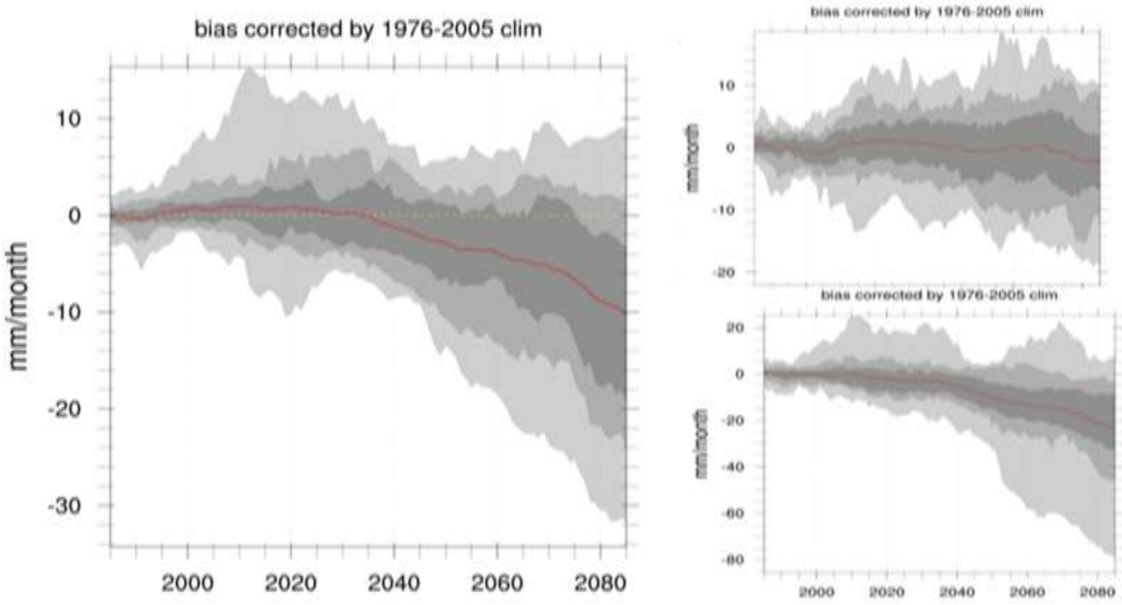


Figure 50-Annual projection in Caribbean rainfall (left) with January (top) and July (bottom) projections (right).

Note difference in scales. Grey areas represent 100%, 80%, and 50% of CMIP5 ensemble models. The average of all CMIP5 ensemble models is represented by the red curve.

Projected changes in annual temperatures are large and show very little seasonal deviation of only about 0.5^{0}C difference between a warmer wet season versus that of the dry season (Figure 51).

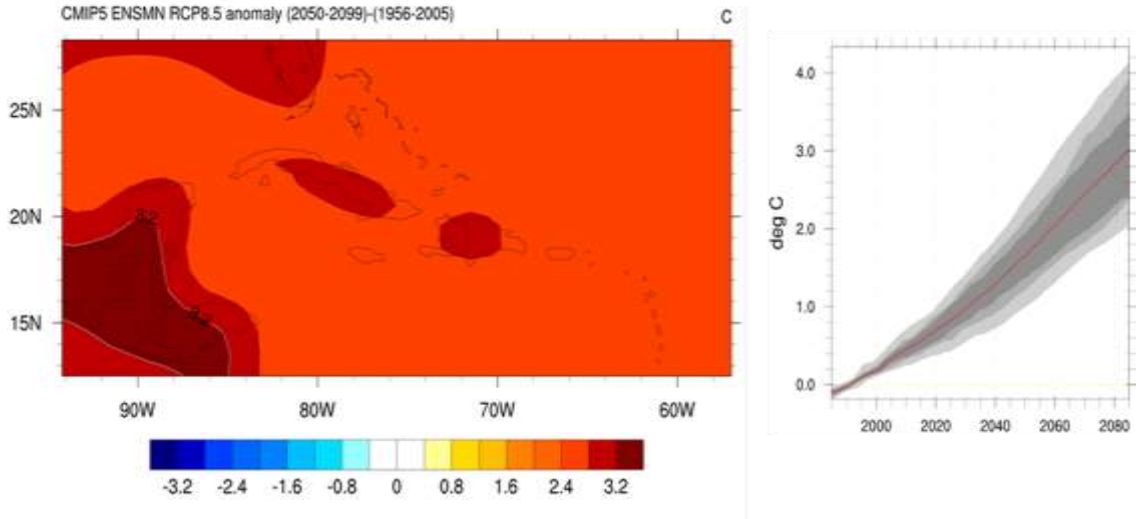


Figure 51-Projected annual surface air temperature anomalies for the end of the 21st century (left).

Grey areas represent 100%, 80%, and 50% of CMIP5 ensemble models (right). The average of all CMIP5 ensemble models is represented by the red curve.

In the absence of historical meteorological station based observations, a homogeneous and long-term modern reanalysis gridded dataset can be used to estimate the average meteorological conditions for Grenada. The Climate Hazards Group Infrared Precipitation with Station data (CHIRPS) starting in 1981, incorporates 0.05° spatial resolution satellite imagery with in-situ station data to create gridded rainfall time series for trend analysis and seasonal drought monitoring. CHIRPS rainfall data are analyzed at the monthly time scale for the purposes of the climate assessment for this subcomponent. The Modern Era Retrospective-Analysis for Research and Applications (MERRA) from NASA is used as the primary source for temperature and soil property analysis.

Rainfall Analysis (1981-2016)

Grenada is one of the driest and water-stressed countries in the Caribbean (CARICOM, 2002; World Bank, 2012). Rainwater run-off is the main source of freshwater: therefore a reduction of the levels of rainfall will impact the availability of water for agricultural purposes (UNDESA, 2012).

Historically, ample rainfall amounts have contributed to favourable crop growth and yields. The seasons are demarcated more by variations in rainfall than in temperature that does not vary significantly over the course of the year (Figure 52).

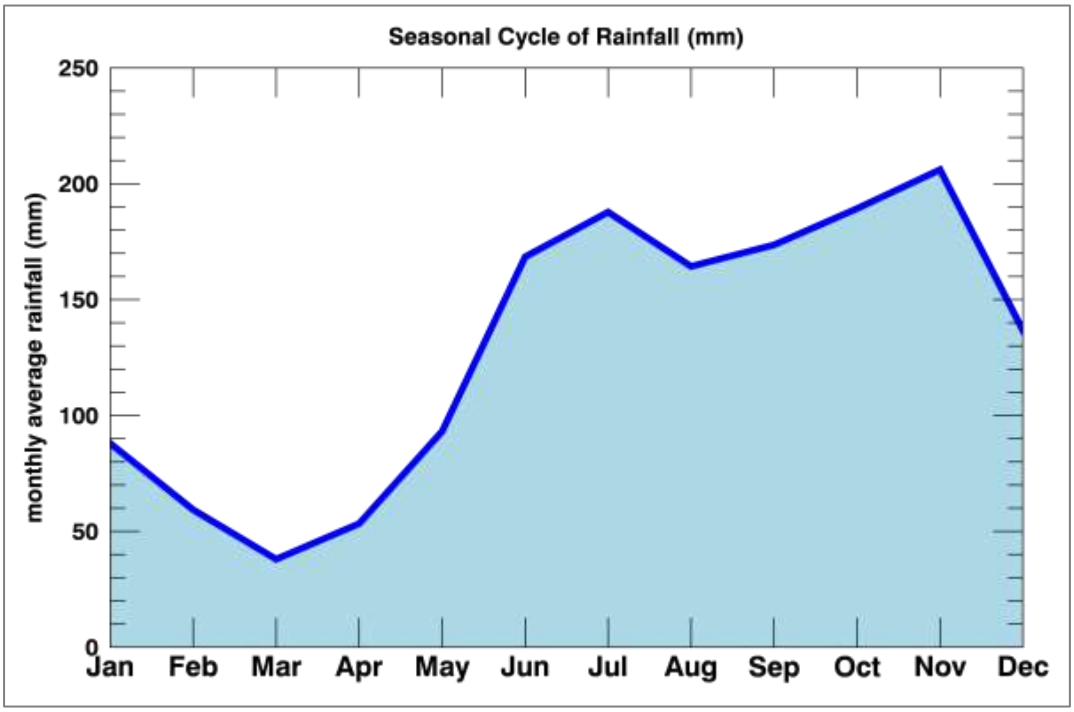


Figure 52-Seasonal Cycle of Rainfall

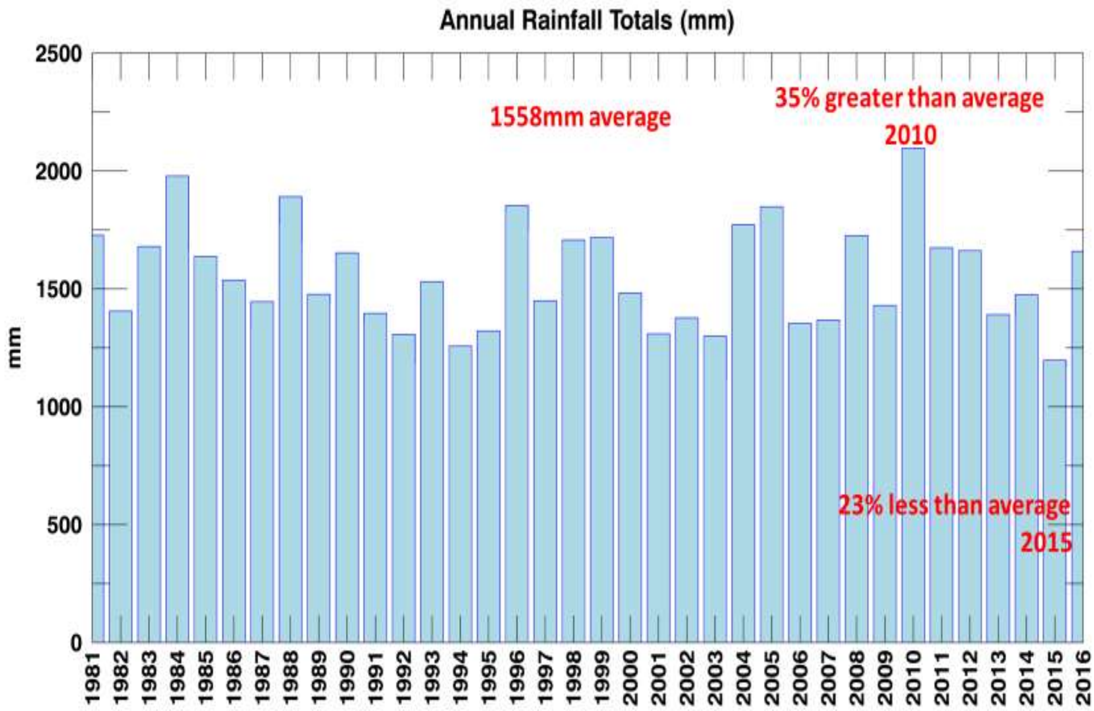


Figure 53-Annual Rainfall Totals (1981-2016)

In addition to higher rainfall totals, the wet season also exhibit greater variability in monthly rainfall compared to the dry season. Dry season rainfall may vary by 80 mm whereas during the wet months rainfall variability upwards of 250 mm is common (Figure 53). Wet season inter-annual variability can cause the strongest shocks to the agricultural sector. Rainfall inter-annual variability during the dry represents a period of weak shock for agriculture. The inter-annual variability and seasonal cycle are evident in the monthly rainfall time series (Figure 54). Monthly rainfall anomalies are calculated from the difference between the monthly time series and the seasonal rainfall cycle and highlight periods of prolonged wet and dry phases for the years 1981-2017 (Figure 55).

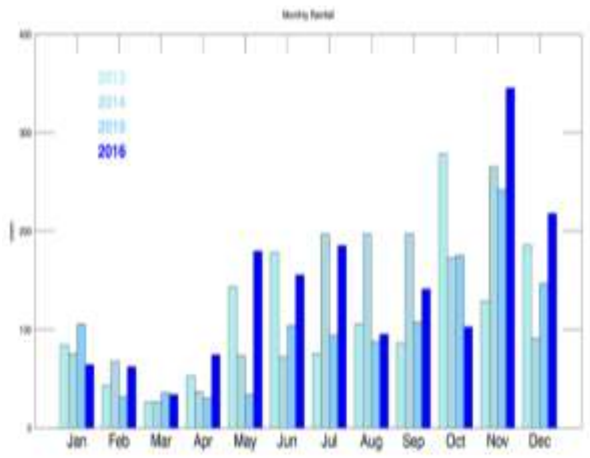


Figure 54-Monthly rainfall time series for 2013-2016

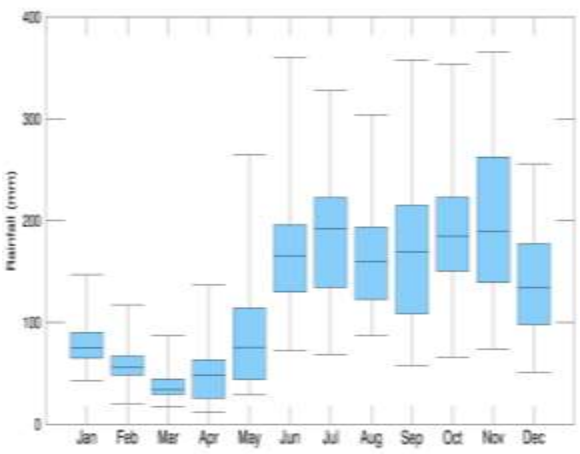


Figure 55-Monthly rainfall variability (1981-2016)

The seasonal rainfall time series (Figure 56 and Figure 57) shows the differences in inter-annual rainfall variability between the wet season and dry season: variability during the wet season is more pronounced.

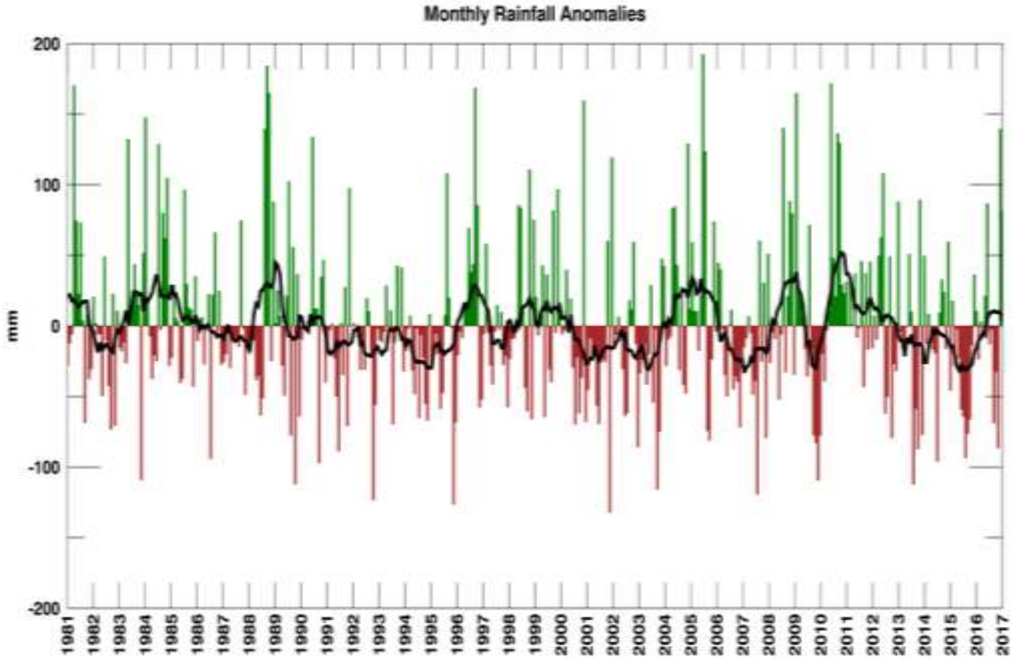


Figure 56-Monthly rainfall anomalies and 12-month running average (black), left for 1981-2017

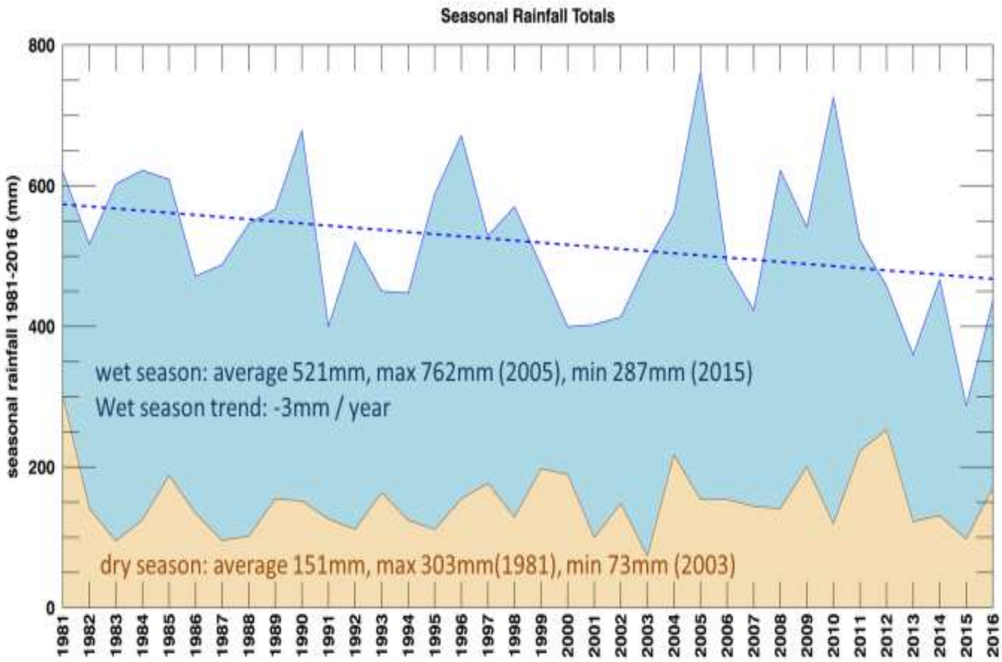


Figure 57-Seasonal Rainfall Totals (1981-2016)

The Standardized Precipitation Index (SPI) is a widely used index to characterize meteorological drought on a range of timescales. On short timescales, the SPI is closely related to soil moisture, while at longer timescales, the SPI can be related to groundwater and reservoir storage. For Grenada, both the SPI-3 (SPI calculated at a 3-month rainfall timescale) and the SPI-7 (SPI calculated at a 7-month rainfall timescale) show values indicating extreme dryness (SPI <-2.0) (Figure 58). Likewise, the SPI-7 for 2010 describes a period of extreme wetness (SPI>2.0).

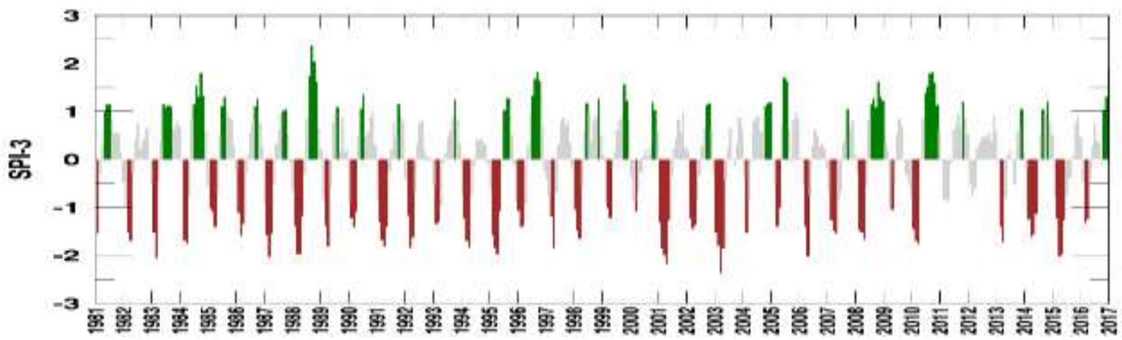


Figure 58-SPI-3 monthly time series

Temperature Analysis (1981-2016)

The annual surface temperature cycle in Grenada is ideal to support tropical agriculture. The vegetation thrives in warm conditions throughout the year that supports a year-round growing season (Figure 59).

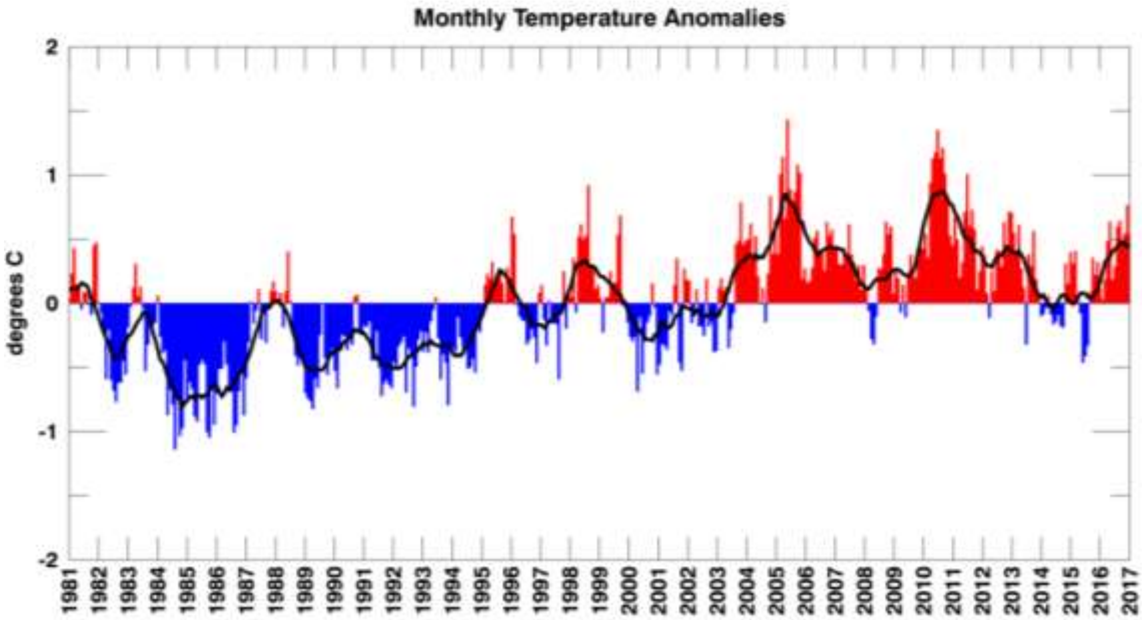


Figure 59-Monthly surface temperature anomaly time series with a 12-month running mean (black). Red colours represent positive anomalies (warmer) and blue colours represent negative anomalies (cooler).

Evaporation/ Potential Evaporation

There are no significant trends in monthly surface evaporation for Grenada although there are cycles in the surface evaporation record (Figure 60).

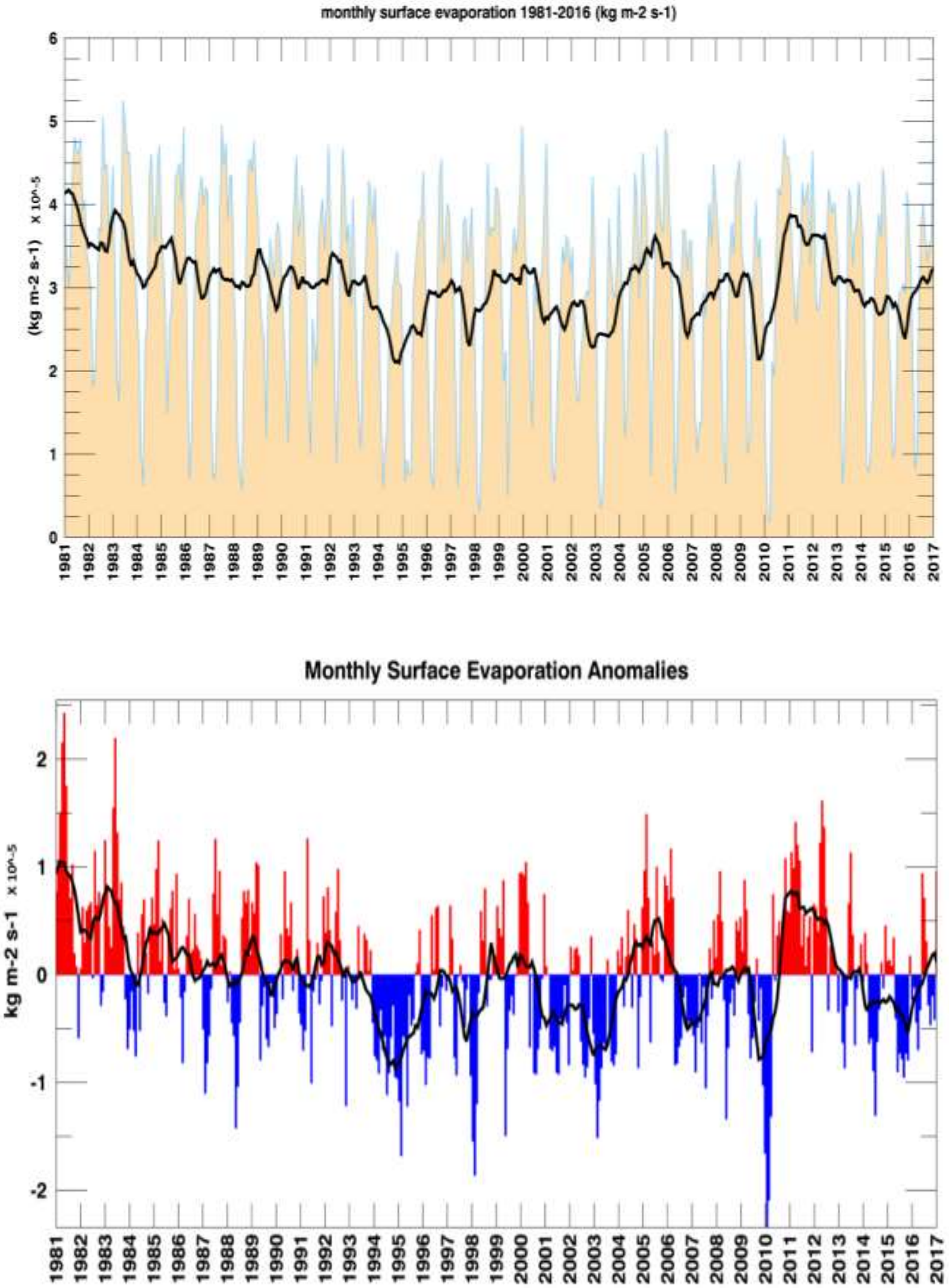


Figure 60-(top) Monthly surface evaporation time series observations and 12-month average (black curve) and anomalies (bottom).

Vegetation Analysis

Variations in rainfall and PE have direct impacts on variations in vegetation growth and hence agricultural production. The NASA MODIS sensor measures spectral reflectance from the earth's surface via satellite to derive vegetation indices that estimate the amount of chlorophyll in vegetation. One widely used vegetation index is the Normalized Difference Vegetation Index (NDVI) that ranges from -1 to 1 where values less than 0 are bare soil and values closer to 1 indicate active chlorophyll presence in plants and hence conditions favourable for crop growth and yields. NDVI in Grenada has about a 2-3 week lagged response to rainfall (Figure 61).

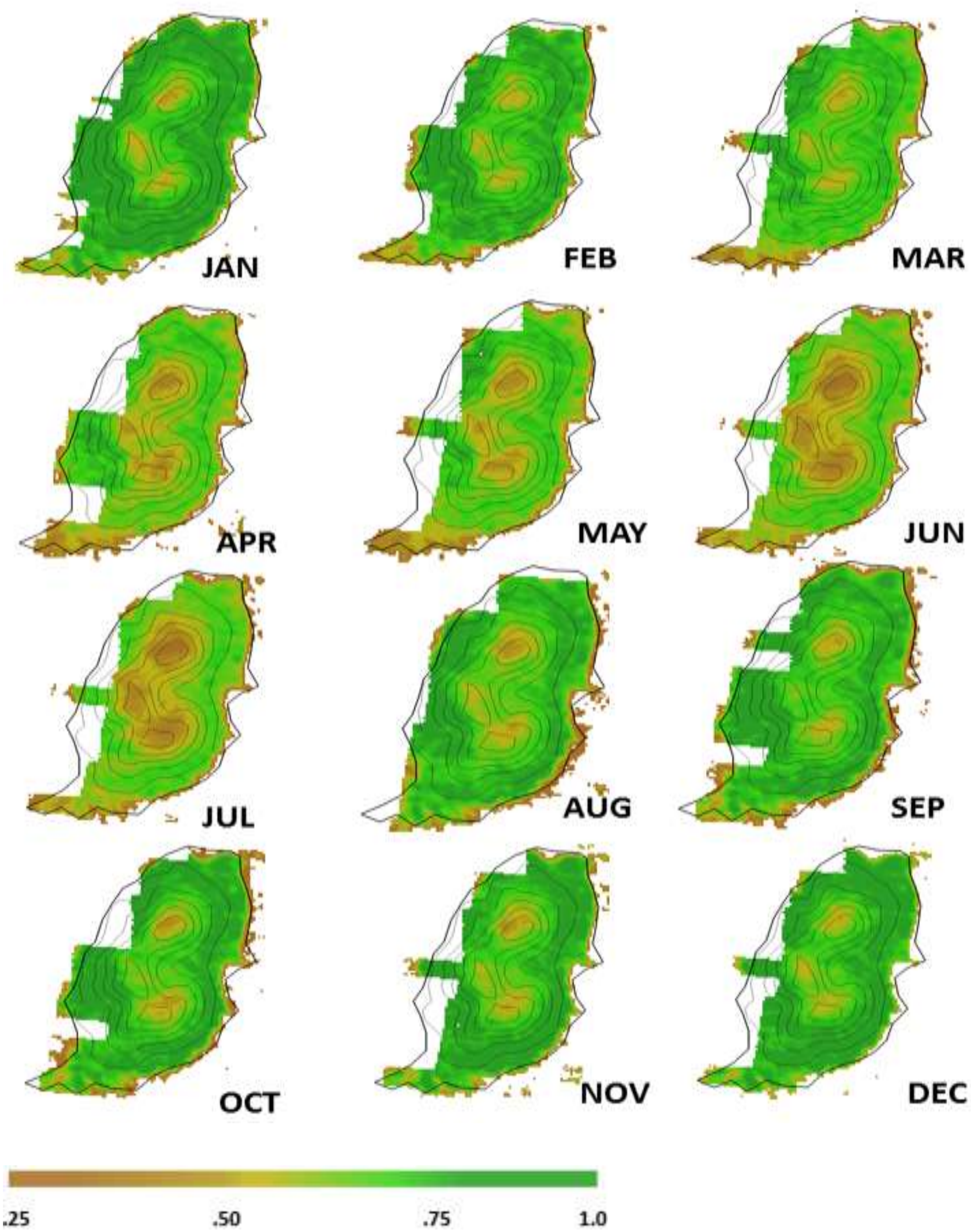


Figure 61-Monthly NDVI averages (colours) with elevation contour (black)

The island-wide NDVI minimum occurs from April to July and on average and begins to increase in August. Seasonality in NDVI is more apparent from the seasonal NDVI differences between the late spring and late wet season period (Figure 62).

The effects of severe wet and dry years on NDVI is seen from the previously describe analogue wet 2010 and dry 2015 years (Figure 63). While many factors contribute to changes in NDVI (leaf defoliation, urbanization, drought, fires, etc.), the changes in remotely sensed vegetation vigour show the largest differences occur in the interior of the island.

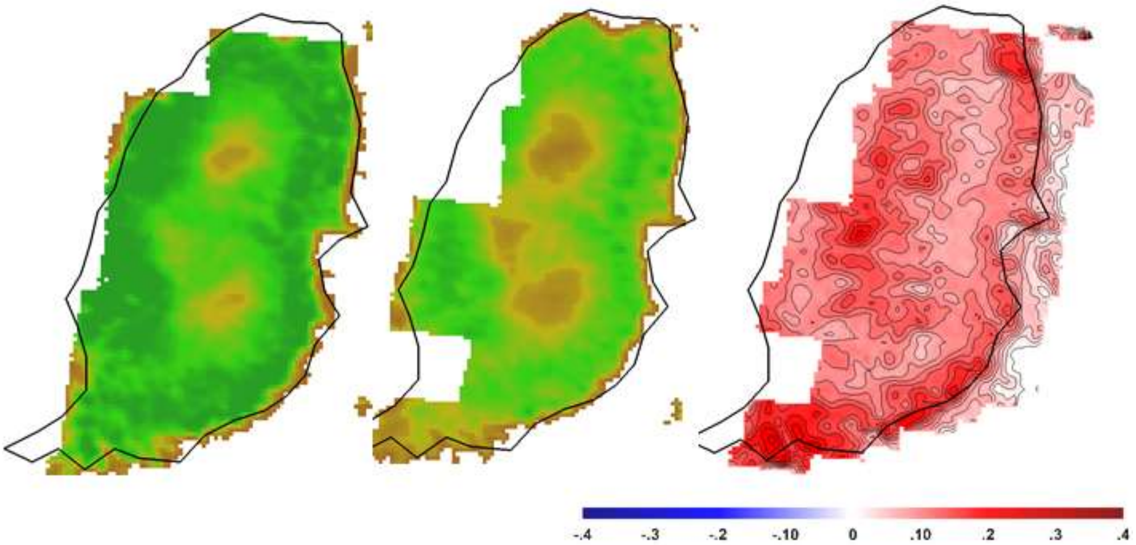


Figure 62-August-September-October (ASO) NDVI average (left), April-May-June (AMJ) NDVI average (middle), and the difference between ASO and AMJ. Black contours are differences at 0.02 interval contours.

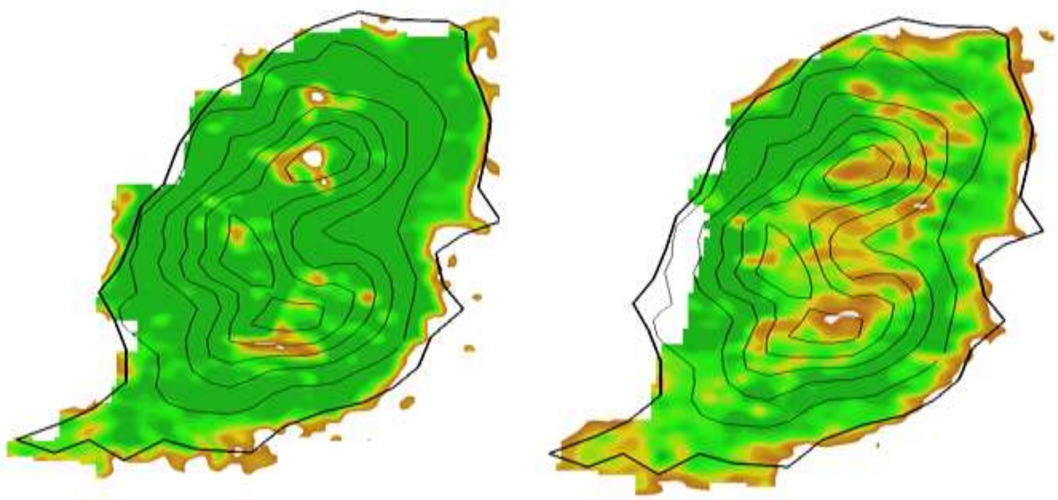


Figure 63-NDVI for the wet September 2010 (left) and the dry September 2015 (right). Elevation contours in black.

3.4.3 Social Impacts Assessment

Despite the sector's low contributions to GDP and the reliance on food imports, agriculture is a significant source of local food supply and plays a major role in economic growth and diversification in Grenada. Grenada is a net importer of food, and climate change impacts in supply countries will affect the price and availability food. Local farmers are already feeling the effects of climate change that is affecting domestic food production and food security. For example, periods of drought, have had a devastating impact on livelihoods within the agriculture industry. Periods of drought require irrigation for continued yields and moderate levels of production and if not would result in extensive crop losses.

The Government of Grenada has identified the agriculture sector as one of the pillars of the national economy. Despite accounting for 6.2% of Grenada's GDP in 2015, agriculture makes a significant contribution to the livelihoods of many rural people and makes up almost 40% of total land use. The principal exports include nutmeg, cocoa, mace, cinnamon, banana, mango, and avocado. Grenada's agricultural sector is highly vulnerable to the existing climate variability and is susceptible to extended periods of drought and hurricanes. Hurricane intensity is likely to increase an average 8% for every 1°C of Sea Surface Temperatures (SST), according to recent projections (Caribsave 2012). The north-eastern region of Grenada is known to experience drought or prolonged dry spells, adversely affecting the yields of crops that are not grown under irrigation (Caribsave 2012).

The end of century climate projection for the Caribbean shows a consistent drying trend across many different models and global warming scenarios in agreement with historically observed trends of increased temperatures in Grenada. Drier conditions will be the result of an increase in mean annual temperature combined with reduced precipitation. Future precipitation reduction is expected throughout the year over Grenada with good agreement across climate models. Larger precipitation reductions are expected between June and August. Although evidence of the anthropogenic influence on historical trends of cyclonic activity is inconclusive, future scenarios at the global scale agree on an increase of intensity (by 2-11%) and a reduction in frequency (by 6-34%), with large discrepancies between regional projections.

A thriving tourism sector influences productivity in related sectors such as agriculture. Estimated GDP values for 2013 show that the agriculture sector had fallen behind; its share of the GDP declined by 40 percent when compared to the year 2000 values (Figure 64).

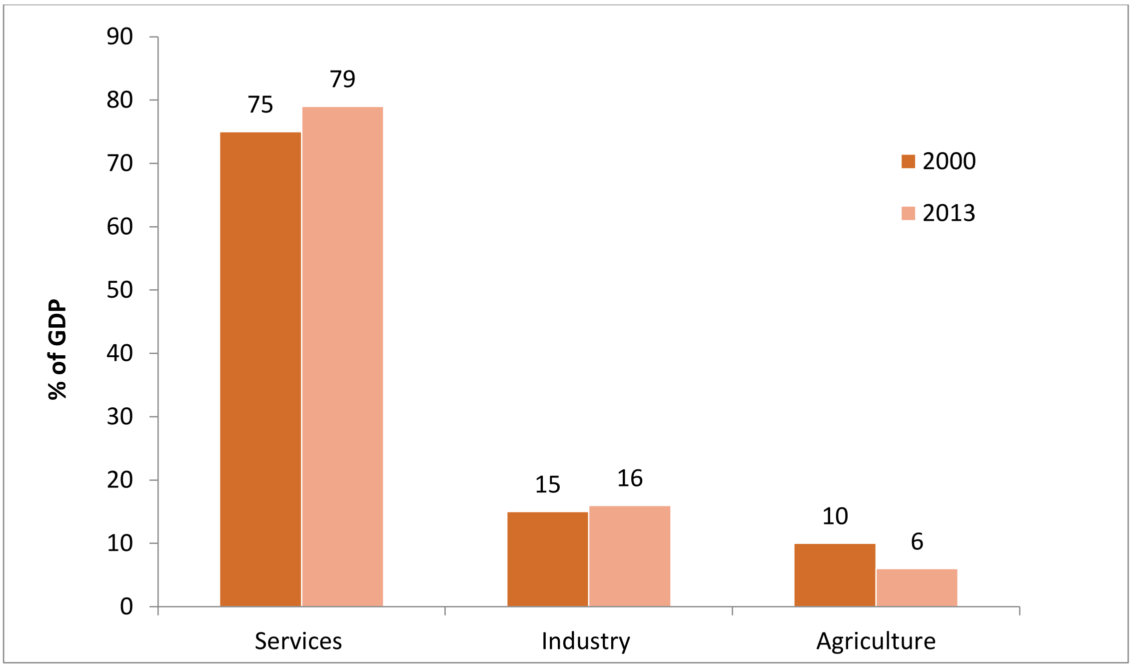


Figure 64-Gross Domestic Product – Grenada (2000 & 2013); Source: data obtained from Government of Grenada (2014)

The decline in the value of the agricultural sector was observed following the devastation caused by Hurricane Ivan in 2004 and Hurricane Emily 2005 (CBD, 2008). According to 2008 estimates, approximately one of every ten Grenadian in the labour force works in the agriculture sector. Given that the majority of workers in the agriculture (and construction) sectors are poor (World Bank, 2012), any decline in the value of the agriculture will impact many households that are living in poverty.

The impact of tropical storms on agriculture in Grenada, especially with nutmeg and cocoa, is strong (World Bank; CIAT; CATIE, 2014). Nutmeg experienced about a 70% decrease in production after Hurricane Ivan (2004) and required an almost 10-year recovery period. Similarly, cocoa experienced a roughly 90% decimation in response to Ivan but witnessed a partial recovery within four years and an almost full recovery after eight years (Figure 65). Damage from Ivan was estimated at $900 million USD, twice that of Grenada's GDP at the time.

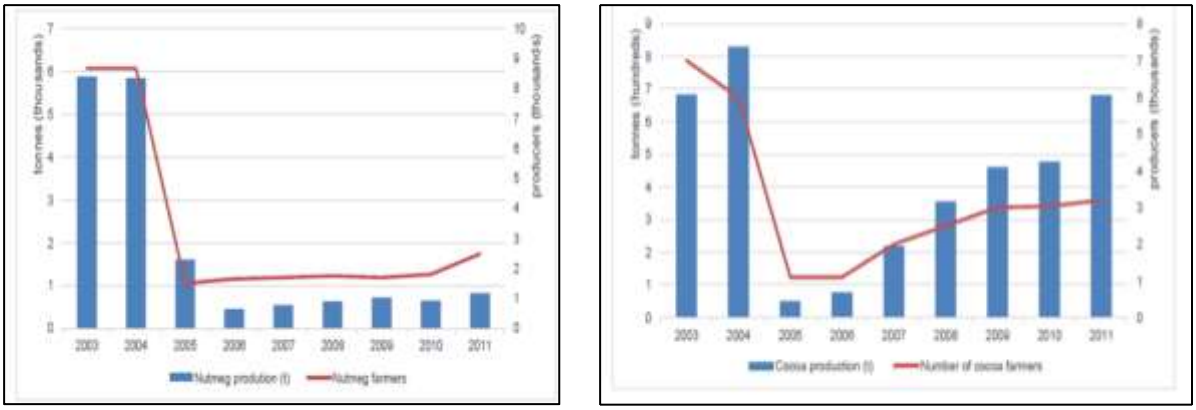


Figure 65-Nutmeg and Cocoa production. (Ministry of Agriculture 2013)

The sensitivity and adaptive capacity of the country will dictate the degree of impact these changes will have on agricultural livelihoods and Grenada's economy in general. The degree of poverty, health conditions, access to water and food are key drivers of sensitivity while the institutional architecture (governance structure), economic, social, technological and cultural factors determine adaptive capacity at various levels. Spatial patterns of social vulnerability indicators for Grenada are summarized in Figure 66. It is noticeable that most of the agricultural areas have poor adaptive capacities.

The most recent poverty assessment revealed that rates had increased by 17 percent between 1998 and 2008 – moving from 21 to 38 percent. The assessment also showed that males are more at risk of being poor than females (CBD, 2008). The poor are over-represented in construction and agriculture/fishing sectors. Livelihoods in the agriculture and fishing sectors are sensitive to extreme environmental conditions and thus increasing the risk of persons falling into poverty (CBD, 2008). Most of the country's poor live in St George (27 percent) and St Andrew (32 percent) (CBD, 2008). The poverty rate of St Andrew is higher than the national average, with 45 percent of residents living below the poverty line. The parishes of St Patrick and St Mark account for 21 percent of the country's poor.

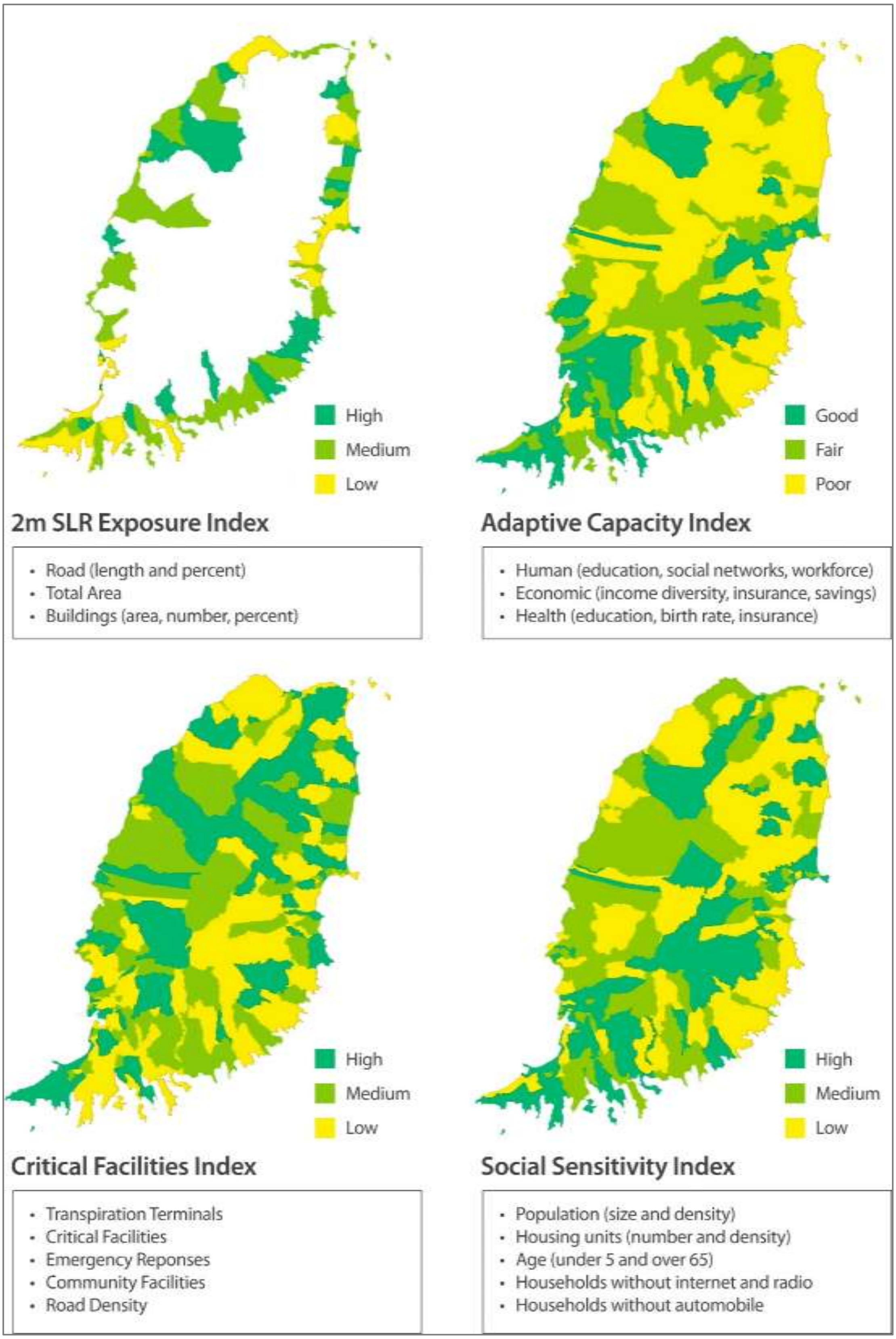


Figure 66-Exposure, critical facility, adaptive capacity and sensitivity indices for Grenada: Source: modified from TNC (2013)

Management of the scarce water resources is, therefore, crucial to the success of agriculture given the projected seasonal decreases in precipitation, especially during the wet season. It has been suggested that research and development of new varieties of Grenada's key export crops (nutmeg and cocoa) and into other varieties such as Soursop, Cinnamon, Pimento and other spices as well as vegetables, be conducted to improve the quality and yield of crops in the context of future climate conditions.

Further efforts to develop efficient irrigation practices in agriculture are also recommended since higher temperatures and longer dry periods would increase surface evaporation rates and thus, have implications for productivity. However, large amounts of arable land are located in areas with limited available water, limiting the development of irrigation (Government of Grenada, 2015). Figure 67 highlights current agricultural land use. Land degradation due to inefficient agricultural practices, such as the land clearing on steep slope, overgrazing (especially in Carriacou and Petite Martinique), poor soil and water conservation practices (including little use of organic matter) and removal of vegetation and farming too close to riverbanks contributes to the vulnerability of the agricultural sector to climate change.

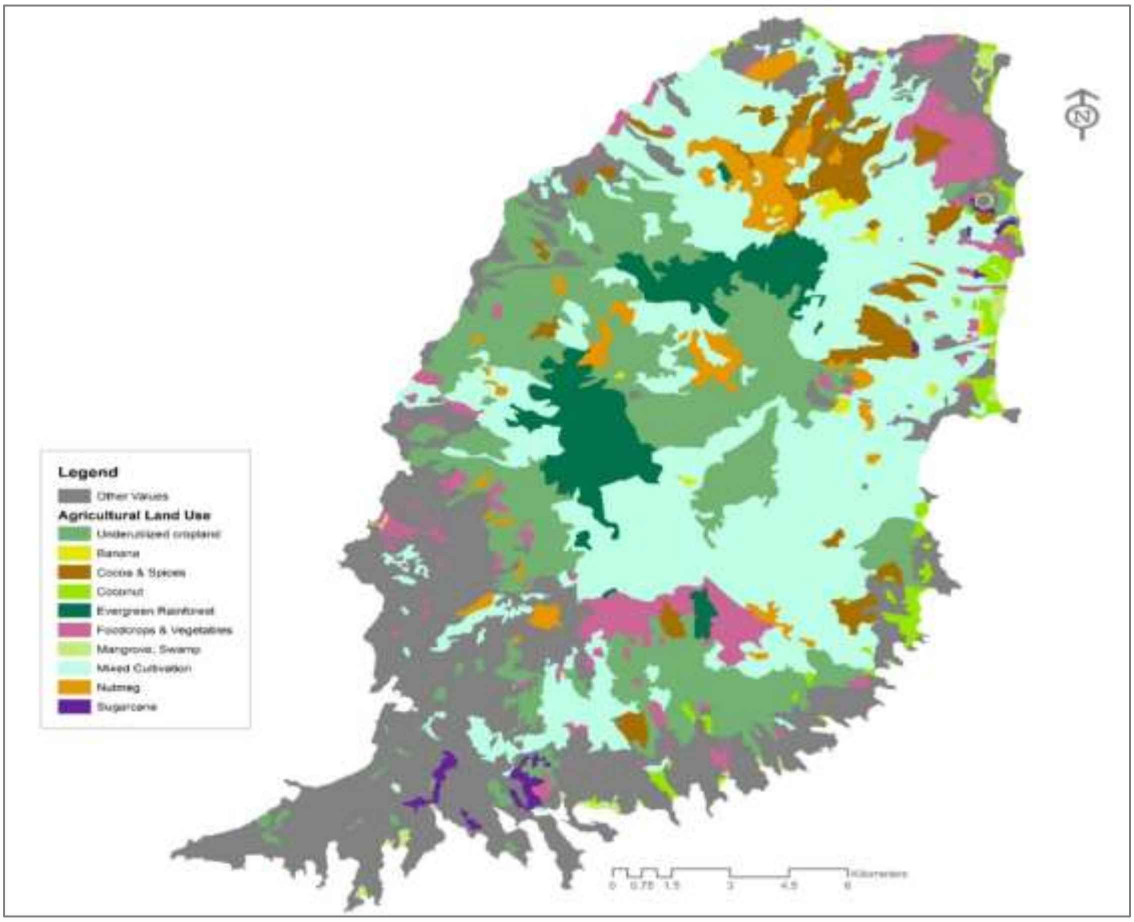


Figure 67-Agriculture land use classification

Climate change and its impacts on agriculture are recognised and prioritised at both the regional and national levels – namely within CARICOM's Agriculture Policy and Grenada's own National Agriculture Plan (2015-2030) as Strategic Focus #3: ***Strengthening the agricultural sector's resilience to climate change and natural disasters, reducing its adverse impact on climate change and the environment, and ensure that development is socially, economically, and environmentally sustainable*** As part of this strategic focus, the main objectives (other than what is already implied in the Strategic Focus statement) include improving preparedness for climate change impacts and extreme events; enhancing the country's response capacity in case of extremes; facilitating recovery from impacts and extremes; and optimising local land resources (James, 2015). This is and will continue to be the basis on which the Government of Grenada will advance climate change adaptation and resilience amongst its local farmers and the agriculture sector at large.

In light of threats from extreme weather and climate and Government's efforts to enable innovative response measures, Grenadian farmers have incorporated climate-smart agricultural (CSA) practices including the use of strip cropping and mixed intercropping; routine tree management; integrated agroforestry practices; grass barriers and contour farming. In addition to Grenadian farmers, work has been done to build capacity of the agriculture technical officers in CSA to support its use at the farm level. Some farmers have also successfully installed irrigation systems to mitigate the consequences of harsh drought conditions. Additionally, since 2004 Grenada started an intensive irrigation programme as a response to the decline in Banana production, following hurricanes Ivan and Emily, to aid recovery.

Rainwater harvesting is practised extensively in Carriacou, owing to the limited ground and surface water resources available to meet local demand. This presents another solution for water resource management in mainland Grenada, where there has been modest uptake compared to Carriacou. While Carriacou's record in rainwater harvesting is heavily need-driven, the same argument can be made for Grenada's farming population, in light of recent extreme drought experiences and the uncertainty of future water budget trends which have collectively placed water resource management high on the Government's adaptation agenda. Therein lays the rationale and opportunity for farmers on mainland Grenada to apply and invest in rainwater harvesting techniques.

However, it has been noted that Grenadian farmers have not fully embraced the wide range of new agro-technology systems available to improve output. Youth involvement in the sector combined with capacity-development initiatives and sustainable modernization strategies could enhance the resilience to climate stressors and shocks. Table 43 summarises existing CSA practices and estimated the degree of adoption in Grenada.

Table 43-CSA Practices in Grenada

System	Practice	Degree of adoption
Nutmeg	Restoration of hurricane damaged plantations	3
Cocoa	Organic cocoa in mixed, multilayer plantations	3
Fruit, Veg, Root crops	Drip feed irrigation	3
	Solar powered irrigation systems	2
	Contour ploughing	2
	Intercropping	3
	No-burn agriculture, with shredding, composting, mulching	3
	Increased cultivation of tubers (hurricane resistant)	3
Livestock	Stabled dairy goats with cut-and-carry fodder production	2
	Beekeeping	3
All agriculture	Controlled use of agrochemicals	2
	Organic agriculture	2
	Water capture and protection of water sources	3
	Terracing	1
	Composting organic waste	2
	Biodigesters	2
	Drought resistant crops/varieties	2
	Risk mapping	1
	Micro-level weather insurance [8]	1
Sector-wide	Develop food-processing capacity [9]	4
	Developing sustainable land management capacity	2
	Integrated watershed management [10]	1
	Developing management and decision making capacity	2

Score	Criteria for practices
0	Suggested by interviewee as a good idea
1	Research and development / policy commitment
2	Validation in field trials / small project / new measures being adopted by one or a few companies / new ideas being promoted by agencies
3	Scattered adoption across the sector(s)/ large project / not known - default score
4	Widespread adoption
5	80 to 100% adoption

Source: World Bank; CIAT; CATIE. 2014

3.4.4

3.4.4 Recommended Adaptation Measures

Many of the adaptive strategies will need to incorporate Climate Smart Agriculture (CSA). The climate-smart agriculture (CSA) concept reflects an ambition to improve the integration of agriculture development and climate responsiveness. It aims to achieve food security and broader development goals under a changing climate and to increase food demand. CSA initiatives sustainably increase productivity, enhance resilience, and reduce/remove greenhouse gasses (GHGs), and require planning to address trade-offs and synergies between these three pillars: productivity, adaptation, and mitigation.

Practices are considered CSA if they maintain or achieve increases in productivity as well as at least one of the other objectives of CSA (adaptation and/or mitigation). However, challenges remain for farmers in Grenada to adopt CSA practices. For example, lack of credit, mountainous topography, small local markets, and the high cost of energy and other inputs all plague family farms.

Key components to CSA include:

- adoption of no-burn agriculture practices (to protect soil from erosion);
- landscape restoration and watershed protection (to build resilience to extreme weather events); and
- the development of drought resistant systems (organic mixed cocoa plantations are resistant to extreme weather by incorporating diverse species).

Capacity building is required to overcome some of these challenges and to improve skills in quality control, business management, and marketing. In addition, farmers are highly encouraged to increase access to and use of climate information as a basis for informed decision making, especially in the face of a changing climate regime.

In order to increase the resilience of the agriculture sub-sector the climate change, the following are some key recommendations:

1. Research and development of new varieties of Grenada's key export crops (nutmeg and cocoa) and into other varieties such as Soursop, Cinnamon, Pimento and other spices and crops that are more suited to the changing climate;
2. The greater use of hurricane proofed greenhouses for the production of vegetables such as tomatoes, peppers, cucumber and lettuce so as to protect against wind and diseases and increase crop yields;
3. The greater use of irrigation water (grey water), especially in the dry season so as to allow year-round agricultural production;
4. Reduce land degradation due to inefficient agricultural practices, such as the land clearing on steep slope, overgrazing (especially in Carriacou and Petite Martinique), poor soil and water conservation practices (including little use of organic matter) and avoidance of farming too close to riverbanks so as to avoid flooding of croplands;
5. Greater adoption and use of CSA (Climate Smart Agriculture) practices such as contour ploughing and planting, intercropping, rationalization of agro-chemicals and crop insurance schemes;
6. Greater support of the Government to the agriculture sector through financial incentives (choice of crops, insurance…).

3.5 FISHERIES AND COASTAL ECOSYSTEMS

3.5.1 Methodology

While fisheries and coastal ecosystems are treated as a sub-component of agriculture in this chapter, they have been given special attention because of their significance in sustainable development and in the broader context of adaptation planning in Grenada. The information provided in this subcomponent was sourced from existing national, regional and international studies, as well as from discussions and meetings with key stakeholders in the sector. The framework used in the assessment of vulnerability is based on the methodology used by the IPCC (2014).

3.5.2 Profile of Grenada's Fisheries and Coastal Ecosystems

Profile of Fisheries Sector

Grenada's fisheries sector is a multi-species marine capture fishery that is conducted under open access conditions around the islands of mainland Grenada, Carriacou and Petite Martinique (FAO, 2007; Mohammed & Lindop, 2015). The fishery is mostly artisanal in nature, but in recent years it has been transitioning into a more commercial type of operation. A major area of growth has been in the offshore pelagic fishery that mainly targets yellowfin tuna for export. Grenada's Exclusive Economic Zone (EEZ) and shelf area (to 200 m depth) are shown in Figure 68.

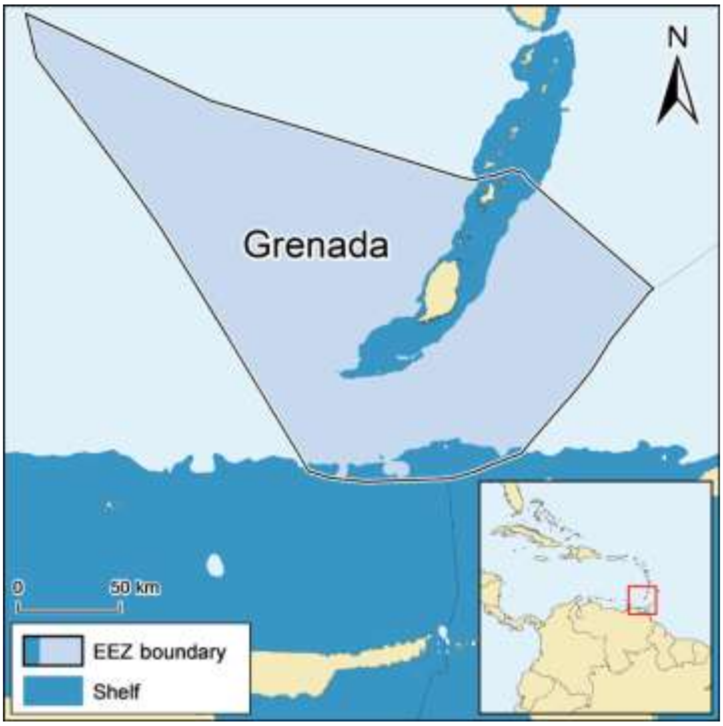


Figure 68-The Exclusive Economic Zone (EEZ) and shelf area (to 200 m depth) of Grenada. Source: (Mohammed & Lindop, 2015)

Grenada's fisheries are currently grouped into four main categories:

- Large offshore pelagics make up 50% of the estimate catch landings annually. This fishing includes long lining for large pelagics such as yellow fin tuna and billfish and trolling for dolphin fish, smaller tunas, wahoo, king mackerel etc.
- Inshore pelagics, also referred to as small coastal pelagics, make up 25% of the catch. This fishing includes an inshore beach seine fishery for small pelagics, mostly scads (jacks).
- Demersal fisheries make up to 15-20% of the estimate landing annually, including snapper, grouper (red hind).
- Lobster and Conch make up 1-5% of the island's catch (WECAFC, 2016).

An outline of Grenada's fishing fleet is given in Table 44.

Table 44-Types and numbers of fishing vessels in Grenada (Source: Fisheries Division Grenada, personal communication, 2016)

Vessel Category	Description	Length	Number of vessels
Type I Longliner	Small indigenous longliner. Wooden open pirogue. Operate < 4 miles. Outboard motor offshore. Day boat. Light palang (approx. 50 hooks)	4.5m - 7.0m	210
Type II Longliner	Fiberglas pirogue with small cabin for shelter. Outboard motor. Overnighter. Icebox. (>200 hooks)	7.3m – 8.8m	120
Type III Longliner	Large fully equipped longliner. Full cabin. Distance up to 100 miles offshore. Inboard diesel. (>400 hooks)	9.7m – 16.6	75
Trolling	Open wooden pirogue. Outboard motor. Day fisher. This type also used as dive boats, towing double-enders and bottom long lining.	5.7m – 7.7m	250
Beach seine	Wooden double-enders used in the deployment of beach seines.	6.1m – 7.6m	15

Grenada has been successful in developing high-value export markets to the United States (tuna, mainly) and parts of the European Union. This has been facilitated by the Government's successful campaign to achieve the quality assurance and post-harvest standards required to export to these countries. The benefits of this development have included foreign exchange generation, and the diversion of part of the catch to domestic requirements (ACP Fish II, 2012). Grenada's success at selling into prime markets at relatively high prices, has allowed the expansion of the fishing industry and especially the commercial long line fishery that might otherwise have been constrained by the limited domestic market (ACP Fish II, 2012). As a result, fish landings in Grenada have increased, unlike many other OECS countries (see Figure 69).

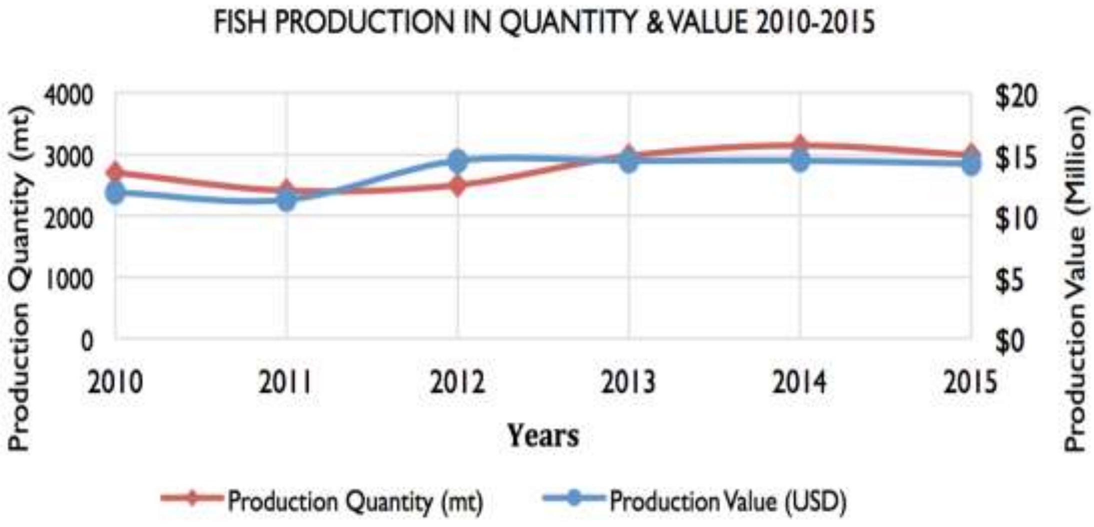


Figure 69-Total fish production in quantity and value from 2010 to 2015 (Source: Fisheries Division Grenada, personal communication, 2016)

Today, Grenada has one of the largest fishing fleets in the Eastern Caribbean islands, with offshore fishing operations accounting for the large majority of fishing effort and fish catches. The fisheries sector is now profiled as semi-industrial.

Fisheries only account for between 1.9 to 2.5% of national GDP but play an important part in providing food (high-quality protein) and livelihoods to the population of this tri-island state (See Table 45). The sector also plays an important role in the culture and traditions of many coastal communities, and often provides employment to more vulnerable groups, such as the young and elderly.

Table 45-Fishery dependency statistics: Data from Fisheries Division, 2016

Fishery Dependency Statistics	
Fish catch volume	3,100 MT
Overall sector contribution to GDP	1.9-2.5%
Fish nutrition (fish as % animal protein) (2009)	28.1
Per capita consumption of fish	23-25 lbs.
Fisherfolk as % national workforce	6.2%
Number of fishers engaged in marine fisheries	2,800
Number of processing sector workers	75
Total number of registered fishing vessel	3500
Number of fishing vessels operating	1500-1800

Management of the Fisheries Sector in Grenada

Fisheries management and governance are entrusted to the Fisheries Division, which operates under the Ministry of Agriculture, Lands, Forestry and Fisheries (MALFF). The Fisheries Division is responsible for extension services, fishing technology, data management, MPA management, resource assessment and fisheries infrastructure management. The Fisheries Division also maintains close collaboration with the Coast Guard, Customs, Ports Authority and other relevant agencies for the enforcement of laws and regulations. Fisheries management is focused on pelagic fish species which account for 97% of the landings (conch account for less than 1% of landings (WECAFC, 2016). According to the Government of Grenada's Corporate Plan for 2015-2017 (MALFF), the priorities of the Fisheries Division are:

- Fish quality assurance and product development;
- Conservation and management of fisheries resources;
- Prevent, deter and eliminate Illegal, unreported, unregulated fishing;
- Implementation of the Fisheries Policy and Action Plan;
- Strengthen fisher organizations;
- Capacity building of fishers;
- Fisheries Development (infrastructure development and maintenance);
- Sustainable utilization of fisheries resource (resource assessment, monitoring and data management); and
- Improved governance and management of the sector.

Fisheries management in Grenada is based on the model used throughout the OECS for "*optimum utilization of fisheries resources for the benefit of the people of the country*". The Grenada Fisheries Act of 1986, amended in 1999, provides for the following:

- Allow for regional cooperation in fisheries and fisheries access agreement;
- Call for fisheries management plans;
- Mandate the Fishery Advisory Committee to provide guidance to the chief fisheries; officer and Fisheries Division;
- Prohibit destructive fishing methods;
- Allow the establishment of MPAs;
- Include a "catch all" provisions for granting general rule making powers to the Minister Responsible for Fisheries;
- Allow for local and foreign fishing operations;
- Allow for designating local fisheries management areas;
- Mandate for control of fish processing and marketing operations; and
- Grant rule-making powers to the Minister responsible for Fisheries.

The Government has endorsed several regional management plans and fisheries policies coordinated by the Caribbean Regional Fisheries Mechanism (CRFM). These include the following:

- The Regional Coral Reef Action Plan (2014-2019);

- St George's Declaration on Conservation Management and Sustainable use of the Caribbean Spiny Lobster (2015);
- Sub-regional Fisheries Management Plan for Flying Fish in the Eastern Caribbean adopted by CRFM ministerial council;
- Sub-regional Fisheries Management plan for FADs (2014);
- Sub-regional Blackfin Tuna Fisheries Management plan.

The government facilitates the management and development of the fisheries sector by maintaining infrastructure and facilities for marketing of fish, cold storage, ice making, marine safety, communication and the provision of general service to fishing communities. There are 45 fish landing sites around the islands. Seven are primary landing sites with fish markets and port facilities (Grenville, Melville Street, Gouyave, Victoria, Duquesne, Sauteurs and Hillsborough in Carriacou); 37 are secondary landing sites (beaches/bays without infrastructure) and one is a tertiary landing site at Grand Mal where two of the four fish processing plants are located. Primary landing sites are strategically located so as to provide a variety of functions – fish marketing, storage, ice making, berthing of vessels and also act as a focal point to facilitate fisheries management in gathering fisheries data and conducting surveys.

The main landing sites ranked by percentage of landings are: Grenville (25%), Gouyave (22% (see Figure 70), Carriacou and Petite Martinique (18%), Grand Mal (12%), Melville Street (11%), other secondary sites (8%), Victoria (2%), Duquesne and Sauteurs (2%).

Figure 70-Main fishing jetty at Gouyave (left) and longline tuna boat (right)

Photo: Owen Day

The government works in close collaboration with the private sector and fisherfolk organisations to enforce regulations and implement policies. The institutional capacity of fisherfolk organisations is generally quite weak, but several projects have tried to address this. The Secretariat of CRFM is helping to promote co-management of fisheries in the region and to enhance the overall capacity of the stakeholders for their involvement and participation in the resource management processes (Phillips and Guiste, 2007).

A current project that addresses these needs is a collaborative effort involving the Caribbean Natural Resources Institute (CANARI) and the Caribbean Network of Fisherfolk Organisations (CNFO) called *Strengthening Caribbean Fisherfolk to Participate in Governance* project. This regional project funded by the European Union is aimed at improving the contribution of the small-scale fisheries sector to food security in Eastern Caribbean countries through building the capacity of regional and national fisherfolk organisation networks to participate in fisheries governance and management.

Effective co-management policies, processes and practices that engage all relevant stakeholders will be essential to overcome the numerous and varied challenges that affect fisheries in Grenada. These challenges include climate change, sea level rise, marine pollution, unsustainable fishing practices, habitat degradation, invasive species (i.e. lionfish), over-fishing; illegal, unreported and unregulated (IUU) fishing; rapid population growth and competition from tourism and other industries.

Profile of Grenada's Coastal Ecosystems

Mainland Grenada and its sister islands of Carriacou and Petite Martinique are surrounded by some of the region's richest and most biodiverse coastal ecosystems. These ecosystems include coral reefs, mangroves, sea grass beds and beach vegetation. They are mostly found along the coastlines of mainland Grenada and Carriacou as shown in Figure 71 and Figure 72.

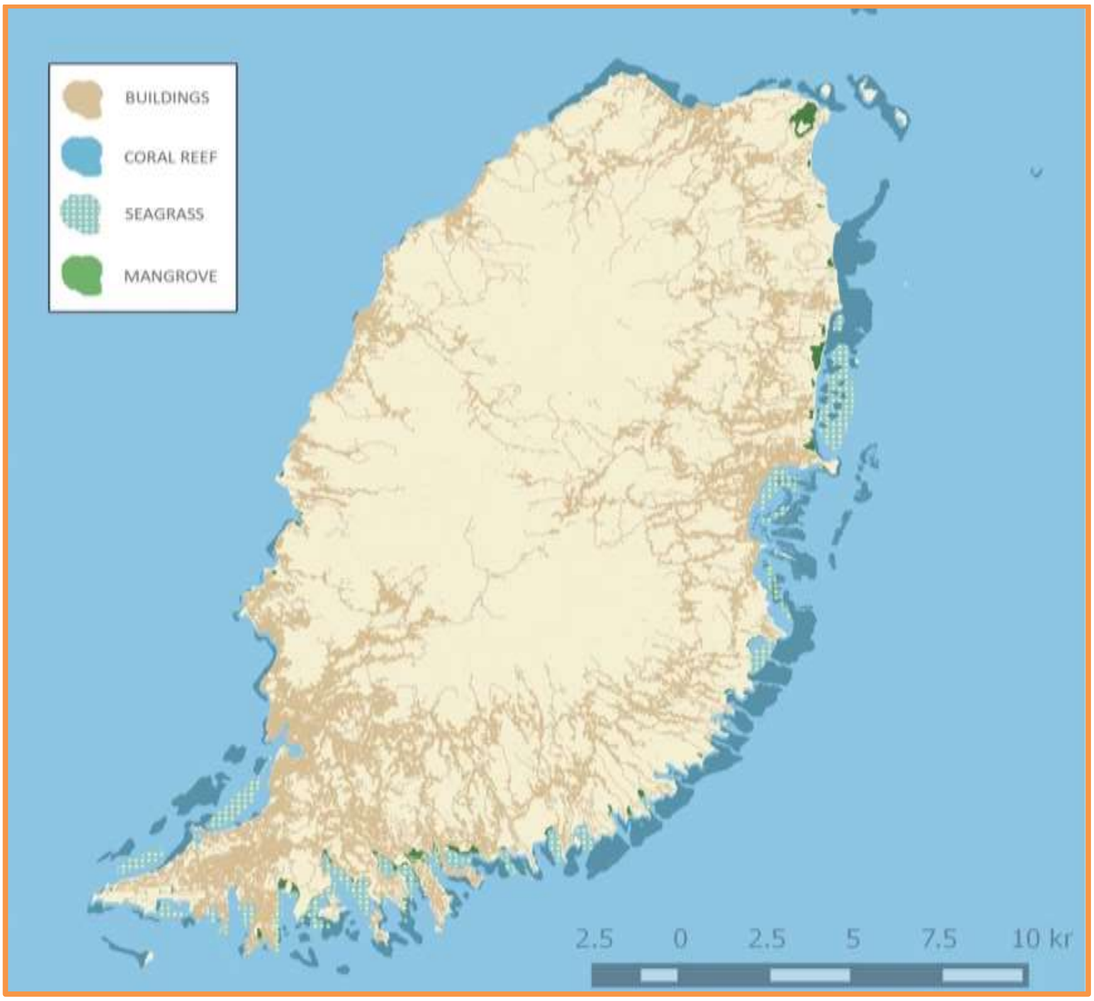


Figure 71-Coastal Ecosystems of mainland Grenada: Source (Day, Van Proosdij, Campbell, Lee, Baker, & Thomas, 2015)

Figure 72-Coastal Ecosystems of Carriacou: Source (Day, Van Proosdij, Campbell, Lee, Baker, & Thomas, 2015)

These coastal ecosystems contribute immeasurably to the aesthetic beauty and biological richness of Grenada, and provide a wide range of economically valuable services to the country's people, communities and businesses. The services provided by these ecosystems are summarized in Table 46 below.

Table 46-Coastal ecosystems and their associated services that can be found around Grenada [34]

Ecosystem Service	Coral Reefs	Mangrove Forest	Seagrass Beds	Coastal Vegetation
Coastal protection	✓✓✓	✓✓✓	✓✓	✓
Sand production	✓✓✓	✓	✓✓	
Soil stabilization		✓✓✓	✓	✓✓✓
Fish nursery	✓✓✓	✓✓✓	✓✓✓	
Fish habitat	✓✓✓	✓✓✓	✓✓✓	
Tourism attraction	✓✓✓	✓		✓✓✓
Recreation	✓✓			✓✓✓
Biodiversity	✓✓✓	✓✓	✓✓	✓✓
Carbon sink	✓	✓✓✓	✓	✓

Source: (Day, Van Proosdij, Campbell, Lee, Baker, & Thomas, 2015)

A recent review (de Groot, et al., 2012) examined the economic values of all ecosystems globally and found that the mean value for coral reefs was US$ 353,000 per hectare per year. This is attributed to the great value that coral reefs provide for coastal protection, tourism and fisheries.

Based on this extensive review, it is safe to assume that coral reefs are the most valuable of all of Grenada's coastal ecosystems, especially given their size, location and relevance to coastal protection, fisheries, and tourism. Most of the coral reefs are located on the northeast and south coasts of mainland Grenada, with large fringing reefs also to be found on the east coast of Carriacou and Petite Martinique. Live coral cover ranged from 13-35% for Grenada's bank reefs, and 16-40% for Carriacou's fringing reefs (CCCCC, 2002).

Anthropogenic activities such as the over-use of agro-chemicals, inadequate solid waste disposal and non-treatment of wastewater also threaten the sustainability of coastal assets. In addition, infrastructure development activities associated with tourism and urbanization in general have been observed to negatively impact on crucial ecosystems in the coastal zone. Table 47 summarises the main threats and resultant impacts associated with Grenada's coastal ecosystem.

[34] The number of ticks represents the relative importance of that ecosystem to the associated ecosystem service.

Table 47-Summary of threats to and potential impacts on Grenada's coastal ecosystems and communities (UNDESA, 2012)

Threats	Impact	Coastal Ecosystems Affected				
		Mangroves	Littoral	Seagrass	Beaches	Coral
Coastal Development	Loss of habitat directly (removal) or indirectly (decreased environmental quality); generation of pollution and litter; loss of turtle nesting sites; eutrophication; sedimentation; loss of coastal defence services	●	●	●	●	●
Die backs*	Increased rates of erosion; loss of livelihood opportunities; habitat destruction	●	●			
Fishing	Overexploited fish populations; local loss of livelihood opportunities; habitat destruction	●		●		●
Introduction of invasive species	Loss of native species; alteration of trophic webs					●
Litter	Entanglement / smothering of marine animals; reduced productivity	●	●	●	●	●
Loss of vegetation /deforestation*	Increased erosions; Loss of habitat; increased sedimentation; reduced productivity; degraded nursery habitat; loss of coastal defence services	●	●	●		
Pollution from inland sources	Increased algal growth; loss of productivity; eutrophication; contamination of water	●	●	●	●	●
Storm surges and wave action	Increased rates of erosion; damage to infrastructure; coastal flooding	●	●	●	●	●
Lionfish (*Pterois volitans*)	Invasive species that is a major threat to juvenile reef fish and hence coral reefs					●

Management of Coastal Ecosystems in Grenada

In Grenada, the management of coastal ecosystems falls primarily under three ministries; the Fisheries Division in the MALFF; the Environment Division in the Ministry of Education, Human Resource Development and the Environment, and in Carriacou and Petite Martinique, the responsibility also falls under the Ministry of Carriacou and Petite Martinique Affairs and Local Government.

Coordination and collaboration between these various agencies is often challenging and complex, and can hinder effective management of coastal resources. An Integrated Coastal Zone Management Policy (ICZM) was approved by Cabinet in 2015, and the potential to establish a Coastal Zone Management Entity is currently under consideration as part of the development of a Coastal Zone Management Act for Grenada.

One of the main management activities undertaken for the protection and sustainable use of important coastal ecosystems is the establishment of marine protected areas (MPAs). Grenada currently has three MPAs; Molinere Beausejour and Woburn Clarkes Court Bay on the main island of Grenada and Sandy Island Oyster Bed in Carriacou. The management of these MPAs is aimed at reducing local stressors, such as overfishing, pollution and anchor damage. These MPAs are critically important for the long-term resilience of Grenada's coastal ecosystems, for conservation of biodiversity and for the competitiveness and sustainability of the tourism and fisheries sectors.

To expand and broaden the objectives of the MPA network, Grenada has also initiated a programme of coastal ecosystem-based adaptation (EBA), in partnership with the United Nations Environmental Programme (UNEP). This activity, funded by the European Union, has developed a national strategy for EBA and has initiated two pilot projects for the restoration of coral reefs in Grand Anse and Carriacou.

Other initiatives focusing on the protection and restoration of important coastal ecosystems include:

- Planting of coastal trees by St. Patrick's Environment Community Tourism Organisation (SPECTO);
- Community-led replanting of mangroves under the Restoration and Community Co-Management of Mangroves (RECCOMM) project as part of the ICCAS initiative, which also includes a training and alternative livelihoods component focused on beekeeping for community members;
- Community-led replanting of mangroves and land reclamation in Windward, Carriacou;
- Community-led replanting of coastal vegetation in Lauriston, Carriacou; and
- Under the World Bank Pilot Program for Climate Resilience (PPCR), the rehabilitation of the Bathway sandstone reef which has been degrading and also suffered severe damage from recent hurricanes is being considered.

Vulnerability of fisheries and coastal ecosystems

Significant impacts from climate change and climate variability are expected to be experienced in the coastal and marine environments of Caribbean SIDS over the next several decades (Nurse, et al., 2014). As fisheries and coastal ecosystems are part of an integrated social-ecological system, climate change will therefore have interconnected bio-physical and social impacts. These will be all the more significant as climate change and climate variability are expected to exacerbate existing stressors as well as introduce additional adverse impacts on fisheries and coastal ecosystems (Allison, et al., 2009; Brander, 2010).

Numerous pathways exist through which climate change can impact fisheries in Grenada (Badjeck et al., 2010). Causal variables of impact include SLR, altered precipitation patterns, varied ocean and coastal processes such as wind velocity, wave action and ocean currents and changes in chemical and physical oceanographic parameters such as pH and water temperature. While the scientific understanding of the cause-effect pathway for many of these variables are not yet comprehensively understood (Allison, et al., 2009), it is acknowledged in the Caribbean that climate change adaptation in the fisheries sector is a necessity (McConney, et al., 2015).

Caribbean SIDS are particularly vulnerable to climate change as they are low-lying, small, economically vulnerable, and located where extreme weather events may intensify because of climate change (Guillotreau et al, 2012). Within Caribbean SIDS, the Lesser Antilles are amongst the most vulnerable due to the high dependence on marine resources, and the high vulnerability of fisherfolk and fisheries infrastructure in the coastal zone (Monnereau, et al., 2015). Consequently, effective adaptation measures for the fisheries sector are particularly critical for sustainable livelihoods, improved food security and protection of marine resources.

The direct (usually ecological) and indirect (both social and ecological) pathways that exist between climate change and the potential impacts on fisheries and coastal ecosystems are highly complex and not fully understood. Figure 73 shows the framework that can be used to better assess the ecological and socio-economic vulnerabilities of the fisheries sector and the linkages between vulnerability, exposure, sensitivity and adaptive capacity.

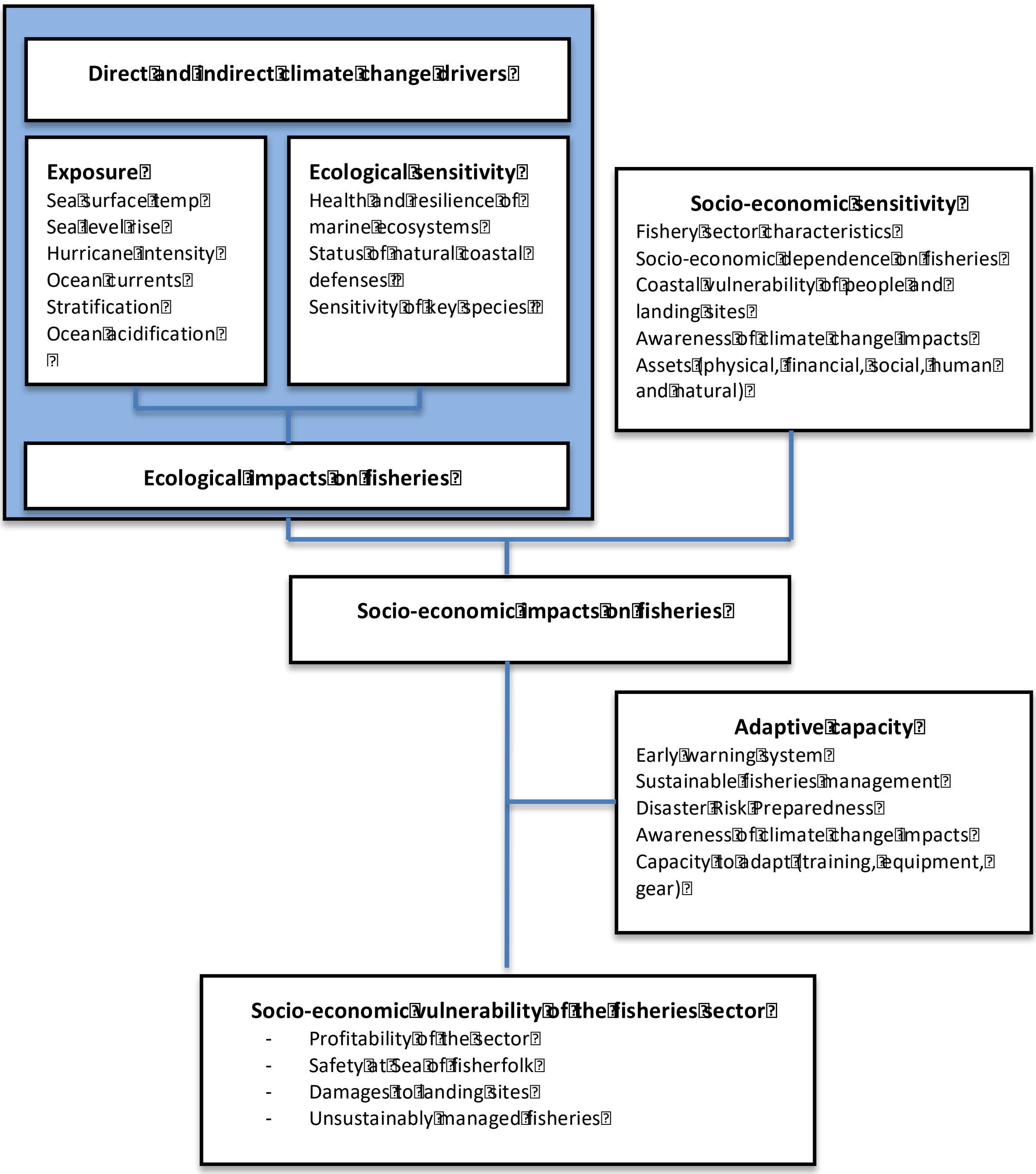


Figure 73-Framework of socio-economic vulnerability of fisheries and coastal ecosystems

In Figure 73, exposure is the degree to which a system is stressed, related to factors external to the sector as well as internal. Sensitivity is the level of susceptibility to harm from climate change. Adaptive capacity is the capacity to offset or reduce climate change impacts. Both adaptation and adaptive capacity occur at multiple scales (local, national, regional and international). Successful adaptation often requires linkages across these different scales.

3.5.3 Bio-physical Impact Assessment

The projected impacts of climate change and ocean acidification on fisheries and coastal ecosystems have been reviewed by many studies (Portner, et al., 2014; Nurse, et al., 2014; Monnereau, et al., 2015; FAO, 2015). The key findings show that the main drivers of change will include sea level rise, increasing coastal water temperatures, increasing intensity of hurricanes, increasing frequency of droughts and ocean acidification. The impact these changes will have locally on coastal ecosystems and fisheries will vary across regions and countries depending on the level of exposure and sensitivity of the ecosystems. The ecological impacts will also be interconnected and sometimes self-reinforcing. A simplified illustration of these bio-physical impacts is shown in Figure 74. The main impacts of concern are:

- Sea level rise affecting coastal ecosystems and infrastructure;
- Increasing intensity of extreme weather events (e.g. hurricanes, heavy rain, droughts);
- Higher sea water temperatures which will bring several ecological impacts:
    - coral bleaching events
    - some fish species to move away from tropics to cooler water in higher latitude
    - high local extinction rates in the tropics and semi-enclosed seas
    - some fish species will have a smaller maximum body size due to reduced oxygen capacity of seawater
- Algal blooms and changes to ocean currents (e.g. sargassum);
- Ocean acidification will affect calcium carbonate producing organisms.

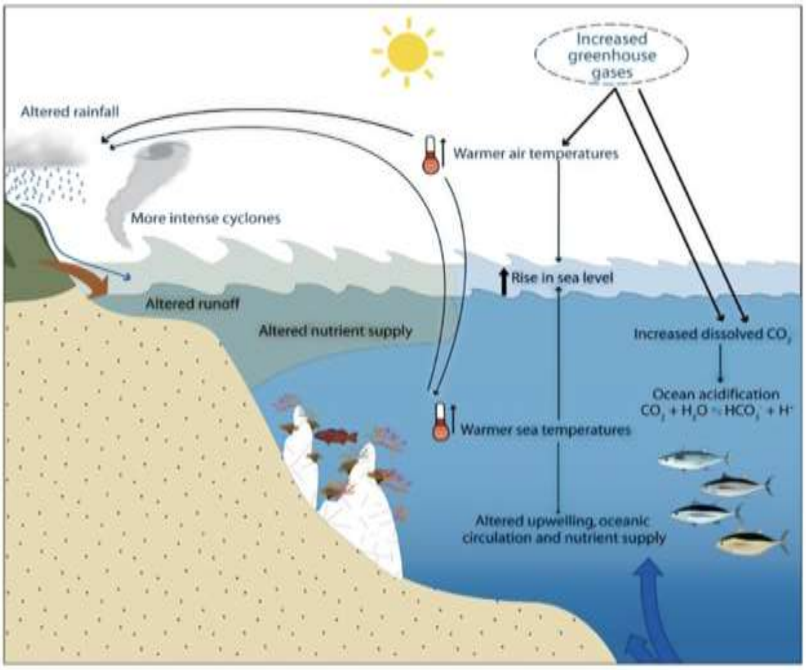


Figure 74-Schematic diagram showing bio-physical impacts of climate change and ocean acidification: Source (Bell et al., 2011).

Sea level rise (SLR) and Storm Surge

Sea level rise poses one of the most widely recognized climate change threats to low-lying coastal areas (Nurse, et al., 2014). This is particularly important in small islands where the majority of human communities and infrastructure is located in coastal zones with limited on-island relocation opportunities. Similarly, the storm surges that accompany hurricanes and tropical storms generate coastal erosion risks in low-lying areas and historical events have resulted in extensive damage (CDERA, 2003).

Coral Bleaching

A recent report by Day et al. (2015) outlines the main reasons for the loss and degradation of coral reefs in the Caribbean and Grenada in particular highlighting the role that elevated SST and associated bleaching events, as well as disease outbreaks have had on these ecosystems. Corals have evolved under conditions of very stable temperature and most are not well equipped to deal with temperatures outside their normal range. The occurrence of stressful SST has increased in frequency and severity, causing serious damage to coral reefs in the Caribbean. In addition, Caribbean coral reefs have also been severely impacted by disease outbreaks, which appear to be more prevalent after coral bleaching events and in locations exposed to local human pressures such as pollution (Riegl et al., 2009; Gardner et al., 2003).

Tropical storms have historically been the primary acute disturbance agent on coral reefs (Rogers, 1993). However observed and projected increases in SST (Simpson, et al., 2012) as well as more recent projections of future increases in windspeed (CCCCC, 2015) all indicate that hurricane intensity, but not necessarily frequency, over the North Tropical Atlantic has the potential to increase in the coming decade. A stronger storm regime will increase the susceptibility coral reefs. As summarised in a recent report (Anthony, 2016) warming and bleaching events lower coral reef resilience by reducing coral growth rates and reproduction. Under cumulative stress regimes where warming-induced bleaching and acidification lower the resilience of coral reefs, these ecosystems may be overwhelmed by regular storm events, and unable to recover in a climate regime in which hurricane intensity has increased. In addition to the physical damage which storms cause to coral reefs, they can also have a negative impact by generating increased run off from land, bringing sediments and possibly the release of nutrients from moribund tissues (Government of Grenada, 2014a). Increased sediment and nutrient loads to coastal waters have been documented to:

- Smother coral reef organisms due to the settling of suspended sediment;
- Reduce light availability for both coral and seagrass photosynthesis due to increased turbidity; and
- Favor the growth of microalgae at the expense of corals due to high nutrient availability (Australian Institute of Marine Science, 2017).

A potentially more worrying, though less visible threat to corals is also from ocean acidification from atmospheric CO_2 absorption. Ocean acidification inhibits the ability of corals to build their limestone skeletons.

Anthropogenic influences including overfishing, land-based sources of pollution (pesticides, sediment and inadequately treated sewage) and anchor damage from boats and coastal development put additional stressors on coral reefs already being challenged by the impacts of climate change.

Of special note, a recent threat to coral reefs has emerged in the form of the invasive lionfish (*Pterois volitans*). The species is considered to be especially threatening because of its high fecundity, its short life cycle, its apparent isolation from known predators and its wide diet-breadth, which includes juvenile reef fish (Government of Grenada, 2014a).

Due to the high sensitivity of corals to changes in the environment, coral reefs are projected to be one of the first ecosystems significantly affected by climate change (Hoegh-Guldberg, et al., 2007). Already, this has caused serious damage to coral reefs all around the world, including the Caribbean, particularly in 1998, 2005, 2010 and 2015.

The corals of the Caribbean have also been severely impacted by disease outbreaks, which appear to be more prevalent after coral bleaching events and in locations exposed to other stressors such as pollution and overfishing (Riegl et al, 2009). The combination of these local stressors and climate change impacts, have driven a sustained, region-wide decline in health of Caribbean coral reefs over the last several decades (Gardner et al., 2003; Jackson et al., 2014).

The branching corals - Staghorn (*Acropora cervicornis*) and Elkhorn (*Acropora palmata*) – were once the dominant reef-building corals in most of the shallow reefs (<6m depth) surrounding Grenada, Carriacou and Petite Martinique. Due to a regional disease in the 1980s and early 1990s, these branching corals suffered significant declines with estimated population losses of up to 95% (Bruckner, 2002). Acroporids (i.e. branching corals) exhibit particularly high growth rates relative to other corals, enabling sustained reef growth during periods of rapid sea level changes (e.g. Pleistocene). Additionally, both species have large branches, providing essential habitat for other reef organisms, particularly fish and lobster. They are critically important for the Caribbean, in terms of reef growth, island formation, fisheries habitats, and coastal protection.

The loss of coral reefs around the main island of Grenada and Carriacou in the past 30 years, in particular of the branching corals, has decreased both the height and roughness of fringing reefs, particularly the reef crests, and hence their ability to dissipate wave energy and reduce coastal erosion. The increase in coastal erosion at many locations (see Figure 75), particularly Grand Anse in mainland Grenada and Windward in Carriacou, is undoubtedly associated with the degradation of their adjacent coral reefs (Day, et al., 2015).

Figure 75-Coastal erosion at Windward in Carriacou and examples of shoreline protection structures used on the island of Carriacou ranging from conch shells to engineered armouring: *Source* (Day, Van Proosdij, Campbell, Lee, Baker, & Thomas, 2015)

In 2005, the Eastern Caribbean experienced the worst mass coral bleaching event ever recorded in the region (Wilkerson et al., 2008; Oxenford et al., 2008a; Oxenford et al., 2008b; Oxenford et al., 2008a;b). This bleaching event corroborates the prediction of more frequent and more severe mass coral bleaching events in the Caribbean with the current trend of global warming (MacWilliams et al., 2005).

The high coral mortality observed in the Eastern Caribbean in 2005 emphasises the vulnerability of tropical small island developing states (SIDS), with a high reliance on healthy marine ecosystems. It further emphasises the urgency for improved national coral conservation and protection measures to mitigate local stressors and improve reef resilience. Studies have shown that increasing the biomass of herbivores, especially parrotfish, increases the ability of coral reefs to recover following bleaching events (Mumby, et al., 2014). The low levels of parrotfish biomass (Day et al., 2016) on most of Grenada's reefs make them much more vulnerable to climate change.

Impacts of Higher Seawater Temperatures on Fisheries

Higher seawater temperatures are projected for the Eastern Caribbean and this will affect the physiology of many marine organisms. The distribution patterns of many marine species have already been shifting towards more northerly regions or into greater depths where the water is comparatively cooler (Perry et al., 2005). Studies focusing on the likely redistribution of maximum fisheries catch potential by 2050 due to climate change show that the potential yield for the Caribbean region will decline up to 40% (Cheung et al., 2010).

Pelagic fishes are expected to be more resilient to climate change impacts, and might even become more abundant in some areas, whereas demersal fishes are expected to be solely negatively impacted (Rijnsdorp, Peck, Engelhard, Mollmann, & Pinnegar, 2009).

The effects of climate change on phenology (seasonal life cycles) will include changes to spawning seasons, reduced larval duration and higher larval mortality (Nurse L. , 2011). Shifts in the seasonal migratory patterns of pelagic species have been linked to changes in production of their zooplankton food source as a result of climate change (Nurse L. , 2011).

Pelagic Sargassum

Changes in ocean circulation have already begun to affect organisms in the coastal waters around the Eastern Caribbean. For instance, officials believe that the presence of unusually large mats of the pelagic Sargassum seaweed across the region is associated with changes in current and weather patterns (Doyle and Franks, 2015). In 2011, 2014 and 2015, vast amounts of the seaweed disrupted recreational and commercial fishing activities across the Eastern Caribbean. It had negative impacts on fishing gear and boat engines, potentially causing engine failure and risk to human life. Many fishers needed to improvise devices to free rudders of weed, to protect engines and free propellers. The use of large strainers on water intake systems is now recommended to prevent blockages and engines from over-heating (Doyle and Franks, 2015). Sargassum has also hampered the movement of marine turtles coming to beaches to lay their eggs, and is also a threat to hatchlings – making it difficult for them to emerge from their nests. It is also a major concern for the tourism sector as many beaches are covered in thick mats of Sargassum seaweed.

The impacts of pelagic Sargassum on fisheries are not all negative, and many fishers have noticed an increase in the number of juvenile fish and lobster, which may use floating mats of Sargassum to hide from predators. This may increase local populations in some locations, but could also make the harvesting of undersized pelagic fish (Dolphin fish) an increasing threat to the sustainability of the industry.

Increasing Storm and Hurricane Impacts on Coasts

In the Caribbean region between 1980 and 2007, nearly 98% of disasters, 99% of casualties and 99% of economic losses related to natural hazards were caused by recurrent meteorological, hydrological and climate-related events, primarily tropical cyclones and storm surges, floods, droughts and extreme temperatures. These natural disasters are expected to be further exacerbated because of climate change (Nurse, et al., 2014). Storms and hurricanes pose threats to the fishing sector as they cause flooding and destruction of landing sites, destruction of boats and gears, economic losses in terms of lost fishing days and reduce the safety of fishers.

3.5.4 Social Impact Assessment

The vulnerability of fisheries and potential impacts on society have been assessed at the national level worldwide (FAO, 2015; Nurse, et al., 2014) and at a regional level within the Caribbean (Monnereau, et al., 2015). There is at present no national framework for assessing climate change vulnerability of the fisheries sector at the local level that can easily be applied in fishing communities. The development of a framework across fishing communities will provide valuable inputs for adaptation strategies within the fisheries sector.

The results from the regional assessment show that fisherfolk in the Caribbean region are highly vulnerable to climate change and suggest that the fisheries sector in Caribbean SIDS is more vulnerable than in other SIDS. The local level of social vulnerability will vary between countries and between sites, depending on the level of ecological impact, the socio-economic sensitivity and adaptive capacity.

Based on the specific characteristics of Grenada's fisheries and coastal ecosystem as outlined in the previous sections, the following socio-economic vulnerabilities are highlighted and explained:

- Reduced profitability of the fisheries sector;
- Limited opportunities for livelihood diversification;
- Increased risks to human lives and fisheries assets;
- Insufficient capacity of fisherfolk organisations for community-based management;
- Inadequate fisheries planning and management by the Fisheries Division; and
- Low levels of aquaculture investment by internal and external investors.

Reduced Profitability of Fisheries Sector

The two main economic challenges felt by fishers in Grenada are the persistent increase in the cost of fuel coupled with fragmented fisheries market arrangements. Rising fuel costs affect the profitability of fishing operations and the potential for moving towards more sustainable offshore pelagic fisheries (e.g. small pelagics such as jacks). The decreasing local demand for fish, as local communities switch to readily available and cheaper substitutes such as imported chicken and salt fish, is an additional challenge facing the fisheries sector. Both these challenges affect the profitability and sustainability of fisheries, particularly of the small-scale operations.

Limited Opportunities for Livelihood Diversification

The adaptive capacity of many fishing communities is often limited, as there are few alternatives to traditional ways of fishing. This makes communities much more vulnerable to a decrease in the profitability of fishing and more likely to switch to less sustainable harvesting methods. A recently completed diagnostic study (CRFM, 2012) to determine poverty and vulnerability in capture fisheries, aquaculture and fish processing levels found that in Grenada and Saint Vincent and the Grenadines, more than 5% of the households in the fisheries/aquaculture sector were classified as being poor: 6.61% and 5.41%, respectively. In both countries, the survey sites were on mainland St. Vincent and Grenada; however, these households were involved in capture fisheries. Grenada topped the list with 25.62% of fisheries households classified as vulnerable, followed by Saint Vincent and the Grenadines at 10.81%. The poor and vulnerable fisheries households depended more strongly on fisheries for their income as compared to other households, and this is replicated in the fishing communities in the Grenadine Bank. Developing opportunities for livelihood diversification in coastal communities is consequently an important priority for poverty alleviation and climate change adaptation.

Increased Risks to Human Lives and Fisheries Assets

More frequent, extreme weather events associated with climate change are increasing risks to human lives and fisheries assets. Disaster management in fisheries has been mainly response-oriented with few programmes and interventions aimed at longer-term adaptation. Early warning systems are not adequate and difficult communications, especially among fisherfolk and coastal communities, pose threats to the fisheries sector as a whole and particularly to the lives and assets of fisherfolk. Limited safety-at-sea training and equipment combined with inadequate uptake of technology is exposing fisherfolk to unnecessary risks.

Boats are being increasingly exposed to large swells and extreme weather events is increasing, a situation often made worse by beach erosion and SLR, which are shrinking the area available for boats to be stored safely (see Figure 76). Equipment required to haul boats into safer areas at landing sites and the infrastructure for safe harbours is limited. These challenges create great risks to the assets of fisherfolk some of whom are uninsured. The limitations on insurance availability and access for small-scale fishers further constrain disaster risk reduction responses to climate change and variability.

Figure 76-Active beach erosion at Grenville and Sauteurs is increasing exposure of small fishing boats to large swells and extreme weather (Photos by: Owen Day)

The need to develop insurance that is accessible and relevant to the fisheries sector was the subject of a recent workshop held by CRFM, FAO, the World Bank and the Caribbean Catastrophe Risk Insurance Facility. Fisheries Ministers from CRFM Member States met in Cayman in October 2016 to review progress towards the activation of the Caribbean Ocean Assets Sustainability Facility (COAST). The COAST insurance scheme will offer an opportunity for countries to buy insurance to help protect their fisheries sector, and hence their food security, from severe weather while promoting resilience to a changing climate and encouraging the conservation of marine environments. It is hoped that COAST will provide 180,000 fisherfolk and associated industries in the Caribbean access to insurance for losses from severe weather (CRFM, 2017).

Insufficient Capacity of Fisherfolk Organizations

The promotion of co-management is considered critically important to the sustainability of fisheries and to reducing the vulnerability of coastal ecosystems and fishing communities. This is particularly true in Caribbean SIDS where the capacity of governments to enforce legislation and manage fisheries is often limited. In Grenada, Carriacou and Petite Martinique efforts are underway to strengthen the capacity of all fisherfolk organisations and increase their engagement with issues relating to climate change and resilience. The current lack of capacity increases the vulnerability of the fisheries sector and of coastal communities (Phillips and Guiste, 2007).

Inadequate Fisheries Planning and Management of Coastal Ecosystems

The effects of climate change on marine ecosystems and fisheries resources cannot easily be managed by engineering or physical measures (Mahon, 2002), but require a more holistic management approach that uses an ecosystem approach to fisheries (EAF) as well the Code of Conduct for Responsible Fisheries (CCRF), and other guidelines and principles recommended by FAO. Grenada currently does not have a national fisheries management plan and has limited capacity and resources for implementing existing polices or for assessing and monitoring the status of commercially important species and ecosystems. This lack of capacity is increasing the long-term vulnerability of the fisheries sector and of the communities whose livelihoods depend primarily on coastal resources.

As seen in the previous sections, fisheries yields are expected to be impacted by climate change while the sector is already under threat from overfishing, loss of habitat, pollution and invasive species. Illegal, unreported and unregulated (IUU) fishing compounds the problems. These factors make it even more critical to promote effective fishery planning and management that incorporates climate change adaptation (CCA) and the recommendations from leading experts and organisations for an ecosystem approach to fisheries (EAF) as well a Code of Conduct for Responsible Fisheries (CCRF).

Low Levels of Aquaculture Investment

Aquaculture is the fastest growing food-producing sector globally. It has become increasingly important in meeting the deficit created by declining capture fisheries and meeting the increasing demand for fisheries products. Aquaculture, both in freshwater and seawater, could assist Grenada in strengthening it's of food security, employment and foreign exchange earnings.

3.5.5 Identification and Prioritisation of Adaptation Options for Fisheries and Coastal Ecosystems

As outlined in the previous sections, the socio-ecological vulnerabilities associated with fisheries and coastal ecosystems in a changing climate are complex and multifaceted. The wide range and potential severity of climate change impacts reinforces the need to urgently increase resilience and reduce vulnerability through comprehensive adaptation measures. While some challenges will be impossible to manage locally (e.g. ocean acidification) most of the key climate-induced impacts can be greatly reduced through effective fisheries and coastal resource management.

Continue to Improve Technical Capacity and Institutional Arrangements for ICZM

In 2014, a Coastal Zone Policy was formulated by Grenada's MALFF, developed through a bilateral-regional cooperation arrangement between the "Caribbean Aqua-Terrestrial Solutions" (CATS) and the ICCAS programmes, both of which are being implemented by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ, 2014). The objective of the ICCAS project is to establish a phased approach for setting up an entity responsible for ICZM in Grenada, and the Policy was approved in 2015.

To further the integration of an ICZM approach, it would be useful to strengthen technical capacity of the Coastal Zone Task Force in a variety of different areas of ICZM, such as coastal water quality analysis, coastal planning, coastal engineering, coastal project management, hydrographic surveying, draughtsmanship, data analysis, archiving and modelling for coastal vegetation. The Board should also be staffed with experts who have the ability to oversee activities and provide expert recommendations on proposed activities, including coastal engineers, GIS experts, marine biologists and environmental lawyers.

Similarly, a Coastal Zone Management Plan for Carriacou and Petite Martinique was developed by the OECS and prepared as part of the Rallying the Region to Action on Climate Change (RRACC) project, which commenced in 2012.

Improve Availability of Ecosystem Data and Strengthen Monitoring of Critical Ecosystems

Improving the availability of ecosystem data is important for long-term monitoring and assessment. There is particular need for monitoring of ecosystems such as seagrass beds and ecosystems protected within MPAs. In this regard, there are a number of actions which could support improved availability of ecosystem data, including:

- Collecting and analysing information on the Molinière-Beauséjour MPA, Woburn MPA and Sandy Island MPA and producing a MPA-specific database that can be accessed freely and searched by all concerned stakeholders;
- Continuing coral reef monitoring programmes to help discern the impacts of diving pressure and define the limit of acceptable change, in relation to diving frequency or maximum number of divers in one location at one time;
- Conducting water quality testing for all MPAs on a monthly basis and identifying data-sharing arrangements within Government (e.g. Ministry of Housing, MALFF, National Water and Sewerage Authority);
- Continuing to expand lionfish reporting and monitoring;
- Updating the current mangrove map on a regular basis and including key coastal woodland areas, identifying ownership of mapped areas and strategically (re)planting littoral and mangrove forests;
- Undertaking regular profiles of prioritised beaches in mainland Grenada, Carriacou and Petite Martinique (proposed beaches for Carriacou: Lauriston, Grand Bay, Harvey Vale, Paradise, Hillsborough, Sandy Island and Sanchez, Anse la Roche, Dumfries –Sabazan, Lillette, Tibeau, Mount Pleasant);
- Initiating the collection of wave and current data;
- Establishing a seagrass monitoring programme with at least an annual survey to determine areal extent, presence of disease, species richness, diversity and density;
- Involving communities and schools in data and information collection for ecosystem monitoring as well as coastal and marine processes.

In addition to the above actions, the establishment of centralised repositories to compile information from survey and monitoring programmes would be advantageous.

Mainstream Climate Change Adaptation (CCA) Into Fisheries Management and Planning

Effective governance and enabling policies are necessary to make fisheries more resilient to climate change. Several recommendations and guidelines to mainstream CCA could be easily applied and/or strengthened to existing fisheries policies. These include:

- The Code of Conduct for Responsible Fisheries (CCRF) published by FAO and other relevant international and regional policy guidance should be to promoted and strengthened in fisheries management programmes/policies;
- The ecosystem approach to fisheries (EAF) is not yet widely practiced and should be considered afresh in mainstreaming CCA and DRM into fisheries;
- Disaster Risk Management and Climate Change Adaptation: formulating a strategic action plan and programme for fisheries and aquaculture, (FAO);
- Voluntary Guidelines for Securing Sustainable Small-scale Fisheries in the Context of Food Security and poverty eradication - Part 2, FAO;
- Benefits of applying good governance and co-management principles are widely discussed and recognised as important to effective CCA, but need to be implemented more actively;
- CCA and DRM need to be institutionalised in order to build adaptive capacity and resilience in fisheries management; and
- Early warning system for weather-related risks adapted to fisheries sector.

There is at present no national framework for assessing climate change vulnerability of the fisheries sector at the local level that can easily be applied in fishing communities. Research could for instance focus on improving the understanding of changes in ocean currents, water temperature and chemistry around Grenada, and the impacts of these changes on production, distribution and species composition.

Improve Policies, Regulatory and Institutional Frameworks to Increase the Resilience of Important Ecosystems

Greater effort is needed to ensure that current and future policies, laws and institutional frameworks support the resilience of important ecosystems. In particular, specific legislation is needed to address the co-management of mangroves and marine protected areas by community-led organizations and improving current stocks of herbivorous fish (e.g. legislation related to bans or closed seasons)

Improve Fisher's Access to Information to strengthen their Resilience to Climate Change Impacts

The resilience of fisherfolk to the projected impacts of climate change should be strengthened by increasing their awareness of the threats and their access to relevant information. New information communication technologies (ICTs) could be used to enable managers to provide fishers with real-time information on weather-related risks, as well as other information relevant to fisheries management, disaster risk reduction (DDR) and climate change adaptation (CCA). Safety-at-sea awareness programmes and information on suitable insurance policies would also help fishers reduce risk to their lives and assets that are being threatened by climate change.

Enhance Livelihood Diversification in Fishing Communities

Livelihood diversification in fishing communities is an important strategy for increasing socio-economic resilience. A livelihood assessment study undertaken in Carriacou (Day et al., 2016; Eristhee et al., 2013) aimed at gaining an understanding of feasible alternative livelihood options for fishers in Carriacou. Extensive stakeholder data clearly identified opportunities to diversify fishing techniques, such as the use of Fish Aggregating Devices (FADs), as the highest priority for livelihood diversification. Seamoss farming was ranked as the second priority and eco–tourism tours as third. Facilitating access to new fishing gear, offshore safety equipment and solar-powered ice-making plants would also increase diversification and competitiveness in the fisheries sector, and strengthen the adaptive capacity and hence resilience of Grenada's fishing communities.

A lionfish containment programme is already ongoing through private initiatives of different dive shops and the Fisheries Division. This programme could be expanded to include training of fishers in the collection and handling protocol, which might encourage persons to become suppliers of lion fish to restaurants.

Develop and Implement a National Plan for Coastal Ecosystem Based Adaptation

Grenada's existing programme of coastal EBA, in partnership with the United Nations Environmental Programme (UNEP), should be expanded and strengthened (UNEP, 2016). It is generally recommended that the initial focus of coastal EBA should be on the preservation and enhancement of existing ecosystems (e.g. coastal vegetation, dune, mangrove, coral) and on removing or reducing local sources of stress, such as pollution, over-fishing, deforestation and unplanned coastal development. The importance of working with coastal communities is particularly important to ensure local ownership of, and engagement with, the EBA process.

Increasing the resilience of Caribbean coral reefs to climate change by strengthening and improving local management is advantageous (Jackson et al., 2014; Mumby and Harborne, 2010). The Regional Plan of Action 2014-2019 for "*Improving the outlook for Caribbean coral reefs*" (Australia Caribbean Coral Reef Collaboration, 2014) builds on these scientific recommendations for EBA and outlines a regional strategy for coral reefs. This plan of action emphasises the need to strengthen the regional network of no-take MPAs, and focuses on four key objectives:

- Improve the health and resilience of Caribbean coral reefs;
- Strengthen adaptive capacity of communities;
- Build foundations for national and regional action;
- Advocate globally for stronger action on climate change;

In order to garner support for Government policies and legislation which promote EBA, more will need to be done to educate the public about the purpose and benefits of EBA. In Grenada there have already been a number of public awareness programmes to raise awareness about ecosystem services and their relevance for climate change adaptation. These can be expanded to include:

- Expanding the ´Reef Guardians´ outreach and education programme from Moliniere/Beausejour MPA to all other MPA's;
- Increasing awareness about herbivores' role in reef health;

- Organising and participating in information sharing events (conferences, seminars) about marine management;
- Increasing awareness of the importance of mangroves; and
- Promoting more lionfish consumption.

Strengthen and Expand Marine Protected Areas

The importance of Grenada's Marine Protected Areas (MPAs) in the context of fisheries sustainability and ecosystem resilience to climate change should be emphasized. Reducing overfishing, and more importantly, protecting and restoring populations of herbivorous fish, has been found to be particularly important in improving the ecological resilience of coral reefs and their ability to recover after major disturbances, such as bleaching events, storms or sedimentation (Mumby et al., 2007; Olds et al., 2014; Mumby and Harborne, 2010). As part of the Caribbean Challenge Initiative, the Government of Grenada has pledged to protect 25% of near shore marine and coastal environment by the year 2020.

The management of Grenada's existing MPAs at Molinere Beausejour, Woburn Clarks Court Bay and Sandy Island Oyster Bed in Carriacou could be improved if they gained more support from local fishers.

There are several other actions which would strengthen current MPAs and their management including:

- Implementing the current MPA Policy and Action Plan;
- In Carriacou, implementing actions ranked as "high priority" in Sandy Island Oyster Bed MPA Action Plan (e.g. develop a zoning plan for the MPA that includes "no take" areas and other areas that permit non - destructive fishing practices, maintaining mooring buoys, removing derelict vessels and other debris);
- Providing infrastructure support for the management and enforcement at new and existing MPA sites through the addition of mooring buoys, patrol boats and field offices for rangers;
- Adopting the 'Ridge to Reef' approach in Moliniere/Beausejour and other watersheds adjacent to MPAs; and
- Eliminating inappropriate disposal of solid waste in coastal areas or watersheds which could impact protected areas.

Guidelines are available on how best to design and manage MPAs in the context of climate change - so called "climate-smarting" MPAs (Green et al., 2012; Flower et al., 2013).

A key aspect of creating successful MPAs is developing alternative livelihoods programme for displaced fishers or encouraging offshore fishing for pelagic or deep-water species. Brokering new partnerships between fishing communities and the tourism sector can also create new livelihood opportunities and improving management capacity in many MPAs (Day et al., 2016).

A recent review (Weigel, et al., 2014) of the factors that make MPAs effective in managing fisheries suggested the following recommendations:

- Integrate conservation and fisheries objectives through incorporating fisheries considerations into MPA design and MPAs into overall fisheries management frameworks.
- Use no-take zones/no-take areas with other fisheries management actions.
- Include fishers in the design and ongoing management of MPAs and conservation specialists in the design of fisheries management plans.
- Create spaces for sharing and processes for meaningful engagement.
- Build trust, social capital, and relationships.
- Create a collaborative network with stakeholders and supporting organizations.
- Increase coordination between agencies through an integrated management framework.
- Monitor, communicate, and adapt management processes.
- Plan and commit for the long-term.
- Recognize access rights and tenure.
- Address the balance of costs and benefits to fishers through alternative livelihood programmes and compensation schemes.
- Consider equity in processes and outcomes.
- Tailor the governance approach to the context.
- Identify multiple pressures on the marine environment and take cumulative impacts into account.
- Analyse and make trade-offs between objectives using available decision-making processes, integrated management approaches, and information processing software and methods.
- Match good governance processes with effective management actions.

Internationally, there is a growing policy consensus towards using Locally Managed Marine Areas (LMMAs) where governance processes fosters local ownership, encourage compliance and support livelihood diversification. These advances in multi-use marine spatial planning policy can also benefit from new technologies for enforcement, monitoring and communications that not only reduce management costs but also engage a wider circle of stakeholders with a vested interest in the future of the coastal zone.

Expand Coral Restoration Efforts

The pilot projects initiated by the Government of Grenada and UNEP in 2015 for coral restoration in Grand Anse and Windward in Carriacou should be scaled up and replicated. Coral restoration is increasingly recognised as a promising strategy for adaptation to climate change in the Caribbean (Bowden-Kirby, 2001; Young et al., 2012; Rinkevich, 2014; Bowden-Kirby and Carne, 2014; Bowden-Kirby and Carne, 2013). These and other coral restoration activities have mostly focused on two of the most important shallow-water reef-building coral species, namely Elkhorn (*Acropora palmata*) and Staghorn (*Acropora cervicornis*).

Coral reefs can provide highly effective coastal protection, dissipating over 80% of wave energy. The most important zone of the reef for wave attenuation was the shallow reef crest dominated by Acropora corals (Ferrario, et al., 2014). Acropora corals also provide important habitat for many reef dwelling species of fish (e.g. parrotfish, snappers) and shellfish (e.g. lobsters), important for maintaining ecosystem resilience.

The aim of coral restoration (sees examples in Figure 77) should be to create genetically diverse coral nurseries and reef restoration sites that incorporate bleaching and disease resistant parent stock. By gathering together corals from scattered remnants and growing them into sizable populations to increase the chances of fertilization and genetic recombination during spawning, it is hypothesised that this approach will help accelerate recovery of the threatened corals while encouraging natural processes of climate change adaptation (Bowden-Kerby & Carne, 2012).

Figure 77-Coral restoration in Grenada: Clockwise from top left: Elkhorn coral nursery in Carriacou (1), nursey for staghorn coral in Grand Anse (2) and outplanting staghorn in Grand Anse
(Photos: Owen Day, 2016)

Enhance Reforestation of Mangroves

Mangrove restoration efforts are taking place in the South, along the East Coast and in the North of the main island of Grenada, which incorporate elements of community co-management, alternative livelihoods and building awareness around the sustainable use of mangroves (e.g. RECCOMM). These initiatives should be scaled up at selected locations to increase the value of the ecosystems they provide for shoreline protection, fisheries habitat and biodiversity conservation.. In Carriacou and Petite Martinique, there should be parallel efforts to replant lost mangrove areas island-wide.

3.6 HUMAN HEALTH

3.6.1 Methodology

This subcomponent was prepared based on interviews with key stakeholders in the Ministry of Health and the Land Use division of the Ministry of Agriculture, Lands, Forestry and Fisheries. A review and analysis of relevant documents and data sets was also conducted including a review of relevant chapters within the Intergovernmental Panel on Climate Change (IPCC, 2014) Fifth Assessment Report (AR5).

3.6.2 Global Climate Change and Human Health

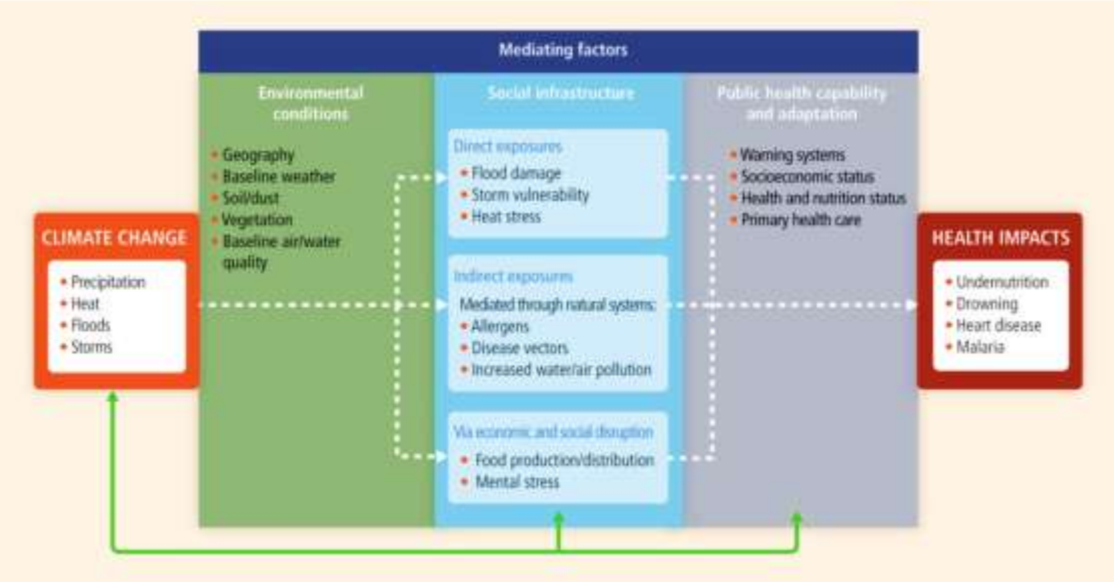
Climate change presents significant risks to human population in in developing countries and small island states as Grenada where health burdens are relatively high and the resources to adequately address these burdens tend to be limited. A number of determinants contribute to population vulnerability to injury and disease, and even moreso under circumstances of a variable and changing climate. These determinants may operate in solo, but more often work in interconnected and complex ways:

- Location is one such determinant: increasing temperatures on outdoor workers in areas where temperatures are already high, as well the impact of extreme heat on health of persons living and working in congested, urban areas, increased flooding in coastal low-lying areas and saline intrusion into coastal aquifers resulting from sea level rise, and the impacts of reduced rainfall on rural farming communities and regions that might increase the risks of under-nutrition and water-related diseases;
- Vulnerability tends to be higher in low-income areas and regions, as limited access to resources do not allow for adequate preventative or adaptive measures;
- Vulnerability to disease and injury is also relatively higher in infants, youths and the elderly compared to other age groups, owing to reasons of physiology (mainly in children) and limited mobility and sub-optimal health in the elderly;
- Mortality from natural disasters is higher amongst women. However, gender risk and mortality trends may also be influenced by domestic, livelihood and cultural factors;
- Quality of, and access to public health infrastructure and service deployment are also crucial to determining vulnerability. The quality of other public service provision and infrastructure (water supply, sanitation, electricity, etc.) also plays a role in reducing or contributing to the vulnerability of populations to diseases and injuries.

Impacts of Weather and Climate on Human Health

The impacts of weather and climate on public health can be categorized as direct or indirect (IPCC; 2014) (see Figure 78).

1. Direct impacts on human health;
2. Indirect impacts from ecological or natural stressors on human health;
3. Indirect impacts mediated by human systems or factors.



Conceptual diagram showing three primary exposure pathways by which climate change affects health: directly through weather variables such as heat and storms; indirectly through natural systems such as disease vectors; and pathways heavily mediated through human systems such as undernutrition. The green box indicates the moderating influences of local environmental conditions on how climate change exposure pathways are manifest in a particular population. The gray box indicates that the extent to which the three categories of exposure translate to actual health burden is moderated by such factors as background public health and socioeconomic conditions, and adaptation measures. The green arrows at the bottom indicate that there may be feedback mechanisms, positive or negative, between societal infrastructure, public health, and adaptation measures and climate change itself (Smith, et al., 2014).

Figure 78-Conceptual diagram showing three primary pathways by which climate change affects health

Direct impacts on human health are brought about by changes in the intensity, frequency and duration of extreme temperature, wind and rainfall events such as tropical cyclones, flooding, drought, heat waves and fires.

Significant research has been conducted to support direct linkages between temperature and health, especially in relation to heat and hot days. Since maximum temperatures have been increasing as a result of climate change, it is inferred that the number of heat-related deaths will increase in the future.

Extremely high temperatures, especially over extended periods can lead to morbidity, specifically in relation to cardiovascular, respiratory and renal diseases and heat exhaustion and stroke. Risks are further amplified if workers are not taking personal measures to minimise impact (e.g. wearing protective gear, hydration, and rest). Persons who engage in extensive outdoor activity (for work, recreation or exercise) have also been flagged for increased risk during extreme heat conditions. Combinations of extreme heat and low rainfall incite bush and forest fires, causing illness and even death. There is greater concern for already vulnerable groups (e.g. the elderly, persons with compromised states of health) and areas or regions with pre-existing high temperature regimes. The eventual impact of these events on human health will vary based on other determinants, including socio-economic status that may determine one's level of access to air-conditioning.

Rapid-onset events such as tropical cyclones, intense rainfall and their associated impacts are also responsible for health impacts and loss of human life. Direct, immediate impacts are most well-known and reported on most frequently: injuries, death, and the incidence of infectious diseases. Impacts are not only limited to physical health, but also mental and emotional health as well: prevalence of mental disorders in aftermaths as individuals and groups grapple with personal losses. The intensity of rainfall events and cyclones are projected to increase on in the Caribbean, with implications for consequent injury and death where adaptation or risk-averse behaviour is minimal.

Indirect impacts stem from climate's influence on ecological or natural stressors on human health, such as those caused by vector- and water-borne diseases, and airborne pathogens and particulates.

Diseases spread by mosquitoes and ticks are highlighted under the vector-borne category. Malaria – a well-known mosquito-transmitted disease – is prevalent in many regions, including Grenada, caused by various species of the plasmodium parasite and spread by various Anopheline mosquitoes. Even under optimal climate conditions for transmission and infection, they can still be significantly tempered by adequate vector control and case management measures.

Dengue Fever is another major mosquito-transmitted disease (Smith, et al., 2014). In this case, transmission is mainly effected by the Aedes aegypti and Aedes albopictus species. Both are considered to be climate sensitive, with strong evidence of direct correlations between specific climate conditions, vector populations, and transmission and infection rates. Variations in temperature, rainfall and humidity affect vector and disease trends, and there is an established seasonal pattern of prevalence, mostly associated with wet seasons. Notably however, both excessive rainfall that leads to water ponding and lack of rainfall that encourages increased water storage in containers both create favourable breeding sites and contribute to vector proliferation and spread of the disease.

Tick-borne diseases such as encephalitis and Lyme disease, and other diseases transmitted by vectors such as rats, other mosquitoes and domestic animals also manifest potential linkages between vector and/or agent behaviour and climate conditions (Smith, et al., 2014). There is concern that projected changes in climate could result in the increase in vector-borne disease incidence and prevalence, owing to alterations in the natural environment that create more favourable conditions for vector development and proliferation, vector effectiveness in disease transmission, and for geographic ranges and transmission routes to expand and persist (Ebi et al., 2012; Smith, et al., 2014).

Food and water borne infections may occur as a result of consumption of contaminated food or water. Diseases that are caused by climate-sensitive agents include cholera, diarrhoea, enteric infections, schistosomiasis and rotavirus, which exhibit patterns of incidence that have been linked to temperature and/or rainfall trends and seasonality.

Indirect impacts mediated by human systems or factors include climate-induced occupational impacts, nutrition, mental stress, and indirect impacts that result from weather-induced damage to or destruction of health care facilities and services.

Concerns of impacts on nutrition arise from the effects of weather and climate on food production quality and quantity, access, trade, prices and nutrition-related disorders. However, climate change may very likely have severe impacts on nutrition, especially child nutrition, in food-insecure areas.

Even without the influence of climate change, most of these psychological stressors would continue to impact human health. Climate change will, however, exacerbate these stressors. With climate change projected to intensify over the coming decades, some of the main concerns that have been highlighted by the AR5 (Smith, et al., 2014):

- Greater risk of injury, disease, and death due to more intense heat waves and fires (very high confidence);
- Increased risk of undernutrition resulting from diminished food production in poor regions (high confidence);
- Consequences for health of lost work capacity and reduced labour productivity in vulnerable populations (high confidence);
- Increased risks of food- and water-borne diseases (very high confidence) and vector-borne diseases (medium confidence);

Health sensitivities in small island states as Grenada are also often compounded by a relative lack of adequate access to basic needs (water, food and sanitation) and to health services (Nurse, et al., Small islands, 2014).

The movement of transboundary dust clouds (e.g. Saharan Dust) has also been linked to various health impacts – respiratory and cardiovascular – in a number of SIDS regions including the Caribbean (Nurse, et al., Small islands, 2014).

3.6.3 Climate Change and Human Health in the Caribbean

The interplay of geographical, social, economic and other development factors within the Caribbean region makes it more susceptible to the impacts of climate variability and change, and by extension the impacts on human health and wellbeing especially where there is pre-existing social and economic hardship, improper or unsafe physical development, low environmental quality or environmental decline and access to quality health services.

Much regional-scale work was conducted under the suite of climate change adaptation projects implemented by the CCCCC (e.g. Chen, et al., 2006; Taylor et al., 2009) and by other regional entities (e.g. CARPHA; ECLAC – Clarke et al., 2013). While regional authorities remain cognisant of the spectrum of climate-related health challenges, some diseases that are given greater attention in the Caribbean include malaria, dengue fever, leptospirosis, and gastroenteritis; owing to established empirical relationships between these diseases and climate. Analyses conducted by Clarke, et al., (2013) conclude that the incidence of malaria and leptospirosis will increase between now and mid-century under both low and high emissions climate scenarios; and that dengue fever and gastroenteritis will have fluctuating degrees of impact. The projected costs to the region for treatment services vary by disease and the projected incidence and are estimated at near USD $2 million over the 2011 – 2050 period (Clarke et al., 2013).

Epidemics have also been strongly tied to the El Niño Southern Oscillation (ENSO) phenomenon. Most epidemics have occurred during an El Niño year, sometimes extending into the first half of the year immediately following; as a result of warmer and wetter than normal conditions that create suitable environments for vector behaviours that increase transmission and infection rates Taylor et al., 2009).

More recently, the Chikungunya and Zika viruses have debuted on the regional health stage, and have become priority concerns for health management authorities as much as Dengue Fever, because all three viruses are transmitted by the same vector.

The current incidence of malaria in the Caribbean is relatively small in Caribbean SIDS (Taylor et al., 2009). Previous studies (Taylor et al., 2009 and Clarke, et al., 2013 have sought to discern any link between malaria incidence, temperature and rainfall patterns and the results from recent research have given weight to potential linkages between the incidence of the disease and temperature and rainfall, suggesting that changes in climate will affect incidence rates.

Several studies within the region highlight strong correlations between the incidence of leptospirosis and rainfall (WHO, 2007; Taylor et al., 2009; Clarke et al., 2013; Nurse et al, 2014). There is potential for incidence of leptospirosis to increase with climate change, especially in countries such as Grenada and due attention is encouraged.

3.6.4 Climate Impacts Assessment

Grenada´s Initial National Communication identified health as one of the most vulnerable sectors in the country. It states that ‘the main effect is likely to be caused by the increased incidence of vector-borne communicable disease. Respiratory diseases associated with regional dust storms during the hurricane seasons are also cause for concern.

Based on the IPCC reports (2007; 2014), Grenada and other SIDS will face direct health impacts from heat waves, floods, droughts and storms, but the indirect impacts, such as changes in infectious disease patterns, pollution, malnutrition, mass migrations, and conflicts will be just as impactful.

Slow-onset climate related changes such as increasing temperatures, sea-level rise, reduced annual rainfall and drought, combined with more intense rains, will most likely give rise to indirect health impacts such as shifting patterns of vector borne diseases. Table 48 below provides an overview of the direct and indirect impacts of climate variability and change on human health in Grenada.

Table 48-Climate Change related health risks identified in Grenada

DIRECT	INDIRECT
Extreme weather events and natural disasters: - Physical injury - Death - Heat stress and heat-related illness - Psychological trauma - Loss of livelihoods - Water, sanitation and hygiene related issues - Food insecurity - Displacement	Rising temperatures and changing rainfall patterns: - Infectious Diseases - Vector-borne: Dengue, chikungunya and possibly Zika Virus - Water-borne: Diarrheal diseases - Rodent-borne: Leptospirosis Airborne particulates from Saharan dust: - Chronic respiratory diseases e.g. Asthma - Acute respiratory infections

According to the recently released Grenada Climate Change and Health Vulnerability and Adaptation Assessment Report (Pochanke-Alff and Meincke, 2016), the climate related health impacts were classified in the following order:

Vector-borne

- Dengue
- Chikungunya
- (Malaria)
- (Zika Virus)

Water-borne

- Gastroenteritis / Diarrhoea

Allergic reactions

- Asthma (Saharan dust)

Direct impacts of extreme events

- Hurricane/ flooding: threat to human life and injury
- Heat stress (human and livestock)

Systems influenced by Climate Change

- Agriculture (impact on food production and livestock health)
- Socioeconomic disruptions (less tourism etc.)

Due to lack of data, the vulnerability and adaptation assessment (V&A) opted for a qualitative/descriptive to evaluate the health impacts of climate change, with the focus placed on diseases of importance such as Chikungunya and Zika. Grenada must introduce a proper (electronic) disease surveillance system to start gathering comprehensive data to map the diseases, and relate them to climate events.

Grenada's Ministry of Health and Social Security (MoHSS) developed a sector-specific 'National Health Sector Disaster Management Plan' in 2006, which aims 'to provide guidance to the Health Sector in the management of an event whether natural or human made, ensuring that the health sector is able to respond, with the goal to save as many lives as possible (MoHSS, 2006). Several elements are highlighted as key to the success of this plan: input by all sectors; preparation and preparedness; ongoing training and re-training; continuous monitoring, evaluation and commitment. Although the plan does not address all phases in the disaster cycle, it is a start for integrating risk reduction into the recovery phases of an emergency situation.

A new 'Corporate Plan' for 2015-2017 was drafted in 2014, providing a road-map for MoHSS programmes and activities, and outlining priority areas for health spending in that period (MoHSS, 2014). SWOT analysis undertaken to develop the plan does identify climate change as a threat to national health. Furthermore, several activities that can be linked to climate change were identified, most of which correspond to the WHO health systems building blocks, and the ten components for building climate resilient health systems (see Figure 79). The activities identified for Grenada include: improvement of health infrastructure (repair and maintenance, preventative maintenance plans); health systems development and strengthening (management information system, health disaster risk management including safe hospitals); health services development and delivery (implementation of international environmental health regulations, improved vector control); and implementation of a functional communications strategy (MoHSS, 2014).

Key stakeholder interviews conducted during the assessment revealed several key constraints to effective climate and health management in Grenada:

- Inadequate human and financial capital,
- Limited collaboration and cooperation at both inter- and intra-sectoral levels,
- Limited functioning surveillance and monitoring mechanism.

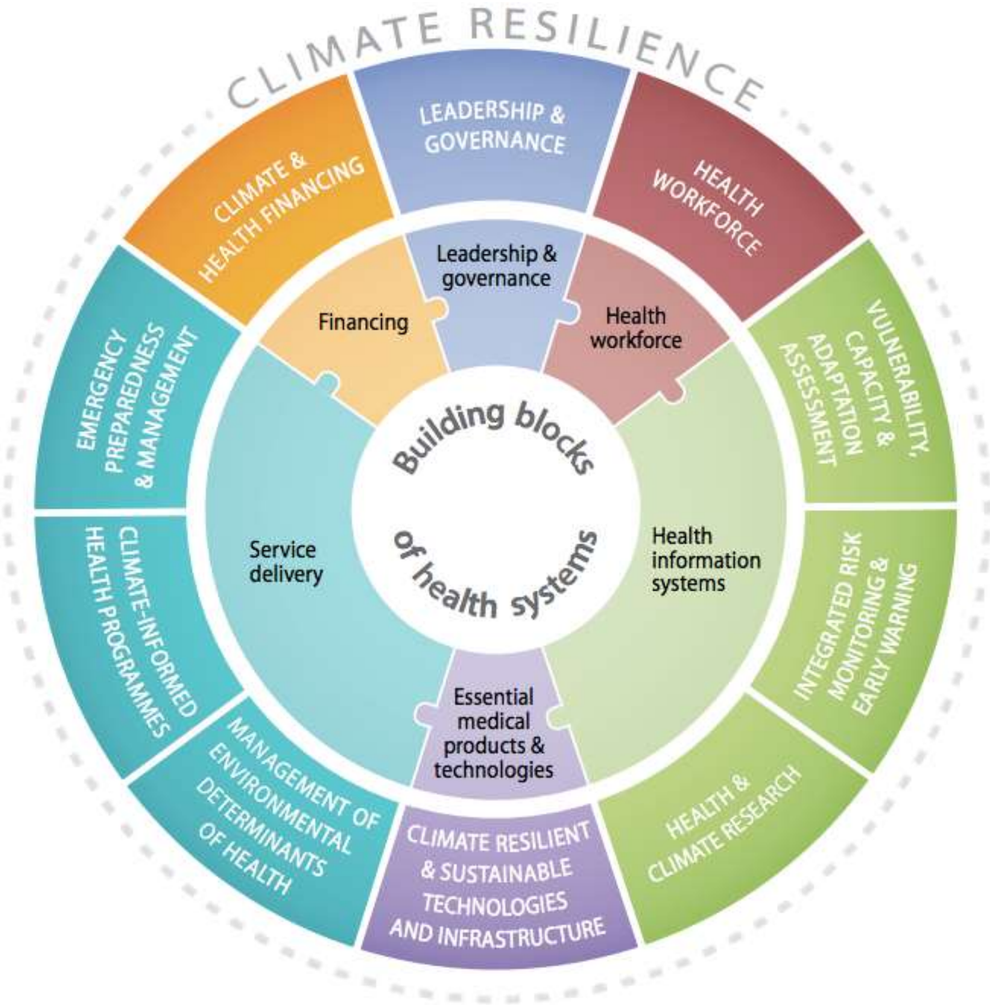


Figure 79-WHO building blocks of Health systems and their respective components for creating climate resilience (Source: WHO)

Climate Change Impacts on Human Health in Grenada

Grenada has a relatively good health information system. Data is collected on an epidemiological weekly basis and includes:

- **Communicable Diseases Data** is collected on a weekly basis from all communities/health stations and some private doctors. Data collected includes clinical presentations and case numbers. This info is collected on Tally Sheets and then entered into EpiInfo - the Ministry of Health Information database.
- **Non-Communicable Diseases** data such as chronic diseases (diabetes, hypertension) is also being collected as well as respiratory diseases (asthma) and gastroenteritis.

The long-term plan is to have one comprehensive database linking health and climate. Work has started in collaboration with the Ministry of Agriculture, Land Use Division to include climate sensitive diseases (NCDs) in the Division work programme so that they can be entered into the District Health Information System-2 surveillance system that links climate and health.

Grenada's population is primarily exposed to diseases transmitted by the *Aedes aegypti* mosquito, a climate sensitive vector that is responsible for the transmission of dengue, chikungunya and Zika viruses (IPCC 2014). All three diseases are arboviruses and pose an on-going threat to the island's population under a changing climate. While dengue has been recorded in the Caribbean region since the 17th century, Chikungunya and Zika are emerging threats, with outbreaks in Grenada first occurring in 2014 and 2016, respectively. The study by Clarke, et al. (2013) provides an empirical analysis identifying variations in disease-specific impacts of climate change under different emissions scenarios (A2 and B2) in the Caribbean. The results indicate that cases of vector-borne diseases including Malaria and Dengue are likely to exceed the number of cases under the baseline scenario in the forecast period 2011-2050.

Vector-borne diseases (particularly Dengue, Chikungunya and Zika virus) are a primary concern of Grenadian public health officials, due to the difficulty of vector management and the outbreak prone nature of these diseases. An increase in intense rainfalls and temperatures is likely to create favorable mosquito breeding conditions, making the control of these diseases a priority in the health sector (Patz et al., 2003). Rodent-borne diseases such as leptospirosis are prone to outbreaks during floods, when sewage can mix with drinking water supplies, increasing the risk of human infection. Moreover, heavy rainfall and hurricanes are often accompanied by an increase in water-borne diseases, when communities using pit latrines are flooded and their water supplies contaminated.

Grenada has been affected by climate variability in the recent past beginning with the drought that started in September 2009 and extended to April 2010. The island has also been experiencing frequent dry spells within the wet season and heavy showers during the dry season. This impacts the water supply and water quality through increased soil erosion resulting in increased turbidity of streams. This decline in water quality during both the dry and wet seasons has resulted in an increase of water-borne diseases (diarrheal diseases in particular). Carriacou and Petite Martinique are particularly affected due to their reliance on rainwater harvesting (CARIBSAVE, 2012).

Dry spells, drought conditions and strong winds during the dry season can also increase particulate matter in the air. This in turn can aggravate persons with respiratory illnesses, such as asthma, and result in an increase of acute respiratory infections. Air-borne respiratory infections may therefore become more common among those who suffer from chronic respiratory diseases (Akpinar-Elci et al., 2015; CARIBSAVE, 2012).

The number of cases of vector borne diseases has been increasing over the last 5 years, especially with the emergence of Chikungunya and Zika. Analysis of data for Gastroenteritis, Chikungunya and Dengue with rainfall data for the same period over the last 5 years shows that there is a relationship between increased cases of these diseases and climate. Comparison of rainfall and gastroenteritis shows that there is an increase of gastroenteritis cases after heavy rainfall. Figure 80 below shows the relationship between average rainfall and gastroenteritis cases.

While there have been no empirical studies showing the relationship between gastroenteritis and climatic variables in Grenada, research done elsewhere has suggested a link between El Niño, that lead to increasing temperatures and dry conditions, on infectious gastroenteritis transmission (Onozuka, 2014; Hall et al., 2010; Verret et al., 2016; Clarke et al., 2013; Gomes et al, 2013). In Grenada, gastroenteritis cases showed an increase after Hurricanes Ivan and Emily Glasgow et al., 2013).

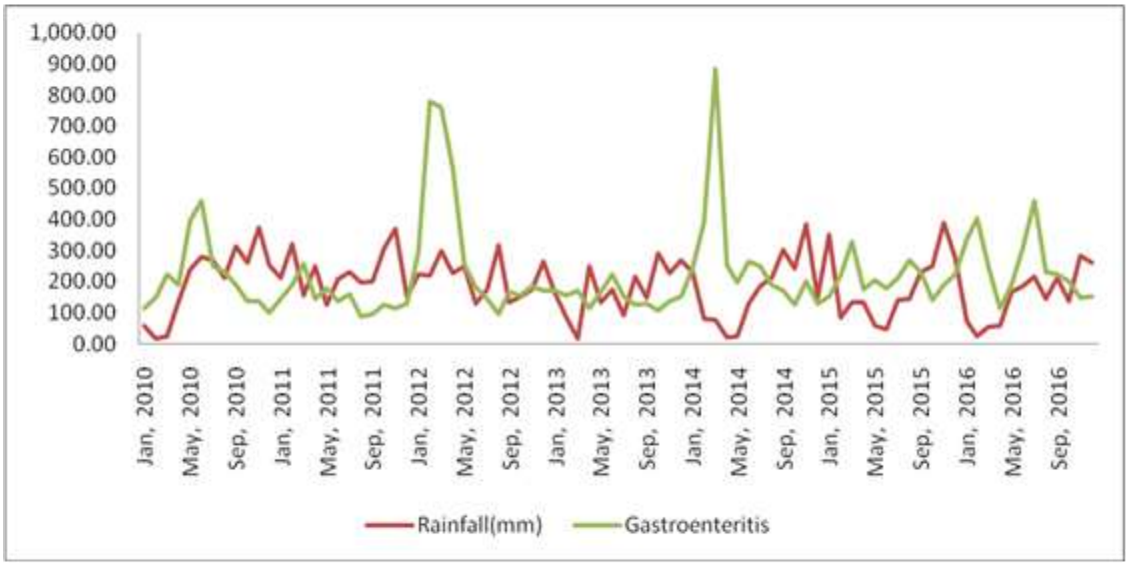


Figure 80-Rainfall and gastroenteritis for June 2010 to September 2016 (Source: Land Use Division, MOA.

Grenada reported its first case of Zika virus in April 2016 and has seen as of January 2017, 335 suspected cases, and 102 confirmed cases. However, it is likely that the number of cases is much higher, as patients do not seek out medical support due to the mild symptoms. Moreover, Grenada's surveillance system is not very robust, with many private clinicians not reporting to the MoHSS. Grenada has also reported ten (10) cases of Guillain-Barré Syndrome, which have been linked to Zika infection and two (2) of these cases resulted in death.

Because the data for Zika is for a short period (10 months) it was not possible to make any definite conclusions. However, Figure 81 below shows the number of Zika cases in comparison to rainfall received over a 10-month period.

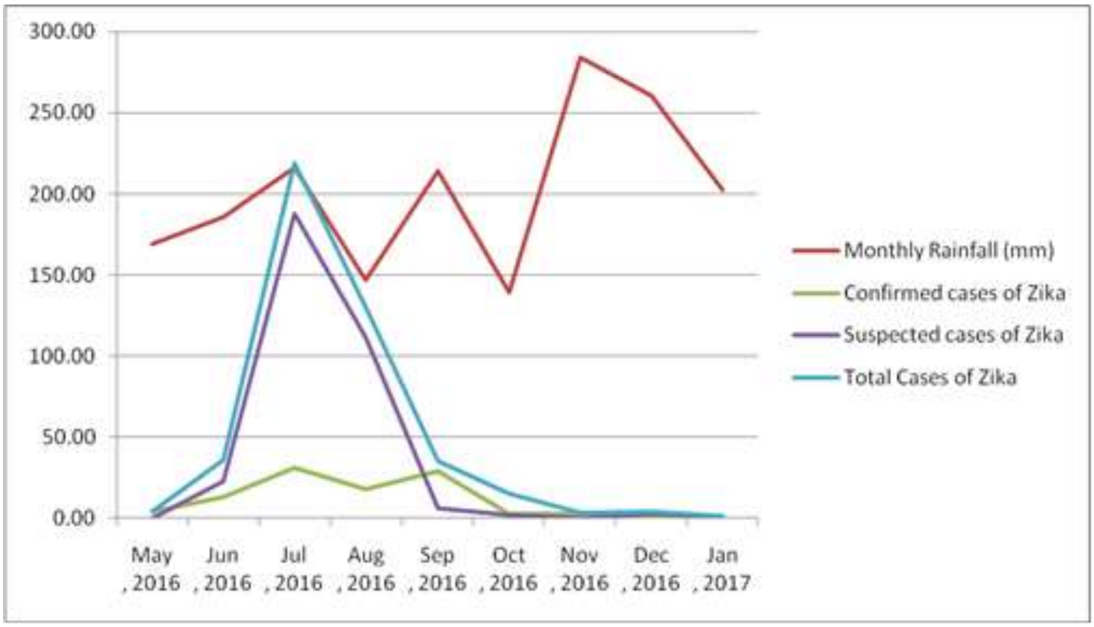


Figure 81-Rainfall and Zika cases from May 2016 to January 2017 (Source: Land Use Division, MOA)

Although dengue is endemic to Grenada, large outbreaks do not occur every year (Ebi et al., 2006). From January 2001 – June 2002 an outbreak with 546 cases was reported in Grenada, with further notable outbreaks occurring in 2010 and 2013.While dengue seasonality has been observed in other Caribbean islands (Taylor et al., 2009; Verret et al., 2016), no studies have so far been done to correlate climate data to dengue cases in Grenada. While most Caribbean countries report dengue outbreaks during the rainy season in the second half of the year, Grenada's dengue outbreak in 2002 peaked during the dry season, with most cases reported in March of that year (Figure 82).

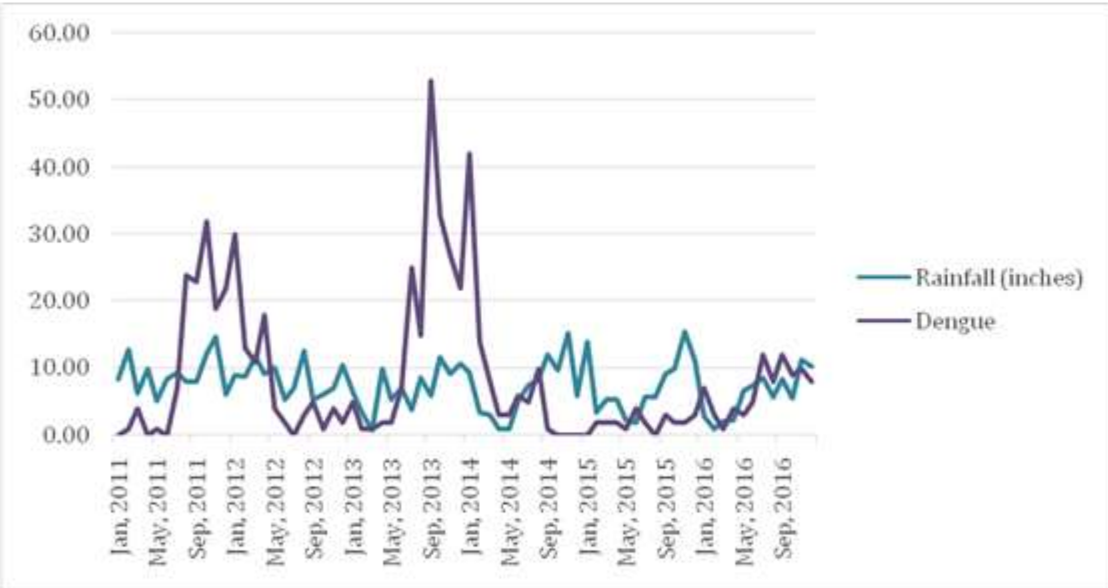


Figure 82-Dengue cases and average rainfall.

While dengue can be considered endemic to the Caribbean region, chikungunya is classified as an emerging threat, which caused a region-wide epidemic in 2014 (Cauchemez, et al., 2014). In Grenada, it is estimated that 60% of the population have been infected with the virus since its emergence in 2014 (Clegg, 2015). The outbreak saw a total number of 3,116 cases in Grenada, with 26 laboratory-confirmed. The outbreak peaked in September, the middle of the rainy season. The outbreak coincided with a period of heavy rainfall and thunderstorms.

In recent years, vulnerability assessments and studies of the health sector infrastructure have been conducted. Lack of water at health facilities during or after climate-related events such as droughts tropical storms or hurricanes is of growing concern and Government has moved to address this issue with the introduction of the smart Health centers and a PAHO project to provide safe, vector proof water storage containers. Some will be rainwater harvesting systems and others will be increased storage of domestic supply.

As part of a SMART health care facilities project, health facilities are being assessed in their infrastructure, services, disaster safety, as well as water and energy efficiency. The results feed into a road-map for investment and will be incorporated within national risk exposure databases. In Grenada, three health facilities will be retrofitted to help reduce downtime and potential damage to the facility in the event of a disaster, as well as reduce operational expenditures by improving water and energy management. Based on the Ministry of Health evaluation of water availability at health facilities, 16 facilities will benefit with increased storage or retrofitting of these facilities. The plan speaks to installing rainwater harvesting or water storage systems at all facilities by the end of 2017. The total water storage will move from 15,600 gallons to 67,000 gallons on completion of the project, an increase of approximately 51,000 gallons.

Grenada's Climate Resilient Water Sector in Grenada (CREWS) project proposal includes new or improved drinking water storage, and improved plumbing and/or rainwater harvesting infrastructure at 16 community health facilities and related services in four parishes of Grenada and in Carriacou.

The Ministry of Health, in response to the climate assessments, has developed various awareness-raising events for health professionals on the link between climate change and health and a flyer is available for the general public to read and be informed on the risk and response measures to adopt.

Food Security and Health

Grenada like other SIDs has very limited land space for agricultural food production. Historically the island relied on rain-fed agriculture for food production during the wet season. The island also has very steep slopes which make it difficult to do mechanized farming. When these factors are added to the island's high vulnerability to current climate variability and its sensitivity to extended periods of drought, increasing temperatures, hurricanes and heavy rainfall, Grenada's agricultural sector and food security is highly vulnerable to climate change. The northeast region of Grenada and the island of Carriacou in particular, experience prolonged dry spells that adversely affect the yields of rainfed crops. This might lead to disruptions in food supply, changing patterns of crop, pest and weed species, lower food production, lower access to food due to reduced supply, and higher prices (ECLAC, 2011). This in turn may result in malnutrition and vitamin deficiencies in poor communities that are unable to afford increasing prices of local or imported foods. To address this threat the island has started since 2006 moving towards irrigation as an adaptation measure to address the issue of national food security.

The most common clinical outcomes of foodborne illness in Grenada are diarrheal illnesses such as gastroenteritis, which affect the entire population and can be caused by an array of viral, bacterial or parasitic organisms (Glasgow et al., 2013).The MoHSS has identified diarrheal illness as a major cause of morbidity, with most cases occurring in children under the age of five (MoHSS, 2014). Risks of contracting food or water borne illnesses tend to rise during dry spells, when there is insufficient clean water for proper sanitation practices, as well as inadequate water storage conditions, and marginally after heavy rainfall, when clean water sources can become contaminated (Verret et al., 2016).

Leptospirosis is a rodent borne bacterial disease caused by *Leptospira* pathogens, and is endemic to the Caribbean region. Humans can become infected by direct or indirect exposure to urine of infected rodents (WHO, 2012). Indirect transmission can occur through contact of contaminated water with cuts or abrasions of the skin, or through mucous membranes of the eyes, nose and mouth (WHO, 2012). Risk of leptospirosis infection is especially high when flooding occurs, such as after a hurricane or heavy seasonal rainfall, which can cause conditions that increase human exposure to contaminated waters (WHO, 2012).

While the number of annual leptospirosis cases in Grenada is not high, a total of 57 cases were reported over 2008-2014. The endemicity of disease, presence of the zoonotic host (rats), and changing climatic conditions, such as heavy rainfall and periodic flooding, are all factors that may increase the risk of disease transmission. As the rainfall and hurricane intensity increase with climate change, so may the instances of flooding, leading to favorable conditions for leptospirosis transmission (Clarke et al., 2013).

Acute respiratory infections (ARI) are the most common reported communicable disease in Grenada. Reported cases of ARIs have almost doubled since 2006, and significantly affect the under-five age group (ca. 1/3 of cases occur in <5 patients). With over 6000 cases being reported annually, ARIs pose a significant threat to the wellbeing of the Grenadian population. Climate variability and change, in particular the presence of Saharan dust have been linked to the increasing number of infections (Akpinar-Elci et al., 2015). The study conducted by Akpinar-Elci et al., 2015 between 2001 and 2005 found that there is a positive correlation between rainfall, humidity, Saharan dust and asthma incidence in Grenada.

The direct and indirect impacts of climate variability and change on human health in Grenada listed above are important considerations to take into account when assessing Grenada's vulnerability and adaptation needs. Table 49 below outlines activities that were identified as climate change related adaptation needs to reduce direct and indirect health impacts in Grenada:

Table 49-Climate Change related adaptation needs in the health sector

Health impacts	General adaptive measures	Specific adaptive measures
Extreme weather events (direct effects on health)	Disaster preparedness and mitigation Disaster protection measures Health infrastructure resilience	Conduct more research on the complex inter-relationship between climate, vector ecology, and human health Link data on epidemiology of diseases with climate data (including historical climate data) Evaluate effectiveness of vector control Implement an electronic health information system for improved disease surveillance, monitoring and control Implement a national information center – linked to relevant regional centers – containing detailed information on temporal, environmental and climatological data Solidify the institutionalized collaboration and cooperation at both inter- and intra-sectoral levels Strengthen the capacity of MoHSS for evidence-based planning and budgeting
Infectious diseases (indirect effects on health)	Early warning systems Improved surveillance of diseases and vector populations Integrated vector management	

The rates propagation of many tropical diseases such as malaria, dengue, chikungunya, Zika, filariasis and schistosomiasis are increasing in small island states (Ebi et al., 2006). Reasons for this include poor public health practices, inadequate epidemiological surveillance, poor infrastructure, increasing global travel, poor waste management, and changing climatic conditions. The abundance of vectors present in Grenada, such the *Aedes aegypti* or *Anopheles* spp. (malaria-transmitting) mosquitoes, can be affected by small changes in ambient temperature and rainfall.

Despite the inherent degree of uncertainty of climate predictions and the complexity of the impact on health in Grenada, priority adaptation actions can be identified. These actions should strengthen existing health programmes: such as those aimed at reducing morbidity and mortality from extreme weather events; secure access to safe water, food and improved sanitation and enhanced vector-borne diseases surveillance and control. Therefore, successful and cost-effective adaption in the health sector is based on including climate change considerations into all main budgeting and strategic health planning processes. Simultaneously these have to be aligned with the overall National Adaptation Plan (NAP) (WHO, 2012).

3.6.5 Social Impacts Assessment

The MoHSS has a vision of an enhanced quality of life, improved health status of individuals, families and communities and maintenance of a state of optimum wellness (MoHSS, 2014). The

MoHSS operates on the philosophy that “Health is a fundamental human right which is achievable through the Primary Health Care approach utilising Health Promotion strategies delivered by trained health professionals” (MoHSS, 2014).

The MoHSS developed a national strategic plan for health (NHSP) 2016-2025 that recognises the impact that climate change is already having on the sector including new and re-emerging communicable diseases. The NHSP states that the Ministry’s overarching goal is to “significantly improve the health of all Grenadians through a strengthened and sustainable health care system”. The NHSP focuses on the six WHO building blocks for health including leadership and governance, health services delivery, human resources for health, pharmaceuticals and medical technology, health financing and health information systems. Each building block has a strategic goal with corresponding strategic objectives, challenges have been identified for each of the building blocks and the action plan seeks to resolves those challenges (MoHSS, 2015).

Sustainable Development Goal (SDG) number 3 seeks to ensure healthy lives and promote well-being for all at all ages. It covers all major health topics including reproductive, maternal, newborn and child health, infectious diseases and non- communicable diseases. Figure 83 below shows the SDGs and indicators related to health.

Figure 83-SDGs related to health

Health Situation

Chronic non-communicable diseases and their complications are the main cause of morbidity and mortality in Grenada, accounting for approximately 65% of total deaths each year in the 2006-2010 period (PAHO, 2012). Cancers, cardiovascular disease, hypertension, diabetes, chronic pulmonary diseases (CPDs), and mental health are priority areas of concern. Table 50 below shows the 10 main causes of death in 2014 in Grenada.

Table 50-The top 10 causes of death in Grenada (2014) Source: (Ministry of Health, 2016)

Disease	Male	Female	Total
Neoplasms	91	65	156
Endocrine and Metabolic diseases	33	52	85
Cerebro Vascular diseases	35	50	85
Ischaemic heart disease	50	34	84
Disease of the respiratory system	36	23	59
Hypertensive diseases	27	29	56
External causes	34	14	48
Diseases of the digestive system	23	10	33
Diseases of pulmonary circulation and other forms of heart disease	15	17	32
Certain conditions originating from the perinatal period	17	13	30

In particular, respiratory diseases such as asthma or acute respiratory infections (ARI), are one of the main causes of morbidity in Grenada, with ARIs the leading cause of morbidity in children under 5 (PAHO, 2012). According to the Epidemiology Unit of the MoHSS, there has been an increase of approximately 8 - 11% of cases reporting respiratory diseases in all age groups for the year 2012. High humidity, especially during the rainy season (June- December) results in the dust becoming respirable, potentially contributing to increased numbers of respiratory illness.

Grenada made significant progress in the health care system for the relevant Millennium Development Goals (MDGs) especially child mortality rates (MDG-4), and maternal health (MDG-5). In particular for MDG-4 the infant mortality rate and infant mortality rate under 5 in 2013 was down to 11 per 1,000 live births and percentage of measles immunization was 94%. For MDG-5 the proportion of births attended by skilled health personnel stood at about 99% and the maternal mortality rate per 100,000 live births stood at three (WHO, 2016).

Health System

Grenada's total health expenditure as a percentage of GDP was estimated at around 6.1% in 2014 (WHO, 2016), down from 6.3% in 2013. Public sector budget shortfalls pose an ongoing threat to the health sector. This accounts for an increasing use of private health care providers and a growing reliance on out-of-pocket payments to finance health care (an estimated 48% of total health spending in 2009) (Hatt, et al., 2012). Furthermore, the higher life expectancy and falling fertility rates is anticipated to cause the age dependency ratio to rise over the long term, thus contributing to increased burden for public expenditure on health care, long-term care and pensions (MoHSS, 2015).

Grenada's health service delivery system includes four public hospitals and the community health service facilities (6 district health centers and 30 medical stations that are all within 5 km of their catchment population's home). Furthermore, civil society organizations are highly engaged in Grenada's health sector. According to Hatt, el al., (2012), the Grenadian health system provides a good coverage of, and access to, primary and basic secondary health care services. Approximately 46% of Grenadians have access to private facilities as their first source of medical care (Hatt, et al., 2012).

Although a sufficient number of general medical practitioners and nurses support the current health service system in Grenada, the country's disease burden requires an increased number and range of human resources for health, such as medical and nursing personnel. Furthermore, the MoHSS's capacity for evidence-based planning and budgeting could be strengthened. For instance, the management of pharmaceuticals and medical supplies benefits from cost-saving due to Grenada's participation in the OECS Pharmaceutical Procurement Service.

In Grenada, health data collection and reporting is paper-based, with health centers sending weekly disease tally sheets to the MoHSS, who input this information into EpiInfo software (communicable diseases) and into Excel (non-communicable diseases). This poses challenges in compiling all the data from the different parts of the tri-island state and prevents timely data analysis for evidence-based response and action. A robust health information system is especially important for the control of epidemic-prone diseases, as these require constant surveillance and reporting, early action, and quick response. Certain epidemic-prone diseases, such as vector-borne diseases, are more climate sensitive than others presenting existing and emerging threats to Grenada. The active surveillance of these diseases, including the vector biology and disease transmission patterns is essential to informing vector control strategies and treatment regimens.

In a SWOT analysis conducted by the MoHSS for their Corporate Plan 2015 – 2017 (MoHSS, 2014), they identified several weaknesses affecting the quality of the health sector. Some of these include:

- Inadequate integration of services i.e. Primary and Secondary;
- Inadequate standards to measure quality of care/services;
- Lack of clearly defined policies and procedures;
- Lack of succession plan for Human Resource Management and Training;
- Inequitable distribution of Health Resources;
- Inadequate infrastructure and equipment;
- Low staff morale;
- Outdated Public Health Legislation and Regulations;
- Weak enforcement of Health Legislations;
- Weak Health Information Systems;

- Inadequate Financial Resources;
- Lack of scheduled preventative maintenance of buildings and equipment.

Government is in the process of developing a National Health Insurance to provide affordable universal access to health care for every citizen. This, it is hoped, will help to address a number of the resources related issues identified above. Additionally, the establishment of the District Health Information System-2 (DHIS-2) in Grenada is a critical step in addressing some of the recognized health information system constraints, and will support the achievement of objectives that directly depend on having an adequate information system in place. Training in the implementation and use of the DHIS-2 has already commenced, and the system has been established with the following features and imported legacy datasets:

- Defined meta data (data elements, data sets) needed to capture and import aggregate data for the various routine reports and forms used in the health facilities by community health nurses;
- Legacy data imported for communicable diseases (2008-2016) and ANC data from 2016;
- Population by village (census data, 2011);
- Rainfall by weather station, linked to village (from the National Water Information System);
- Vector control by village;
- Organizational structure of the health system in Grenada including health district, health facilities with GPS coordinates. Private clinics listed, but missing GPS coordinates;
- GIS/maps with health district shape files and health facility and village GPS coordinates;
- With census villages as ‘standard’ included in the system as ‘atomic’ basic building blocks, they can be used to construct districts and parishes and other geographical areas in the DHIS2.

Health Infrastructure

In recent years, vulnerability assessments and studies of the health sector infrastructure have been conducted (PAHO/WHO 2014, PAHO/WHO 2010, PAHO, 2008). In 2008, the main healthcare facility of the country, Grenada General Hospital located in St. George´s, was assessed using PAHO’s Hospital Safety Index (HSI) (PAHO/WHO, 2014). Due to the buildings’ location on the shoreline, it is particularly vulnerable to tsunamis and storm surges. The second largest healthcare facility, the Princess Alice Hospital, located in the north of the island, was assessed using HSI in 2009. Its vulnerability to natural hazards like earthquakes, hurricanes and volcanic eruptions is similar to all other facilities of Grenada. However, as a result of its inland location and flat environment, it is not vulnerable to tsunamis, storm surges and landslides.

Both institutions have been assessed to determine the Hospital Safety Index. This index measures the resilience of hospital facilities to determine their ability to remain functioning after a hazard event. As part of the activity 15 officers of the Ministry of Health, Ministry of Works and the RGPF were trained in the application of the Hospital Safety Index.

Environmental Health

The Environmental Health Division (EHD) of the MoHSS is a branch of public Health that is concerned with all aspects of the natural and built environment that may affect human health

(Ministry of Health, 2016). The EHD is responsible for monitoring and ensuring the best Environmental health practices are adhered to at all times. The EHD also has a Vector Control Unit, which periodically monitors, investigates and terminates various forms of vectors that threaten human wellbeing.

The Vector Control Division did a commendable job managing the high incidence of mosquitoes during the outbreak of Chikungunya, through fogging, public awareness campaign, application of the Anti-Litter Act on violators and rigorous surveillance activities (MoHSS, 2014).

Waste Management

The EHD is faced with several concerns regarding waste disposal including illegal dumping, disposal of pharmaceuticals, scrap metal and tyres (MoHSS, 2016). Two national clean up campaigns utilising community resources in response to Chikungunya outbreak in the region were conducted in Grenada. Many illegal dump sites and mosquito breeding sites were eliminated in response to the Chikungunya outbreak including at the Hospital compound in St. George's (MoHSS, 2014).

The Environmental Health Department also embarked on a series of intervention measures which includes:

- Public awareness programmes;
- Fogging operations;
- Entomological surveillance and treatment.

Other environmental health related concerns include sanitation and clean drinking water. Approximately 97% of the population has access to improved drinking water and 98 % of the population has access to improved sanitation services (WHO, 2016).

Challenges in the Health Sector

The MoHSS in its NHSP (MoHSS, 2015) identified many challenges in the health sector in relation to the six building blocks for health. Some of the major challenges identified are:

- Weak sector coordination structures and arrangements;
- Inadequate disaster management structures and emergency preparedness;
- Inequalities in accessing health services;
- Inadequate outreach and referral services;
- Low motivation of health workers;
- Inadequate number of trained health professionals;
- Outdated policies and guidelines for medicines, medical supplies and equipment, vaccines and medical technologies;
- Inequitable and inefficient allocation of health sector resources;
- Lack of standards and guidelines for data collection, analysis and reporting.

3.6.6 Recommended Adaptation Strategies for the Human Health Sector

The MoHSS in its NSHP recommended several activities to address the many challenges identified in the action plan consisting of several measures to address some of the challenges. Below are some recommendations of the action plan:

One of the major challenges identified throughout the NHSP was related to the data and information systems; all aspects of the health sector face a challenge in this respect. The recent integration of the DHIS-2 into the sector's operations is a promising start in addressing some of these data and information challenges. With the able support of the DHIS-2, MOHSS should aim to develop a national data use policy to guide the management, access and distribution of health and climate related data. The MoHSS should work closely with the Meteorology Office and the Land Use division of the Ministry of Agriculture to develop this policy. The policy should take into consideration the following:

- Standard Operating Procedures for digitising and uploading health data to the recently established DHIS-2 platform, building and expanding on the training and data input that has already been conducted;
- Central geographic unit for health, environmental, and meteorological data, so that mapping can be performed;
- One reporting timeframe for health, environmental, and meteorological data;
- The reporting indicators for health under the sustainable development goals; and the
- Definition and management of sensitive data.

There are no climate change specific measures recommended in the NSHP action plan, even though climate change was acknowledged throughout the document it was not considered under the building blocks. The NHSP did however indicate that a separate climate change action plan will be developed for the health sector in collaboration with the updating of the disaster plan.

Greater promotion of healthy Lifestyle choices for the population should be prioritized at a high level; this can be implemented following the development of a communication strategy by the MoHSS. The MoHSS should coordinate with other relevant ministries and private sector entities such as insurance companies and supermarkets to ensure a wide range of the population receive key messages.

Priority should also be placed on updating all relevant health related policies and legislation. These should be harmonized to facilitate effective and efficient implementation of health regulations. The MoHSS should conduct a review of all existing policies and legislation; this would be able to identify which polices need updating and policy gaps and overlaps.

3.7 TOURISM

3.7.1 Methodology

An extensive literature review was conducted on the impacts of climate change on tourism, with special attention on Grenada. The literature review was used to make inferences and perform a climate impact assessment and a social impact assessment of Grenada's tourism sector. Outputs from the stakeholder consultations for the preparation of the National Adaptation Plan were also used to identify policies, programmes and projects that address climate change adaption in the tourism sector.

3.7.2 Climate Impacts Assessment

Climate change is anticipated to have a significant impact on the three primary factors that influence destination choice of tourists: climate, natural environment, and personal safety. Destination communities and tourism operators, particularly those with large investments in immobile capital assets (e.g. hotels), have less adaptive capacity in response to choice of destination (UNWTO-UNEP, 2008).

The key predicted changes that will likely impact Grenada's tourism sector are outlined in Table 51 below.

Table 51-Predicted climatic changes for Grenada that will likely impact tourism: Data from (Simpson, et al., 2012)

Parameter	Predicted Change
Air temperature	Warming by 1°C to 3.7°C by the 2080s
Sea surface temperature	Increases of +0.9°C to +3.1°C by the 2080s
Sea level rise	Rise by 0.5m - 0.6m by 2081-2100
Rainfall	Changes in annual rainfall range from -40 mm to +7 mm per month (-66% to +12%) by the 2080s
Tropical cyclones	Uncertainty regarding future trends

Rising Air Temperature

Temperature is considered the most important climate variable when analysing tourism flows because, outside a certain temperature range, tourists' perceptions of favourable weather and comfort may be impacted (Gössling & Hall, 2006). With regional air temperatures projected to rise, there are concerns that tropical regions like the Caribbean may become "too hot" for tourists during the summer months (typically June to August), not to mention the risk of early storms and hurricanes. Little impact during the peak winter season (November to February) is anticipated, however (Simpson et al., 2011).

Optimal temperatures for tourists coming from major source markets vary according to countries. British tourists prefer a maximum daytime temperature threshold of 30.7°C, (Maddison, 2001 in Gössling and Hall, 2006). Lise and Tol (2002 in Bujosa and Rosselló, 2013), found that tourists originating from Organisation of Economic Co-operation and Development (OECD) countries preferred an average temperature of 21°C for the hottest month of the year at their destination choice. Surveys of European tourists revealed that the optimal conditions for beach tourism is between 27°C and 32°C (Simpson et al., 2011). Canadian tourists indicated a preference for temperatures between 27°C and 30°C (Rutty and Scott, 2016). Grenada currently experiences a mean annual temperature of 27.5°C (Government of Grenada, 2011c), which falls within the preferred range of European and Canadian visitors coming for coastal tourism.

These findings suggest that tourists' thermal preferences can vary by type of activity, nationality, climatic region of origin, age and gender (Rutty and Scott, 2015; Rutty and Scott, 2016). However, information on other parameters such as humidity or wind speed also has to be factored in (Gössling and Hall, 2006). Other natural or socio-cultural features that contribute to destination choice must also be taken into consideration.

With that said, higher temperatures will have implications for other climate parameters that could adversely impact the tourism sector: heat stress and other heat-related illnesses, injuries or mortality brought about by extreme weather events, and changing patterns in infectious diseases.

The impact of climate change and SLR on tourism would be both direct and indirect. As climate in the higher latitudes becomes milder, Grenada could be less desirable as a tourist destination. Another possible negative impact on tourism could be the loss of beaches or the deterioration of the beaches due to erosion. Water sports, a key growing feature of tourism, would become less attractive in the absence of quality beaches.

The high vulnerability of the Grenada tourism sector, most of which is located on the coast, is well documented. The hotel sector suffered much damage from Hurricane Lenny (1999) and Hurricane Ivan (2004).

Tourism in Grenada tends to be focused on traditional leisure (beach) tourism and eco-tourism. These activities are of particular interest to the Draft Grenada ICZM Policy objective of climate change adaptation and vulnerability reduction. The achievement of this objective will depend on a healthy and vibrant coastal and marine environment and shoreline development planning that minimises the risks to climate change hazards.

Where the environment is an important resource base for the tourism product, strategies adopted to limit climate change impacts should be island and area specific and driven by environmental features that are valued by tourists (Uyarra, et al., 2005). For example, in popular dive tourism locations building resilience of the reefs to coral bleaching and associated disease impact might entail improving water quality by, for instance, limiting sewage pollution from coastal resorts (Wooldridge and Done, 2009). Similarly, in areas where beaches are valued, 'hard' (e.g. sea walls or breakwaters) and 'soft' (e.g. beach nourishment) engineering methods for shoreline protection can be adopted in efforts to guard against erosion associated with SLR and storm surges (Phillips and Jones, 2007).

The tourism sector, particularly the sun, sea and sand (3S) market, is highly climate-sensitive due to its dependence on favourable environmental conditions and natural resources to drive demand. This is especially true for Caribbean islands like Grenada where climate is the principle resource for tourism, augmented by warm temperatures, beaches and coral reefs (Cashman et al., 2012; Uyarra et al., 2005). Climate change and its associated environmental changes can have a profound effect on the perceived attractiveness of a destination and may lead to a reduction in tourism demand. For instance, a study by Uyarra, et al. (2005) found that 80% of tourists in Bonaire and Barbados would be unwilling to return for the same holiday price in the event of coral bleaching due to elevated sea surface temperatures and reduced beach area as a result of sea level rise, respectively.

Models such as the Tourism Climate Index have also revealed that under climate change, the competitiveness of destinations in tropical and subtropical locations may decline (Scott et al., 2012; Rosselló et al., 2014). In fact, a gradual shift in international tourism demand to higher latitude countries is projected, especially under warmer scenarios and in the mid- to -later decades of the 21st century. It is anticipated that tourists from temperate countries such as the United States of America (USA), the United Kingdom (UK), Canada and Europe would adapt their travel patterns to take advantage of new climate conditions closer to home (Scott et al., 2012; Cashman et al., 2012).

Climate change impacts on tourism can be categorised as direct physical impacts (e.g. higher temperatures or sea level rise) and indirect impacts (e.g. vector-borne diseases or safety and security issues). This subsection will discuss the projected climate change impacts on Grenada's tourism sector: warmer air and sea surface temperatures, rising sea levels, changing rainfall patterns, and changes in the intensity of tropical cyclones (Forster et al., 2012).

Sea Level Rise

Although the magnitude of future global sea level rise (SLR) remains uncertain, it is considered to be one of the most certain and significant consequences of climate change for Caribbean coastal tourism destinations (Scott et al., 2012). The potential impacts of SLR most pertinent to tourism include inundation of coastal lands and damage to tourism infrastructure, coastal erosion and loss of beach area through the process of "coastal squeeze" (where the coastal margin is prevented from landward migration by a fixed boundary such as a sea wall or road), loss of coastal habitats and defences (e.g. coral reefs and mangroves), impeded drainage and increased risk of inland flooding, salinity intrusion into freshwater supplies, higher water tables which can adversely affect the stability of foundations of coastal infrastructure, increased need for shoreline protection, and changed coastal aesthetics (Scott et al., 2012a; Scott et al., 2012b; Cashman et al., 2012; ECLAC, 2011a).

Global SLR will continue in the years ahead and by the end of the century, total SLR could reach as much as 1.5 m to 2 m above present levels (Simpson et al., 2010). Volcanic islands like Grenada with only narrow coastal areas will be vulnerable to significant beach erosion, localised flooding due to storm surges, coastal landslides, and loss of coastal ecosystems and infrastructure (Simpson et al., 2010).

Beaches are critical assets for tourism in the Caribbean. Wider beaches are also generally favoured by tourists, and beach quality on the whole plays an important role in the selection of Caribbean destinations and the price tourists are willing to pay (Schuhmann, 2012b; Scott et al., 2012). Already, it has been observed that Grenada's beaches have recently undergone an average yearly change in beach width of -0.30 m yr^{-1}, and about 75% of beaches showed signs of erosion. Elevated rates of erosion were also observed in years the island was impacted by hurricanes (Cambers, 2009). The finding that more than 80% of tourists would be unwilling to return to Caribbean islands like Grenada for the same holiday price in the event of reduced beach area due to SLR underscores the value of beaches to coastal tourism, and the impact eroded beaches can have on destination attractiveness, room rates, and property value (Uyarra et al., 2005; Scott et al., 2012).

Higher sea levels will accelerate beach erosion due to increased wave action. Table 52 highlights the potential loss of beach area at three beaches in Grenada under several SLR scenarios. For example, Grand Anse, a popular beach for tourists, is projected to lose up to 77% beach area under a 2 m SLR (Simpson, et al., 2012).

Table 52-Beach Area Loss at Three Beaches in Grenada (Adapted from Simpson, et al., 2012)

	Grand Anse		Marquis Beach		Soubise Beach	
SLR Scenario (m)	Beach Area Lost to SLR (m^2)	Beach Area Lost to SLR (%)	Beach Area Lost to SLR (m^2)	Beach Area Lost to SLR (%)	Beach Area Lost to SLR (m^2)	Beach Area Lost to SLR (%)
0.5	2,148	4%	4,077	100%	3,169	100%
1.0	10,097	22%	-	-	14	-
2.0	29,584	77%	-	-	-	-
3.0	12,680	100%	-	-	-	-

Tourism infrastructure, most of which is located on or near the coast, is at great risk to inundation and storm surge due to SLR. Under a 1 m SLR scenario, 73% of major tourism resorts in Grenada would be impacted; with the percentage increasing to 86% of resorts under a 2 m SLR scenario (Simpson, et al., 2012). Under a scenario of 1 m SLR, Grenada's current airport runway would be completely inundated.

As beaches degrade, price structures for coastal accommodations may decline, affecting profitability and potentially leading to closures, unemployment and further decline in overall destination image (Scott et al., 2012).

Based on the study by Simpson et al. (2010), the costs of SLR will escalate significantly towards the end of the century, as greater SLR combines with increasing populations. As Table 53 shows, the economic implications of mid-range SLR on Grenada's tourism sector have been estimated at US $19 million/year in 2050 to US $66 million/year by 2080. While the capital or rebuild costs for tourist resorts can range from US $334 million in 2050 to US $788 million in 2080 (see Table 54) (Simpson et al., 2010).

Table 53-Annual costs of mid-range and high SLR on Grenada's tourism sector (US$ million) Source: (Simpson et al., 2010)

	2050	2080
Mid-range SLR scenario	$19	$66
High SLR scenario	$35	$127

Table 54-Annual costs of mid-range and high SLR on Grenada's tourism sector (US$ million) Source: (Simpson et al., 2010)

	2050			2080		
	Tourist Resorts	Airport	Ports	Tourist Resorts	Airport	Ports
Mid-range SLR scenario	$334	$30	$10	$788	$90	$30
High SLR scenario	$801	$56	$20	$2,538	$170	$62

Changing Rainfall Patterns

Parameters such as rainfall can impact destination choice and timing of travel. For the Caribbean region, projected increases of 1.5°C to 2°C in regional air temperature could lead to an increased length of the dry season (Pulwarty et al., 2010). This is particularly worrisome for the southern Caribbean where climate change is anticipated to reduce the availability of freshwater resources to the point where they become insufficient to meet the demands of locals and tourists alike, at least in periods of low rainfall (Pulwarty et al., 2010; Simpson et al., 2011). Where Grenada is concerned, projections span tend towards overall reductions in annual rainfall by as much as 66% by the 2080s (Simpson, et al., 2012).

A prolonged drought in 2009/2010 had serious implications for Grenada's tourism sector, particularly hotels which consume large quantities of water for guests use and comfort (an estimated 600 to 700 litres/day/person), irrigation and on-site cultivation of fruit and vegetables to be consumed by guests. The highest use of water by the sector is during the dry season when available surface and ground water resources are at their lowest. A survey of Grenadian hotels during the 2009/2010 drought reported the following hardships:

- Unreliable water supply;
- Increased water shortages at the facility;
- Increased costs of water due to the high costs of trucking;
- Increased complaints from guests;

- Loss of ornamental plant and garden stock; and
- Loss of onsite production of fruit and vegetables (Peters, 2015).

Water had to be trucked to all the major hotels on the island, with a few larger hotels in the tourism belt of Grand Anse being forced to purchase truck delivered water at prices as high as $US 28.15 per cubic metre for transportation alone. Water-based tourism activities were interrupted by reduced river flow, and bird watching was affected by the damage to the dry forest by fires. Also, between February and April 2010, at the height of the tourist season, water for guests was rationed at some small hotels and guesthouses in Carriacou and Petite Martinique where shortages of water were more acute (Peters, 2015).

Although uncertain, the direction of rainfall changes seems to be leaning towards higher probabilities of a drying trend (Simpson et al., 2010). On the other hand, greater rainfall would deter British tourists and impact their choice of destination (Maddison et al., 2006). Similarly, for Canadian tourists to the Caribbean, 48% of the beach tourists indicated that ≤ 15 minutes of rain was ideal for their holiday, while 28% preferred no rain and 24% would accept 30 minutes to 1 hour of rainfall. However, the majority, 97% and 60%, felt that ≥ 5 hours or between 2 to 4 hours of rainfall, respectively, would be unacceptable (Rutty and Scott, 2016).

Therefore, there appears to be an inverse relationship between rainfall and tourism demand. On the one hand, tourism is a very water intensive sector which requires fresh water supply to meet tourists' consumptive, hygiene, aesthetic and recreational needs; while on the other, tourist tend to prefer little or shorter periods of rainfall during their holiday.

Human health concerns, and by extension destination risk perceptions, also arise from higher temperatures and changes in rainfall. Water scarcity can impact on sanitation and human health; and irregular rainfall could contribute to increased incidences of waterborne and vector borne diseases. Amongst the environmental attributes that influence tourists' choice of some Caribbean destinations are few tropical diseases and no vaccination requirements (Uyarra et al., 2005).

Of special concern for Grenada is the prevalence of mosquito-borne viruses: Dengue Fever, Chikungunya and, more recently, Zika. These vector-borne diseases can induce epidemics which could lead to a loss of tourism from negative publicity and health fears (Oduber et al., 2014). The outbreak of Zika from late 2015 into 2016 in South America and the Caribbean is another good example[35]. In early 2016, agencies such as the US Centre for Disease Control (CDC) issued a travel warning for several Caribbean islands, recommending that pregnant women should not travel to these countries due to the risk of contracting Zika which could cause microcephaly in their babies (BMI Research, 2016). As a result, the region recorded a number of travel cancellations (Idar, 2016), and it has been suggested that countries whose economies depend

[35] Grenada reported its first case of Zika virus in April 2016 and has seen as of January 2017, 335 suspected cases, and 102 confirmed cases.

significantly on tourism could suffer foregone incomes in the order of 0.8% to 1.6% of GDP (The World Bank, 2016). Such declines in arrivals reflect the findings of a survey of Americans which revealed that 44% would avoid planning, or would cancel (43%) their trip to areas affected by the Zika virus (Fluent, 2016).

Increased Sea Surface Temperature and Ocean Acidification

Healthy coral reef ecosystems are critical to Caribbean tourism. It is estimated that the economic activities (hotels, dive operators, restaurants, etc.) associated with Bonaire's coral reefs earn about US $23 million annually (Talbot and Wilkinson, 2001); while the annual Total Economic Value (TEV) of Bermuda's coral reefs to tourism averages US $405.9 million (van Beukering, et al., 2010). Grenada's tourism sector, like Bermuda's, is bolstered by cruise arrivals. In 2007, Bermuda's cruise ship tourism sector generated approximately US $190 million from reef-associated activities (van Beukering, et al., 2010). These figures demonstrate the potential earnings Grenada, a renowned diving destination, can receive annually from healthy coral reef ecosystems.

Recent sea surface temperature (SST) increases are greatest throughout the Lesser Antillean islands such as Grenada (Simpson et al., 2010); between 1960 and 2006, increases in SST around Grenada ranged from 0.05°C to 0.08°C per decade (Simpson, et al., 2012). It is projected that SST can increase by +0.9˚C and +3.1˚C by the 2080s (Simpson, et al., 2012). Further exacerbating coral bleaching and stress, the projections of current ocean acidification portends reductions of 14% to 30% in calcification rates of corals by 2050 (Pulwarty et al., 2010).

These changes could adversely impact reef fish compositions and the aesthetic values of coral reefs, as well as the net revenues of reef-based tourism operators (Uyarra et al., 2005; ECLAC, 2011b). Furthermore, it has been noted that more than 80% of tourists in Bonaire would be unwilling to return to the island for the same price if corals were severely bleached as a result of increasing sea temperatures (Uyarra et al., 2005). Survey results indicate that 38.3% of the tourists interviewed are motivated to visit Bermuda for coral reef-associated reasons, with snorkeling and touring the reef being the most popular activities. Furthermore, 14% of tourists interviewed confirmed they would not return to Bermuda should the health of the coral reefs decline (van Beukering, et al., 2010).

Greater Intensity Tropical Cyclones

Tourists are significantly less likely to choose holiday options where hurricane risk is perceived to increase; suggesting tourists may seek alternative holiday destinations. It should be noted that risk perceptions varied among different demographic groups, with older individuals, Americans, and persons who prioritise beach activities tending to be most concerned about hurricanes (Forster et al., 2012). In fact, it is anticipated that hazards such as high intensity hurricanes and flooding will become more of a deterrent where Caribbean tourism is concerned (Emmanuel, 2014).

Observed and projected increases in SST indicate the potential for increases in hurricane activity (ECLAC, 2011a). Although an increase in potential hurricane intensity is anticipated, there appears to be little likelihood that hurricane frequency would increase under climate change scenarios (Pulwarty et al., 2010). Even in the absence of increased intensity or frequency of tropical storms and hurricanes, SLR will intensify the impacts of tropical cyclones on Caribbean coastlines (Simpson et al., 2010).

With most of Grenada's tourism infrastructure concentrated on or near the coast, the sector is more exposed to the impacts of tropical cyclones. The passage of Hurricane Ivan in 2004, a Category 3 system, resulted in damages to about 90% of all tourist accommodation, with close to 70% of the hotel infrastructure rendered inoperable after sustaining significant direct damages amounting to XCD $167 Million (The World Bank, 2005; Alexander, 2007). Damages were concentrated in the capital St. Georges, while insignificant or no damages were registered in Carriacou and Petite Martinique. The yachting subsector also sustained millions of dollars in damages due to the strong winds. At the time of the hurricane, Grenada hosted 800 yachts. Of these, 15 sank, 6 disappeared, and 50 were found stranded on land; while roughly 400 boats received damages (OECS, 2004). Facilities such as historical sites, marinas, and other tourism infrastructure were also entirely destroyed or damaged bringing the total impact to the tourism sector to over XCD $264 million (Alexander, 2007). The following year Hurricane Emily, a Category 1 system, while not as devastating to the accommodation, still left in its wake direct losses of XCD $738,725 (OECS, 2005).

Repeated and widely publicised incidences of extreme weather events at destinations like Grenada could influence travel decisions in the longer term, as tourists become more aware of the associated risks and either adapt or adjust their travel plans and behaviour to suit the perceived weather conditions (Gössling and Hall, 2006).

3.7.3 Social Impacts Assessment

It has been established that tourism is critical to the socio-economic development of SIDS like Grenada. As Clayton and Hayle (2009 in Emmanuel, 2014) points out:

"The [tourism] industry is, in many countries, the biggest consumer, the largest customer, the main constructor, the largest employer, the biggest building operator, and drives the procurement of many ancillary goods and services."

Therefore, beyond the direct physical impacts of climate change discussed above, the phenomenon will also have farther reaching socio-economic implications. This is because climate change affects both the demand side (e.g. destination image and tourist arrivals) and the supply side (e.g. beaches and accommodations) of tourism.

Intense hurricanes are perhaps the best lens through which to conceptualise the potential fallout of the corollaries of climate change on Grenada's tourism sector. For example, the negative impacts of Hurricane Ivan on the tourism sector were felt throughout the economy in terms of:

- Loss of aggregate income and employment;
- Lower contribution and negative effect to the overall rate of growth of the economy;

- Increase in imports due to the need to purchase intermediate goods and raw materials for repairs;
- Increase in insurance flows; and
- Lower contribution to government revenue (OECS, 2004).

Overview of Grenada's Tourism Sector

Grenada's tourism sector is one of the main drivers of economic growth, particularly with the decline in the agricultural sector (Bhola-Paul, 2015). Tourism's significance as a foreign exchange earner, employer and catalyst for investment in Grenada is reflected in the commitments by the government, private sector and communities. For instance, one of the six strategic objectives outlined in Grenada's Growth and Poverty Reduction Strategy, 2014 – 2018, is "Developing Tourism and Hospitality Industries" to help improve the country's competitiveness both regionally and globally (Antoine et al., 2014). The Government of Grenada plans to create conditions for the sustainable prosperity of the people and future generations through, amongst other things, developing "a world class service industry especially in tourism" (Government of Grenada, 2014f).

In 2015, visitor arrivals to Grenada reached 443,368; of which cruise passengers accounted for 63% of arrivals, followed by stayover visitors (32%), and yachters (5%). Carriacou continued to receive more than 50% of yacht calls to Grenada. The main source market was the USA, followed by the UK, the Caribbean (Trinidad & Tobago and St. Vincent and the Grenadines), Canada, and Germany. Visits were mainly for leisure, business, and study (Grenada Tourism Authority, 2016). The direct contribution of travel and tourism to GDP for 2015 has been estimated at XCD $168.4 M, or 7.5% of total GDP. More widely, the total sectoral contribution was XCD $572.8 M, or 25.5% of GDP (WTTC, 2016).

The tourism sector has led to positive socio-cultural impacts with the continued development and sustainability of cultural events and festivals such as Spicemas and Parang and Saraka festivals which highlight the unique afro-Caribbean heritage of Grenada. Besides the traditional 3Ss, the island has also focused on developing niches such as eco-tourism, yachting, sailing, and agritourism (Bhola-Paul, 2015; Grenada Tourism Authority, 2016). As a result of their participation in such activities and products, hotels, communities, taxi operators, and various local businesses have become more economically stable. Health care and education in particular have improved due to the impact of tourism on the economy. The development of the tourism sector has also created economic challenges through overdependence on the industry, excess demands on the island's resources and economic leakages (Bhola-Paul, 2015). Given that climate change is predicted to contribute to the geographic redistribution of tourism demand, these pre-existing challenges of the sector will only be exacerbated, affecting property values, foreign exchange earnings, employment, food and water supply, energy usage, and insurance costs (Scott et al., 2012; Cashman et al., 2012).

Impact on Destination Image and Risk Perceptions

The *pull factors*, or extrinsic motivations, which influence tourists' choice of destinations like Grenada include "good weather, beaches, clear waters, biodiversity, landscape and exotic sceneries, low health risks, local hospitality and accommodation services, and cultural attractions (Uyarra, et al., 2004; Heymann and Ehmer, 2009; Moore, 2010; Prayag and Ryan, 2011; Yiamjanya and Wongleedee, 2014). All of these pull factors can be negatively impacted by climate change, which in turn can alter the destination's image and affect tourists' behaviour.

Similarly, risk perceptions, whether real or simply perceived, can have a great effect on international travel. It has been found that tourists avoid certain geographic regions and destination where health and safety risks are high (e.g. diseases, natural disasters, terrorist attacks, crime and political instability) (Baker, 2015). Avoidance of the Caribbean region during the 2016 Zika outbreak is a good example of this.

Forster et al., 2012 in investigating the implications climate-induced variations in Atlantic hurricane activity may have for the tourism-dependent island of Anguilla (whose tourist market is similar to Grenada's) found that tourists were significantly less likely to choose holiday options where hurricane risk is perceived to increase and it will exacerbate the current hazard environment in islands and increase disaster risks (Becken et al., 2014), thereby increasing tourist risk perceptions.

Compounding the situation is the fact that the tourism sector in developing countries as Grenada lacks the capacity to adequately cope with hazards and risks because of, inter alia, a lack of preparedness and knowledge, inadequate place-based hazard and vulnerability assessments, and limited integration of tourism in national disaster risk management systems (Becken et al., 2014). This in turn hampers destinations' ability to develop tourism safety and security plans that cover aspects such as the detection and prevention of risks, media management, crisis management, and safety standards and practices for the accommodation sector (AICST, 2006).

Impact of Climate Change Mitigation Policies

International climate policy poses one of the most immediate economic risks to Caribbean tourism (Simpson et al., 2011). National and international climate change mitigation policies that increase the costs of long-haul travel to certain regions will have important implications for shaping tourism demand (UNWTO-UNEP, 2008; Scott et al., 2012). Examples of such policies include the UK Air Passenger Duty (APD) and the inclusion of the aviation sector in EU Emissions Trading System (EU ETS) which seeks to put a cap on the greenhouse gas emissions of all flights from, to and within the European Economic Area (EEA)[36].

The Caribbean tourism industry is highly dependent on long-haul travel from primary source markets. Therefore, the introduction of higher travel taxes that will consequently increase ticket

[36] In the period 2013-2016, only emissions from flights within the EEA fall under the EU ETS. However, based on the Post-2016 Review, the Commission will report to the European Parliament and Council and propose measures as appropriate to take international developments into account with effect from 2017 (European Commission, 2016).

prices could negatively impact Caribbean tourism. For example, the APD makes long distance travel to the Caribbean[37] significantly more expensive compared to other regions, especially for vacationing families (Emmanuel, 2014). The Caribbean Tourism Organisation has determined that the APD will continue to affect UK tourist arrivals to the Caribbean due to its impacts on the price competitiveness and demand for regional tourism: UK visitors using economy class to travel to the Caribbean declined very rapidly with a rise in air fares beyond £500) (CTO, 2010).

Some destinations have already expressed concern that growing 'guilt' over the impact of jet fuel on global warming could adversely impact the tourism economy (UNWTO-UNEP, 2008; Scott et al., 2012).

Impact on Tourist Arrivals

The geographic and seasonal redistribution of tourist arrivals may be very large for individual countries by the mid- to late-century. These impacts include a gradual shift in preferred destinations to higher latitudes and to higher elevations in mountainous areas; tourists from temperate nations spending more holidays in their home country or nearby to take advantage of new climatic opportunities closer to home (UNWTO-UNEP, 2008). Four climate change scenarios for the Caribbean suggest that in worst-case scenarios tourist arrivals to the region could fall by about 1% per year, costing the region about US $118 million to US $146 million per annum (Moore, 2010).

For the first half of 2005, after the passage of Hurricane Ivan in September 2004, stay-over tourist arrivals to Grenada declined by 36% to 48,023 persons compared with 78,335 visitors in the comparable six-month period of 2004 (CDB, 2012a). Overall, 2005 saw the sector contract by 42.5%, with more than half the room stock lost and with most of the island's major hotels closed. For the year, arrivals declined by 26.6% from 135,536 in 2004 to 98,241 (CDB, 2012b). The disaster and the consequent drop in tourist arrivals had devastating effects on persons working in the sector. For example, larger tour operators reported losses of XCD $75,000 on average per month in the months following the disaster; while smaller tour operators reported losses of XCD $10,000 on average for the months of September, October and November (OECS, 2004).

Impact on Operational Costs and Government Expenditure

The projected costs associated with climate change in terms of adaptation, and rebuild efforts are considerable. For example, due to SLR which is slated to continue for centuries after 2100 even if global temperatures are stabilised at 2°C or 2.5°C, Grenada's tourism will be impacted by both rebuild costs of tourist resorts (upwards of US $334 million or 3.5% of GDP by 2050) and a reduction in contribution to national GDP from beach loss (Simpson et al, 2010).

[37] In 2015, the APD was readjusted to a two-band system. Band A (0 to 2,000 miles from London) and Band B (over 2,000 miles from London). The Caribbean falls within Band B. (GOV.UK, 2016)

From an operations standpoint, climate change will impact costs associated with insurance, heating-and-cooling, pest management, and the need to augment the water supply for drinking and irrigation needs. Of importance will be the effects of extreme weather events on infrastructure and insurance costs. Already it has been suggested that the insurance premiums for the Caribbean region could increase by 20% to 80% by mid-century. In fact, private sector insurance coverage may no longer be available in particularly high-risk areas, forcing governments to provide insurance for tourism development or causing the retreat of development from these areas (Simpson et al, 2011).

Using Hurricane Ivan as a case study, damages resulted in higher rates of utility costs. The interruption of electricity supply forced many tourism establishments to buy or rent a generator plant which incurred high diesel fuel expenses. The absence of drinking water also led establishments to pay for transportation costs to provide drinking water, costing as much as XCD $900 per day. These hurricane losses and expenses in the tourism sector had spill-over effects for the balance of payments (increasing imports mostly for reconstruction of tourist accommodations and yacht repairs), growth and income (decline in travel earnings due to the decline in stay-over arrivals), and expenditure (OECS, 2004).

Impact on Employment and Gender

In 2015, Grenada's tourism sector directly supported 3,550 jobs (8.7% of total employment). Most of these employees were women (2,055 or 11.1% of the total female population), compared to 1,495 men (6.7% of the total male population) (Grenada Statistics Department, 2016a). According to the World Travel and Tourism Council, the total contribution of the sector to employment for the same period was 11,500 jobs (23.3% of total employment) (WTTC, 2016).

The projected effects of climate change are expected to significantly impact employment. Alterations in tourism seasonality and visitor arrivals imply changes in employment demand by the sector. For example, it is likely that there will be increasing demand for casual-workers, thereby reducing full-time contracts. Job losses may also be expected due to closure of hotels and accommodations due to damages from tropical cyclones. In addition, increasing costs for cooling, insurance and disaster recovery would impact the profitability of the hotels, accommodations, and restaurants, forcing some micro-enterprises out of business due to their lower capacity to assume these costs (ILO, 2014). Given the larger number of females employed in the tourism sector, women could be disproportionately impacted by climate change in this sector.

Experiences have shown that Grenada's two main economic income earners – tourism and agriculture – are hardest hit by the passage of hurricanes such as Ivan resulting in the loss of income and employment for a large number of households. Estimates suggest that unemployment spiked from 12% to above 30% immediately after Ivan, a substantial proportion being tourism workers; with female unemployment higher at 25.5%, compared with 12.5% male unemployment (CDB, 2012a; The World Bank, 2005). In Grenada, some 48% of women head households; and among poor women the proportion is even higher at 52%.

3.7.4 National Policies, Strategies and Projects Addressing Climate Change and Tourism

Grenada has produced a number of policy directives, sector-specific plans and projects directed towards increasing resilience to climate change. While these initiatives may not have specifically targeted the tourism sector, they nonetheless recognised the critical importance of tourism to Grenada's economy and highlighted how they could enhance tourism-related activities.

Grenada has previously produced a Master Plan for the Tourism Sector – Grenada, Carriacou and Petite Martinique 1997 and the Grenada Board of Tourism Strategic Plan 2011-2014. Although climate change and associated adaption and mitigation measures are not featured in these documents, there is at least the recognition of the importance that weather and climate-related factors play in Grenada's tourism product and tourist decision-making. In terms of projects, the Grenada Strategic (Investment) Program for Climate Resilience has interventions of direct relevance to the tourism sector.

Master Plan for the Tourism Sector

Grenada's (1997) Master Plan for the Tourism Sector – Grenada, Carriacou and Petite Martinique was intended to establish the role of tourism in the context of the economy of Grenada, and to guide the development of the sector over the ensuing 10 years, with a view to mitigating or eliminating any adverse effects of further tourism development. Whilst the plan does not give specific consideration to climate change as a threat to the industry it recognises climate as one of the primary attractions for visitors.

Grenada Board of Tourism Strategic Plan 2011-2014

The development of the Grenada Board of Tourism Strategic Plan (May Hinds Consulting Inc, 2011) was spurred by the declines in tourism experienced in 2004 due to Hurricane Ivan and 2010 due to the global recession. In response, policy makers prioritised the need for a strategic developmental approach for the tourism sector, a critical revenue generator for the country. The objective of the plan is to provide technical guidance to the Grenada Board of Tourism in its role as the principal agency involved in the development of the tourism industry. The plan highlights the importance of Grenada's climate to tourists, as well as the threat posed by natural hazards in tourist decision-making.

Grenada Strategic Program on Climate Resilience

The Grenada Strategic (Investment) Program for Climate Resilience (SPCR) (Government of Grenada, 2011c) is the key component of the Pilot Program for Climate Resilience (PPCR), developed by the Ministry of Finance, Planning, Economy, Energy and Co-operatives in cooperation with and under financial assistance of the World Bank. The SPCR highlights tourism as a vital sector of the economy that is susceptible to climate change. In addition, it highlights the current and predicted impacts of climate change on Grenada's natural resources and the threat that this poses to future tourism activities.

The SPCR proposes six main areas of intervention through investment projects and technical assistance, several of which are of specific relevance to the tourism sector:

- The proposed "Disaster Vulnerability and Climate Risk Reduction Project", part of which would be allocated to support critical investments at the Maurice Bishop International (MBI) Airport to maintain its current operational certification and ensure that commercial aircrafts, which are critical to tourist arrivals, are able to use the facilities;
- The "Forest Rehabilitation Project" notes that extreme weather events and droughts have made it difficult for forests to naturally regenerate, which has affected eco-tourism activities: the project proposes a series of activities to rehabilitate degraded forest areas and build the capacity of the Forestry and National Parks Departments.
- The "Preparation of a Roadmap for Coastal Zone Management in Grenada" notes the importance of coastal waters to tourism activities that would address, in part, coastal water quality through better management of land-based sources of pollutants and assess other investments that might be needed in coastal tourism-related facilities.

Given the linkages of Grenada's coastal and agricultural resources to ecotourism activities, there are a number of projects and plans focused on building climate change resilience in these sectors, which provide inputs to tourism activities. Of mention is the ICCAS initiative being implemented by GIZ, UNDP and the Government of Grenada, which is supporting a number of national climate change programme activities in Grenada, including activities in agriculture and coastal resources management.

3.7.5 Recommended Adaptation Strategies for the Tourism Sector

In terms of the way forward, it is important that Grenada focuses its adaptation efforts on evidence-based strategies that will bolster both tourism demand and supply. This entails taking actions that safeguard destination image, make tourism infrastructure more resilient, and enhance destination experiences in the face of climate change.

Island-specific Tourism Research

As Cashman et al. (2012) points out, "one of the barriers facing adaptation of the tourism sector is the lack of data generated by appropriate research and development". In order to have a more accurate understanding of the potential impacts of climate change on Grenada's tourism sector, the following studies should be undertaken to help prioritise strategies to limit the economic impacts of climate change on the tourism sector:

- Climate-risk profile for the tourism sector: this should investigate the destination's key tourism assets (pull factors) and their vulnerability;
- Climate preferences and key thresholds study of Grenada's main tourism markets.

This should also take into account peak seasons and preferred activities:

- Willingness-to-pay and contingent visitation analyses based on main tourism assets and projected climate change impacts;

- Tourism labour vulnerability impact assessment to climate change.

Diversification and Enhanced Linkages

There should be continued diversification of Grenada tourism towards more climate resilient products such as festivals, heritage tourism, community tourism, and eco-based tourism. This will help reduce dependency on the 3S model which is predicted to sustain the greatest negative impacts from climate change. In addition, the mutually beneficial linkages between tourism and other sectors such as agriculture and health care should be explored further and capitalised.

Mainstreaming Tourism

Tourism is integrally connected to various sectors and activities, and should therefore be mainstreamed into the climate change adaptation processes related to integrated coastal zone management, land-use planning, water resources management, disaster risk management, environmental health management, and sustainable development.

Climate Resilient Tourism Master Plan

Given that the last tourism Master Plan was crafted two decades ago, and did not address the issue of climate change, this document should be updated and revised. The new Master Plan should have a basis in current, island-specific tourism research; and should chart the way forward for a climate resilient tourism sector. Provision for periodic review and amendments should also be built into the Plan.

Resilient Beaches and Coastal Infrastructure

An assessment of Grenada's coastal tourism assets and infrastructure should be undertaken to determine the most appropriate measures to address erosion, storm surges, and SLR (whether structural, ecological, and/or regulatory in nature). This assessment could inform a "roadmap" on how measures should be implemented.

Protecting Critical Ecosystems

Grenada's tourism sector relies heavily on ecosystem services such as sandy beaches, clean and clear waters, diverse fish species, and coastal protection. Pilot projects can be developed to encourage the participation of tourists, communities, hotels and tourism operators in ecosystem management (e.g. an "adopt a mangrove" initiative, organised lionfish hunting, and proper disposal of sewage and other wastes).

Managing Water Resources

Given that tourism is a highly water intensive sector, efforts by hotels to capture rainwater should be continued, and in some cases enhanced or initiated. Incentives should be put in place and strategies adopted to improve water efficiency (e.g. installing low-flow and other water-saving fittings, irrigating lawns with greywater and using micro-irrigations systems, and covering swimming pools when not in use to avoid evaporation). Larger hotels may also invest in onsite wastewater treatment systems for the recycling of wastewater. Additionally, improving water conservation could act as an impetus for "greening" other hotel operations, such as improving energy efficiency, which can give them a competitive edge.

Resilient Infrastructure and Land Management

As tourism assets along the coast and inland can be vulnerable to climate risks, enabling policy frameworks and incentives should be in place to encourage the construction of climate-resilient infrastructure. Finance mechanisms should also be available for retrofitting tourism assets (e.g. hotels) to be more climate-resilient. It is also imperative that policies such as the Carriacou Land Policy be approved and implemented. This would allow for the undertaking of a strategic and climate-smart plan for coastal and inland tourism development zones with a focus on providing alternatives to coastal tourism and diversifying the tourism product to decrease ecosystem stress (e.g. a move towards cultural tourism, gastronomic tourism, ecotourism, and agritourism).

Risk and Crisis Planning

Given the impact hazards, many of which are related to climate change, can pose to tourists and destination image, a National Tourism Safety and Security Plan, as well as crises management plans for tourism operators, should be developed. These plans should take into account and evaluate the potential human health risks (considering the safety of tourists and employees alike), as well as provide guidance on hazard preparedness, response and recovery. Attention should also be given to effective communication strategies, inclusive of media management. The successful execution of such plans will also require appropriate training and capacity building.

Climate Finance

Climate finance, whether from international adaptation funds, official development assistance, regional development banks, or local government initiatives, will be central to the tourism sector's ability to adapt to climate change (do Nascimento, 2016). Tourism operators and agencies therefore should improve their understanding of available climate finance mechanisms and criteria, as well as their capacity to access such funds. As access to funding may require the involvement of regional and local stakeholders and multiple national agents, including the local private sector, a collaborative approach to pursuing climate finance should also be adopted where appropriate.

3.8 HUMAN SETTLEMENTS AND INFRASTRUCTURE

3.8.1 Methodology and Approach

This chapter provides an analysis of the potential impacts that climate change can have on human settlements in Grenada. Through a series of literature reviews and informal interviews with key personnel, the following issues were assessed:

- Factors contributing to the vulnerability of human settlements and infrastructure;
- Vulnerability of human settlements to climate change in the context of Grenada;
- Impacts of climate change on social factors;
- Institutional arrangements for the management of human settlements;
- Recommended adaptation strategies; and
- Challenges to adaptation.

Areas vulnerable to the impacts of natural hazards (in particular, floods and landslides) were identified as well as vulnerable infrastructure. The roles of Government departments and key stakeholders in the management and use of land were identified and a review of policies and actions on land management practices and adaptation strategies for this sector were recommended based on the status of past and present projects and future initiatives aimed at strengthening the sector.

3.8.2 Factors Contributing to Vulnerability of Human Settlements and Infrastructure

The vulnerabilities of Grenada's people, communities and infrastructure are shaped by several factors, namely, natural, social, economic and cultural which often interact in various, and sometimes complex ways to create vulnerable circumstances.

Grenada's geographic location places it within the zones of influence of various atmospheric phenomena. The most notable is the Tropical Atlantic Hurricane Belt, where the passage of various storm systems has considerable effect on day-to-day weather patterns by generating much of the observed rainfall for Grenada during the June to December period (Charles et al., 2014). This is exemplified by the impacts of Hurricane Ivan in 2004 devastated the country, and underscored the high vulnerability Grenada to extreme weather conditions. Ivan was followed shortly by Tropical Storm Emily in 2005 which further exacerbated the island's social and economic fragility. The Grenadian reality between 2004 and 2005 reinforces the dangers of extreme weather, and more so the increasing possibility of similar occurrences with a changing climate.

Other physical factors such as topography and geology expose sections of the country to climate-induced secondary hazards such as landslides and flooding, especially during or in the aftermath of extreme rainfall:

- Human activities (agriculture, construction and development, etc.) further contribute to slope destabilisation and landslide risk as significant construction activities occur on very steep slopes (>45°), and landslides often impact the road network (GFDRR, 2010).
- Grenada's relatively dense drainage and steep relief give rise to flash flood events during periods of heavy rainfall, which typically affect settlements and other infrastructure located close to rivers, especially those located near the lower stages of river channels and within coastal areas. Coastal flooding can also be caused by storm surges or other high swell events (GFDRR, 2010). The mountainous terrain of Grenada has caused the majority of the population to be located in close proximity to the coastline thus making them more susceptible to impacts from flooding due to storm surge, and gradual sea level rise.

Whereas historically, most extreme rainfall events were concentrated during the hurricane season, the changing climate regime may result in landslides and flood events occurring in the dry season also. Aside from natural factors, socio-economic conditions play a major role in determining vulnerability in Grenada. Exposure and sensitivity to current climate hazards are, for many cities and settlements, a result of historical location factors: many coastal settlements and urban areas have developed without consideration of increasing risks posed by climate change.

Poverty, caused by low wages, high unemployment, weakness in social infrastructure and limitations in human resource development is a major contributor to vulnerability. The last Country Poverty Assessment conducted for Grenada over the 2007/2008 period (Kairi Consultants Ltd, 2008b) revealed a poverty rate of 37.7% and an indigence (extreme poverty) rate of 2.4%. Poor and indigent citizens are considered the most vulnerable groups to weather and climate change impacts. Conditions of poverty often dictate where persons choose to reside, and encourage the construction of informal settlements and houses with little structural integrity. As a result, the sensitivity level is such that one or successive hazard events can plunge already poor or vulnerable persons and families deeper into poverty with the loss of housing and other physical assets. Residences that double as workspaces are a common feature for poor and low-income citizens engaged in cottage industries, and loss of infrastructure and assets therefore impacts both personal and livelihood activities (Revi, et al., 2014).

Inadequate or sub-standard infrastructure design and installation also increases sensitivity and risk. Disregard for building codes[38] and other development guidelines increase the risk of, and sensitivity to impacts from primary and secondary weather events. This trend of non-compliance is not specifically limited to the poor, but has been observed across all socio-economic groupings in Grenada.

[38] In Grenada's case, the applicable code being the OECS Building Code Sixth Revision (2015) for Grenada, St. Vincent and the Grenadines, Saint Lucia and Montserrat. The original Code was published in 1992. The codes and guidelines are based on the Caribbean Uniform Building Code (CUBiC) and other regional codes such as the Bahamas Building Code, the draft Jamaica National Building Code and the Turks and Caicos Islands Building Code (OECS, 2015b).

Population and infrastructure densities can also influence vulnerability to climate and other hazards. Urban areas are denser by nature, and are therefore linked to greater exposure compared to less populated and congested rural areas (Revi, et al., 2014). Rural vulnerabilities to climate hazards can also be discerned, especially in cases where infrastructure may be strongly tied to livelihood activities (agriculture, fisheries) (Dasgupta, et al., 2014).

Critical infrastructure such as airport and seaport facilities which are major supply and international transit points are located along the coast. These include the Maurice Bishop International Airport (MBIA), the ports of St. George's, Grenville, Lance Aux Epines, St. David's Harbour and Petit Calivigny in Grenada; and Tyrrel Bay and Hillsborough in Carriacou (Grenada Ports Authority, 2015). The growth of the local tourism sector has also resulted in the construction of hotels and other amenities in close proximity to the coast. The coastal development trend has been implicated in compromising the ability of natural defences (beaches, mangroves) to adapt naturally to changing climate and ocean dynamics (Schleupner, 2008, in (Nurse, et al., Small islands, 2014)).

3.8.3 Vulnerability of Human Settlements to Climate Change in the context of Grenada

The majority of the population is concentrated on the mainland of Grenada with approximately 10% residing in Carriacou and Petite Martinique collectively (Government of Grenada, 2011c). Approximately 40% of the population is classed as urban area residents (UNDP, 2015).

The type of construction for housing structures which is most common is timber and concrete/brick structures. A greater percentage of the timber structures are inhabited by the poor and the vulnerable while those who are considered to have better financial stability reside in the concrete/brick structures (Kairi Consultants Ltd, 2008b).

This correlation in living conditions and socio-economic status implies greater vulnerability for poor persons or families living in timber dwellings, which are structurally weaker and more prone to damage from high winds and excess rainfall. In 2004, the passage of Hurricane Ivan resulted in damage to 89% of Grenada's entire housing stock: the timber units and those which were less structurally sound experienced the most damage (OECS, 2004).

Land Use

The Government's (2015) report to the United Nations Convention to Combat Desertification provides a snapshot of the state of land use in 2010 and trends over the previous decade (Government of Grenada, 2015). The biggest change reported over this period was the increase in urban areas (by 13.41%). Additionally, the areas of shrubs, grassland, sparsely vegetated areas and wetlands and water bodies decreased by roughly 5%. Croplands and forested areas each decreased by less than 2%. The report also cites that areas of abandoned cropland in Grenada have increased, likely due to neglect. Grenada's Fifth National Report to the Convention on Biodiversity (2014) attributes this increase in abandoned cropland to the decline of the country's agriculture sector over the last 20 years (Government of Grenada, 2014).

The 2015 report identified the following as direct drivers of land degradation in Grenada:

- On mainland Grenada, deforestation is occurring mainly in the central area and southwestern end of the island;
- On Carriacou, where livestock rearing is commonplace and animals are left to forage for food during the dry season, soil erosion is occurring as a result of overgrazing;
- Uncontrolled and unregulated mining of gravel, sand, and other aggregates for the construction industry weakens ecosystems and increases their vulnerability to natural hazards (e.g. hurricanes and storms);
- Inappropriate agricultural practices are a major cause of land degradation in Grenada; particularly indiscriminate use of synthetic herbicides, pesticides and fertilisers, slash and burn, and planting of shallow rooted crops on steep slopes; and
- Extreme climatic events, such has hurricanes and floods have degraded lands: Hurricane Ivan in 2004 and Emily in 2005 not only severely damaged forests, but also caused extensive erosion on some exposed slopes (Government of Grenada, 2015).

Tropical Storm and Hurricanes

Between 1900 and 2017, Grenada has been impacted by six extreme weather systems (five storms and one flood event) which has resulted forty-five deaths and more than USD 899 million (XCD242 million) dollars in damages (Centre for Research on the Epidemiology of Disasters, 2016). Hurricane Ivan (September 2004, a Category 3 storm), resulted in damage and losses in the amounts of USD 888 million (XCD 2.4 billion) and 28 fatalities (Organisation of Eastern Caribbean States, 2004). Hurricane Emily (July 2005), a Category 1 storm, resulted in damage and losses in the amounts of USD 52 million (XCD 140 million) and one fatality.

There are storm shelters located in all seven parishes however the largest concentration of these shelters is situated in the capital of St. Georges located on the southern coast of the island and is vulnerable to the impacts of storm surges associated with tropical storms and hurricanes (Government of Grenada, 2016) The impacts from storm surge events can increase the potential for coastal erosion risks in low lying areas which could affect major access roads between the coast and the interior of the island.

Intense rainfall associated with tropical storms and hurricanes along with the mountainous terrain expose Grenada to incidents of land slippage and flash flood events. Areas which are susceptible to flooding are those which are at least 2 m below sea level such as St. Georges, Grenville, Hillsborough and the southwest peninsula of the island.

Intense Rainfall

In recent years throughout the Caribbean, there has been an increase in the intensity of rainfall events which have occurred both within and outside of the wet season (Atlantic Hurricane Season) and which have resulted in flooding and significant damage to infrastructure. The wet season runs from the beginning of June to the end of November and it peaks between the months of August to November. Figure 84 shown below identifies the areas of Grenada which are most susceptible to flood hazards. As can be seen, the eastern coast of the island appears to be highly susceptible to the impacts of floods, in particular, the parishes of St. Patrick and St. Andrew.

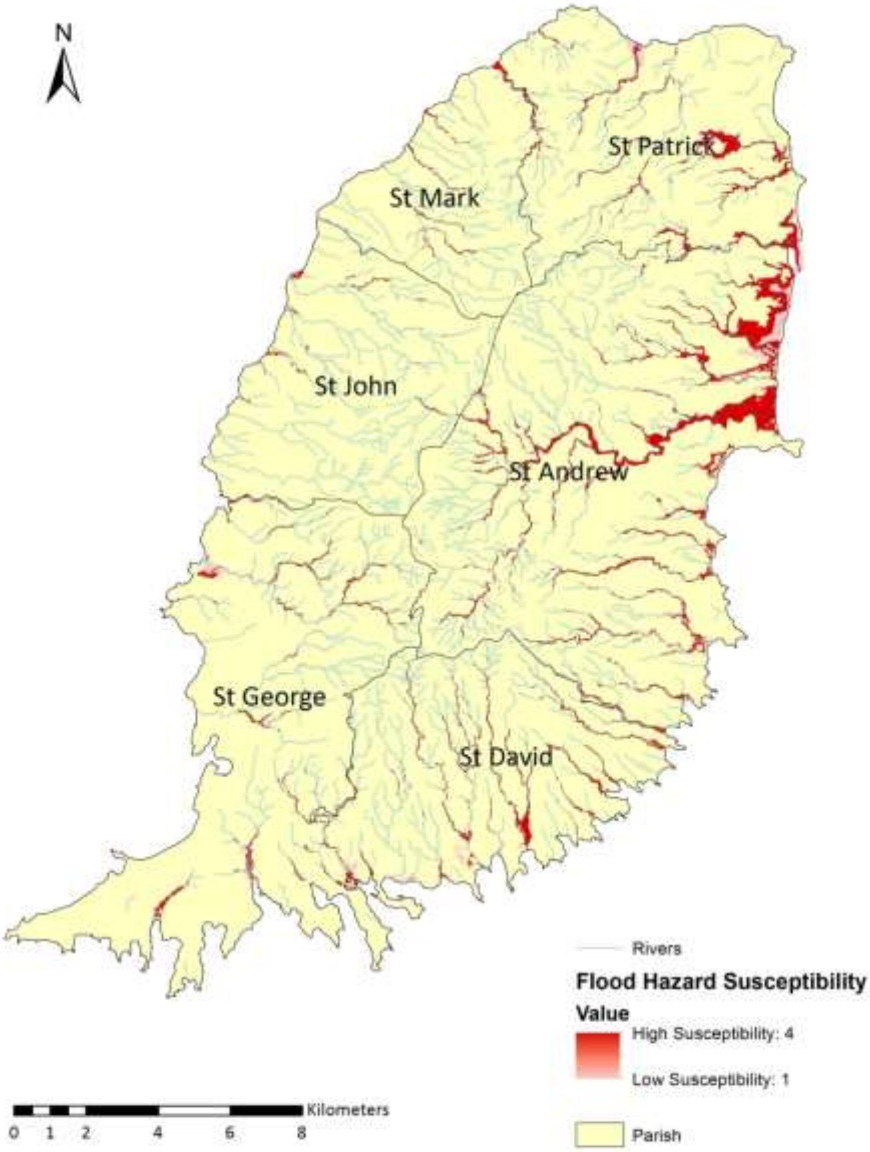


Figure 84-Map showing the areas in Grenada which are susceptible to floods: Source: (Jetten V. , 2016)

In September 2014, intense rainfall from a Tropical Wave caused significant land slippages which resulted in damage to private and public properties in Grenada and further exacerbated the vulnerability of communities which were already susceptible to flood risks (NOW Grenada, 2004). The steep topography, soil conditions and intense rainfall created the perfect conditions for land slippage. Figure 85 below shows the areas in Grenada which are most susceptible to the impacts of landslides and land slippage. The majority of the island is susceptible to land slippage, in particular, the parishes of St. Mark, St. George and St. John which are situated on the western coast of the island.

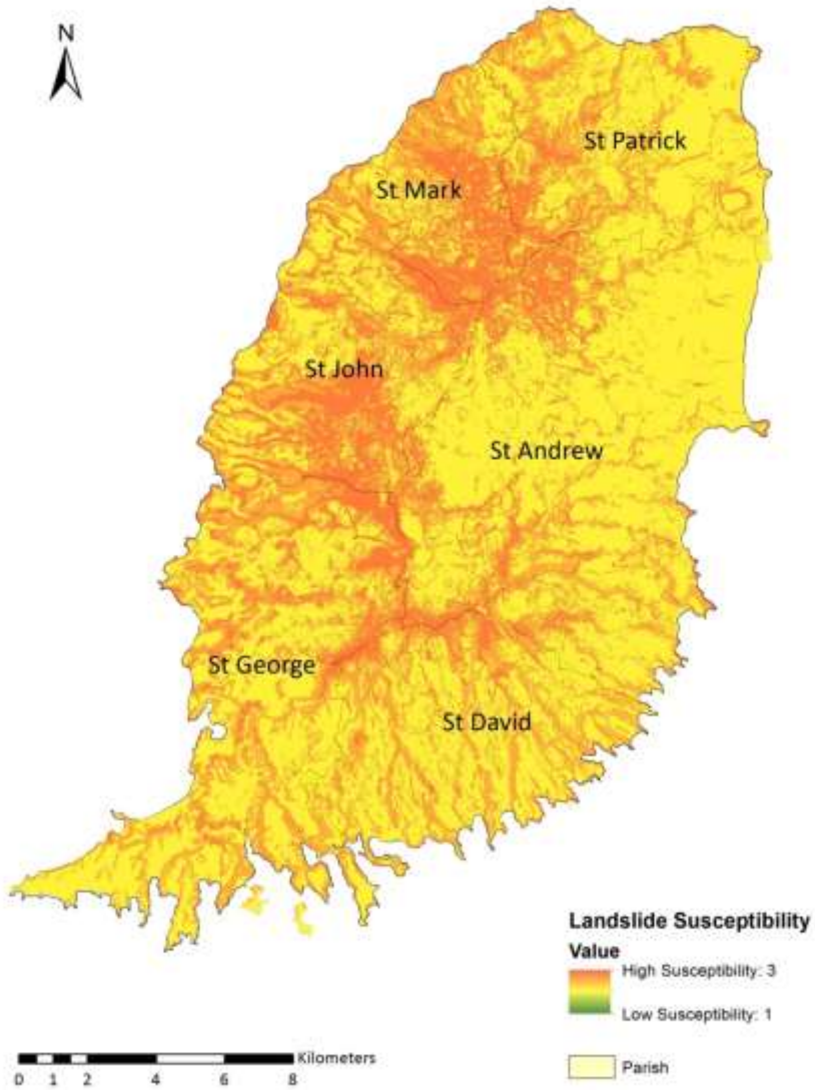


Figure 85-Map showing the areas in Grenada which are susceptible to landslide: Source (Van Westen, 2016).

Drought

Grenada's SPCR document notes that drought events are not very prevalent in Grenada the severity of drought events is noted to have increased recently (Government of Grenada, 2011c). Grenada and the Caribbean at-large experienced two major droughts, one in 1995 and another between 2009 and 2010 which produced the lowest rainfall on record in Grenada; negatively affecting water supply and the agricultural sector, particularly the local banana industry (Government of Grenada, 2011c). The event prompted the Government to explore mitigating actions for such future occurrences in conjunction with regional partners such as CIMH.

Sea Level Rise and Storm Surge

Significant flood deriving from storm surge events are rare in Grenada: however, in November 1975 Grenada experienced its most catastrophic flood event which resulted in USD 4.7 million (XCD12.7 million) in losses (Government of Grenada, 2011c). Increased frequency of flooding in low-lying areas, as a consequence of climate change, is likely to cause a reduction in the distribution of mangroves, settlement and available land. Some coastal groundwater aquifers are already being affected by saline intrusion based on current sea levels, and further increases in sea level could eventually result in their abandonment for public water supply purposes. Anthropogenic activities that lead to the removal and degradation of natural coastal defences also lead to coastal erosion and/or make the areas more vulnerable to SLR and storm surge.

3.8.4 Expected Impacts of Climate Change on Human Settlement

Grenada is already experiencing some of the effects of climate variability and change through damages from severe weather systems and other extreme events (such as Hurricane Ivan in 2004), as well as more subtle changes in temperatures and rainfall patterns (The CARIBSAVE Partnership, 2012).

Detailed climate modelling projections for Grenada predict:

- An increase in average air temperature;
- Reduced average annual rainfall;
- Increased Sea Surface Temperatures (SST); and
- The potential for an increase in the intensity of tropical storms.

Grenada, like many of the islands of the Caribbean, is vulnerable to impacts from floods, inundation and sea level rise on coastal communities and infrastructure (GIZ, 2013). The passage of Hurricane Lenny in 1999, although the system passed well north of Grenada, exposed the vulnerability of the coastal communities in particular to extreme weather events.

The report on the Economic Effects of Climate Change on Grenada (GIZ, 2013) also confirmed the climate risks to which the following communities are exposed as shown in the Table 55below:

Table 55-Climate Impacts and Communities-at-Risk (GIZ, 2013)

CLIMATE IMPACTS	COMMUNITY
Salt water intrusion	Carriacou
Floods due to high seas or excess rainfall	St. George’s (Carenage and Melville Street in particular)
Floods due to high seas or excess rainfall	South West Peninsula
Coastal Erosion due to sea level rise and storm surge	Gouyave, Grand Mal, Duquesne, Soubise and Marquis
Coastal Erosion due to sea level rise and storm surge	A number of access roads on the western coast

Many of the roads mentioned above are located below sea level, become impassable during high tides and sustain severe damage during storm surges. In fact, the Maurice Bishop International Airport is considered the most vulnerable CARICOM airport with regards to the potential impacts of sea level rise (GIZ, 2013).

3.8.5 Impacts on Critical Infrastructure

Grenada is very disaster-prone to disasters related to natural events such as hurricanes (Ivan 2005 and Emily 2005 being particularly devastating), landslides, rain and drought. These hazards have caused significant and recurrent damages to national infrastructure (much of it within the coastal zone) including housing, road networks, schools, hospitals and other facilities such as telephone lines, water and electricity. The resulting impacts significantly affect human welfare, national economic activities, property, and natural resources.

Community Infrastructure (Relocation)

From 2006 to 2008, all residents squatting on crown lands in the Mt. Pandy area of South St. George were relocated to La Sagesse, St. David's and Beausejour, in the northwest region of St. George. The residents were relocated to new areas that have steep terrain and undeveloped infrastructure, which poses some degree of risk and makes residents and their homes vulnerable to climate impacts (Barry, 2011).Under the ongoing Disaster Vulnerability Reduction Project, infrastructural works are nearing completion in these two communities to mitigate these locational risks (The World Bank, 2017).

Public Accommodation for the Elderly

The Cadrona Home in rural St. Andrew's and Hills View home in rural St. John's are at different levels of physical vulnerability to natural hazards (Barry, 2011). While the improvements needed at these sites may not be accommodated by the DVRP, it is hoped that future development projects can incorporate these two sites, and improvement works can be conducted once the financial resources are made available (Theodore, 2017).

Physical and Locational 'At-Risk' Schools

A number of educational institutions in Grenada also double as places of shelter during times of extreme weather. These buildings are required to meet certain standards in order to function as hurricane or storm shelters related to structural integrity, space, accessibility, amongst other criteria; and they are normally assessed each year to determine their suitability. For this reason, their upkeep and maintenance should be priorities for attention, given the annual storm activities that affect Grenada (Government of Grenada, 2011b).

The vulnerability of education buildings was exhibited with the passage of Hurricane Ivan in 2004, where the education sector suffered over XCD $200 million in loss and damage to infrastructure, with numerous occurrences of roof damage and loss, water-related damage and damage to the building structures. The education buildings sector was the second most severely impacted sector after Housing (OECS, 2004). Each time an event severely affects these buildings; it not only disrupts instruction, but also reduces national shelter capacity.

The Holy Cross Roman Catholic (RC) and St. Patrick's Anglican Primary Schools have also been earmarked for upgrades so that they can serve as hurricane shelters (Barry, 2011). The DVRP has undertaken rehabilitation works at both of these institutions which, when completed (expected between 2017 and 2018), will allow these schools to return to proper education and communal functions, and also facilitate storm shelter needs for the immediate communities (The World Bank, 2017; Theodore, 2017).

Communities/Businesses/Public Services in Flood Prone Areas

Family dwellings, businesses and public service institutions that are located in coastal areas in the parishes of St. John, St. Mark, St. George's and St. Patrick are categorized as vulnerable to flooding, based on the densities of drainage within these four parishes (Charles et al., 2014). Most recently, flooding events in April 2011 affected residential and commercial areas in St. John and St. Mark, and especially within the coastal town of Gouyave. Torrential rainfall caused rivers to overflow their banks, and resulted in the relocation of 19 families and approximately XCD 11.2 million (USD 4.2 million at then prices) in damage (Government of Grenada, 2011; Charles et al., 2014). In order to address some of these flooding risks, civil works have been earmarked for some areas under the DVRP, specifically along River Road and adjacent to St. John's River (The World Bank, 2017; Theodore, 2017).

Road Networks and Commuters

Land slippage has occurred on Gouyave estate and Constantine Main Road which over time has resulted in the gradual loss of road surface area (Barry, 2011). The occurrence of such loss can be rapid during periods of heavy or prolonged rainfall which can occur during both the wet and dry seasons and can result in traffic diversions, delays and even vehicle accidents.

Rock falls have also been a concern for some areas located on unstable hillsides as in the town of St. George's (Sendall Tunnel site), Brizan and Grand Anse (Barry, 2011). Some areas that are at high-risk for land slippage or rock fall events, have benefitted from ongoing mitigation works, including landslip mitigation at Market square, River road, Constantine, and Rockfall mitigation works at Sendall Tunnel in St. George's (The World Bank, 2017).

Bridges

Some bridges have become increasingly vulnerable to weather impacts over time, as a result of aging and weather-induced deterioration of the structure. The Lance and Hubble bridges are specifically noted, the latter having been closed to vehicular traffic for some years owing to its condition. The Lance Bridge, and the Hubble Bridge when it was open, served as important travel arteries, and therefore any major impacts on the bridge structure that may render it unusable or impassable will exacerbate emergency situations (Barry, 2011). To this end, improvement works have been started or planned for both of these bridges to restore their structural integrity (The World Bank, 2017; Theodore, 2017).

3.8.6 Institutional Arrangements for the Management of Human Settlement

The impacts of climate change can have an effect on water supply, physical infrastructure, provision of energy and the transportation network, with local economies being disrupted and populations stripped of their assets and livelihoods (United Nations Human Settlement Programme, 2011). Therefore, implementation of land and resource management policies and collaboration between government ministries and relevant agencies is essential in order to reduce the impacts of climate change on the population and the environment.

In 2011, the Land and Marine Strategy for Grenada was introduced with the aim of managing the limited land and marine resources of Grenada through the provision of a consistent framework for local communities, managers and for policy makers within Government (JECO Caribbean, 2011). However, sound land use management practices are usually hindered by a number of issues but can be overcome through the implementation of the following:

- Sustainably managed areas, where competing demands and pressures are taken into account and the social and economic needs of society are reconciled with the need for conservation of the natural and historic environment;
- A clear policy and regulatory framework into which the principles of a holistic and coordinated approach are embedded;
- A new strategic management approach in the marine environment which is effectively integrated with the management of the land;
- More consistent application of the best management practices and principles of sound holistic and coordinated management around the coast;
- A management approach that builds on existing structures and responsibilities while encouraging organizations to improve relationships coordinate work plans;
- A flexible management approach, which supports local initiatives and solutions to address local circumstances within an overall regulatory framework;
- Appropriate and effective stakeholder and local community involvement throughout management processes (JECO Caribbean, 2011).

In the 2011 strategy, four strategies were identified each with specific goals and assigned responsibilities to various government ministries to implement between 2011 and 2015.

- Strategy 1 – Legislative Policy Framework for Land and Marine Management Developed;
- Strategy 2 – Network Administrative Organisation Established;
- Strategy 3 – Tools for Management of Land and Marine Resources Developed; and
- Strategy 4 – Framework for Planning, Execution, Monitoring and Review.

Some of the key Agencies/Ministries which are responsible for Land and Marine Management in Grenada are listed as follows:

- Ministry of Finance;
- Marine Management Authority;

- Ministry of Health;
- The Environment Division;
- Ministry of Agriculture, Lands, Forestry and Fisheries
- National Disaster Management Agency; and
- Ministry of Communications, Works, Physical Development, Public Utilities, ICT and Community Development

Although the Government of Grenada has made some advances in land management practices, there are some actions which require urgent attention such as the implementation of the national land use policy and sustainable land management plan to avert unsustainable land use change and land use intensification (Spencer, 2016). Also, there is a need to ensure that biodiversity conservation issues are mainstreamed in national land policies and related legislation. The Ministry of Agriculture, Lands, Forestry and Fisheries has been tasked with taking the lead on this action with support from the Physical Planning Unit, Ministry of Finance, Ministry of Tourism and Ministry of Communications, Works, Physical Development, Public Utilities, ICT and Community Development.

For adaptation policies to be efficient at the national level, several principles are fundamental for an integrated, multi-stakeholder approach to be successful:

- It must be recognised that no single mitigation or adaptation policy is equally well-suited to all countries and must be adapted as necessary;
- It would be beneficial to take an opportunity/risk management approach in a sustainable development perspective,
- Consideration should be given to risks that are present in a range of possible climate and socioeconomic futures;
- Policies should emphasise, encourage, and reward ‘synergies’ and ‘co-benefits’ (i.e. what policies can do to achieve both developmental and climate change response goals);
- Climate change policies should address both near-term and longer-term issues and needs; and
- Policies should include new approaches that support multiscale and multisector action, rooted in the different expectations of a wide range of partners.

Programmes such as the Grenada Disaster Vulnerability Reduction Project and Resettlement Policy Framework, which commenced in 2011, also contribute to shaping policies and sustainable development that will benefit communities and the general population. It proposes a number of civil works in order to reduce the infrastructure vulnerability to natural hazards and climate change. The project is co-financed by the World Bank and the Climate Investment Fund up to USD 26.2m (XCD 70.7 million), including a grant of USD 8m (XCD 21.6 million) and is being co-ordinated by the Ministry of Finance. Some of the activities completed to date include:

- Upgrading infrastructure (road network, drainage, sewerage, retaining walls, etc.) for 50 households in the communities of La Sagasse and Beausejour;
- River embankment Reinforcement upstream of the Lance Bridge and the Hover Bridge respectively;

- Rehabilitation of the St. Patrick Anglican and the Holy Cross Roman Catholic primary schools which will be used as future hurricane shelters

Future activities which are expected to be completed under the programme are:

- Flood mitigation civil works by the river which is situated in close proximity to the National Stadium;
- Development of soil mapping exercises and a hydrometeorology network;
- Enhancing the capacity within the National Disaster Management Agency (Rapid Alert System to be installed);
- Collaborating with the National Water Service Authority to acquire 2 storage tanks with a capacity of 550,000 gallons which would allow for increased capacity to meet the needs of St. Georges.

The project is based on the World Bank's Involuntary Resettlement Policy and its primary aim is to ensure that necessary resettlement activities related to natural disasters and climate change take social concerns into account (Grantham Research Institute on Climate Change and the Environment, 2011).

3.8.7 Recommended Adaptation Strategies

The lives and livelihoods of the people of Grenada will be largely dependent what actions are taken to address the impacts of a changing climate and extreme weather events. The experiences of Hurricanes Ivan and Emily have exposed the risks to which the country is exposed. Successful adaptation programmes should result in the overlap of actions being implemented by individuals, households and the commercial/industrial sector which can either be through government programmes or donor-funded through external agencies.

Adaptation measures for Grenada related to human settlement should focus on the following:

- Continued improvement on the regulatory and institutional framework as it relates to Government policies for sustainable land management practices and enhancing the structural integrity of infrastructure. Enforcement of the national building code and continued development of legislation through capacity building exercises for the Physical Planning Unit through either increased human resources and/or enhanced technical capabilities is also necessary.

- The identification of land and infrastructure which are presently vulnerable to the impacts of a changing climate: the three airports (Dumfries, Maurice Bishop International and Pearls), that are of vital importance to the Tourism sector, should be subjected to a detailed climate change vulnerability assessment, including critical areas such as the runway and parking areas to understand the severity of the climate risks to which the airports are exposed.

- Capacity building within the public sector as well as the private sector (Grenada Institute of Professional Engineers (GIPE), Grenada Society of Architects and construction companies, among others) in data management, risk modelling and climate smart approaches towards sustainable development: collaborate with institutions such as the T.A. Marryshow Community College, the New Life Organisation and the Programme for Adolescent Mothers to develop and implement training programmes on climate resilient building practices, guidelines and standards. An action plan to ensure the long-term sustainability for spatial data management should be developed and implemented. This action plan should also consider improving capacity for risk modelling for natural hazards such as sea level rise, storm surges, inland flooding and land slippage.

- Improve the resilience of key infrastructure assets and implement community adaptation plans: establish a revolving loan fund for home improvement of vulnerable households in the building sector. Furthermore, a disaster management fund should also consider mitigation and preparation activities and not only response and recovery. Collaboration between the Government, communities and civil society should be explored to develop action plans to identify vulnerable infrastructure and develop monitoring and evaluation programmes for the maintenance of drainage systems, watershed management, climate smart agricultural programmes and coastal resources management.

- Build awareness amongst the general public about their vulnerability to climate change and how this vulnerability may be influenced by a variety of factors: the location of their homes and livelihoods; the physical state of the buildings which they occupy and their ability to withstand exposure to extreme events. Awareness efforts would likewise emphasise to the public the need to ensure that adequate measures are put in place to adapt to and recover from extreme weather – including the various options that are available which members of the public may or may not be familiar with (e.g. retrofitting infrastructure to be more weather resistant, adhering to proper physical development standards, etc.).

3.8.8 Challenges to Adaptation

Small island developing states such as Grenada have been identified as being extremely vulnerable to the impacts of climate change. Although there have been advances in terms of implementing policies and programmes which are intended to reduce vulnerability, there are obstacles which hinder climate change adaptation measures from being incorporated within legal and regulatory frameworks which contribute to reducing vulnerability to a changing climate.

One issue is getting climate change to be understood as a key component of development and more importantly, a key component towards strengthening the economy and reducing poverty (United Nations Human Settlement Programme, 2011).

The Government of Grenada also needs to consider how best to continue to reduce climate risks as part of their plans and investments for infrastructure development and land-use management. However, in an economy where investment capacity may be constrained, there will be resistance to allocating extra costs for adaptation to projects as other non-climate related issues may need urgent attention.

One of the main barriers to implementing adaptation measures is the lack of human resources and technical capacity within government ministries and key institutions. Also, there may not be available financial resources to ensure the delivery of sustainable training and capacity building programmes for staff to ensure the successful implementation of climate change adaptation measures. General public awareness, or lack thereof, also hampers adaptation efforts in this regard, as persons are not always knowledgeable or empowered to make climate-smart choices.

3.9 ROLE OF INSURANCE IN CLIMATE ADAPTATION

3.9.1 Methodology and Approach

The section provides an analysis of how insurance and risk transfer mechanisms can be used to reduce the impacts of climate change and extreme weather events. Information/data was gathered form secondary sources and discussions with persons who work or have worked within the insurance industry In Grenada.

A review of how climate change has impacted the insurance sector in Grenada was completed along with the type of insurance instruments which are currently being used in Grenada at the micro, meso and macro level.

Recommendations on how insurance can be further used to increase resilience in Grenada are outlined and that take into account the potential for introducing new products into the market and the further incorporation of insurance as part of comprehensive risk management and national action plans.

3.9.2 Climate Change and Insurance

In recent years there has been a shift in the management of climate change related risks from ex-post to ex-ante risk management frameworks with the insurance sector becoming more involved.

The insurance sector has been identified as one of the core sectors which could provide support to enhance society's understanding of the impacts of climate change due to its expertise in finance and risk management.

Climate change and extreme weather events can result in natural disasters which are difficult to manage for insurance companies. Natural disasters which can be classified as "low frequency, high severity" events are difficult for insurance companies to manage as the type of risks which they prefer to cover are "low severity, high frequency". Over the past decade, the impacts of climate change and extreme weather events have increased which has caused insurance coverage to being highly priced and inaccessible for those for whom it was designed to protect.

3.9.3 Insurance Industry and Climate Change in Grenada and the Caribbean

The islands of the Caribbean are prone to the impacts of extreme weather events as well as other non-climate related events/hazards. During the period 1979-2005, economic losses incurred by the Caribbean as a result of climate related events was approximately USD 16.6 billion (current value) or USD 613 million annually (World Bank, 2013): about one-half of those years could be described as "natural hazard free".

The Caribbean insurance industry comprises of a number of entities which represent international companies that share the market with a relatively smaller number of Caribbean-owned companies. The number of agencies and companies operative in the region are also large in comparison to the volume of the risk which is underwritten in the region (Vermeiren, 2000). The proportion of risk retained by the insurance companies in the region is also relatively small, with reinsurers outside of the Caribbean retaining the remainder and majority of the risk.

After the passage of Hurricanes Gilbert and Hugo in 1988 and 1989 respectively, there was an observed increase in the premium rates across the Caribbean (Vermeiren, 2000). Several reinsurers refused to provide coverage for the Caribbean and those that did, applied a 2% deductible to the value of the property insured. As the insurance companies rely heavily on reinsurers, the high costs incurred by the insurance companies had to be passed on to property owners. The increase in insurance premiums had an impact on tourism and commercial projects which were under development and also the poor and vulnerable who should be the main beneficiaries of an insurance programme.

The past 15 years has seen the exposure of the Caribbean to extreme weather events which have resulted in severe impacts to various sectors, in particular the agricultural and tourism sectors. The passage of Hurricanes Ivan and Emily in 2004 and 2005 respectively resulted in 85% of the nutmeg trees in Grenada being totally destroyed and inflicted almost 200% GDP damage (The World Bank, 2005).

There has been the emergence of a suite of risk transfer tools within and outside of the Caribbean which continue to contribute towards reducing vulnerability at the micro, meso and macro levels. These tools are intended to increase the resilience of individuals, communities and countries with the Caribbean being one of the leaders in this field through the development of the world's first multi country insurance risk pool.

3.9.4 Climate Change and the Grenada Insurance Sector

There are presently at least 20 insurance and reinsurance companies which are operating in Grenada and are regulated by the Grenadian Authority for the Regulation of Financial Institutions (GARFIN). GARFIN aims to promote and maintain public confidence in, and the integrity of the financial system in Grenada through the effective regulation and supervision of designated non-bank financial institutions (GARFIN, 2010). Insurance services are categorised as commercial, personal and travel products with commercial services including services such as business interruption while personal products include general and life insurance. The Insurance Act, No.5 has repealed the Insurance Act 1973 which is aligned with international standards and practices. The Act allows for stronger regulation and supervision of insurance companies and imposes penalties for companies for non-compliance.

The insurance companies in Grenada are usually branches or affiliates of larger regional or international companies. The insurance sector for Grenada and the entire Caribbean is also grouped with Florida and neighbouring states for reinsurance purposes. This means that damage and losses incurred in these states will affect insurance rates in the Caribbean although the Caribbean may not have been directly impacted.

The passage of Hurricane Ivan in 2004 resulted in domestic insurance pay-outs which were equivalent to about 35 percent of Gross Domestic Product (GDP). All insurance companies were able to honour all of their financial obligations with insurance pay-outs totalling approximately USD 154 million (The World Bank, 2005). Also, many of the properties were underinsured and therefore the amount received from insurance companies in some instances would have been substantially less than the claim for damages incurred by the insured. As a result, full rehabilitation would have been hindered and many would have used their savings or sold their assets to undertake the recovery process.

The insurance sector in Grenada has already commenced to explore the use of insurance as a component of disaster risk reduction and climate change adaptation practices and therefore the role of insurance in enhancing resilience to climate change is recognised.

3.9.5 Risk Transfer Instruments for Climate Resilience: Examining the Suite of Insurance Products Available

The Paris agreement and the G7 InsuResilience Initiative (also referred to as the G7 Initiative on Climate Risk Insurance) have propelled insurance forward as a key mechanism which can further contribute to reducing the impacts of climate change across the globe. This initiative will be implemented through close partnerships between the G7 states, developing countries and emerging economies (Hagemann, 2015). The period 2016-2020 has been identified for preparation and implementation of insurance products/solutions that explore:

- How to reach new markets and provide insurance for those most in need but have limited access;
- Reviewing the present insurance approaches and identifying the lessons learned; and
- Capturing technology and ways to reduce costs while ensuring risk adequate premiums

The types of insurance instruments which have already been implemented or planned in Grenada are as follows:

- Sovereign Disaster Risk Insurance;
- Micro-Insurance;
- Agricultural Insurance;
- Property Catastrophe Risk Insurance; and
- Health Insurance

Sovereign Disaster Risk Insurance

These types of insurance tools increase the financial response capacity of governments in the aftermath of natural disasters. Governments are usually best served by retaining most of their natural disaster risk while using risk transfer mechanisms to manage the extra volatility of their budgets or to access immediate liquidity after a disaster (Cummins and Mahul, 2009)..

Grenada is a member of the CCRIF SPC (formerly CCRIF – Caribbean Catastrophe Risk Insurance Facility) which is a sovereign risk transfer instrument that provides liquidity to 17 member states (Governments in the Caribbean and Central America) within 14 days of the occurrence of the event. CCRIF SPC offers parametric insurance designed to limit the financial impact of catastrophic tropical cyclones, earthquakes and excess rainfall events by quickly providing short-term liquidity when a policy is triggered. It is the world's first regional risk pooling fund issuing parametric insurance and, as such, gives its member governments the opportunity to purchase natural catastrophe coverage at a price substantially below what they would be able to obtain through a non-pooled arrangement (CCRIF SPC, 2016).

The 17 participating member states pay an annual premium which is related to the amount of risk that each country transfers to CCRIF SPC and purchases coverage up to a limit of US $100 million for each insured hazard/peril (tropical cyclone, earthquake and excess rainfall events) (CCRIF SPC, 2016). The pooling of the catastrophe risks into a single diversified portfolio allows for a reduction in capital needs for paying claims. As a result, premium rates which the participating member states pay are at least half of what it would cost if the countries had to purchase coverage on an individual basis.

CCRIF represents a cost-effective way to pre-finance short-term liquidity to begin recovery efforts for an individual government after a catastrophic event, thereby filling the gap between immediate response aid and long-term redevelopment (CCRIF SPC, 2016). Since inception, CCRIF SPC has made twenty-one pay-outs which total USD 68 million to ten (10) member states. Total payments related to the impacts of climate events totalled approximately USD 58 million. Grenada has not received any pay-outs from the facility to date (CCRIF SPC, 2016).

Sovereign Disaster Risk Insurance programmes are still relatively new to Grenada and the Caribbean as CCRIF SPC has only been in existence since 2007. These types of programmes are usually complex and are not easily understood by persons at both the macro level and also at the micro level. For the CCRIF SPC to be a viable tool to Grenada, personnel from within the Ministry of Finance must continue to understand the operations of the policy as it relates to:

- The type of coverage purchased (TC, EQ, Excess Rainfall);
- The amount of coverage to be purchased; and
- The role of the facility and use of funds as disbursed by CCRIF SPC.

The role of the facility should clearly be understood by the general public: the insurance industry is already met with distrust and scepticism. In an effort to address the concerns, CCRIF SPC has partnered with a number of institutions in an effort to introduce an insurance product which will benefit low income persons, Micro Small and Medium Enterprises and persons who have difficulty gaining access to insurance.

Micro-Insurance

A micro-insurance programme can be described as one which provides protection of low-income persons against specific perils in exchange for regular premium payments proportionate to the likelihood and cost of the risk involved (Ingram & McCord, 2011). Similar to sovereign disaster risk transfer insurance like CCRIF SPC, micro-insurance provides quick liquidity to the insureds, subsequent to an event, which could be used to secure livelihoods and assist with the reconstruction/recovery process (Hellmuth et al., 2009).

Grenada was selected to participate in a pilot micro-insurance project entitled "Climate Risk and Insurance in the Caribbean" in 2011. (Zissner, 2014) The project was developed through a partnership between Munich Re, Munich Climate Insurance Initiative (MCII) and CCRIF SPC which saw the introduction of two micro-insurance products into the insurance market. These products are the Livelihood Protection Policy (LPP) and the Loan Portfolio Cover (LPC).

The Livelihood Protection Policy (LPP) is a weather-index based insurance policy designed specifically to help vulnerable, low-income individuals recover from the damage caused by strong winds and/or heavy rainfall during hurricanes and tropical storms. The Loan Portfolio Coverage (LPC) policy is also a weather-index based insurance policy that protects Micro Finance Institutions (MFIs) by helping them manage their credit risks by covering losses which may occur due to high incidence of loan defaults as a result of the impacts of heavy rainfall and strong winds.

As both of these products are index based, once the agreed threshold for rainfall and wind speed has been exceeded, a payment will be made to an individual (LPP) or a MFI (LPC). Policyholders will also be encouraged by insurers to adapt risk management techniques independent of the insurance products which would enhance their resilience to the impacts of climate change.

Similar to the Sovereign Disaster Risk Transfer Insurance Schemes, micro-insurance is a relatively new programme as it was only introduced to Grenada within the last 4 years. But for any micro-insurance programme to be effective it must be introduced with a public awareness programme and capacity building as it relates to the operations of the programme.

Target groups for micro-insurance programmes should be engaged before the insurance product is designed to ensure that the premium rates, type of coverage and limit of coverage meet their specific needs which traditional insurance may fail to address.

The LPP was launched in Grenada through Guardian General Insurance (OECS) Limited) which partnered with financial institutions in which small businesses make up a greater part of their portfolio. There has not been much uptake as it relates to the purchase of this type of coverage which could be due to premium rate being too high, lack of knowledge as to how the policy works or a general distrust as it relates to insurance programmes.

The Micro-insurance Network and the Centre for Financial Regulation and Inclusion (CENFRI) have recommended the following guidelines for the regulation of emerging micro-insurance products as shown below in Table 56:

Table 56- List of guidelines for the regulation of micro-insurance programmes (Lloyds of London; Microinsurance Centre , 2009)

GENERAL GUIDELINES	ACTION
Policy	Take active steps to develop a micro-insurance market. Adopt a policy on micro-insurance as part of the broader goal of financial inclusion.
Prudential	Define a micro-insurance product category. Tailor regulation to the risk character of the micro-insurance product category. Allow micro-insurance underwriting by multiple entities Provide a path for formalisation.
Market Conduct	Create a flexible regime for the distribution of micro-insurance. Facilitate the active selling of micro-insurance.
Supervision and enforcement	Monitor market developments and respond with appropriate regulatory adjustments. Use market capacity to support supervision in low-risk areas.

Agricultural Insurance

The agriculture and fisheries sectors are extremely vulnerable to the impacts of climate change and extreme weather events. However, these two sectors are usually viewed as high risks by insurers and therefore many companies are not willing to provide coverage to these groups or the premium rates are cost prohibitive.

Fisherfolk have also experienced difficulty in accessing insurance that would adequately protect their livelihoods from being severely impacted. An increase in the intensity of events both within and outside of the Atlantic Hurricane Season in recent years have forced fisherfolk to consider alternative risk management measures to protect their livelihoods. It has also revived discussions at a regional level with respect to the development of an insurance programme that benefits fisherfolk and the fishing industry (The World Bank, 2017).

Grenada was a member of the Windward Island Crop Insurance Programme (WINCROP) which provides coverage to banana farmers in the Windward Islands. However, WINCROP did not make any pay-outs in Grenada between 2004 and 2015. In 2015, in partnership with the Marketing and National Importing Board of Grenada, WINCROP was reintroduced to the market and made a pay-out to a single farmer who was impacted by a weather event.

Agricultural insurance is a tool to manage agricultural production risks and help producers reduce the effects of negative shocks and improve the allocation of their resources. It provides a mechanism to transfer a variety of risks faced by crop, livestock, forestry, or aquaculture production (Carballo and dos Reis, 2013). As previously mentioned, there is only one agricultural programme presently being offered in Grenada (WINCROP) but it only provides coverage for bananas and plantains against hurricanes, hail and earthquakes.

As there has been a decline in banana production across the region for many reasons, including diseases such as Black Sigatoka and lack of access to markets, there is definitely a need for the implementation of an agricultural insurance programme which encompasses a wider variety of crops. Agricultural insurance programmes are usually designed as a traditional indemnity insurance programme or as an index based weather programme. Given that Grenada has been a participating member of a regional agricultural insurance programme, the introduction of a new product or a revised programme to the insurance market in Grenada should be accommodated within the regulatory framework and policies.

Traditional Indemnity Insurance

Traditional indemnity crop insurance is based on the principle of indemnity, where damage to the insured's property would be assessed and the insured will receive compensation which should restore the insured property to its position prior to the loss. Crop Insurance can further be categorised as "Named Peril" crop insurance or "Multi-Peril" crop insurance.

Named Peril Crop Insurance (NPCI) programmes are usually based on assessments of the damage caused to the crops as a result of specific named perils. Trained assessors are usually deployed subsequent to a loss in order to quantify the damage incurred by the insured. Compensation is then agreed upon based on the policy in place or an agreement between the insurer and the insured.

Multi-Peril Crop Insurance Programmes (MPCI) programmes are usually based on the insured yield and historical average yield of the farmer. Subsequent to an event, should the yield be less than the insured yield, then the insured is entitled to an indemnity. This type of insurance programme covers a suite of perils which impact farmers (flood, drought, high winds…), although certain limitations could hinder the success of the programme (Iturrioz and Arias, 2010).

Premium rates are usually high and therefore in order to ensure farmer uptake, government in Grenada may have to provide subsidies although given the current economic climate, this may not be reasonable at this time. MPCI programmes sometimes attempt to cover risks which are considered uninsurable and therefore may be seen as actuarially unsound. Similar to an NPCI programme, it is also subject to moral hazard. MPCI programmes are also considered to be expensive to administer at times and it can be difficult to confirm damage caused by a named peril under the policy in comparison to mismanagement and poor farming practices.

Index Insurance

Index insurance programmes are linked to an index such as rainfall, temperature, rainfall, yield or humidity rather than the actual damage and/or loss incurred (Hellmuth et al, 2009). There are two types of insurance programmes which are Area Yield Index Programmes and Weather Index Programmes.

Area Yield Index programmes are linked to farm-level field shortfalls and pay-outs are based on estimates of the yields in defined areas. A threshold for the policy is designed which is less than the expected area yield and payments are made to farmers once the realised area average does not exceed the threshold.

Index based insurance programmes are not linked to the actual damage incurred by the insured and therefore there is no need for damage assessments to verify losses. As a result, monitoring costs are low which can allow for premiums to be more affordable for the intended target groups.

Property Catastrophe Risk Insurance

In the Caribbean, most homeowners that have a mortgage are obligated to purchase property insurance as stipulated by their financial institution and this assists with increasing insurance penetration. Property catastrophe insurance can contribute to reducing vulnerability to the impacts of climate change. However, there are some considerations as it relates to identifying the role of property catastrophe insurance adaptation (Lloyd's of London, 2008) which is being flexible in response to climate change, ensuring that valuations take the impacts of climate change into account.

In the context of Grenada where a lot of infrastructure is situated on the coast, implementing adaptation measures are necessary to maintain the availability of affordable insurance for existing properties. Adaptation solutions such as installing hurricane straps, elevating properties and erecting flood defences are part of a suite of measures which contribute to the provision of maximum insurance coverage.

Health Insurance

The economy of Grenada is very vulnerable to the impacts of extreme weather events and the government of Grenada has always prioritised health care within its national budget. In 2009, health expenditure in Grenada was approximately 7.4 percent of GDP with "out of pocket" payments to financial health care accounting for approximately 48 percent of total spending for that same year (Hatt et al., 2011; Private Sector Assessment,2011). This indicates that during this period there was an increase in the use of private health care, although those who are considered poor and vulnerable cannot afford the burdensome costs which are associated with health care.

3.9.6 Limitations of Insurance in the Context of Climate Change

Insurance must be viewed as one component within an overall framework which contributes to the reduction of vulnerability as it relates to climate change impacts. However, there are some key limitations of insurance in the context of climate change that should be considered (Warner, et al., 2009). As the potential for the frequency and intensity of extreme weather events increases, climate change will cause additional challenges for the insurance industry. Two challenges which have been identified are the potential un-insurability associated with the increasing frequency and intensity of extreme weather events; and unsuitability of traditional insurance for longer term foreseeable hazards such as sea level rise and desertification (Warner, et al., 2009).

The United Nations Environment Programmes Finance Initiative reports that insurers may withdraw coverage from some markets by the year 2025 as risks become too high for the pool of premium available. The exploration of alternative risk transfer products such as catastrophe bonds may be more beneficial to address this challenge as the risk is transferred to investors in the capital market as opposed to reinsurers. Given the large amount of uncertainty as it relates to the impacts of climate change, higher risks will cause premium rates to increase unless feasible risk reduction measures are implemented.

Another issue is that traditional insurance programmes may not be suitable for longer-term foreseeable natural hazards such as sea level rise and desertification. For disasters to be insurable, sudden and unforeseen losses and the ability to spread the risks over time, regions and between individuals/institutions should be considered. Sea level rise and desertification are slow onset events that can have an impact on populations in multiple regions and as a result are difficult to be considered as insurable risks.

The problems with insurance and constraints on expanding risk management strategies in Grenada (and the Caribbean), are linked to both the limited domestic risk-bearing capacity and the dynamics of international market forces (World Bank, 2001). The domestic capacity constraints are:

- High exposure to perils such as hurricanes (which can affect a large proportion of a domestic insurer’s book of property business at a time, an event termed a catastrophe in insurance parlance);
- Limited fiscal capacity for insurance companies to fund major disaster reconstruction for public properties and low-income communities that often require substantial government assistance as they are usually uninsured;
- Insufficient vulnerability reduction measures taken for properties and physical assets;
- Limited reserves of domestic insurance capital; and
- Consequent under-insurance.

The characteristics of the international insurance and reinsurance markets have also impacted the development of local risk management practices through:

- Past premium rate volatility, which has limited insurance coverage to middle/higher income sectors;
- Lengthy past delays in rate adjustments and capacity replenishments following global disaster events;

- High level of reinsurance provided to local insurers who benefit from the commission, which is a strong incentive to maintain high insurance premiums; and
- Proportionately higher insurance costs for catastrophic-level risks, given insurers' and reinsurers' need to maintain high and costly levels of capital to fund such eventualities' (World Bank, 2001).

Despite these challenges, the insurance sector in Grenada has recognised the importance of insurance in strengthening various sectors and protecting capital investments. Insurance alone cannot be the sole tool to address some of the dire effects of climate change and pre-insurance loss mitigation measures should be introduced in order to mitigate losses.

3.9.7 Recommendations for Insurance Industry

Grenada has already started to introduce innovative types of risk transfer mechanisms to the market through its participation in CCRIF SPC and the launch of a micro-insurance programme. However, there are some recommendations which could be followed to further contribute to the growth of the insurance sector as it relates to climate change adaptation initiatives and the role of insurance in this process.

Continue to Incorporate Comprehensive Risk Reduction as part of National Adaptation Plans

National Adaptation Plans are critical in order to analyse the relative roles of various risk reduction measures and to develop strategies to implement these measures. Comprehensive risk reduction measures play an import role in the implementation of sound actuarial practices and insurance systems. Access to accurate risk information; appropriate risk pricing; and a comprehensive risk reduction plan will allow the Government of Grenada to be involved in the implementation of suitable insurance programmes that benefit their countries at the macro-, meso and micro-level.

Continued Development of Innovative Insurance Products

Grenada is off to a good start through their participation in CCRIF SPC and the Caribbean Climate Insurance Initiative which are macro and micro insurance programmes respectively. GARFIN is aware of these innovative risk transfer mechanisms and now it should be easier for similar risk transfer mechanisms to enter the market and increase market penetration.

The Government of Grenada should also work with WINCROP to confirm how their portfolio could be amended to provide coverage to other crops besides bananas and plantains. Consideration should also be given to confirm whether WINCROP could develop a hybrid insurance product which is a combination of traditional insurance and an index-based insurance programme.

Quality Data

Access to data, dissemination of data and data stored in a useful format is usually an issue in most Caribbean islands including Grenada. The availability of data is necessary to ensure that the risk is measured accurately and the pricing is adequate to allow for the insurance programme to be sustainable. Systems to store meteorological data as well as historical loss date from past events which impacted Grenada should be enhanced to ensure any gaps in data are filled.

Risk Reduction and Insurance

In regards to the impacts of climate change, insurers should emphasise to their customers the importance of implementing risk management strategies either at the time of issuing the policy or at the time of renewal. Insurers could consider providing incentives to those customers who implement risk reduction strategies such as installing hurricane straps and hurricane shutters on their homes. Insurance companies and the government should collaborate to develop a mechanism which allows for the insured to receive fiscal incentives when their understanding of risks is coupled with the implementation of risk reduction measures.

As Grenada is already participating in a micro-insurance programme, this is a prime opportunity to raise awareness on the benefits of implementing risk reduction measures. The pay-outs for the micro-insurance programme in Grenada is linked to the exceedance of a threshold (climate variable) and not based on the actual damage on the ground. Therefore, the incentive for the insured to practice risk reduction would be that the difference between the amount needed for recovery and the pay-out received by the insurance company will increase. The insured will then have extra funds available which could be further invested into their livelihoods as the amount needed to restore their lives to normalcy has been reduced.

Summary of Recommendations

Table 57 below lists the recommendations for the insurance sector as discussed above. A timeframe for the implementation of each recommendation is also shown in the table as defined by short (within 5 years), medium (5-10 years) and long term (more than 10 years).

Table 57-Recommendations for the insurance sector and a timeframe for the implementation of each recommendation

RECOMMENDATIONS	TIMEFRAME
Continue to Incorporate Comprehensive Risk Reduction as part of National Adaptation Plans Government should continue to assess the role of insurance within the framework of the National Climate Change Adaptation Plan. Develop a framework which makes a correlation between comprehensive risk reduction measures and the implementation of sound actuarial practices	Short Term
Insurance companies should continue to contribute to the introduction of innovative insurance products into the local markets	Medium Term: Designing and piloting successful innovative insurance products within the

Insurers must be creative in the development of innovative insurance products that expand benefits to the most vulnerable individuals and communities Government and GARFIN must continue to create a policy environment to accommodate the creation of innovative insurance products Continue to participate in CCRIF and support the establishment of national catastrophe fund Undertake major capacity building in the area of agriculture insurance Continue discussions with WINCROP to discuss the possibility of extending coverage to farmers outside of banana farmers Promote and launch micro-insurance products and index-based weather insurance for agriculture	existing insurance culture will take at least 5 years
Availability of Quality Data Systems to store historical meteorological and loss data should be in place and easily accessible Government should continue dialogue with regional and international institutions and the private to facilitate capacity building as it relates to data storage and the building of information	Short Term
Risk Reduction and Insurance Provide financial incentives for policyholders that implement risk reduction initiatives Governments and insurers should provide further financial incentives for adaptation	Short Term

CHAPTER 4.

MEASURES TO MITIGATE CLIMATE CHANGE

4.1 INTRODUCTION

Global GHG emissions have increased since pre-industrial times and will continue to increase, despite the climate change mitigation policies and sustainable development practises that are currently in place. Grenada is committed to implementing mitigation strategies that will reduce GHG emissions, promote sustainable development and facilitate Grenada's drive towards becoming a low-carbon economy. Appropriate mitigation strategies also serve as a no-risk option, which, although needing investment, offer additional social, economic and environmental benefits in the long term.

Grenada's Historic GHG Emissions

The Caribbean region, including Grenada, was responsible for less than 0.35% of global GHG emissions in 2012 (World Bank, 2014). However, Grenada is committed to implement mitigation strategies to become a sustainable, low carbon economy, that is resilient to the effects of climate change (Government of Grenada, 2015). For the 2014 inventory year, Grenada's emissions were estimated to be 3.8 tCO_2e per capita.

Grenada's annual Greenhouse Gas emissions have increased by 49% between 2000 and 2014, with most of this increase coming from Energy Industries (54% of the increase). Of the sub-sectors in the Energy Industries, electricity & heat production and road transport represent 38% and 21% of the increase respectively. Similarly, the IPPU sector accounts for 42% of the increase, while AFOLU and the Waste sectors represent increases of 1% and 2% respectively[39]. In 2014, total GHG emissions for Grenada were estimated to be 407 Gg CO_2e[40], and energy production and consumption (including domestic transport) accounted for 70% of emissions. Figure 86 below presents a summary of the historical emissions highlighting the key sources and trends.

Since 2010, emissions in Grenada have seen an overall increase from 217 Gg CO_2e to 407 Gg CO_2e, representing an increase of 87%. This is largely due to unusually low emissions in 2010, because of the agriculture, forestry and other land use (AFOLU) sector acting as a carbon sink between 2006 and 2010 following the catastrophic impact of the hurricanes Ivan (2004) and Emily (2005) (Government of Grenada, 2017). The financial costs of these events have been estimated to be more than US$900 million and US$110 million respectively, together representing more than twice the country's GDP (World Bank, 2009) (OECS, 2005). Not accounting for the AFOLU sector, emissions in Grenada have solely increased 3% between 2010 and 2014, mainly due to increased road transport and IPPU emissions.

[39] Note these individual increases add up to greater than their total reciprocal percentage increase as there have been some smaller decreases in the commercial and residential and agriculture sectors.

[40] Grenada's National GHG Inventory (sub-component 2) quantified GHG emissions sources and sinks from various socio-economic sectors in Grenada.

Besides the impact of the hurricanes on the AFOLU sector, Energy represents the only sector that has seen an overall emissions reduction since 2010, with a reduction of 3%. The largest sub-sectors reductions have been achieved by the stationary combustion in manufacturing industries and construction, and electricity and heat production with reductions between 2010 and 2014 of 42% and 7% respectively.

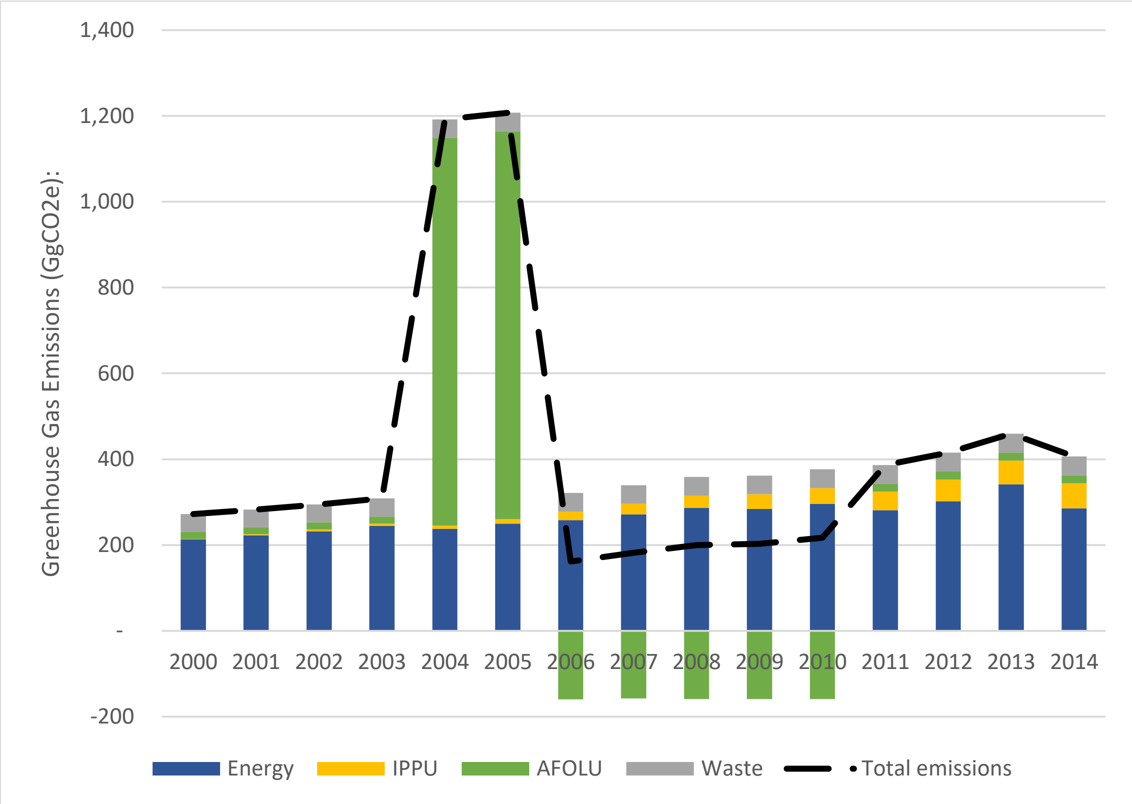


Figure 86-Summary of the historical emissions highlighting the key sources and trends

The drastic increase in AFOLU emissions in 2004 and 2005 is a direct result of the impact of the hurricanes Ivan (2004) and Emily (2005). During the following five-year period between 2006 and 2010, the AFOLU sector acted as a carbon sink, before return to pre-hurricane levels in 2011. In the 2014 inventory, the agriculture sector represented all the emissions of the AFOLU sector.

Targets to Reduce GHG Emissions

As outlined by its Intended Nationally Determined Contribution (INDC) submitted to the UNFCCC in 2015 for the 2015 United Nations Climate Conference held in Paris, Grenada aims to reduce its greenhouse gas emissions by 30% by 2025 compared to a 2010 baseline, with an indicative reduction of 40% by 2030 (Government of Grenada, 2015). This represents an average annual reduction of 2% per year, which can be compared to Grenada's historical emissions increasing by an average of 4% per year between 2000 and 2014.

The cost of implementing Grenada's INDC has been estimated to US$161,430,500, and Grenada anticipates to meet these costs through access to multilateral and bilateral support such as the Green Climate Fund, bilateral agreements, and multilateral agencies (Government of Grenada, 2015).

Future Scenario Analysis

Analysis of potential future scenarios have been undertaken as a part of the country's preparation of the INDC (September 2015), and subsequently updated for the preparation of this report. The analysis assessed the likely future projected GHG emissions and removal scenarios, including and excluding implemented, planned, proposed, and possible mitigation actions divided into the following scenarios:

- The 'INDC' scenario (dark red line) shows the planned path to the target of a 30% reduction by 2025, and the indicate target of a 40% reduction by 2030 compared to a 2010 baseline.
- The BAU baseline (blue line) suggests that, due to projected GDP growth (forecasted to grow approximately 4 % per year between 2014 and 2030) (IMF, 2014), energy demand (and associated emissions) are likely to steadily increase to 2030. This represents a challenge for Grenada. However, it also offers opportunities to achieve economies of scale and reasonable returns on investment in renewable energy generation and energy efficiency implementation.
- The 'With Existing Measures' (WEM) scenario (purple area) includes implemented actions or actions in an advanced planning stage. These actions are most likely to be implemented. They assume no further action beyond those specified in the action plan. Any additional carbon reductions planned would be included under WAM and or WPM.
- The 'With Additional Measures' (WAM) scenario (pink area) includes additional actions deemed possible in the medium to long-term that are reasonably certain to be undertaken, including implementation beyond 2020 or 2025.
- The 'With Possible Measures' (WPM) scenario (orange area) includes any additional actions deemed possible in the medium to long-term, utilising the near-full potential for identified renewable energy sources in Grenada and would mainly be implemented beyond 2025.

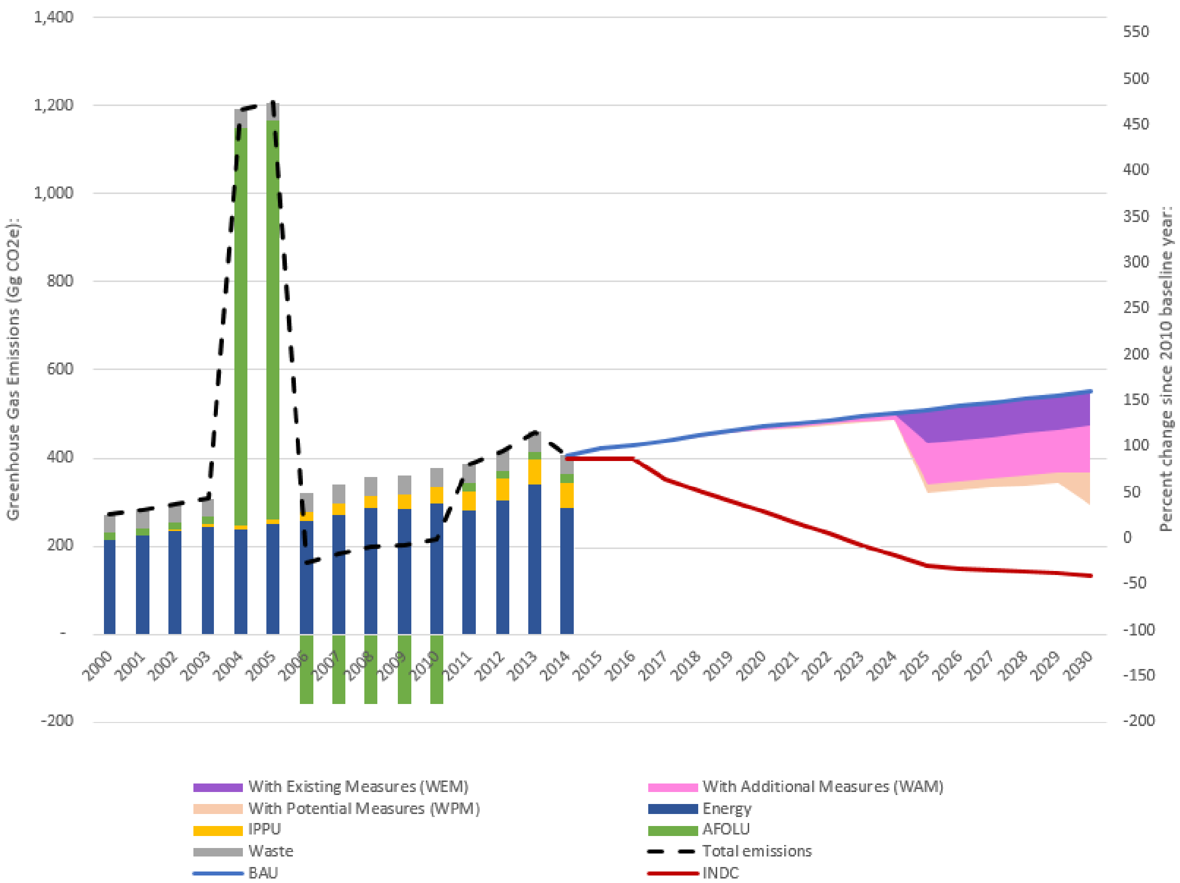


Figure 87-Emissions projections to 2030 representing BAU emissions, and emissions under three scenarios (WEM, WAM, and WPM) compared to Grenada's INDC target

Additional information about the mitigation actions is available in Table 58 as well as Appendices IV and VI.

The analysis confirmed that the implementation of intermittent (wind and solar) and non-intermittent (cogeneration and Waste-to-Energy) energy sources would contribute to reduce GHG emissions. However, the analysis further revealed that due to economic growth, the Government should make sure its focus includes ensuring that efforts are sustained beyond 2020. Furthermore, the analysis suggests that adequate emphasis should be put on developing a low-carbon economy, and decoupling economic growth from GHG emissions. This focus will then reduce electricity generation costs as well as GHG (particularly CO_2) emissions and Grenada's long-term dependency on fossil fuels.

The government and private sector are both involved in the supply and distribution of energy and working in collaboration to meet Grenada's sustainable energy objectives. The main institutional entities in the energy sector are:

- Government of Grenada (Ministry of Finance and Energy)
- Grenada Electricity Services (GRENLEC)

The Government's key role in country's GHG mitigation and sustainable energy strategy is in the development and improvement of comprehensive energy conservation and efficiency programmes. These programmes will be developed to maximise the efficient use of energy, the diversification and expansion of the energy mix, and increased the role of renewable energy in the economy.

Current and Planned Public and Private Initiatives, Policies and Programmes

Current and planned public and private initiatives, policies and programmes identified as a part of the development of the Second National Communication include:

- Developing tax and custom duty incentives on energy-efficient products and renewable energy generation to encourage efficiency measures and energy conservation.
- Develop programmatic energy policy-based loans to encourage sustainable energy initiatives, public education and awareness, institutional strengthening, and help diversify Grenada's energy mix, including;
    - Continuing development of national **geothermal energy** resources through grants supplied to Grenada by the Global Environment Facility through the Inter-American Development Bank, with the CDB in 2017 (Government of Grenada, 2017).
    - Funding the continued sustainable development of renewable and efficiency measures through projects such as the Energy for Sustainable Development project to **reduce GHG emissions in residential and commercial buildings** (GEF, 2016).
    - Leveraging private finance for development of renewable energy generation and alternative transport modes such as electric vehicles (GRENLEC, 2016).
    - Encouraging improved energy efficiency and renewable energy generation in the hotel and tourism sectors through schemes such as the Caribbean Hotel Energy Efficiency Action Program completed in 2017. Grenada has seen GHG reductions of 5,800 tCO_2 annually (Duffy-Mayers, 2014).

Several implemented, planned and possible renewable energy, energy efficiency, and waste management projects have been identified by Grenada for the development of this report. Many of these are currently being promoted and developed by various Government-lead initiatives described above – for example, the Government of Grenada's Geothermal Energy Project Management Unit (GPMU) (see **Error! Reference source not found.**). These mitigation ctions are elaborated on in the section on Information On Programmes And Measures.

Table 58-Identified implemented, planned, and potential climate actions 2014 - 2030, and their respective emission reduction by 2030 and percent reduction of BAU emissions by 2030

Scenario	ID	Action name	Description	Gg CO_2e reduction by 2030	% reduction
With Existing Measures	30	Mt. St. Catherine Geothermal energy	Development of 15 MW geothermal energy site at Mt. St. Catherine	76.6	14%
	33	Solar farm	11 solar PV installations at Grand Anse, Queen's Park and Plains carried out by	0.9	0%

Scenario	ID	Action name	Description	Gg CO_2e reduction by 2030	% reduction
(WEM)			GRENLEC in 2016		
	36	Solar system (Korean funded)	Emission reductions from off-grid solar PV (24 kW) funded by the Republic of Korea	0.0	0%
With Additional Measures (WAM)	32	Electric Vehicles	Policy promoting the uptake of electric vehicles in Grenada	0.5	0%
	34	Wind power	Development of a 2 MW wind power farm by 2030 with a total annual generation of 15,770 MWh	9.3	2%
	37	LED public lighting	Uptake of 1% LED public lighting by 2020, and 15% by 2030	0.2	0%
	39	G-Hydro In-Conduit hydropower	Development of 0.2 MW In-Conduit hydropower with a total annual generation of 600MWh	0.4	0%
	40	PV systems	Development of up to 25 MW solar PV installations (additional 23.33 MW beyond current installed capacity of 0.937 MW and Petite Martinique PV system treated as separate mitigation action) with total annual generation of 52,809 MWh	19.9	4%
	54	Petite Martinique off grid solar PV system	Development of solar PV off-grid PV system incl. battery storage for the island of Petite Martinique off the coast of Grenada. Annual generation estimated to approximately 1,668 MWh by 2030.	1.0	0%
	56	15 MW additional geothermal	Development of additional 15 MW geothermal energy beyond the 15 MW currently under development	76.6	14%
With Potential Measures (WPM)	45	Biogas systems in agriculture, tourism and residential sectors	Development of biogas systems in agriculture, tourism and residential sectors	1.3	0%
	55	Integrated solid waste management	Capture of landfill gas at existing landfill site	24.6	4%
	57	10 MW additional wind power	Development of an additional 10 MW wind power farm with a total annual generation of 83,000 MWh	46.4	8%

Constraints and Gaps

The work on the Second National Communication provided several recommendations on how to best address constraints and gaps, and how to enhance and facilitate the implementation of identified mitigation actions. These recommendations are further elaborated on in the Section 4.5, and include:

- Strengthen legal and regulatory frameworks regarding renewable energy, energy efficiency, and GHG emissions;

- Improve public awareness of environmental challenges related to climate change mitigation and adaptation, improving acceptance and behaviour change;
- Improve capital investment, funding and leveraging of private capital, and encourage public and private sector partnerships to address cases of high investment costs;
- Develop skills and technical capacity building for energy efficiency and renewable energy technologies;
- Improve data quality and availability, as well as analysis to monitor/measure, report/communicate and verify progress and potential challenges (MRV);
- Increase research and development of renewable energy and energy efficiency solutions such as solar, seawater air conditioning and biomass cogeneration relevant to Grenada;

These recommendations listed above support Grenada's vision for a low carbon and sustainable economy as outlined by its National Energy Policy (Government of Grenada, 2011). Effective actions to mitigate climate change will require efforts by the government and private sector alike as there is a mix of private companies and state-owned entities involved in energy productions, supply and distribution (e.g. solar PV installers and GRENLEC). Successfully delivering these mitigation actions will require significant investment in alternative technologies, data collection and strengthened technical capacity. Established mechanisms, including those developed through the UNFCCC, should be explored and utilised.

4.2 OVERVIEW OF MEASURES TO MITIGATE CLIMATE CHANGE

Global GHG emissions will continue to increase in the future, and adaptation to climate change is therefore essential, in particular for island states such as Grenada. However, adaptation could result in high economic and social costs (World Bank, 2017). Thus, mitigation policies are essential even for small nations like Grenada which contributes a relatively small proportion of global GHG emissions.

4.2.1 Priority Sources and Categories for Mitigation Action and Sustainable Development

Grenada' National GHG Inventory (see GHG inventory - chapter 2) quantified the GHG emissions sources and sinks across various socio-economic sectors. A summary of relevant information is shown in Figure 88 below. Total GHG emissions in 2014 were estimated at 407 gigagram (Gg) of carbon dioxide equivalent (CO_2e), with 70% of that produced by the energy sector (including domestic transport).

Category		Gg CO2e 2000	Gg CO2e 2010	Gg CO2e 2014	% share in 2014	% of 2000 - 2014 trend
Energy		213	296	286	70%	54%
	Energy Industries	78	138	128	32%	38%
	Manufacturing industries and Construction	6	8	5	1%	-1%
	Domestic Transport	89	118	116	29%	20%
	Commercial/Residential	41	32	36	9%	-3%
Industrial Processes		1	37	58	14%	42%
AFOLU		17	- 159	18	4%	1%
Waste		41	44	44	11%	2%
	Landfill	19	20	21	5%	2%
	Wastewater	22	23	24	6%	1%
Total		**272**	**217**	**407**	**100%**	**49%**

Figure 88-GHG emissions and removals for Grenada and % contribution to the 2000 – 2014 trend (+ = increase and - = decrease)

Since 2000 total emissions are estimated to have increased by 49%. GDP is expected to grow by around 4% per year between 2014 and 2030 (IFS, 2017). This projected growth is underpinned by several key economic strategies designed to increase the value of tourism, international business, and manufacturing sectors and increased GDP per capita. Grenada also expects its population to rise by around 5% over the 2014 – 2030 period (WPR, 2017). These trends present a challenge through their impact on future GHG, and meeting Grenada's INDC target of a 30% reduction b 2025, and the indicative target of 40% by 2030 compared to the 2010 baseline.

The analysis of potential future scenarios was undertaken in the preparation of the INDC (September 2015) and has been updated for the preparation of this report. This analysis assessed the likely future projected GHG emission and removal scenarios including and excluding implemented, planned, proposed, and possible mitigation actions.

Grenada has identified the following target categories for its mitigation efforts. These categories individually make up the key contributors to the increase in emissions between 2000 and 2014 (as shown by **Error! Reference source not found.** above):

Energy Industries (Electricity Generation)

- **Driven by** increased demand for heat and power through economic growth.
- **Represents** 32% of 2014 emissions.
- **Contributes to** 38% of the total 49% increase in emissions between 2000 and 2014 as during this period the electricity production increased from 135 GWh to 200 GWh, an increase of 48% (Government of Grenada, 2015).
- Baseline projections for energy demand suggest demand for electricity will reach 235 GWh by 2020 (139 Gg CO_2e) and 291 GWh by 2030 (172 Gg CO_2e) respectively (Government of Grenada, 2015). Unless energy efficiency measures are implemented, this will represent a doubling of electricity demand by 2027 from a 2000 baseline.
- The Projection scenario 'With Additional Measures' which includes several renewable energy generation measures, suggests that there is potential for annual savings of up to 108 Gg CO2e by 2030. This contributes to 26% of the reduction required from the BAU scenario to achieve Grenada's INDC target of a 40% reduction on 2010 by 2030 (Government of Grenada, 2015).

- **Solutions** include increasing generation of renewable energy and reduced demand for electricity through behaviour change and energy efficiency measures such as Light-emitting diode (LED) street lighting. In 2015, street lighting represented 2.35% of Grenada's total electricity consumption. Through the increased efficiency of using LED lighting, Grenada aims to substantially reduce public lighting electricity demand through the deployment of such LED infrastructure. These actions are implemented through the 'LED public lighting' mitigation action incorporated in this report (see WAM actions).

Domestic Transport

- **Driven by** increased use of vehicles, airplanes and maritime navigation due to economic growth and increased social desire and affordability of mobility.
- **Represents** 26 % of the 2014 emissions.
- **Contributes** to 20% of the total 49% emissions increase between 2000 and 2014.
    - Projected trends have not been studied in detail for domestic transport. However, emissions have risen steadily since 2000 and, without mitigation measures, would be expected to rise further into the future with increasing GDP.
- **Solutions**: Improve transport efficiency, switch to low carbon transport forms and integrate renewable into the fuel mix**.**

Waste Landfill

- **Driven by** increasing amounts of waste disposed to landfill due to economic growth and increased availability of products.
- **Represents** 5% of 2014 emissions.
- **Contributes** to 2 % of the total 49 % emissions increase between 2000 and 2014.
    - Projected trends have not been studied in detail for waste. However, emissions have risen steadily since 2000 in line with GDP and without mitigation measures would be expected to rise further into the future with increasing GDP.
- **Solution**: Reduce waste to landfill through waste prevention and recycling. Increase waste to energy if possible.

Agriculture Forestry and Land Use (AFOLU)

- The agriculture, forestry and other land use sector has not been reviewed in terms of mitigation opportunities.

4.3 STEPS TAKEN AND ENVISAGED FOR NATIONAL AND REGIONAL PROGRAMMES CONTAINING MEASURES TO MITIGATE CLIMATE CHANGE

4.3.1 Steps Taken to Mitigate Climate Change

Grenada has taken steps to implement several mitigation actions. These measures include pilot programme in the use of electric vehicles, development of solar PV, rural biogas projects, and the started development of a geothermal energy site.

In September 2015, Grenada's licensed electricity provider GRENLEC launched the country's first electric vehicle (EV) pilot programme supported by the Government of Grenada. The pilot aims to test the energy efficiency, range, cost savings, road performance and environmental benefits of electric vehicles in Grenada, compared to conventional internal-combustion (ICE) cars (GRENLEC, 2015). As of 2017 it is estimated that five EVs currently operate in Grenada, and the country aims to increase this number in the future. The emissions savings associated with these electric vehicles depend on the energy used to generate the electricity. Therefore, substantial savings of GHG emissions will only be achieved through the consumption of non-fossil fuel low carbon sustainable energy in electricity production. Electric vehicles do represent an immediate co-benefit in the reduction in the emissions of air pollutants and will reduce human health problems in urban areas.

The Energy Transition Initiative estimates the total potential of solar PV in Grenada to be approximately 25 – 50 MW (Energy Transition Initiative, 2015). To date, Grenada has developed approximately 2.2 MW, primarily through the development of 11 solar PV installations carried out by GRENLEC at Grand Anse, Queen's Park and Plains in 2016. Additional residential projects have also been carried out, including some limited residential solar PV, and the provision of solar PV and battery storage solutions to off grid communities (mitigation action ID 36).

As one of the largest economic sectors in Grenada, the tourism industry affects the national energy demand. Electricity consumption in the Grenada hotel sector alone accounts for approximately 1.4% of the country's total GDP. The main source of electricity demand is generally air conditioning, accounting for up to 48% of the electricity demand. However, mitigation actions such as improved energy efficiency and improved energy management can achieve substantial savings, and Grenada's hotel sector has seen GHG reductions of 5,800 tCO_2 annually (Duffy-Mayers, 2014). This reduction represented approximately 1.4% of Grenada's emissions in 2014.

Rural biogas installations have been developed and used in Grenada since the 1980s, but additional measures will need to be taken in the future to increase uptake of these solutions.

Finally, as one of Grenada's principal mitigation actions, the development of a geothermal electricity generation plant has been commenced, including exploratory drilling. The current ambition is to complete a 15 MW installation at Mt. St. Catherine by 2025 if the required funding can be obtained (see mitigation action ID 30).

4.3.2 Future Mitigation and Sustainable Energy Prospects

Given Grenada's projected economic and population growth, with associated demand additional energy supply, there are significant opportunities for economy-of-scale production and increased price effectiveness for embedding renewables. However, to facilitate growing renewable demand, and to address technical challenges associated with the increased share of renewables, the country's grid and storage infrastructure needs to be further developed. Grenada also needs capital to invest in initially more expensive renewable and energy efficiency solutions. Addressing these challenges, through measures such as smart grid advancements, has the potential to transform the energy sector.

98% of the country's electricity is currently sourced from fossil fuels. Projected population growth and increased demand for electricity will necessitate increased electricity production. Dependency on oil means that Grenada is currently a relatively high per capita GHG emitter for its electricity generation. Fluctuations in the price of oil pose a challenge for Grenada. Grenada depends heavily on imported fossil fuels, which destabilises the country's competitiveness and its economic and social development. However, this dependency encourages its commitment to implement mitigation actions for climate change.

The Government of Grenada's intention is to maximise the efficient use of energy, diversify the energy mix and ensure that renewable energy plays a progressively more significant role in the economy. These strategies not only promote energy conservation and efficiency and hence competitiveness and economic and social development, but also reduce GHG emissions.

For renewable energy technologies to be preferred over fossil fuels, they must be economically viable (Bazilian, et al., 2013). This viability can be evident in the amount of energy that can be produced and the money that can be saved.

The high cost of fuel, variable operating and maintenance expenses, capital expenditures, and energy loss of conventional sources can be avoided through the development and installation of renewable energy technologies, making them economically viable in Grenada. If the cost of a fossil fuel power source, including installation, return on investment, operation, fuel and maintenance costs, is calculated over its lifetime and compared to a similar cost for a solar system, then the solar system is more economically compelling (Clean Energy Council, 2013). In 2014, the cost of imported petroleum products in Grenada amounted to approximately US$67 million (Government of Grenada, 2017). This could be compared to the implementation cost of a 15 MW geothermal energy plant, estimated to be approximately US$128 million.

As such, renewable energy technologies can be considered as insurance against the rising cost of fossil fuels such as coal and gas (Clean Energy Council, 2013).

One of the strategic elements of the Liliendaal Declaration[41], which was endorsed by Caribbean Community (CARICOM) Heads of Government, is 'Promoting actions to reduce GHG emissions through fossil fuel reduction and conservation, and switching to renewable and cleaner energy sources' (CCCCC, 2017). The Government of Grenada' climate change mitigation efforts will

[41] https://www.lcds.gov.gy/index.php/documents/reports/national/liliendaal-declaration-on-climate-change-and-development

therefore seek to enhance sustainable development prospects and provide co-benefits to other sectors, policies, practices and strategies in Grenada.

4.3.3 Links to Sustainable Development Goals

Following the destructive impacts of Hurricane Ivan (2004), Hurricane Emily (2005) and the 2008 global financial crisis, poverty levels in Grenada reached 37.7 % in 2008 (UNDP, 2017). These economic challenges, combined with other systemic vulnerabilities relevant to small developing island states like Grenada, have left the country vulnerable to exogenous shocks. Apart from weather events such as hurricanes, Grenada is further vulnerable to volatility in international markets (including energy and oil prices), and economic downturns affecting key economic sectors such as tourism. Taking these challenges into consideration, Grenada strives to develop its mitigation actions to enable the greatest possible synergies with the 17 UN Sustainable Development Goals (SDGs).

While levels of extreme poverty dropped to only 2.4 % in 2008, unemployment levels of up to 25 % and challenges regarding education all present potential obstacles and opportunities for the development of a more sustainable Grenada. Through the delivery of actions designed to mitigate climate change, Grenada aims to deliver a fair economy reducing poverty, hunger and inequalities.

As a part of the stakeholder engagement process undertaken in preparation of Grenada's Second National Communication to the UNFCCC, a mapping exercise was undertaken to identify key mitigation actions and their linkages to the SDGs. Figure 89 below presents the outcome of the mapping exercise, displaying the linkages between the principal SDG connecting all mitigation actions (SDG 13: Climate Action). The mitigation actions, divided into energy and waste actions, are then linked to the most relevant SDGs, with strong benefits indicated in green, weak benefits in black, and potential strong adverse impacts in pink.

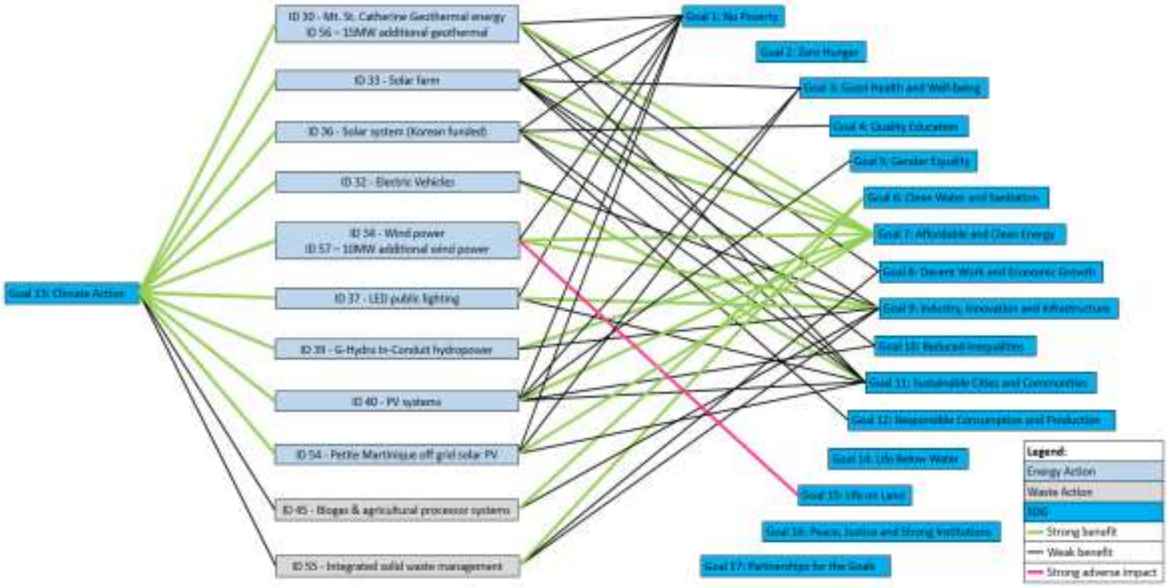


Figure 89-Mapping of mitigation actions and UN Sustainable Development Goals (SDGs)

(All mitigation actions are linked to SDG 13: Climate Action. Strong benefits are indicated in green, weak benefits in black, and potential strong adverse impact in pink)

The key mitigation actions and their co-benefits identified through the mapping exercises were;

- **ID 30 - Mt. St. Catherine Geothermal energy plant**
  As one of the largest renewable energy projects under development in Grenada, the Mt. St. Catherine geothermal energy plant has the potential to contribute to several UN SDGs. Through domestic renewable energy generation and reduced dependence on imported diesel fuel, geothermal energy could provide Grenada with affordable and clean energy as well as employment opportunities. Data from the international geothermal industry further suggests the possible creation of more than 32 full time equivalent (FTE) employments through the commissioning of a 15 MW at Mt. St. Catherine (EESI, 2015)[42]. Similarly, a more extensive utilisation of geothermal resources across Grenada through the deployment of 50 MW of geothermal energy could generate more than 106 FTEs[42].

- **ID 33 - Solar farm, PV systems**
  Generation of electricity through solar PV have strong opportunities to contribute to the SDGs, either in the form of solar farms developed by GRENLEC, or through a roll-out of PV systems in the domestic and commercial sectors. In particular, these systems link to opportunities for citizen engagement and poverty reduction through economic benefits

[42] Based on US statistics corresponding to 2.13 FTE per MW of capacity installed when accounting for related governmental, administrative and technical positions (EESI, 2015).

achieved by displacing more expensive diesel generated electricity. Solar energy also has substantial co-benefits such as improved air quality, related to Goal 3: Good Health and Well-being.

- **ID 34 - Wind power**
  Following the increased cost competitiveness of both on- and offshore wind power, the development of a 2 MW wind farm has the potential to positively influence Grenada's uptake of renewable energy. However, present analysis of past projects damaged by strong winds suggests the need to primarily focus on micro-scale storm-proof wind turbines that could be dismantled during extreme weather events such as hurricanes. Additional analysis will be required to analyse impact of such generations on local wildlife in Grenada.

As indicated in Figure 89, the proposed mitigation actions were linked to 13 of the 17 SDGs. Beyond Goal 13: Climate Action, the mitigation actions were linked more strongly to three of the SDGs, discussed in greater detail below.

- **Goal 1: No Poverty**

  With 37.7% living in poverty and 2.4% in extreme poverty, opportunities for local employment co-benefits are particularly relevant for sustainable development in Grenada. In particular, additional links need to be made in connection to Quality Education (Goal 4) enabling people to fill opportunities, and ensuring school retention.

  Grenada's economy is further challenged by high levels of emigration, with 85.1% of tertiary educated students leaving the country (UNDP, 2017). The ambition is that alongside other non-climate related measures already implemented, e.g. increased government spending on education, employment in the renewable energy sector could provide attractive employment and apprenticeship opportunities in Grenada.

- **Goal 7: Affordable and Clean Energy**

  At US$ 0.34/kWh, the electricity rates in Grenada are in line with the regional average for the Caribbean region, but substantially higher than other countries in the region. Due to this strong dependence on imported fossil fuels, Grenada spends approximately 18 % of GDP on fuel imports, out of which electricity represented 13% alone (Energy Transition Initiative, 2015). This situation, combined with price volatility of global oil prices, provides a strong business case for renewable energy generation.

  Grenada-specific data from 2014 estimates costs of utility-scale solar to US$ 0.21 – 0.44/kWh, and wind energy to US$ 0.05 – 0.20/kWh (Energy Transition Initiative, 2015).

- **Goal 9: Industry, Innovation and Infrastructure**

  Grenada's industries and infrastructure suffered heavily from the devastating impacts of Hurricane Ivan (2004) and Hurricane Emily (2005). Beyond the World Bank's Hurricane

Ivan Emergency Recovery Project (HIERP), Grenada receives support from the IMF under its Emergency Assistance Programme. The country has also commenced the development of a Bridges and Roads Investment Project (UNDP, 2017; World Bank, 2009).

The findings from the linking exercise suggests that additional efforts will need to be undertaken to ensure linkages between Grenada's attempts to reduce GHG emissions and facilitate a transition towards a sustainable development. These efforts are particularly relevant for SDGs where few or no linkages were identified, including; Zero Hunger, Quality Education, Responsible Consumption and Production, Life Below Water, Life on Land, Peace, Justice and Strong Institutions, and Partnerships for the Goals. Furthermore, the development of wind generators in Grenada will need to be done in a way to reduce any potential adverse impact on life on land.

4.4 INFORMATION ON PROGRAMMES AND MEASURES

Details of implemented and planned programmes and measures which contribute to mitigating climate change in Grenada are presented below. The programmes and measures are embedded within a framework of sustainable development objectives and consider wider social, economic and environmental factors. Throughout the stakeholder engagement undertaken as part of the development of this report, a total of 52 climate actions were identified, ranging from mitigation actions such as the geothermal energy power plant currently under implementation, to the development of policy documents (e.g. INDC) and enabling policies.

To meet the indicative target of 40% by 2030, emissions will need to be reduced by an additional 163 Gg CO_2e, beyond the impact of the WEM, WAM and WPM mitigation actions (see Figure 90). Beyond the 13 priority mitigation actions quantified for the development of this report, other additional mitigation actions that could be expected to reduce Grenada's emissions include:

- ID 4 – Reforestation efforts under PPCR projects
- ID 12 – Encourage the practice of zero grazing and semi-intensive management systems
- ID 44 – Solar dryers for cocoa farmers

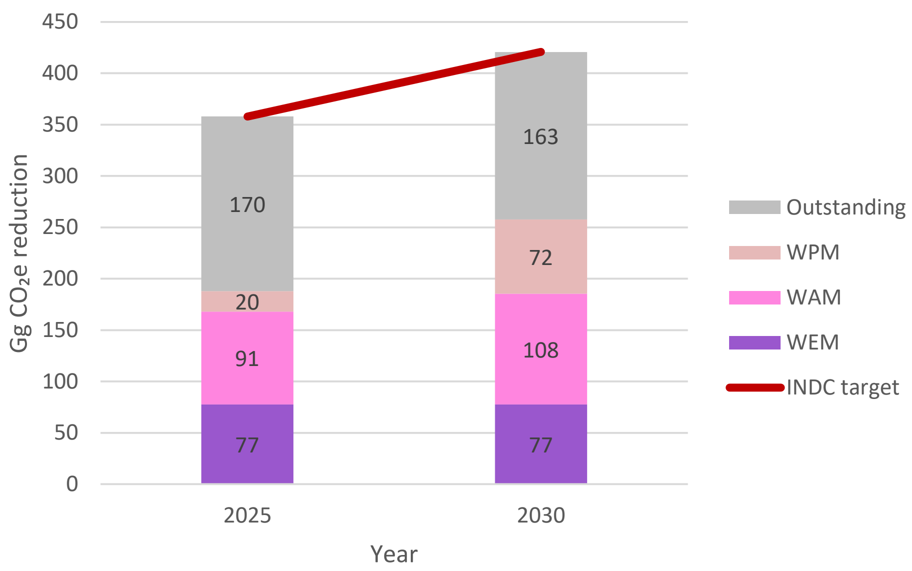


Figure 90-Required emission reductions by 2025 and 2030 to meet NDC target of a 30% reduction by 2025, and the indicative target of 40% by 2030 on a 2010 baseline

In the future, Grenada aims to quantify other mitigation actions beyond the actions prioritised for the development of this report.

This section on programmes and measures is separated into the financial investment programmes that facilitate mitigation actions (see Section 4.4.1) and the implemented, planned and possible mitigation actions themselves (see Sections 4.4.2 and 4.4.3). Appendix VI provides a summary of the programmes and measures indicating their status, objectives and start and end dates.

4.4.1 Financial Investment and Strategic Programmes for Energy Sustainability, Transport and Greenhouse Gas Mitigation

Significant strategies for energy reform and sustainability have been developed to facilitate investment in sustainable energy initiatives in Grenada. These strategies have been facilitated by the Government of Grenada, the Caribbean Development Bank (CDB) and Global Environment Facility (GEF).

International Funding Sources

In 2017, Grenada received a grant for geothermal energy development by the Global Environment Facility, through the Inter-American Development Bank's Sustainable Energy Facility, with the CDB. The grant of US$231,630 or approximately XCD$625,401 will facilitate the Government's capacity for planning and implementing its Geothermal Energy Development

Roadmap (GEDR).[43] Current estimates suggest that approximately US$128 million (XCD$ 346 million) will be needed to completely develop the 15 MW geothermal site at Mt. St. Catherine (see mitigation action ID 30).

Grenada and the Eastern Caribbean region has together received a project grant of US$3,013,698 (approximately XCD$8,136,985) funding from the Global Environment Facility (GEF) through the Inter-American Development Bank to fund regional sustainable energy projects in the Eastern Caribbean (SEEC) (GEF, 2017). Additional funding has also been made available to the Caribbean region for developing Energy for sustainable development, building capacity to reduce GHG emissions in residential and commercial buildings (GEF, 2016) and for the establishment of the Sustainable Energy Facility that will support geothermal energy development in the Eastern Caribbean (GCF, 2017).

International Market Mechanisms

As stated in its NDC, Grenada does currently not use any market mechanisms for the development of its mitigation actions. However, the country is willing to explore the potential of such market mechanisms, as well as other mechanisms under the UNFCCC, demonstrating adequate environmental integrity (Government of Grenada, 2015).

Private Finance

Private finance has acted as an additional source of funding, in particular for financing pioneering uptake of alternative transport technologies and small-scale renewable energy generation. One such example includes the first electric car imported to Grenada in 2014 (GRENLEC, 2016). Additionally, the high potential for solar energy on Grenada due to the country's high irradiation has led to a burgeoning uptake of small-scale solar PV installations. As of March 2015, 40 small (<40 kW) PV systems were in service, as well as several larger installations such as the Maca Bana Villas (10 kW) totalling approximately 2.2MW.

These financial initiatives stimulate the research, analysis and practical implementation of sustainable energy initiatives (listed in Section 4.4.2) which have and will continue to deliver greenhouse gas reduction achievement as well as wider social, economic and environmental benefits.

4.4.2 Specific Mitigation Actions Implemented and Planned (WEM)

A total of three Implemented or Planned actions have been quantified for Grenada, listed in Table 59 below. The climate actions listed are deemed to be either under implementation, or in an advanced planning stage, and are together designated as 'With Existing Measures' (WEM). These actions are mainly focused on renewable energy generation. These actions are estimated

[43] http://www.gov.gd/egov/news/2017/mar17/24_03_17/item_2/grenada-receives-grant-geothermal-energy-development.html

to achieve a reduction of 0.9 Gg CO_2e by 2020, and 77.5 Gg CO_2e by 2030, representing approximately 14% of Grenada's BAU emissions by 2030. Priority actions with a large potential impact include geothermal energy development such as that at Mt. St. Catherine accounting for 76.6 Gg CO_2e emissions reductions respectively by 2030.

Table 59-Implemented and planned climate actions in Granada and emissions reductions by 2020 and 2030 in Gg CO_2e

Scenario	ID	Action name	Emissions reduction by 2020 (Gg CO_2e)	Emissions reduction by 2030 (Gg CO_2e)
With Existing Measures (WEM)	30	Mt. St. Catherine Geothermal energy	0.0	76.6
	33	Solar farm	0.9	0.9
	36	Solar system (Korean funded)	0.0	0.4
		Total emissions reduction	**0.9**	**77.5**

A description of each action is included in Appendix VI.

4.4.3 Possible Future Mitigation Actions

Additionally, ten possible future mitigation actions have been quantified for Grenada, listed in Table 60. The climate actions listed in Table 60 are deemed to be possible medium to long-term actions that could be developed through additional funding. These policies are together designated as 'With Additional Measures' (WAM) and target renewable energy generation in Grenada, utilising a larger proportion of the renewable energy potential in Grenada for wind-, hydro-, solar PV, and geothermal energy as indicated by assessments carried out by the Energy Transition Initiative in 2015 (Energy Transition Initiative, 2015). The possible emissions reduction of these mitigation actions has been estimated to be 6.2 Gg CO_2e by 2020 and 107.8 Gg CO_2e by 2030, representing approximately 20% of Grenada's BAU emissions by 2030. Priority actions include wind power developments, representing substantial emissions reductions through the development of 2 MW installed wind energy capacity, utilising approximately 10% of the wind power potential indicated by the Energy Transition Initiative (Energy Transition Initiative, 2015).

Table 60-Possible future climate actions in Grenada and emissions reductions by 2020 and 2030 in Gg CO_2e

Scenario	ID	Action name	Emissions reduction by 2020 (Gg CO_2e)	Emissions reduction by 2030 (Gg CO_2e)
With Additional Measures (WAM)	32	Electric Vehicles	0.0	0.5
	34	Wind power	0.0	9.3
	37	LED public lighting	0.0	0.2
	39	G-Hydro In-Conduit hydropower	0.0	0.4
	40	PV systems	5.7	19.9
	54	Petite Martinique off grid solar PV	0.4	1.0
	56	15 MW additional geothermal	0.0	76.6
		Total emissions reduction	**6.2**	**107.8**

The climate actions listed in Table 60 are deemed to be possible medium to long-term actions that could be developed through additional funding. These policies are together designated as 'With Potential Measures' (WPM) and target renewable energy generation and waste management. These actions would represent a larger utilisation of wind energy potential in the country, as well as capture of landfill gas at one of Grenada's landfill sites. The possible emissions reduction of these mitigation actions has been estimated to 1.1 Gg CO_2e by 2020 and 72.4 Gg CO_2e by 2030, representing approximately 13% of Grenada's BAU emissions by 2030. Priority actions include a larger utilisation of the wind energy potential.

The limited emissions reductions by 2020 represented by the climate actions listed in Table 60 and Table 61 indicates the limited deployment of these actions likely to happen before 2020, and consequently these actions should mainly be seen as medium to long-term developments.

Table 61-Possible future climate actions in Grenada and emissions reductions by 2020 and 2030 in Gg CO_2e

Scenario	ID	Action name	Emissions reduction by 2020 (Gg CO_2e)	Emissions reduction by 2030 (Gg CO_2e)
With Potential Measures (WPM)	45	Biogas systems in agriculture, tourism and residential sectors	1.1	1.3
	55	Integrated solid waste management	0.0	24.6
	57	10 MW additional wind power	0.0	46.4
Total emissions reduction			**1.1**	**72.4**

A description of each action is included in Appendix VI.

4.5 CONSTRAINTS AND GAPS TO IMPLEMENTING MITIGATION ACTIONS

A number of constraints and gaps were identified that adversely impact the implementation of mitigation actions. This section highlights recommendations for overcoming some of these limitations to help accelerate Grenada's progress and enable it to develop a sustainable low carbon economy.

4.5.1 Access to Funding for Mitigation Action Investment and Tracking

With 18% of GDP spent on Fuel and Imports, and the need for investment in other sectors such as education and infrastructure, funding availability is the primary constraint identified for the implementation of mitigation actions in Grenada.

As the principal mitigation action identified in this report, the development of a geothermal energy site at Mt. St. Catherine is expected to require an investment of approximately US$ 128 million. Whereas such renewables projects, including development of wind power both have the potential to achieve cost competitiveness in the medium- to long-term, a large initial investment is generally required (see Table 62). Additionally, the ability to provide match-funding is also identified as a constraint. E.g. For the development of a 2 MW wind plant on the island of Carriacou, the required investments were estimated to be approximately 2 – 3 times the budget that would have been provided by the EU.

Table 62-Identified funding needs

ID	Project	Funding acquired	Outstanding funding need
30	Mt. St. Catherine geothermal energy	US$ 231,630 acquired from CDB in March 2017 for development of geothermal energy development roadmap.	US$ 128 million
34	Wind farm	NE	NE

4.5.2 Technology Transfer

In the past, Grenada has benefitted from some types of technological transfer, including provision of solar PV technologies by the Republic of Korea. However, in line with Grenada's ambition for an increasingly green economy (Smith, Halton, & Strachan, 2014), more technology transfer will be needed to ensure the contribution of environmental projects to the local economy. Grenada is seeking partnerships to implement new technologies for energy saving and renewable energy generation.

4.5.3 Institutional Capacity Funding for Sustained MRV and NC/BUR Production

As a part of the development of this report, Grenada has continued to develop its institutional capacity related to the MRV of Grenada's climate change mitigation. For the development of this report, two internal workshops were held within the Government of Grenada, identifying mitigation actions and mapping linkages to the UN Sustainable Development Goals. Basic training was performed with some of the relevant stakeholders.

During the quantification of the mitigation actions and projecting of emissions until 2030, an MRV portal, methods for quantifying mitigation measures and QA/QC system were implemented. This included tools and templates for the quantification of measures, QA/QC and to facilitate engagement of stakeholders.

Grenada is currently at a very early stage with this process and risks losing the gained institutional memory during the production of its SNC. In the future, Grenada aims to continue developing its institutional capacity and stakeholder engagement related to MRV of mitigation, adaptation measures and climate finance and linking these to co-benefits and wider SDGs.

Grenada needs support to continue to develop its centres of excellence in MRV of adaptation and mitigation measures in an integrated way. It needs to develop and maintain its GHG inventory and expertise and data to inform decision makers on GHG projections, targets and projected risks and vulnerably to climate change related issues. Grenada needs to get support to develop its MRV systems so that its experts and stakeholders can work efficiently to produce needed outputs (reports) and inform stakeholders and decision makers.

CHAPTER 5.

OTHER INFORMATION CONSIDERED RELEVANT TO THE ACHIEVEMENT OF THE OBJECTIVE OF THE CONVENTION

5.1 INTRODUCTION

This chapter on other information relevant to the achievement of the goals of United Nations Framework Convention on Climate Change focuses on a number of cross-sectoral thematic areas with relevance to climate change adaptation and mitigation. It describes issues of policy and legislation, technology, research, capacity building, education and information as they relate to national efforts in adaptation and mitigation, and how these were introduced and evolved over time, mainly since the publishing of the Initial National Communication (INC) for Grenada in 2000.

CARICOM and other regional groupings successfully lobbied for financial assistance and technical co-operation from international development aid agencies in order to advance national climate change agendas across Grenada and other Caribbean SIDS. This support was integral to building national and regional capacities related to climate change, importantly, the establishment of the Caribbean Community Climate Change Centre (CCCCC) and National Focal Points for climate change within national governments across the region. These developments in turn have catalysed a collective, concerted effort towards building resilience, particularly in those climate-sensitive sectors that are intrinsic to social and economic development. Such support has also contributed to the region's active participation in international dialogue on climate change and resilience, providing Caribbean SIDS with a much-needed voice to petition the international community for addressing climate change.

A range of development partners are credited with the support provided to the region. These include international agencies such as the World Bank, the Inter-American Development Bank and the Global Environment Facility (GEF); as well as national and conglomerate bodies operating on behalf of their respective overarching or commissioning governments: the European Union, the United States Agency for International Development (USAID); the German International Development Agency (Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH, GIZ) the Canadian Department of Foreign Affairs, Trade and Development (DFATD), the UK Department for International Development (DFID), the Australian Agency for International Development (AusAID), the Caribbean Development Bank (CDB) and the Japan International Cooperation Agency (JICA), the Food and Agricultural Organisation of the United Nations (FAO), the United Nations Development Programme (UNDP), the Economic Commission for Latin America and the Caribbean (UNECLAC), the United Nations Environment Programme (UNEP), the Organisation of American States (OAS), the Organisation of Eastern Caribbean States (OECS), the CCCCC and the Caribbean Disaster Emergency Management Agency (CDEMA); as well as local Government ministries and agencies. Technical cooperation has been provided by the Inter-American Institute for Cooperation on Agriculture (IICA).

Table 63 summarises some of these initiatives, and provides an indication of the level of investment in regional resilience goals:

Table 63-Externally Funded Support of Grenada's National Climate Change Programming: Key Initiatives, Milestones and Contributors

Programme/ Project	Timeframe	Overall Objective	Implementing Agency(ies)	External Financing	Amount	Scale	National Activities and Outputs
DIRECT CLIMATE CHANGE FINANCING							
Initial National Communication Enabling Activity – Phase 1	1999 - 2002	To assist the national Government to comply with the provisions of the UNFCCC	UNDP, GOG	GEF	USD 184,370	National	• Preparation and submission of the Initial National Communication (INC) • Formation and training of National Climate Change Committee • Analysis and recommendations for ratification of Kyoto Protocol • Development of project proposal for funding under Enabling Activity Phase 2 (Top Up) • Establishment of web site • Development of Public Awareness Strategy
Initial National Communication Enabling Activity – Phase 2 (Top Up)	2003	To consolidate the work done in the Enabling Activity, and to further strengthen Grenada's ability to develop a structured, coherent response to climate change	UNDP, GOG	GEF	USD 100,000	National	• Awareness and outreach in Tourism sector • Provision of materials and training to Education sector • Strengthening capacity of water sector to monitor stream flows

Programme/ Project	Timeframe	Overall Objective	Implementing Agency(ies)	External Financing	Amount	Scale	National Activities and Outputs
							• Strengthening capacity of meteorological and agro-met services to analyse weather data
National Capacity Self-Assessment of Capacity Building Needs	2005 - 2006	To conduct a comprehensive assessment and analysis of the capacity needs and constraints.	UNDP, GOG	GEF		National	• Assessment of climate change initiatives • Development of the project proposal for the Second National Communication
Strategic Program for Climate Resilience (SPCR)	2012 - 2015	To provide incentives for scaled-up action and transformational change in integrating climate resilience into national development planning.	GOG	World Bank (Climate Investment Fund)	USD $8 M (Grant) USD $12 M (Concessional)	National	Priority Investment areas for Grenada: • Disaster vulnerability and climate change reduction • Forest rehabilitation • Technical assistance for water resources and coastal sectors, and use of data and GIS for adaptation Region-wide activities focus on climate monitoring, institutional strengthening, capacity building and knowledge sharing.
Integrated Climate Change Adaptation	2012 - 2018 (Ongoing)	To enhancing the resilience of parts of the population and	GIZ, UNDP, GOG	IKI, UNDP	€ 5.2 M	National	• The National Climate Change Adaptation Plan (NAP)

Programme/ Project	Timeframe	Overall Objective	Implementing Agency(ies)	External Financing	Amount	Scale	National Activities and Outputs
Strategies (ICCAS)		ecosystems that are particularly vulnerable to the effects of climate change					• Review and update of National Climate Change Policy and Action Plan • Establishment of Community Climate Change Adaptation Fund • Climate change mainstreaming in public sector activities • Capacity building for integrated water resource and coastal zone management • Education and awareness
Reform of the Electricity Sector to support Climate Policy in Grenada (G-RESCP)	2014 – 2017	To support the Government of Grenada in restructuring the energy sector and thereby enable the Government to achieve the objectives of their climate policy	GIZ, GOG	IKI	€1.395 M	National	• Technical assistance with /support of review of act/regulations, consultation and negotiation processes • Training/capacity building of Energy Officers • Support for Project Co-ordination • Pilot project with installation of biogas plants by means of development partnership with German private sector

Programme/ Project	Timeframe	Overall Objective	Implementing Agency(ies)	External Financing	Amount	Scale	National Activities and Outputs
							• Training and capacity building in biogas plant installation and maintenance • Pilot project in micro hydropower • Support of public awareness activities related to RE and EE
DIRECT CLIMATE CHANGE FINANCING - REGIONAL							
Caribbean Planning for Adaptation to Climate Change (CPACC)	1997 - 2001	To build capacity in the Caribbean region for the adaptation to climate change impacts, particularly sea level rise	World Bank, OAS, CARICOM	GEF	USD $5.6 M	Regional	• Participation in relevant CPACC regional components • Training in, and pilot coastal vulnerability assessments conducted for three coastal areas in Grenada
Adaptation to Climate Change in the Caribbean (ACCC)	2001 - 2004	Designed to sustain activities initiated under CPACC and to address issues of adaptation and capacity building not undertaken by CPACC, thus further building capacity for climate change adaptation in the Caribbean region.	World Bank, CARICOM	CIDA	CAD $3.5 M	Regional	• Supported adaptation planning to reduce adverse impacts of climate change, • Strengthened sustainable institutional capacities to address these issues • Provided additional knowledge of potential climate change and its impacts and tools for assessment of adaptation

Programme/ Project	Timeframe	Overall Objective	Implementing Agency(ies)	External Financing	Amount	Scale	National Activities and Outputs
							options to the private sector and government
Mainstreaming Adaptation to Climate Change in the Caribbean (MACC)	2003 - 2009	To mainstream climate change adaptation strategies into the sustainable development agendas of the small-island and low-lying states of CARICOM.	World Bank, CCCCC	GEF	USD $5 M	Regional	• Climate vulnerability risk assessment in the areas of water resources, tourism, health, agriculture and the coastal zone • Development of Stage II adaptation strategies and measures • Public Education and Outreach strategies
Review of the Economics of Climate Change in the Caribbean (RECC)	2010 - 2011	To assess the likely economic impacts of climate change on key sectors of Caribbean economies through applying robust simulation modelling analyses under various socio-economic scenarios and carbon emission trajectories.	CCCCC, ECLAC	DFID (UK)		Regional	• Economic impact assessment of climate change on Grenada's water sector
Intra-ACP GCCA (Global Climate Change Alliance)	2011 - 2015	To enhance local, national and regional capacities and resilience in ways that	CCCCC	EU		Regional	• Climate Change Vulnerability and Capacity Assessment (VCA) of the Chemin

Programme/ Project	Timeframe	Overall Objective	Implementing Agency(ies)	External Financing	Amount	Scale	National Activities and Outputs
Programme – Caribbean Component		link sustainable development, risk management, and adaptation for a win-win-win situation.					Watershed area • Development of a National Adaptation Strategy and Action Plan (NASAP) for the Water Resources sector in Grenada
Reduce Risks to Human & Natural Assets Resulting from Climate Change (RRACC) Project	2011 - 2016	Focus on adaptation measures in the areas of coastal/marine zone management and freshwater resources management across OECS Member Countries.	OECS	USAID	USD $15.2 M	Sub-Regional (OECS)	• Build an enabling environment for reducing vulnerability to climate change by improving the regulatory framework in support of national adaptation strategies. • Direct support at the country level for initiatives focusing on adaptation measures in areas of coastal zone management and freshwater resource management. • Public awareness and education programs to raise the level of awareness on climate change and steps being taken to address or reduce impacts across the

Programme/ Project	Timeframe	Overall Objective	Implementing Agency(ies)	External Financing	Amount	Scale	National Activities and Outputs
							region.
INDIRECT CLIMATE CHANGE FINANCING – NATIONAL AND REGIONAL							
Disaster Vulnerability Reduction Project (DVRP)	2011 - 2018 (Ongoing)	To measurably reduce vulnerability to natural hazards and climate change impacts in Grenada and SVG	GOG, GOSVG	World Bank	USD $53 M	Sub-Regional (Grenada and SVG)	Five components with various thematic sub-projects under each component: • Prevention and Adaptation Investments • Capacity Building and Data Development • Hazard Risk Management and Evaluation • Natural Disaster Response Investments • Payment of CCRIF Insurance Premium (first two years)
Sources: (Thomas, 2005; CCCCC, n.d.; IKI, 2015; The World Bank, 2017)							

Other initiatives of note, not centred on climate change but contributing nonetheless to national adaptation by supporting disaster risk reduction and management activities, as well as ecosystem-based adaptation include:

- Caribbean Disaster Management Project (CDMP), implemented by the Caribbean Disaster Emergency Management Agency (implemented by CDEMA between 1995-1999;
- Caribbean Risk Management Initiative (CRMI) completed by the United Nations Development Programme (UNDP; 2004-2009);
- Community Alerts Project: an effective implementation in the Caribbean through integrated Early Warning Systems (implemented by UNDP) (2013-2014);
- Preserving Nature: protecting Lives (being implemented by the Nature Conservancy and the Grenada Red Cross Society) – part of the At the Water's Edge (AWE) initiative (ongoing);
- Implementing a Ridge to Reef Approach to Protecting Biodiversity and Ecosystem Functions within and around Protected Area Systems in Grenada (funded by GEF and implemented by UNDP and the Government of Grenada) (2014-2019);
- Building Capacity for Coastal Ecosystem-based Adaptation in Small Island Developing States (SIDS): Grenada and other SIDS (ongoing, funded by the European Commission and implemented by UNEP and the Government of Grenada).

5.1.1 Methodological Approach

This chapter provides information that may be deemed relevant to the achievement of the objective of the Convention, forming Subcomponent 5 of the Grenada SNC and broadly includes information on:

- Steps taken to integrate climate change into relevant social economic and environmental policies;
- Activities related to Technology Transfer;
- Climate Change Research and Systematic Observations;
- Research to Adapt to and Mitigate Climate Change;
- Education, Training and Public Awareness;
- Capacity-building at the national, regional and sub-regional levels;
- Efforts to promote Information Sharing.

The chapter also incorporates, insofar as data and information were available, the recommended inputs outlined in the ***Template on cross-cutting themes in national communications from Parties not included in Annex I to the Convention***, (UNFCCC, 2007). Limitations were due to what data and information were available or provided by stakeholders at the time of compilation of this SNC report.

5.2 INTEGRATING CLIMATE CHANGE INTO NATIONAL POLICIES

5.2.1 Climate Change in National Development Planning

Grenada's ***Growth and Poverty Reduction Strategy (GPRS) 2014 – 2018*** is currently the country's medium-term (5-year) overarching development strategy document, prepared by Antoine et al., (2014) on behalf of the Government of Grenada, with key premises of "pro-poor growth" and the "new economy". The GPRS outlines four thematic areas of focus: (1) Building Resilience; (2) Developing Competitiveness with Equity; (3) Reducing Vulnerability and (4) Strengthening Governance and Security.

Climate change mitigation is articulated as a component of the first thematic area – Building Resilience – in recognition of the need to pursue a sustainable energy strategy. Adaptation is more specifically highlighted in the third thematic area – Reducing Vulnerability – in recognition of the devastating impacts that extreme weather and climate have on Grenada's economy and society, and the need to pursue programmatic activities that encompass climate change adaptation, mitigation and overall environmental sustainability and management (Antoine et al., 2014).

Recently, climate change has come to the fore, acknowledging implications of extreme climate events and of the potential for these events to increase in intensity and frequency over time.

The preceding Millennium Development Goals (MDGs) and Grenada's headway in meeting these goals as a measure of progressive, sustainable development are reflected within the GPRS 2014 – 2018. Notably the GPRS reflects on the results of Grenada's earlier Country Poverty Assessment (Kairi Consultants Ltd., 2008) which intimated that Grenada had achieved (at the time of the assessment) (a) Universal Primary Education and (b) virtually no maternal mortality. Strides were also made in respect of poverty alleviation, increasing child immunization, reducing child and infant mortality rates, increasing access to anti-retroviral drugs for HIV/AIDS and increasing telephone access (Antoine et al., 2014).

Some measure of concern is still expressed, however, especially in regards to weather and climate, which in extreme cases, can cause severe social and economic hardships particularly affecting the poor and otherwise disadvantaged (Antoine et al., 2014).

Under the ICCAS initiative, Grenada has produced a ***Draft National Climate Change Policy 2017-2021*** which is currently in the Final Draft stage, and is expected to be approved by Cabinet this year. Building on the previous version of the climate change policy, this updated/revised Policy will be a crucial instrument for guiding and monitoring the progress of Grenada's national climate change programme within the near term. The policy revision process is being conducted in parallel with the development of Grenada's National Climate Change Adaptation Plan (NAP) 2017-2021, which is also in its Final Draft stage.

Over the previous decade, climate change activities were guided by the ***National Climate Change Policy and Action Plan (NCCPAP) 2007 – 2011*** (Government of Grenada, 2007) which followed upon the findings and recommendations expressed in the Initial National Communication, work completed under the CPACC Pilot Project, and other subsequent technical assessments conducted in collaboration with stakeholders across the country.

The 2007 – 2011 Policy affirmed a vision of "an empowered Grenadian population capable of managing the risks from climate change, at the individual, community and national levels" and sought to set the stage for an "organised long term response to climate change" (Government of Grenada, 2007). Eight (8) strategies were outlined to achieve this Policy objective, as follows:

1. Climate-proofing present and future national development activities by requiring a climate risk analysis of all ongoing and new development initiatives;
2. Strengthening the collection, analysis and use of climate-related data and impacts;
3. Building local human capacity to assess and respond to climate change, including through the access and use of appropriate technologies;
4. Reducing greenhouse gas emissions through increased energy efficiency and the use of renewable energy;
5. Eliminating unsustainable livelihood and development practices that increase climate change vulnerabilities;
6. Sustained public awareness and education programming;
7. Foreign policy advocacy for international action on climate change;
8. Joint Implementation and networking with OECS and CARICOM partners and other SIDS.

Targeted actions included policy and programme mainstreaming, impact assessments, monitoring and response plans for critical sectors such as health, agriculture, water, housing, human settlements, coastal developments, national disaster management; reviewing and reshaping the energy and electricity sector to encourage renewable energy uptake, energy efficiency and security; and the establishment of a National Meteorological Service to support climate data collection and dissemination (Government of Grenada, 2007). There were moderate successes in implementation of these policies, but resource constraints compromised attempts at a sustained effort and thus affected full implementation (Felician and Joseph-Brown, 2014). Notwithstanding, the achievements and status of climate change programmes are highlighted within the revised policy.

Climate change programming in Grenada is generally co-ordinated by the Ministries responsible for Finance and the Environment. The former plays a role in economic and technical co-operation arrangements, and the latter in operations and implementation. The National Focal Point (NFP) role for the UNFCCC rests with the Ministry of Education, Human Resource Development and the Environment (MEHRDE). This Ministry, along with the Ministry of Agriculture, Lands, Forestry and Fisheries (MALFF), serve as the NFP for a number of the regional and international Multilateral Environmental Agreements (MEAs) to which Grenada is party, and a committee of NFPs was recently established to facilitate more information sharing and harmonisation of efforts required to meet the multiple MEA commitments.

The ***National Climate Change Committee (NCCC)*** is a body of personnel from government and non-government entities and it represents the inter-institution arrangement established to provide technical oversight and input to climate change-related activities in Grenada. The NCCC is chaired by the Ministry serving as the National Focal Point (NFP) for the UNFCCC and the Kyoto Protocol and has four working groups: 1) Mitigation, 2) Adaptation, 3) Finance and Sustainable Development, and 4) International Negotiations and Relations.

5.2.2 Priority Sectors and Policy Interventions for Vulnerability and Adaptation

Priority sectors for vulnerability and adaptation were first highlighted, at the regional level, by the outputs of the CPACC project, and at the national level by the Initial National Communication (INC) which identified the following sectors for further research and priority consideration for adaptation (Government of Grenada, 2000b):

1. Water resources;
2. Agriculture and Fisheries;
3. The Coastal zone (including human settlements and coastal infrastructure);
4. Tourism; and
5. Human Health.

These sectors were reiterated as priority sectors for vulnerability and adaptation in the National Climate Change Policy (Government of Grenada, 2007), where a range of research, policy, capacity building and planning responses to climate risks were recommended. These recommendations were then highlighted in eight Policy strategies which entailed: 1) climate-proofing existing and future national development activities and 2) eliminating unsustainable livelihood and development practices that increase climate change vulnerabilities.

Amongst the recommendations, the National Climate Change Policy called for promoting climate change adaptation and resilience through the development and enforcement of a Land Use Policy, and the revision and enforcement of coastal building setbacks, and the incorporation of climate sensitivity analyses in all new development projects (Government of Grenada, 2007).

To date, a number of policies now include climate change vulnerability and adaptation considerations in the priority areas:

1. National Water Policy;
2. Grenada Disaster Vulnerability Reduction Project and Resettlement Policy Framework;
3. Comprehensive Disaster Management Policy;
4. National Adaptation Strategy and Action Plan for the Water Sector;
5. Grenada Protected Area System Plan – Part 2;
6. Integrated Coastal Zone Management Policy;
7. The National Energy Policy which mainly focuses on mitigation and low carbon development.

The development of Grenada's National Climate Change Adaptation Plan (NAP) which is being led by Government in conjunction with GIZ under the ICCAS project represents one of the most recent efforts aimed at climate change vulnerability and adaptation integration into national planning.

If successful with the implementation of the programmes of action contained within the NAP, by 2021, the Government of Grenada hopes to attain the following goals:

1. The institutional set-up to support coordination, mainstreaming and implementation of climate change adaptation action has improved;
2. Climate Change Adaptation is reflected in the process of the National Sustainable Development Plan 2030 formulation and implementation;
3. Climate change is systematically considered in new government projects;
4. A climate-responsive water governance structure is established;
5. Management and conservation of protected areas and other key ecosystems areas are improved;
6. The institutional, professional and technical capacity for integrated coastal zone management is built;
7. Selected infrastructure is located, planned, designed and maintained to be resilient to climate change, including increasingly extreme weather events and land is managed sustainably;
8. External funding for comprehensive disaster risk management has increased and climate-sensitive disease surveillance and control is established;
9. Strengthening the collection, analysis and use of climate-related data;
10. An informed public that will demand and support public policies aimed at building national resilience to climate change;
11. Successful project applications ensure external climate finance support to Grenada's adaptation efforts;
12. Successfully access Grenada's public budget for financing NAP implementation.

The NAP calls for the revision of some existing policies to incorporate climate change, and lists potentially new entry points supported by the NCCC:

- The National Sustainable Development Plan (NSDP) 2030;
- Sectoral Corporate Plans (with a focus on priority sectors);
- The Public Sector Investment Programme (PSIP) approval process;
- Environmental Impact Assessments (EIAs).

Developed specifically for the Caribbean, the Caribbean Climate Online Risk and Adaptation Tool (CCORAL)[44] by the CCCCC aims to provide Caribbean users with a resource that adds a climate

[44] The **C**aribbean **C**limate **O**nline **R**isk and **A**daptation Too**l** (CCORAL) – A risk management tool by the CCCCC: http://ccoral.caribbeanclimate.bz/

lens to development projects and other activities for climate resilient decision-making (CCCCC, n.d.). Initially used to assess the National Budget on a preliminary basis with the assistance of GIZ in 2015, the Government of Grenada is now taking steps to obligate CCORAL-based assessments for all public sector investment projects, and to integrate its application in in planning and budgetary processes.

5.2.3 Priority Sectors and Policy Interventions for Mitigation

The priority areas or sectors for climate change mitigation are based on the planned and/or ongoing interventions intended to reduce greenhouse gas emissions and increase in sequestration capacity. These sectors include:

1. Energy
2. Transportation
3. Agriculture
4. Land Use and Forestry
5. Waste

These priority sectors are targeted based on their mention and relevance in recent national policy and strategy documents. These documents mainly include:

1. the National Climate Change Policy and Action Plan (2007);
2. the National Energy Policy (2011);
3. Grenada Protected Area Systems Plan (2012);
4. the Growth and Poverty Reduction Strategy (2014 – 2018); and more recently
5. the Nationally Determined Contributions (NDC) report.

The ***National Energy Policy – A Low Carbon Development Strategy for Grenada, Carriacou and Petite Martinique*** charts a course towards increasing efficiency in energy use and renewable energy uptake, as well as reductions in energy costs and greenhouse gas emissions (Government of Grenada, 2011d). Detailed in the policy is a 20-year vision which is accompanied by a 10-year action plan for implementing a series of projects that aim to cut emissions across the board by 20% by 2020. The policy also proposed that Grenada could be 100% green in meeting its domestic energy demand by 2030.

The policy development process included national consultations, including public and private sectors, professional organizations, non-governmental organizations (NGOs) and community-based organizations (CBOs), (Government of Grenada, 2011d). The policy incorporates and is built on eight (8) principles, which not only highlight how the country intends to pursue climate change mitigation objectives, but also underscore why energy is a priority for national development:

1. **Energy Security** – Ensure affordable and reliable supply of energy sources to sustain long-term socio-economic development;
2. **Energy Independence** – Achieve reduced national reliance on imported energy sources;

3. **Energy Efficiency** – Maximize the efficient use of energy resources;
4. **Energy Conservation** – Ensure significant energy conservation in the production and end-use of energy, in particular the consumption per capita;
5. **Environmental Sustainability** – Prioritize clean and sustainable energy technologies to transition to a lower carbon economy and reduce potential environmental or public health effects associated with energy production and consumption;
6. **Resource exploitation** – Avoid the irresponsible exploitation of energy resources beyond the regeneration capacity;
7. **Energy Prices** – Ensure rational and effective market conditions and energy services to lower energy prices for the consumer; and
8. **Energy Equity and Solidarity** – Ensure that all sectors of society have access to affordable and reliable energy services for current and future generations.

The policy notes several actions intended to reduce greenhouse gas emissions across the power generation, transport, agricultural, manufacturing, tourism, commercial, public and household sectors, and to create the necessary legal and institutional environment, as well as related policies and financial support (both domestic and externally-sourced), that will support these actions. A mere few of the wide gamut of actions outlined in the policy are presented below:

- Establish relevant government entities with the adequate mandates, authority and staffing to address objectives of the energy policy, starting with the establishment of a National Sustainable Energy Office;
- Formulate legislation and contracts governing the energy and related sectors, consistent with the needs and duties of a modern developmental energy sector;
- Prioritize the use of Grenada’s indigenous renewable energy sources to provide maximum economic performance and growth;
- Promote and facilitate the introduction of renewable energy technologies in the country’s energy matrix;
- Provide fiscal incentives (e.g. tax rebates, subsidies, feed-in tariffs, et al) based on objective cost-benefit analysis to all sectors of the economy and society (considering equitable access to such) to encourage increased use of renewable energy and energy efficiency technology and systems;
- Encourage and facilitate energy-conservation behavior by all consumers;
- Provide incentives for the introduction by electricity generators of renewable energy technologies and fuel sources that reduce dependency, increase energy conversion efficiency and lower greenhouse gas emissions (environmentally-sound);
- Create the appropriate tax regime to encourage importation of fuel efficient vehicles, the development of the supporting infrastructure and ethanol and other “green fuels” (e.g. biodiesel, including algal oil);
- Encourage and facilitate the use of energy audits in businesses and households.

The later development of the GPRS 2014 – 2018 reiterates and reinforces a number of the principles and actions first outlined within the National Energy Policy, in continued pursuit of low carbon development, and to further place sustainable energy development thinking within the framework of national climate resilience. It is explicitly captured within the GPRS as follows (Table 64Table 64):

Table 64-GPRS (2014-2018) Principles and Actions outlined in the National Energy Policy

THEMATIC FOCUS	Thematic Focus I: Building Resilience
PRIORITY AREA	Priority Area 4: Developing Sustainable Energy
STRATEGIC OBJECTIVE	Strategic Objective 4.2: Up-scaling Investment in Development of Clean and Renewable Sources of Energy
PROPOSED ACTIONS	There is an urgent need to “up-scale” investment in the development of clean and renewable sources of energy, such as wind, hydro and solar power through: i. Encouraging the development of alternative sources of energy for domestic and industrial use; ii. Providing direct incentives to energy service providers who produce direct heating, cooling, or mechanical services such as solar water heating and other mechanisms which reduce demand for electricity from the grid; iii. Considering the use of tax rebates and other fiscal incentives for technology used in the stabilization of the grid; iv. Evaluating the use of geothermal and PV energy; v. Prioritising steps towards third party financing of energy efficiency services and products for the public, commercial and, to a lesser extent, the domestic sector; vi. Launching the Pay-as-You-Save (PAYS) and Lease Financing Initiatives to support financing of energy efficiency activities; vii. Mainstreaming the sustainable energy economy into climate change adaptation strategies so that the focus of the sustainable energy strategy becomes *resilience-building*.

Grenada’s most recent instrument detailing climate change mitigation activities is contained in its Nationally Determined Contribution (NDC) report to the UNFCCC that represents Grenada’s commitment to the international mitigation effort under the recently enforced Paris Agreement. Grenada’s NDC highlights the country’s commitment to reducing greenhouse gas emissions by 30% of 2010 levels by 2025, with an indicative reduction of 40% of 2010 by 2030, and these reductions are anticipated to be achieved in the electricity, transport and waste sectors. Expansion of sequestration capacity is intended mainly through an increase in the total area of protected land and the replacement of invasive bamboo with indigenous species that mature quickly and are ecologically appropriate for the planting areas (Government of Grenada, 2015d).

5.3 ACTIVITIES RELATED TO TECHNOLOGY TRANSFER

5.3.1 Background

Technology transfer, in the context of climate change, may be defined as "a broad set of processes covering the flows of know-how, experience and equipment for mitigating and adapting to climate change amongst different stakeholders such as governments, private sector entities, financial institutions, NGOs and research/education institutions" (IPCC, 2000).

- Mitigation-driven technologies aim to minimise emissions and improve efficiencies in greenhouse gas sectors, including energy efficiency, renewable energy development and deployment, clean energy activities for the transport sector, and applications in agriculture and land management to reduce emissions.
- Adaptation technologies are more wide-ranging and are geared to address challenges in one or several sectors. Thus, they can vary dramatically in size, scale and cost (IPCC, 2000).

Governments and other facilitators need to mainstream and create the necessary enabling environments that promote technology investment and trade that would allow for the easy flow of technologies into and/or out of the country. Strengthening legal, institutional, technical and other capacities may also be necessary to facilitate technology transfer (IPCC, 2000).

5.3.2 Technology Transfer in the UNFCCC Process

Technology development and transfer for climate change adaptation and mitigation were featured within the UNFCCC process in 2001 with the establishment of a Technology Transfer Framework and an Expert Group on Technology Transfer (EGTT). The Framework was superseded in 2010 with the establishment of a **Technology Mechanism** by the Cancun Agreements (COP16) in Mexico.

TheTechnology Mechanism has two components to carry out its mandate, both of which are guided by the Conference of the Parties: (UNFCCC, 2015).

The **Technology Executive Committee (TEC)**, or the Policy arm of the Mechanism, serves to facilitate technology development and transfer by identifying and promoting policy arrangements that support the preparation of Technology Needs Assessments (TNAs) and Technology Action Plans (TAPs).

The **Climate Technology Centre and Network (CTCN)**, represents the Implementation arm of the Mechanism, and facilitates technology development and transfer by providing technical assistance to developing countries; creating access to information and knowledge on climate technologies and fostering collaboration among climate technology stakeholders via its network of regional and sectoral experts" (UNFCCC, n.d.).

In support of the Technology Mechanism work programme, a **Poznan Strategic Programme on Technology Transfer** was elaborated by the Global Environment Facility (GEF) in an effort to increase investment in technology development and transfer. The Programme focused on encouraging countries to undertake technology needs assessments (TNAs), developing technology pilot projects, and implementing climate projects (UNFCCC, 2016). GEF has further identified the following support areas over the long term implementation of the programme, namely:

- Support for Climate Technology Centres and a Climate Technology Network;
- Piloting Priority Technology Projects to Foster Innovation and Investments;
- Private Public Partnership for Technology Transfer;
- Technology Needs Assessment; and
- GEF acting as a Catalytic Supporting Institution for Technology Transfer (GEF, 2016)

5.3.3 Technology Development and Transfer in Grenada

Mitigation Technologies

Technology transfer and uptake related to climate change mitigation has been steadily increasing in Grenada, specifically in relation to renewable energy technologies (RETs) and energy efficient technologies (EETs). Some of these policies and programmes are namely:

- Caribbean Sustainable Energy Programme;
- Caribbean Renewable Energy Development Programme;
- CARICOM Sustainable Energy Roadmap and Strategy;
- Caribbean Clean Energy Programme;
- Sustainable Energy for All;
- The National Energy Policy; and
- The National Climate Change Policy.

Solar, and to a lesser extent wind technology systems are the predominant RET technologies installed across Grenada currently. Over time, with the introduction of service providers to the market and the gradual reduction of technology costs, matched against high public electricity costs[45], there has been an increase in consumer uptake of RET technologies.

Solar Photovoltaic (PV) Systems: Solar PV uptake in Grenada is mainly concentrated at the household level, with small rooftop-mounted systems being installed by home-owners. There are now a few technology product and service providers operating in the market, (e.g. GrenSol) which make it possible for homeowners, businesses and other private entities to invest in solar technology (see Figure 91). At a larger scale, Grenada's electricity utility (GRENLEC) has also undertaken solar PV system installations (32kW system on Petite Martinique installed in 2013, to be increased to 100kW) to contribute to grid supply (Jica and Yonden, 2015).

[45] Electricity tariff averaged about US $0.34 per kilowatt-hour in 2015, one of the highest in the region.

Figure 91-Photos of Installed Solar PV Systems in Grenada. Source: (GrenSol, n.d.)

Thermal Solar Applications: Solar water heating was the first solar technology to take off in the Caribbean. Grenada's Renewable Readiness Assessment Report (IRENA, 2012) indicated that the number of solar systems imported to Grenada increased by 400% between 2000 and 2008; in 2008, 4,000 systems were installed (IRENA, 2012).

Wind Power Generation Systems: Grenada experiences the necessary wind conditions to support aero-powered activities, particularly along the eastern corridor of the island. However, challenges arise from site suitability (rugged terrain, especially in mainland Grenada), land ownership issues, high initial technology costs and limited potential to benefit from economies-of-scale as a result of fewer installations (IRENA, 2012). Other public concerns of noise pollution and aesthetic interference have also been raised (IRENA, 2012). Notwithstanding these challenges, a number of small scale systems have been installed on a private or public demonstrative basis (IRENA, 2012; Jica and Yonden, 2015).

Energy Efficient Technologies: The uptake of energy efficient technology has been promoted in the public, private and household sectors. Within the public sector, Government buildings (ministry buildings, hospitals) have been outfitted with LED lighting and A/C inverters. GRENLEC has also spearheaded a solar street light replacement project to install LED fixtures on 4,000 posts across the country with the support of the Government of Turkey, as well as the introduction of 'smart meters' across its customer base (Jica and Yonden, 2015; Government of Grenada, 2015a).

Three sectors: *energy, waste* and *transport* were selected as priority sectors for mitigation technology interventions, based on local expert judgement and the contribution of these sectors to the national emissions profile.

Adaptation Technologies

Adaptation technology development is not common in Grenada, and thus technology import and uptake are more dominant. A number of adaptation technologies that aim to highlight the types of technologies acquired and used across some of the priority sectors are provided below as examples, although the list is not exhaustive.

The *water resources sector* was selected as the priority focus for adaptation, in light of projections for highly variable or decreasing rainfall, with consequent implications for freshwater availability. Agriculture, tourism and domestic water supply were selected as priority sub-sectors, because of the high dependence of these sub-sectors on freshwater availability.

Examples of technologies that have been employed in the agriculture sector include greenhouses (to optimise crop cultivation and protection), drip irrigation (now widely used by farmers), micro-sprinklers, and micro-dams (to address rainfall variability, freshwater shortages and to employ general best-practices for water conservation in agriculture) (Environmental Solutions Ltd., 2015); (NAWASA, 2015).

Other farming technologies, however, geared specifically towards improving yield and efficiency in field activities, are noted to have increased significantly between 1995 and 2012. Specific mention was made of use of seed planters (which increased by 850%), brush cutters (by 770%), chain saws (by 556%), motor vehicles (by 166%), plucking machines (by 190%) and mist blowers (by 90%) (James, 2015).

Rainwater harvesting technology has been historically featured on the Grenada landscape, mainly on Carriacou which depends greatly on man-made rainwater catchments to meet local demand, given limited ground and surface water resources. Subsequent projects have supported the acquisition and installation of rainwater harvesting systems which are now in use across multiple sectors on all three islands.

To augment coastal defence and protection against the impacts of sea level rise, storm surge and coastal erosion, both hard and soft engineering measures have been implemented. In Petite Martinique, a seawall was constructed with support provided by the RRACC project (funded by USAID). Additionally, Grenada is in the process of implementing activities under the Building Capacity for Coastal Ecosystem-Based Adaptation in Small Islands Developing States: marine protected areas, coral restoration, dune stabilisation and mangrove restoration to be implemented at sites in Grenada (Grand Anse) and Carriacou (Windward, Lauriston)

The ongoing Disaster Vulnerability Reduction Project (DVRP) funded by the Wold Bank has made significant contributions by way of infrastructure development and protection (bridge and road repairs / fortification) and land stabilisation (rock face shaping and stabilisation, installation of retaining walls, river bank enforcement) at a number of sites across Grenada. The project has also contributed to the repair and rehabilitation of two schools which will be used as hurricane shelters (The World Bank, 2017).

A number of previous and ongoing projects (RRACC, EU-GCCA, GEF Ridge-to-Reef, and DVRP) have played major roles in the procurement of hydro-meteorological monitoring equipment to allow personnel in the agriculture, land use and meteorological services sectors to monitor rainfall and other variables.

5.3.4 Technology Needs and Needs Assessment

Grenada recently completed activities under the second phase of the Technology Needs Assessment (TNA) project, being implemented globally by the partnership between the United Nations Environment Programme and the Technical University of Denmark (the UNEP DTU Partnership).

Technologies Prioritised for Further Assessment

Of the original list of options proposed, the adaptation and mitigation technologies selected for (further) assessment and implementation across Grenada are outlined in the following Table 65:

Table 65-Technologies Prioritised for Further Assessment by the Ongoing Technology Needs Assessment

	TECHNOLOGY	SECTORS	RATIONALE FOR INITIAL SELECTION
Adaptation Technologies	Micro Sprinkler Technology	Water (Agriculture)	The increased uptake of micro-sprinkler technology could result in more efficient use of agricultural water and support adaptation efforts by reducing water demand.
	Drip Irrigation Technology	Water (Agriculture)	The increased uptake of drip irrigation technology could result in more efficient use of agricultural water and support adaptation efforts by reducing water demand.
	Micro Dam Technology	Water (Agriculture)	Again within the context of variable rainfall, micro-dams can be greater employed to store water for farmers during prolonged dry periods and serve as retention ponds during intense rainfall.
	Reverse Osmosis Desalination	Water (Domestic water)	This technology will not be impacted by changes in rainfall pattern. It is the only option to increase potable water supply apart from surface and ground water, which are vulnerable to rainfall changes and sea level rise.
	Waste Water Recovery And Reuse Technology	Water (Tourism)	Small Foot Print (SFP) type systems such as Membrane Bioreactors (MBRs) and Biologically Engineered Single Sludge Treatment (BESST) Systems are recommended for SIDS such as Grenada where space may be a limitation, and are suitable for tourism sector use.
Mitigation Technologies	Solar Photovoltaic Arrays For Rooftops	Energy	The viability of solar PV arrays for roof tops makes it an attractive option. Solar incidence and irradiation levels make it a good candidate for renewable energy generation locally.
	Energy Efficient Technologies	Energy	Energy efficient technologies are relatively popular, easy to access and increased use can contribute greatly to reducing emissions.
	Solar Water Heater Pumps	Energy	Water heating, like solar PV systems, is another viable option for increasing uptake. Solar water heating is already in use across the country at private residences, hotels and other commercial buildings, but its use is still relatively small and can be expanded
	Anaerobic Digestion (Solid + Green Wastes)	Waste	Posited as a solution to both waste management and energy concerns locally, the process will assist in reducing waste quantities and can contribute to electricity production.
	Biomass Incineration	Waste	A biomass incineration has been recommended for providing an alternative source of energy. However, further research into this technology has also been recommended, in light of potential negative consequences.
	Biofuel Blend	Transport	To reduce emissions from the transport sector.

5.3.5 Enabling Environments and Mechanisms for Technology Transfer

The technology transfer process has been encouraged and facilitated locally by several key factors, including: calls for action by regional climate change programming, subsequent policy-driven interventions, legislative responses by government, the inputs to local projects and other initiatives by development partners and aid agencies, and increasing consumer demand for technology uptake. Notable contributors to ongoing and previous projects include:

DONORS	IMPLEMENTING PARTNERS/AGENCIES:
• GEF • The World Bank • IDB/CDB • The EU • UKAid • USAID • IKI • The Governments of Germany, Japan, Canada, Sweden, China, Cuba and Denmark	• GIZ • OAS • Agencies within the UN (UNDP; UNEP)

Other bilateral arrangements with the Governments of countries such as Turkey, Japan, China and Finland, and local and regional public-private partnerships have also supported the technology transfer process.

The Government of Grenada has also strived to incentivize technology uptake – moreso in respect of RETs and EETs – amongst local households and companies, through the provision of tax exemptions (e.g. some RETs are VAT- exempted), and is further considering the establishment of feed-in-tariffs and an ESCO facility (Duncan, 2015).

To date, Grenada has submitted one request proposal (in February 2017) to the CTCN via its National Designated Entity (currently the Ministry of Education, Human Resource Development and the Environment), entitled "Improvement of water supply management through GIS-based monitoring and control system for water loss reduction" (CTCN, 2017). Through this activity, Grenada aims to integrate climate smart water resource monitoring and management efforts as a means of adaptation and resource optimization. Specifically, Grenada has asked for assistance with the:

- Creation of a GIS data model;
- Development of schematic drawings of water supply networks;
- Establishment of a pilot District Metered Area (DMA); and the

- Development and implementation of a concept and program for electricity generation using in-conduit turbines within The National Water and Sewerage Authority (NAWASA) piped network system (CTCN, 2017).

Despite progress and achievements, access and diffusion have been hindered by factors related to trade and customs procedures within Grenada and the OECS and policy and legislative inconsistencies. These challenges have been recognized and flagged for attention in recent sectoral documents (IRENA, 2012; Antoine et al., 2014; Environmental Solutions Ltd., 2015; James, 2015; IDB, 2013 and Government of Grenada, 2015a; 2016).

To address some of these challenges, the Government of Grenada is spearheading reforms in specific areas, such as the new Electricity Supply Act (to encourage greater RET uptake and micro-independent power producer activity). Transport sector incentives and regulations are also being prioritised for assessment under the TNA, specifically looking at fuel tax, vehicle standards, public transport promotion and promotion of hybrid vehicles.

Given the recent surge in donor and development assistance activity in Grenada, there has also been a call for increased co-ordination and harmonization of donor efforts to avoid potential duplication and redundancy in assistance activities (James, 2015).

To further support technology transfer, recommendations geared towards building local capacity in technology design, development, assessment, installation, operation and maintenance have been put forward (IRENA, 2012, James, 2015; JICA and Yonden, 2015). Local institutions such as the T. A. Marryshow Community College and the Grenada Solar Energy Technology Research Institute have been earmarked for these capacity building initiatives, through the development and introduction of relevant curricular and other programmes that would help to create a pool of trained and competent local talent to fill current gaps.

5.4 CLIMATE CHANGE RESEARCH AND SYSTEMATIC OBSERVATION

5.4.1 Climate Change Research and Systematic Observation in the UNFCCC Process

The Subsidiary Body for Scientific and Technological Advice (SBSTA) is the main driving force for implementing and monitoring systematic observation activities under the UNFCCC. It works with other agencies for this purpose, including the World Meteorological Organisation (WMO), the Global Climate Observing System (GCOS), the Global Ocean Observing System (GOOS), the Global Terrestrial Observing System (GTOS), the Committee on Earth Observation Satellites (CEOS) and other global and regional climate observation, information and services organizations (UNFCCC, 2016).

The UNFCCC Guidelines for National Communications from non-Annex I Parties encourages Parties to provide information on climate change research and systematic observation, including their participation in and contribution to activities and programmes, such as the GCOS, GTOS and GOOS (UNFCCC, 2003; 2016). A new set of Essential Climate Variables (ECVs) were incorporated within the 2016 GCOS Implementation Plan (GCOS, 2016).

An Assessment of Grenada's Systematic Observation Capabilities in the Context Of Climate Change aimed at assessing the extent to which Grenada had the systematic observation capacity to support its efforts at responding to climate change and to fulfill its systematic observation obligations under the United Nations Framework Convention on Climate Change was completed (Charles and Associates, Inc., 2009).

5.4.2 The Global Climate Observing System (GCOS)

The Global Climate Observing System (GCOS) programme aims to establish a comprehensive, Global Observing System for Climate which represents the combination and integration of observing systems at national, regional and global scales to deliver quality climate data and products (GCOS, 2016).

GCOS typically undertakes a three-phase approach for ensuring continuity and improvement of systematic climate observation activities, particularly to meet the needs of the UNFCCC and IPCC, which is outlined below and as described in the 2016 Implementation Plan (GCOS, 2016) (See Table 66).

Table 66-List of GCOS Essential Climate Variables Published in the GCOS 2016 Implementation Plan

Measurement Domain	Essential Climate Variables (ECVs)	
Atmospheric	Surface	Air temperature, Wind speed and direction, Water vapour, Pressure, Precipitation, Surface radiation budget.

	Upper-air	Temperature, Wind speed and direction, Water vapour, Cloud properties, Earth radiation budget, Lightning*.
	Composition	Carbon Dioxide (CO_2), Methane (CH_4), Other long-lived greenhouse gases (GHGs), Ozone, Aerosol, Precursors for aerosol and ozone.
Oceanic	Physics	Temperature: Sea surface and Subsurface Salinity: Sea Surface and Subsurface Currents, Surface Currents, Sea Level, Sea State, Sea Ice, Ocean Surface Stress*, Ocean Surface Heat Flux*
	Biogeochemistry	Inorganic Carbon, Oxygen, Nutrients, Transient Tracers, Nitrous Oxide (N_2O) *, Ocean Colour
	Biology/ecosystems	Plankton, Marine habitat properties*
Terrestrial	Hydrology	River discharge, Groundwater, Lakes, Soil Moisture
	Cryosphere	Snow, Glaciers, Ice sheets and Ice shelves, Permafrost
	Biosphere	Albedo, Land cover, Fraction of absorbed photosynthetically active radiation, Leaf area index, Above-ground biomass, Soil carbon, Fire, Land Surface Temperature*
	Human use of natural resources	Water use, GHG fluxes*
		New ECVs are denoted by an (*) Adapted from the GCOS 2016 Implementation Plan (GCOS, 2016)

In order to support an improved understanding of energy, water and carbon budgets, as well as of the evolution of climate, GCOS provides rationales for the new ECVs as follows (GCOS, 2016):

- Quantifying Anthropogenic Greenhouse Gas Fluxes;
- Lightning;
- Biology;
- Land Surface Temperature (LST):
- Two Ocean properties (ocean surface stress, ocean surface heat flux).

5.4.3 National Systematic Observation Activities

Grenada has been undertaking corresponding activities for hydro meteorological observation for a number of decades.

Synoptic observation activities are still principally carried out by the Grenada Meteorological Service. The establishment of the entity at the Maurice Bishop International Airport was primarily to provide supporting services to the aviation industry according to prescribed international standards, but this had since evolved to encompass national weather forecasting and other climate services for public benefit (Grenada Meteorological Service, 2017).

The Meteorological Service currently owns and operates a number of Automated Weather Stations (AWS). Data generated by these stations is collected by Satellite telemetry and stored at the MBIA Meteorological Service base for analyses and archival. A number of key weather and climate variables are measured, including:

a) Air Temperatures (Maximum/Minimum, Average);
b) Relative Humidity (%);
c) Rainfall Amounts (mm- hourly, daily, monthly, annual totals along with rainfall intensities);
d) Continuous Wind Speed and Direction (knots and /km/h, degrees true);
e) Atmospheric Pressure (hPa);
f) Visibility (Metres and km);
g) Cloud amounts and type;
h) Weather occurrences;
i) Sunshine duration (hrs); and
j) Solar radiation (joules/m^2).

Recently however, the network of stations had been augmented by the addition of new instruments provided through a series of projects, namely the RRACC project funded by USAID, the EU-GCCA project implemented by the CCCCC, the GEF Ridge-to-Reef initiative, and most recently by the DVRP funded by the World Bank.

Hydro-meteorological data is generally shared across these same departments, and also fed into repositories at the regional level hosted by CIMH. The recently established Hydro meteorological or Hydro Met Committee will serve to provide guidance and oversight on the improvement and implementation of hydro meteorological observation activities in Grenada for multi-sectoral purposes and benefits.

Some gaps in the operation of the existing hydro meteorological monitoring network in Grenada include geographic coverage and representation, systematic data collection and management. In order to address these issues, the establishment of an auto-monitoring network is proposed which will consist of 20 synoptic, climate and agro-climate stations across Grenada and its dependencies (see Table 67). On Grenada, the network would include three synoptic stations representing the south, central, and northern regions of the island, four climate stations, and six agro-climate stations (see Figure 92). The auto network station density on the dependencies (Carriacou and Petite Martinique; see Figure 93) will be lower owing to their smaller sizes, lower elevations, limited surface drainage and rainfall patterns. A manual rain network will also complement the auto-network, with approximately 45 stations, many of which include existing and long-standing stations at NAWASA facilities (Boals, 2017-Unpublished).

Table 67-Proposed Network of Auto-Stations Across Tri-Island State

Island	Location of Station	Type	Elevation (m)	Latitude (N)	Longitude (W)
GRENADA	Point Salines	Synoptic	11	11° 59’ 58”	61° 46’ 50”
	Kubla Cable and Wireless	Synoptic	662	12° 09’ 54”	61° 39’ 42”

	Marli Cemetery	Synoptic	49	12° 13' 20"	61° 38' 24"
	Grand Etang National Park	Climate	538	12° 05' 46"	61° 41' 49"
	Mamma Cannes WTP	Climate	291	12° 04' 31"	61° 39' 06
	Mon Plaisir WTP	Climate	194	12° 07' 44"	61° 43' 53"
	St George's- Botanical Gardens	Climate	51	12° 02' 50"	61° 44' 35"
	CARDI AgroMet Station	Agro-Climate	28	12° 01' 35"	61° 43' 05"
	Mirabeau AgroMet Station	Agro-Climate	191	12° 07' 57"	61° 39' 06"
	Maran Propagation Station	Agro-Climate	76	12° 10' 55"	61° 43' 24"
	Peggy's Whim	Agro-Climate	249	12° 10' 15"	61° 38' 37"
	Levera Information Centre	Agro-Climate	14	12° 12' 48"	61° 36' 38"
	Laura Stock Farm	Agro-Climate	178	12° 02' 37"	61° 41' 46"
CARRIACOU & PETITE MARTINIQUE	Carriacou Airport	Synoptic	8	12° 28' 41"	61° 28' 18"
	Mount Pleasant (Harbour Light)	Climate	19	12° 29' 13"	61° 25' 37"
	Belair Royal Hospital	Climate	184	12° 29' 22"	61° 26' 43"
	Royal School near Harvey Vale	Climate	47	12° 27' 31"	61° 28' 37"
	Belair Agriculture Station	Agro-Climate	34	12° 29' 53''	61° 25' 56"
	Dumfries Agriculture Station	Agro-Climate	26	12° 27' 43"	61° 27' 21"
	Petite Martinique	Synoptic	50	12° 31' 27"	61° 23' 02"

WTP: Water Treatment Plant
Source: (Boals, 2017-Unpublished)

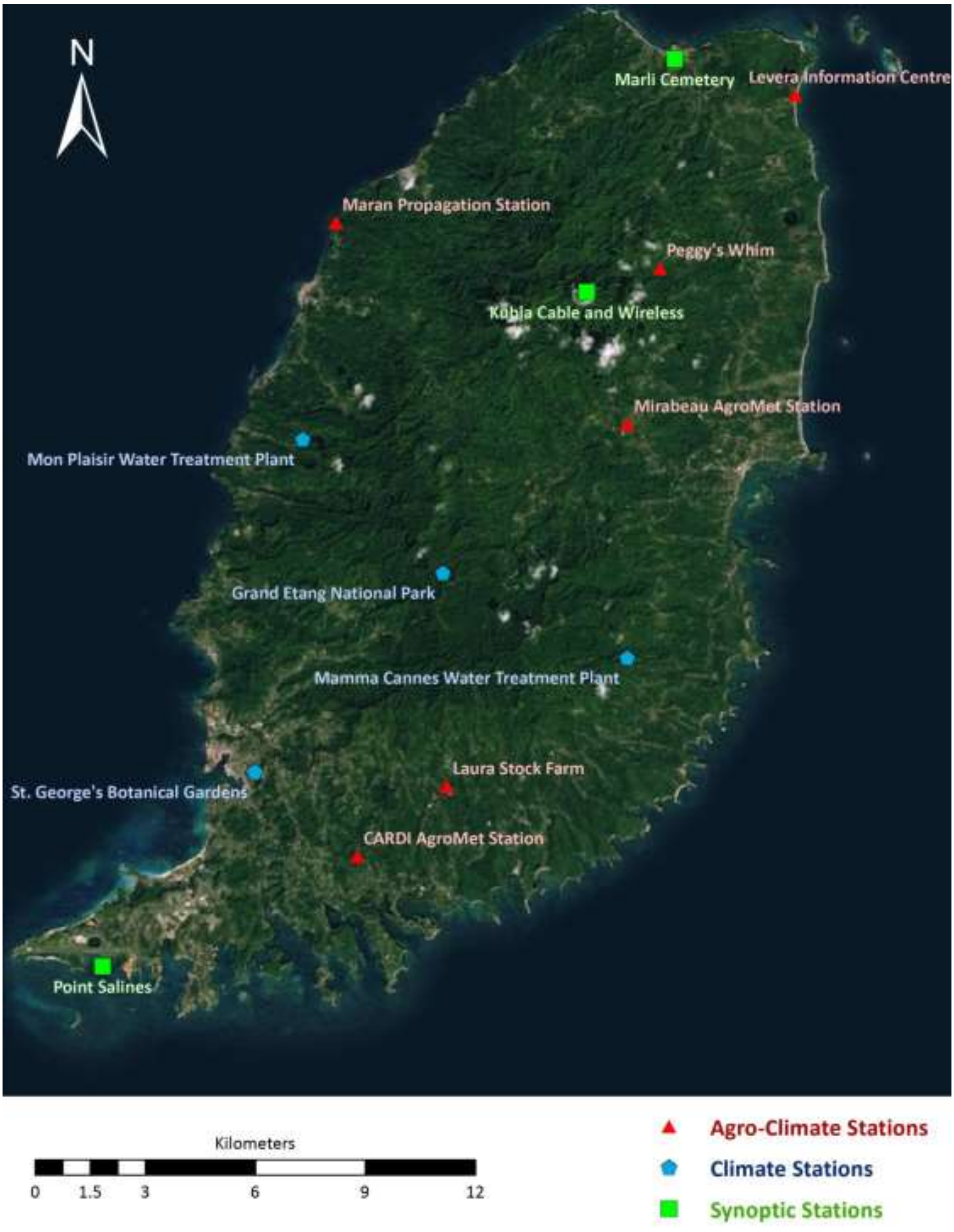


Figure 92-Proposed Hydro Met Auto-Network for Grenada

Figure 93-Proposed Hydro Met Auto Network for Carriacou and Petite Martinique

5.4.4 Participation in Regional and Global Research and Systematic Observation Activities

The World Meteorological Organization and the Caribbean Meteorological Organization

Grenada is a member of the Caribbean Meteorological Organization (CMO), which is a "Specialized Agency" within CARICOM, and based in Trinidad and Tobago. It was established by Governments of the English-Speaking Caribbean "to undertake the ***coordination of the joint scientific activities*** of the respective National Meteorological Services of its Member States, the ***establishment of joint technical facilities and systems***, the creation of ***joint training facilities***, and the promotion of a reliable ***severe weather warning system*** for the protection of life and property in the region" (CMO, 2016).

The 17th WMO Congress held in 2015 adopted a new Strategic Plan which outlined seven (7) priorities for implementation over the 2016 – 2019 period (CMO, 2015; CMO, 2016):

1. Further enhancement of WMO's ***Disaster Risk Reduction*** (DRR) programmes and activities to improve the accuracy and effectiveness of impact-based forecasts and multi-hazard early warnings of high-impact hazards;

2. Implementation of the **Global Framework for Climate Services** (GFCS), particularly for countries that lack adequate climate services;
3. Strengthen the global observing systems through full and mandatory implementation of the **WMO Integrated Global Observing System** (WIGOS) and the ***WMO Information System*** (WIS);
4. Improve the ability of National Meteorological Services to provide sustainable high quality **Aviation Meteorological Services**;
5. Improve operational meteorological and hydrological monitoring, prediction and services in **Polar and high mountain regions** (“Third Pole”);
6. ***Capacity Development*** for developing and least developed countries aimed at the delivery of improved weather, water and climate predictions;
7. Improving the **Governance of WMO** based on a strategic review of WMO structures, operating arrangements and budgeting practices.

Global Framework for Climate Services

The Global Framework for Climate Services (GFCS) is being implemented by the WMO with the aim of developing and improving the quantity, quality and application of climate services in Grenada. The established priority areas for the GFCS include agriculture and food security, disaster risk reduction, energy, health and water (GFCS, 2017).

CMO Member States have benefitted from some of the GFCS capacity development projects being conducted under the GFCS Implementation Plan, including (CMO, 2015):

1. Establish frameworks for climate services at national level in developing countries;
2. Strengthening capacity for disaster risk reduction and early warnings;
3. Improving communications between the climate and agriculture and food security communities;
4. Strengthening regional systems for providing climate services;
5. Large-scale data recovery and digitization.

WMO Policy for the International Exchange of Climate Data and Products

A resolution for a WMO Policy for the International Exchange of Climate Data and Products to Support the Implementation of the Global Framework for Climate Services (GFCS) was adopted to catalyze global access to climate data and information to promote sustainable development and climate resilience (CMO, 2015). The implementation of the GFCS requires the following types of data and products, which can be provided by national and regional observation systems (CMO, 2015):

1. Historical climate time-series from the Regional Basic Climate Networks (RBCNs), the GCOS Upper-Air Network and GCOS Surface Network at a temporal and spatial resolution necessary to resolve climate statistics, including trends and extremes;
2. Essential climate variables for the ocean (full depth) (as defined by the GCOS Implementation Plan);
3. Climate relevant coastal interface data, in particular sea level, waves and storm surges;
4. Data on the composition of the atmosphere including aerosols;

5. Climate relevant satellite data and products;
6. Climate relevant cryospheric data, in particular snow cover, snow depth, glacial monitoring, permafrost and lake and river ice.

WMO Integrated Global Observing System – Pre-Operational Phase (2016-2019)

The WMO Integrated Global Observing System (WIGOS) aims to integrate a number of observing systems into a single framework. The development and implementation of a WMO Information System (WIS) is anticipated to lead to overall improved data provision and service delivery (CMO, 2016).

The Caribbean Institute of Meteorology and Hydrology

As the education, training and research arm of the CMO, the Caribbean Institute of Meteorology and Hydrology (CIMH) provides these services for the benefit of CMO countries, with a mission to "assist in improving and developing the Meteorological and Hydrological Services as well as providing the awareness of the benefits of meteorology and hydrology for the economic well-being of the CIMH member states" (CIMH, n.d.).

Caribbean Climate Outlook Forum

The Caribbean Climate Outlook Forum (CariCOF)[46] is intended to construct and disseminate credible seasonal climate forecasts based on the collective consultation and consensus of regional entities and experts (Caribbean RCC, 2017).

CariCOF is convened twice a year prior to the start of the Caribbean wet and dry seasons to produce forecasts for the coming season, with climatologists and meteorologists providing monthly updates between forums for the benefit of stakeholders across the region (Caribbean RCC, 2017).

The range of forecast products currently prepared by the forum includes:

- Seasonal rainfall outlook map (3-month lead);
- Seasonal minimum temperature outlook map (0-month lead);
- Seasonal minimum temperature outlook map (3-month lead);
- Seasonal maximum temperature outlook map (0-month lead);
- Seasonal maximum temperature outlook map (3-month lead);
- Seasonal mean temperature outlook map (0-month lead);
- Seasonal mean temperature outlook map (3-month lead);
- Drought Outlooks, that are accompanied by alert information based on exceedance forecasts of the Standardised Precipitation Index (SPI) (six- and twelve-month SPIs) (See Figure 94 and Figure 95);

[46] The Caribbean Climate Outlook Forum (CariCOF), hosted by CIMH: http://rcc.cimh.edu.bb/caricof/

- Extreme rainfall forecasts within the 0-month lead and a three month outlook period (See Figure 96) (Caribbean RCC, 2017).

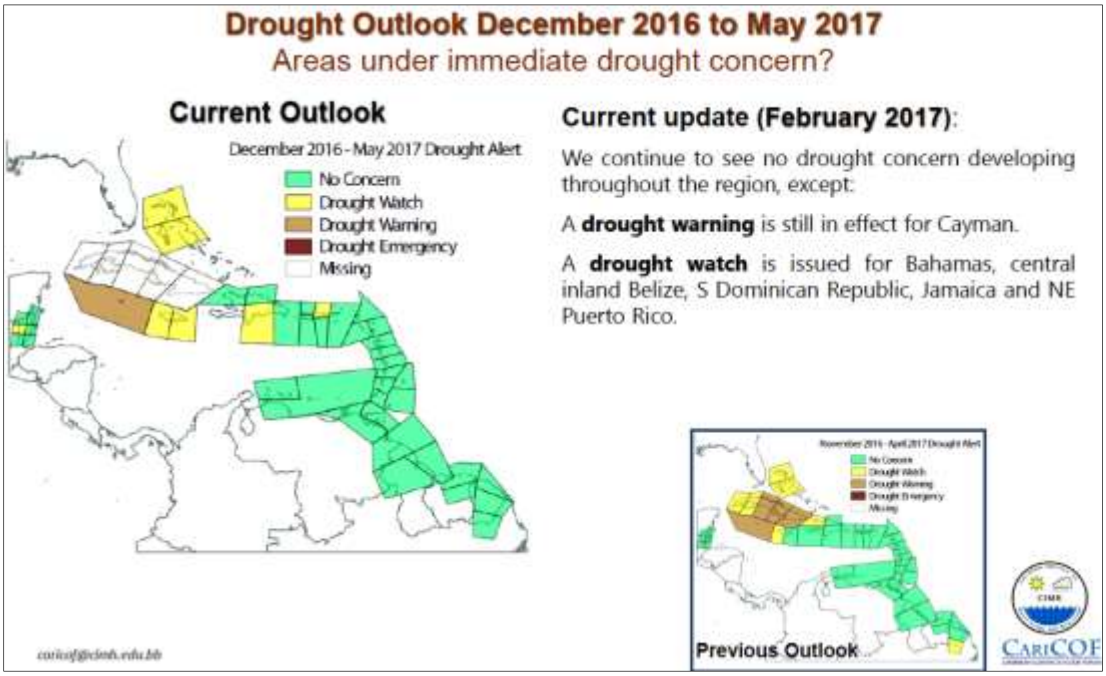


Figure 94-CariCOF Drought Outlook December 2016 to May 2017 (Source: (CIMH, 2017)

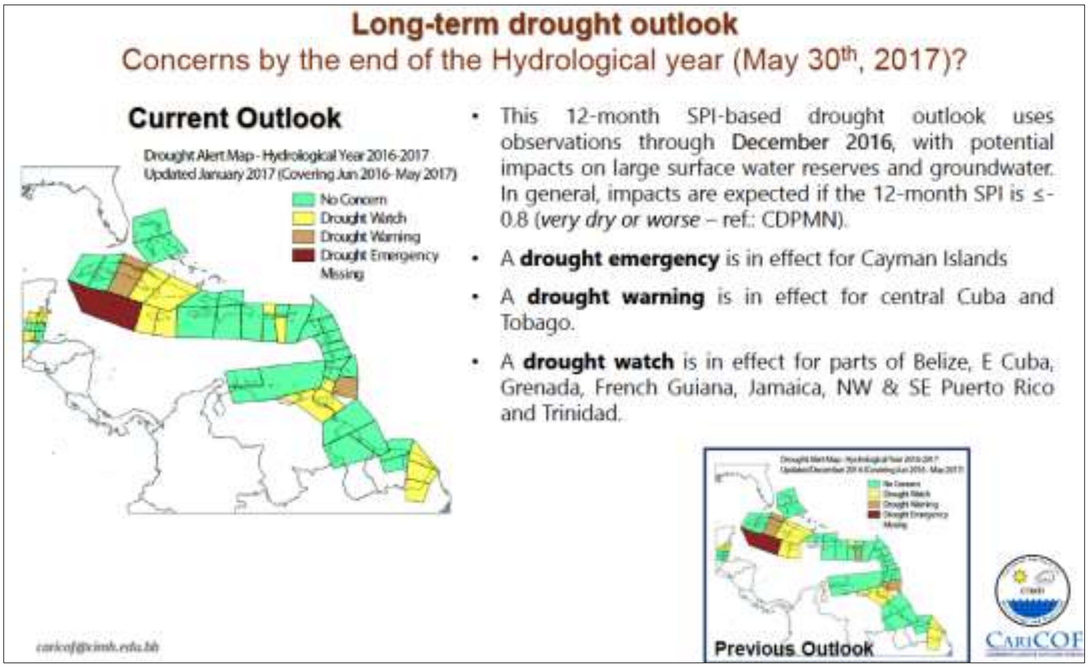


Figure 95-CariCOF Long Term Drought Outlook (June 2016 - May 2017) - Updated January 2017 (Source: (CIMH, 2017)

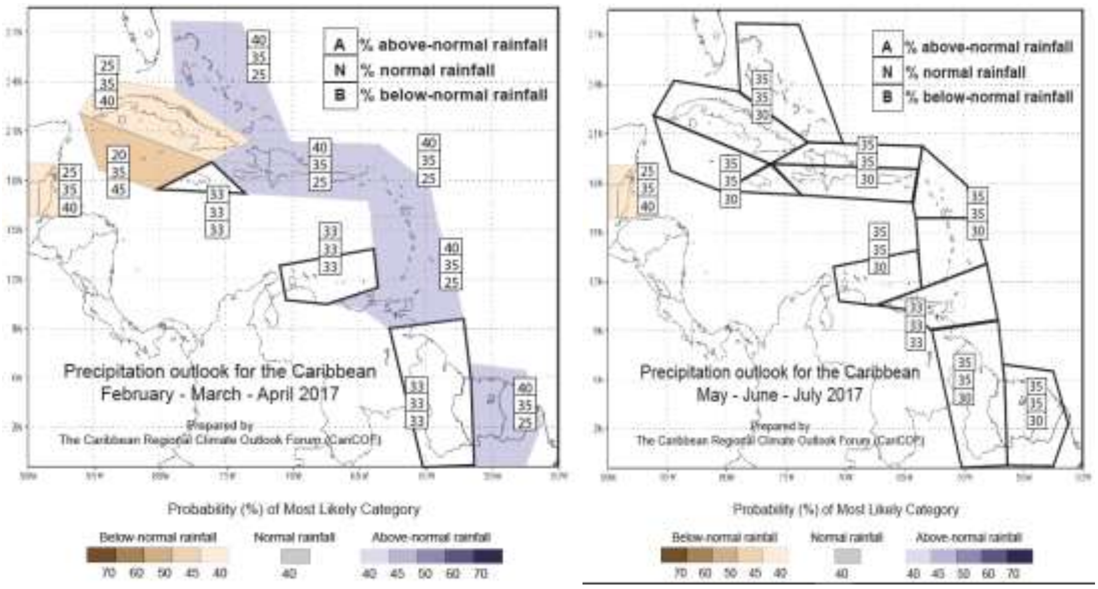


Figure 96-CariCOF Precipitation Outlooks for February - April 2017 and May - July 2017; Source: (CIMH, 2017)

Caribbean Drought and Precipitation Monitoring Network

The Caribbean Drought and Precipitation Monitoring Network (CDPMN)[47] was one of the decision support tools for Integrated Water Resources Management (IWRM), formulated under the Caribbean Water Initiative (CARIWIN) project.

Some of the indices and tools include the Standard Precipitation Index (SPI; see Figure 97), Deciles, the Crop Moisture Index (CMI), Normalized Difference Vegetation Index (NDVI), and the Climate Predictability Tool. From these indices, precipitation outlooks are generated for short-term (between 1- and 6-month) periods (Caribbean RCC, 2017); (Blakeley and Trotman, 2012).

[47] The Caribbean Drought and Precipitation Monitoring Network (CDPMN), hosted by CIMH: http://rcc.cimh.edu.bb/climate-monitoring/caribbean-drought-precipitation-monitoring-network/

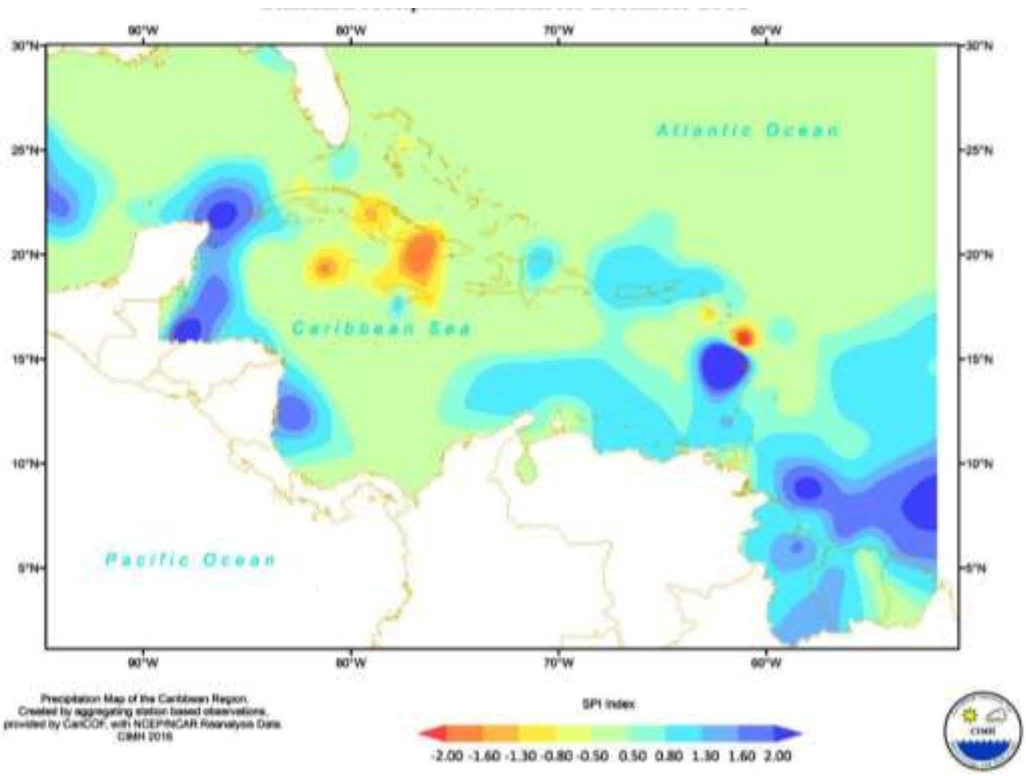


Figure 97-Standard Precipitation Index (SPI) for the Region for December 2016

Other Initiatives

CIMH is implementing other mentionable initiatives which are described briefly below, and largely stem from the ongoing **Programme for Building Regional Climate Capacity in the Caribbean (BRCCC)**, funded by USAID.

CIMH has partnered with the U.S. National Oceanic and Atmospheric Administration (NOAA) to develop a Caribbean Coral Reef Watch programme (Caribbean RCC, 2017).

In an effort to institutionalize and build capacity for developing and delivering climate services within several socio-economic sectors, CIMH is working with several regional entities (CARICOM specialist agencies) to implement **Sectoral Early Warning Information Systems Across Climate Timescales (EWISACTs)**. These sectoral EWISACTs aim to “co-design, co-develop and co-deliver sector-specific products, services and capacity building efforts” to close the gaps between providers and users of climate information and services (CIMH, 2016).

There are six (6) sectors of interest for EWISACTs in the region: Agriculture and Food Security, Disaster Risk Management, Energy, Health, Tourism and Water (CIMH, 2016). Based on these priority sectors, CIMH is working with regional sectoral agencies for the implementation of EWISACTs, namely:

- the Caribbean Agricultural Research and Development Institute (CARDI);

- the Caribbean Water and Wastewater Association (CWWA);
- the Caribbean Disaster Emergency Management Agency (CDEMA);
- the Caribbean Tourism Organisation (CTO);
- the Caribbean Hotel and Tourism Association (CHTA);
- the Caribbean Public Health Agency (CARPHA) and
- the Caribbean Centre for Renewable Energy and Energy Efficiency (CCREEE)

(CIMH, et al., 2016; van Meerbeeck, 2017).

5.4.5 Gaps, Needs and Priorities in Research and Systematic Observation Activities

The CIMH has highlighted that constraints on data collection and stewardship with national meteorological and hydrological services across the region have impeded its own efforts in conducting systematic observation activities and providing climate services (Blakeley and Trotman, 2012).

5.5 INFORMATION ON RESEARCH PROGRAMMES

5.5.1 Research Programmes for GHG Inventories and Mitigation

Research for climate change mitigation has largely been focused on scoping and assessments of renewable energy, alternative energy and energy efficient technologies. Examples of these include the Renewables Readiness Assessment (IRENA, 2012), research on energy efficiency potential in the transport sector (Emanuel and Gomes, 2014) and mitigation impact potential as captured by the supporting research that fed into the NDC (Government of Grenada, 2015d).

5.5.2 Research Programmes for Vulnerability and Adaptation

At the regional level, the series of climate change adaptation projects (CPACC, ACCC, MACC) implemented by CARICOM and CCCCC provided support for research programmes in vulnerability and adaptation undertaken across the region.

Climate related-research is generally spearheaded by the CCCCC and its partners (UWI Mona, UWI Cave Hill, Instituto de Meteorología de Cuba (INSMET), and other extra-regional partners) for climate change projections through the use of the PRECIS (Providing Regional Climates for Impact Studies) Regional Climate Model; and by CIMH for short-term/seasonal climate projections and climate variability studies (Farrell et a.,2010; Campbell et al., 2011; Taylor et al., 2012; Karmalkar et al., 2013; Jones et al., 2015).

Regional-level projects also included research on vulnerability, impact and adaptation in the water resources, coastal resources, agriculture, land resources, health and transport sectors of Grenada.

5.6 INFORMATION ON EDUCATION, TRAINING AND PUBLIC AWARENESS

5.6.1 Education, Training and Public Awareness in the UNFCCC Process

The role and importance of climate change education, training and public awareness in the UNFCCC process is not limited to only formal education and training, but broader public awareness building of climate change across a range of audiences, so as to enable society to be part of the solution to the climate change problem (UNFCCC, 2015) (See Box 1).

BOX 1: UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

ARTICLE 6 | EDUCATION, TRAINING AND PUBLIC AWARENESS

In carrying out their commitments under Article 4, paragraph 1(i), the Parties shall:

a) Promote and facilitate at the national and, as appropriate, subregional and regional levels, and in accordance with national laws and regulations, and within their respective capacities:
   i. The development and implementation of educational and public awareness programmes on climate change and its effects;
   ii. Public access to information on climate change and its effects;
   iii. Public participation in addressing climate change and its effects and developing adequate responses; and
   iv. Training of scientific, technical and managerial personnel.
b) Cooperate in and promote, at the international level, and, where appropriate, using existing bodies:
   i. The development and exchange of educational and public awareness material on climate change and its effects; and
   ii. The development and implementation of education and training programmes, including the strengthening of national institutions and the exchange or secondment of personnel to train experts in this field, in particular for developing countries.

Source: (UN, 2002)

5.6.2 Formal Education and Training in Climate and Climate Change Topics

Formal education in climate change plays a crucial part in increasing basic awareness amongst the population. Since 2000, the increasing attention paid to climate change has resulted in the evolution of curricula at most levels, especially secondary and tertiary, to introduce climate change issues.

At the Primary School level (average age range: 4 – 11), students may have been exposed to climate and climate change topics optionally. However, the under the ICCAS project, a Climate

Change Toolkit for Primary Schools entitled ***How to Become a Greenz Climate Champion***[48] was produced and launched in 2016, to facilitate the integration of climate change into primary school learning (See Figure 98). It utilises child-friendly language, illustrations and interactive learning sessions – geared to children between Grades 3 and 6). The development of the toolkit was an initiative of the Ministry of Agriculture, Lands, Forestry, Fisheries and the Environment, the Ministry of Education and GIZ (ICCAS, 2016).

Figure 98-The Greenz Climate Champion Logo

At the Secondary School level, greater exposure may be garnered by students who are undertaking specific subjects at the Caribbean Secondary Education Certificate® (CSEC®) level, Instruction in subjects for students pursuing the more advanced Caribbean Advanced Proficiency Examination® (CAPE) certificates and CXC® Associated Degree, also administered by CXC, is delivered by the T. A. Marryshow Community College (TAMCC) in Grenada, (TAMCC, 2011). TAMCC also confers Associate Degrees that include climate change (optional) (TAMCC, 2011).

Grenadian nationals who aspire to higher education opportunities for the study of climate and climate change can do so at a number of regional tertiary education institutions, most prominently, the University of the West Indies (UWI): undergraduate level degrees in Alternative Energy, Geography, Ecology, Environmental Science, Energy and Environmental Physics and Meteorology include courses that touch on or deal specifically with climate-related issues (UWI, 2017; CIMH, n.d.).

Masters and Doctoral-level studies in climate and climate change are specifically offered by:

[48] All of the materials for the toolkit for both teachers and students are available for download from the Government of Grenada's website: http://www.gov.gd/articles/greenz-champion/greenz-climate-champions.html

1. The Centre for Resource Management and Environmental Studies (CERMES), based at the UWI Cave Hill Campus in Barbados, which offers a Natural Resources and Environmental Management degree with a Climate Change specialisation;
2. The Physics Department at the UWI Mona Campus in Jamaica, which hosts the Climate Studies Group – Mona; and
3. The Geography Departments at the Mona and St. Augustine Campuses (the latter based in Trinidad and Tobago).
4. The University of Technology, based in Jamaica, has also recently launched a graduate programme in Sustainable Energy and Climate Change[49].

At CERMES specifically, also offers the foremost post-graduate programme in climate change in the Caribbean, (CERMES, pers. comm., 2017). These offerings are the most comprehensive for building capacity within the workforce in climate change and development in the Caribbean (See Table 68)

Table 68-Graduate Programmes with Climate Change-Related Courses or Topics

INSTITUTION	GRADUATE PROGRAMMES
UWI Cave Hill Campus	• Renewable Energy Technology • Natural resources and Environmental Management - Climate Change, Water Resources Management, Coastal Zone Management
UWI Mona Campus	• Disaster Management • Environmental Management • Marine & Terrestrial Ecosystems • Natural Resource Management – Disaster Risk Management; Tropical Ecosystems Assessment and Management; Water Resources Management • Renewable Energy Technology • Renewable Energy Management • Sustainable Development • Urban and Rural Environmental Management
UWI St. Augustine Campus	• Renewable Energy Technology • Occupational and Environmental Safety and Health • Biodiversity Conservation and Sustainable Development in the Caribbean • Tropical Earth and Environmental Science • Crop Science • Tropical Crop Protection • International Relations

[49] Press release for the launch of the Sustainable Energy and Climate Change programme: https://caribbeanclimateblog.com/2017/02/28/utech-launches-graduate-degree-in-sustainable-energy-and-climate-change/

	• Global Studies • Water and Wastewater Services Management • Environmental Engineering • Coastal Engineering and Management • Geoinformatics • Urban and Regional Planning
St. George's University	• Environmental and Occupational Health
Sourced from relevant faculty and Programme Handbooks, available online (UWI, 2017)	

5.6.3 Communicating Climate Change and Building Awareness

Activities Initiated at the Regional Level

Activities for communication and awareness-building in regards toclimate change have largely been project-centered, where regional climate change projects that were funded by international development partners included components of public education and outreach.

The series of early regional climate change adaptation projects implemented by the CCCCC incorporated public education and outreach activities, which can be credited with cementing climate change as an awareness priority across the Caribbean, including Grenada. These included:

- **Caribbean Planning for Adaptation to Climate Change Project (CPACC; 1997 - 2001):** This project hosted a number of national consultations in the participating countries across the region in aim of raising awareness of climate change (OAS and CPACC, 2002).
- **Adaptation to Climate Change in the Caribbean Project (ACCC; 2001 - 2004):** The ACCC project further prioritised public education and outreach (GCSI & deRomilly and deRomilly Ltd., 2005). Capacity building was also a key focus, targeted at regional institutions such as CIMH and CEHI, and the project incited the formal establishment of the Master's Programme in Climate Change, provided by CERMES (GCSI & deRomilly and deRomilly Ltd., 2005).
- **Mainstreaming and Adaptation to Climate Change (MACC; 2004 - 2007):** The subsequent MACC project sought to continue and build upon the achievements of the previous CPACC and ACCC projects. General and technical capacities continued to be built across the region in a number of sectors and disciplines. Specifically, there was a special effort to include stakeholders of mass media corporations across the region, in order to channel and expand the reach of the messages that the projects sought to deliver to the public (CCCCC, n.d.) (MACC, 2005).
- **The 1.5 to Stay Alive Campaign:** The 1.5 to Stay Alive Campaign was launched in 2009, to (a) build awareness of the regional populace of the Caribbean on sensitivity to climate change impacts and (b) to implore urgent action across the global community to stabilise greenhouse gas concentrations and to keep temperature increase below a 1.5°C threshold (CCCCC, n.d.).
- The **Reducing the Risks to Human and Natural Assets Resulting from Climate Change (RRACC)** project which was implemented by the Organisation of Eastern Caribbean States

(OECS), comprised of several such activities. Over the course of the project, a series capacity and awareness building forums were hosted across the OECS Member States targeting a range of audiences [50,51,52,53].

Other regional entities have also been instrumental in climate change education and awareness efforts. These include Panos Caribbean, the Eastern Caribbean Coalition for Environmental Awareness, the Caribbean Red Cross Society, the Caribbean Natural Resources Institute (CANARI), the Caribbean Disaster Emergency Management Agency (CDEMA), and regional and international development partners, including UNESCO.

National Level Activities and Public Participation

The formulation of the National Climate Change Policy and Action Plan (NCCPAP) 2007 – 2011 incorporated an extensive consultation process, which saw approximately 700 persons participating in a total of 16 stakeholder consultations and community-level fora (Government of Grenada, 2007).

There are a number of non-governmental and community based organizations that facilitate climate change education and awareness building in Grenada, including the Grenada chapter of the Caribbean Youth Environment Network, the Grenada Green Group (G3), and the ICCAS suite of community projects[54] approved under the Community Climate Change Adaptation Fund (CCCAF) (ICCAS, 2015).

The Integrated Climate Change Adaptation Strategies (ICCAS) initiative[55] represents a major climate change public education and awareness in Grenada. The project, being implemented by the Government of Grenada, UNDP and GIZ, has several ongoing capacity and awareness building activities:

[50] 2013: OECS Climate Change Exhibition Excites Anguillian Students: http://theanguillian.com/2013/10/oecs-climate-change-exhibition-excites-anguillian-students/

[51] 2014: *Nevis participates in OECS Secretariat consultation on awareness campaign for flood risks and mitigation*: http://www.nevispages.com/nevis-participates-in-oecs-secretariat-consultation-on-awareness-campaign-for-flood-risks-and-mitigation/

[52] 2015: OECS presents 'Climate Fest' from September 6-8 in Antigua-Barbuda: https://www.themontserratreporter.com/oecs-presents-climate-fest-from-september-6-8-in-antigua-barbuda/

[53] 2016: OECS Commission Facilitates A Workshop on National Drought Management Policies and National Drought Early Warning Information Systems (Saint Lucia): http://reliefweb.int/report/saint-lucia/oecs-commission-facilitates-workshop-national-drought-management-policies-and

[54] The list of ongoing and pipelined projects are available here: http://www.iccas.gd/?q=community-projects

[55] The ICCAS initiative in Grenada: http://www.iccas.gd/

- The project has an established and well known visual brand and logo, which incorporates Grenada-themed elements. The logo, in addition to documents and flyers, has been mounted on roadside signs and banners across Grenada in a state-wide effort to promote the project and to rouse national interest (see Figure 99).

Figure 99-ICCAS "Grenadapts" Project Logo

- The project supported training and capacity building in management and leadership skills, coastal zone planning, international environmental laws and international negotiations, climate change diplomacy and lionfish management. Additionally, a training needs assessment was conducted and training sessions were implemented for Coastal Zone Management.
- The project has published a series of briefs on Coastal Zone Management, Agriculture (Nutmeg), and water resources; as public information goods on the issues affecting these sectors, and how the project intends to address some of these issues.
- Establishment of a project website to facilitate information sharing as it relates to climate change and the environment.
- The project supported a campaign to raise awareness on the consequences of climate change, including the production and release of the music video for a local song entitled “Can’t Do This Alone“[56].
- An ICCAS Climate Change Walk was organised as a fun awareness-building activity, which drew approximately 1,300 persons to participate. Similarly, a Climate Change Football Cup challenge was also organised as a means of combining awareness with popular sport.

5.6.4 Public Access to Information

Public access to climate change information has increased dramatically over the last decade, made possible by the increased access to the internet, and also by the advent and rapid rise in

[56] The video is hosted on the GIZonlineTV channel on YouTube and can be streamed at: https://www.youtube.com/watch?v=G2ED5tIyQ_I

popularity of multiple social media platforms, which provide cheaper or cost-free channels for creating an online information presence

The CCCCC has established a Regional Clearinghouse[57] - an extensive and active repository with the aim of housing any and all relevant materials, whether with national, regional or international foci. It is intended to serve as a comprehensive first-stop for individuals or entities that need to access any regionally-relevant climate change documentation (CCCCC, 2016).

5.6.5 Institutional and Legal Frameworks

There is no specific institutional or legal framework, in their generic definitions, for climate change education, training and awareness in Grenada. This is not to suggest, however, that the issue was not held in high regard. The NCCPAP explicitly expressed climate change education, training and awareness as one of its eight priority strategies which encompassed four main actions for implementation:

a. Educational activities targeted at strengthening the knowledge base of decision makers;
b. Public awareness programming to generate a national awareness of climate change and its impacts and the role of the individual in responding to the impacts;
c. Implementation of practical demonstration projects at the community level that can be used to highlight the impacts of climate change and the potential of community led response activities;
d. Support the teaching of Climate Change at all levels of the education system.

5.6.6 Gaps, Needs and Priorities

The needs and priorities for education and awareness in Grenada are reflected in the ongoing development of the Grenada National Climate Change Adaptation Plan (NAP). The stated goal is to create “an informed public that will demand and support public policies aimed at building national resilience to climate change” by the year 2021. In pursuit of this goal, three objectives and a subset of priority actions have been detailed, as follows:

Objective 1: To strengthen the knowledge base of decision makers with regard to climate change and adaptation.

Objective 2: To support the teaching of Climate Change at all levels of the education system.

Objective 3: To further generate a national awareness of climate change and its impacts and the role of the individual in responding to the impacts.

[57] The CCCCC Regional Clearinghouse, available at http://clearinghouse.caribbeanclimate.bz

5.7 CAPACITY BUILDING

5.7.1 Capacity Building Activities Related to Climate Change in Grenada

Regional and National Initiatives

To effectively meet national needs and priorities in respect of climate change, heavy emphasis has been placed on capacity building within the public sector, which has the ultimate responsibility for seeing the integration and prioritization of climate change issues at the national level. This is exemplified by the elaboration of a National Climate Change Policy, the most recent medium-term development plan (the GPRS 2014-2018), and the forthcoming National Climate Change Adaptation Plan (NAP).

Opportunities were also extended to the private and non-government organisation sectors as important social partners with common goals in climate change adaptation and mitigation, (e.g. OAS Civil Society Forum). Some of the capacity building activities that have been supported over the years are listed below:

- training in conducting vulnerability, risk and capacity assessments of both natural and human systems, at the national, sectoral and community levels;
- training in environmental monitoring and management;
- training in spatial mapping, and the use of GIS and other interactive digital tools for conducting assessments;
- training in the application of risk management principles and approach to climate change adaptation;
- training in technical and data management aspects of meteorology, climatology and hydrology;
- the integration of climate change risk into the Environmental Impacts Assessment process;
- training in the development of emissions factors, GHG emission calculations and inventory development using UNFCCC software;
- capacity building for developing and implementing public education and outreach programmes related to climate change;
- capacity building for the integration of climate change in public policy and programming at the national level.
- A National Designated Authority for the Green Climate Fund (GCF) has been established and relevant stakeholders have been trained in climate finance.

Community-level Activities

Communities and grass-roots level organizations have benefitted over the years from the range of climate change projects (regional, national and community-level) that have been implemented in Grenada.

The Global Environment Facility Small Grants Programme (GEF SGP) has and continues to be a key agent for community-level capacity building in Grenada. GEF SGP has supported a number of community projects related to climate change, touching on broad themes such as organic farming and climate smart agriculture, renewable energy, livelihood diversification in tourism, agriculture and fisheries, and protection and enhancement of community environment assets and services. (GEF SGP, 2017).

Most recently, the ICCAS project in Grenada established a Community Climate Change Adaptation Fund (CCCAF). Launched in 2014, the CCCAF is providing communities with an opportunity to leverage another source of needed financial support, and specifically for community-based climate change adaptation efforts at the community level. Projects are eligible for up to USD $50,000.00 in funding (ICCAS, 2017).

Some of the ongoing and pipelined community projects included climate smart agriculture, soil conservation, water capture and conservation, community education and awareness, livelihood diversification, environment protection and alleviation of pollution threats that compromise environmental health (ICCAS, 2017).

The Inter-American Institute for Cooperation in Agriculture (IICA) has also been instrumental in implementing community- and grass-roots organisation-focused initiatives in agriculture, and building capacities in several areas, including climate change and sustainability concerns in agriculture and food security.

5.7.2 South-South Co-operation for Capacity Building

Grenada is one of 44 member and observer countries of AOSIS, which is characterised as "a coalition of small-island and low-lying coastal countries that share similar development challenges and concerns about the environment, especially their vulnerability to the adverse effects of global climate change" (AOSIS, 2015).

In a recent effort to promote the engagement of young or early career professionals in climate change issues, AOSIS established a Climate Change Fellowship Program[58] in 2014, which is open to suitably qualified residents of all AOSIS member countries. Persons participating in the programme undergo intensive training on issues during a one-year experiential stint at the UN offices in New York, with the final objective of empowering professionals to further contribute to the climate-resilient development agenda of their respective home countries.

Grenada's Prime Minister, the Rt. Hon. Dr. Keith Mitchell, along with the Presidents of Palau and Seychelles, currently serve as the Co-Leaders of the Global Island Partnership (GLISPA). GLISPA is recognized as a key facilitator amongst its SIDS members for promoting the implementation of

[58] More information on the Program can be found on http://aosis.org/apply-to-be-a-2017-climate-change-fellow/

the SDGs, the conservation of island biodiversity, particularly as represented within the Convention for Biological Diversity, and overall SIDS resilience ideals (SIDS Partnerships Steering Committee and UNDESA, 2016).

Grenada assumed the chairmanship - lasting two years - of the Small States Forum of the World Bank, a grouping of 49 small countries across the world. The Government of Grenada understands its role in this forum as an advocate for SIDS to strengthen international relations as to access official development assistance and securing resources to fight climate change.

Grenada is also a part of the SIDS Lighthouses Initiative: a collaboration between SIDS, IRENA and other partners, which aims to “advance renewable energy deployment in island settings” (SIDS Partnerships Steering Committee & UNDESA, 2016).

At the sub-regional level, Grenada is chairing the Council of Environmental Ministers Meeting of the OECS in 2017 until the end of 2018.

Between 2012 and 2013, Grenada was one of two Caribbean States amongst 10 countries worldwide to participate in the China and South-South Scoping Assessment for Adaptation, Learning and Development (CASSALD) exercise. Through CASSALD, the People’s Republic of China sought to assess and engage participating countries for potential South-South collaboration and exchange on experiences, goods and services related to adaptation in light of the commonalities shared between China and these countries (Simpson, et al., 2012).

Specifically, China would be providing support to these countries in respect of adaptation strategy development and implementation, and the introduction of adaptive science and technology to promote climate compatible development in Grenada. For Grenada, the priority sectors identified were water resources, coastal zone management, energy, infrastructure, land use and ecosystems, agriculture, tourism, health, as well as industries and livelihoods sectors (Simpson, et al., 2012).

5.8 INFORMATION AND NETWORKING

5.8.1 National Efforts at Information Sharing and Networking

Since its Initial National Communication Grenada has made various efforts to establish and advance information and networking systems.

Under the Caribbean Water Initiative (CARIWIN), a pioneering National Water Information System (NWIS) to act as a central repository for hydrological and other water management data was developed and implemented in Grenada. Amongst other outcomes, the IWCAM project and national review activities highlighted the deficiencies in water management data availability and access that hindered planning and decision-making efforts, and the resulting need for an improved data collection and management process (St-Jacques, et al., 2010).

5.8.2 Participation in Regional and International Information Sharing Networks

The efforts being led by CIMH and CCCCC, both of which are recognised Centres of Excellence within the Caribbean, facilitate broad information sharing and networking across CARICOM Member States.

Grenada is connected to the CDPMN and CariCOF initiatives spearheaded by CIMH, where the National Meteorological Service provides CIMH with meteorological data and in turn, CIMH provides Grenada and other CMO member states with a range of climate services and products for decision making purposes (e.g. via the CPDMN and CariCOF).

Further to this, CIMH is in the process of establishing a ***Caribbean Climate Impacts Database*** which is intended to act as a repository of impacts data from climate-sensitive sectors across the region, and to support climate-based damage and loss analyses, risk forecasting and risk reduction activities. This is being made possible through an international cooperation arrangement with the US Higher Education Development Programme and the International Research Institute for Climate and Society (IRI) programme at Columbia University (CMO, 2015).

The CCCCC is also custodian to other information sharing platforms, namely:

1. The ***Knowledge Navigator*** Tool[59] – specifically intended to connect users and groups to other climate change online platforms and networks beyond the region; and
2. The ***Caribbean Regional Environmental & Atmospheric Database Management System (C-READ)***[60] which is "an integrated data management platform developed for enhancing the

[59] Available at http://www.caribbeanclimate.bz/general/knowledge-navigator.html

[60] Accessible at http://c-read.net/

monitoring of environmental change in the wider Caribbean region" powered by CKAN[61] open-source data portal platform solutions. With a catalogue component as well as a GIS interface, information and datasets are being solicited from regional territories to support data sharing and analyses in the following key categories:

a. Hydrology and Meteorology
b. Risks and Hazards
c. Environment
d. Ocean
e. Land Cover and Land Use
f. Agriculture
g. Water
h. Energy
i. Socio-Economy
j. Emergency and Critical Infrastructure

[61] More information available from https://ckan.org/

CHAPTER 6.

CONSTRAINTS AND GAPS, AND OTHER FINANCIAL, TECHNICAL AND CAPACITY NEEDS

6.1 INTRODUCTION

This component of the Second National Communication (SNC) provides information on the constraints and gaps, the financial, technical and capacity needs of Grenada. Special consideration is given to those areas which have been reported in the INC. Activities which the Government of Grenada have implemented since the INC and other recommendations for overcoming some of these constraints and gaps are also presented.

Relevant literature (reports, papers etc.) were reviewed and drawn upon to complete this chapter. Key stakeholders were thereafter consulted to further add to, and validate the information included herein.

6.2 FINANCIAL, TECHNICAL AND CAPACITY NEEDS

The following sections specifically describe the constraints and gaps which posed challenges in the preparation of the Initial National Communication (INC), how these may have been addressed, and similarly the constraints and gaps highlighted for the preparation of this Second National Communication (SNC). Further, information is presented on the technical and capacity needs and gaps that have affected, and may continue to affect this and other national reporting processes, as well as the implementation of the national climate change programme.

6.2.1 Addressing Constraints and Gaps Identified in the Initial National Communication

Grenada's INC to the UNFCCC published in 2000 (Government of Grenada, 2000b), highlighted a series of gaps and areas for attention in respect of (a) continuous assessment and integration of climate change related issues and (b) the more efficient and cost-effective completion of future national reports and Convention obligations (National Communications reports). Some of the mentioned gaps and recommendations for improvement from the INC are outlined below:

Greenhouse Gas (GHG) Inventories Reporting

Gaps related to GHG Inventories that were mentioned in the INC included:

- Lack of data
- Data ambiguities
- Lack of relevance of much of the IPCC Guidelines to Grenada: many of the indicators were not relevant to Grenada, and the emission factors that were proposed were not developed in comparable circumstances.

To detail further:

- **Data centralization**: At the time of preparation, required GHG Inventory data was not centralized, but located in repositories of various state and non-state agencies. While the Energy

Unit maintained most of the energy-related data, some data categories were not collated or maintained by the Unit, and thus had to be sourced individually from other entities. Other issues were also raised in relation to data availability, characterization, and quality assurance/quality was:

- Data pertaining to the variation in the inventory of petroleum products were not readily available (little attention was given to compiling/preparing same by the Energy Unit).
- Charcoal production (lack of data/need for more credible estimates).
- Variation in the stock of fuels (data existed, but was not readily retrievable).
- Marine Bunkers (existing data needed disaggregating).
- Biomass (lack of fuel wood, sugar cane, and other primary fuel data).

- Without exact data to work with in some cases, estimates of emissions (and particularly carbon dioxide emissions) from some sectors were provided instead. These included the manufacturing and construction industries, as well as residential, institutional and commercial sectors.
- Emissions of other GHGs (e.g. non-methane volatile organic compounds or NMVOCs) were estimated or omitted because of irrelevance, limited levels of emitting activities.
- The INC also noted the exclusion of non-forest trees in their calculations of sequestration capacity, as growth rate data was not available to allow for accurate calculations.

Based on these gaps and issues, Grenada's INC mentioned its intentions to improve the quality of future GHG inventories through the following recommended actions:

- Initiating appropriate measures to ensure that the information gaps identified previously (petroleum products, charcoal production, etc.) are filled and updated, through the improvement of existing databases at the Customs and Excise Department, the Central Statistical Office and the Inland and Revenue Departments.
- Assessing the options for capturing annual production and consumption data on primary fuels (firewood, charcoal, coconut and nutmeg shells, sugar cane products, etc.). It was further recommended that the assessment could be conducted by the then- Energy Unit (now Energy Division), along with the Ministry of Finance (Central Statistics Department) and the Ministry of Agriculture. The assessment would include a survey to determine with greater accuracy, the levels of fuel wood and charcoal consumption, and the impact that this was having on Grenada's natural forest reserves.
- Collaborating with other countries in the Caribbean region in the development of emissions factors for activities that emit greenhouse gases, which will more accurately reflect the practices in the region. This would include a review of emissions factors for activities already reported in the INC inventory, as well as the development of updated emissions factors.

Since the INC, the Energy Unit has evolved into a Division, and has scaled up its data collection and collation efforts in light of the requirements for GHG emissions and sequestration reporting. In order to streamline data collection and management, the Division has initiated efforts to collaborate with other entities, and receives and processes relevant data on a regular basis from the following agencies:

- The Grenada Electricity Services Limited (GRENLEC);

- The Petroleum Marketing Companies;
- The Central Statistics Department, Ministry of Finance;
- The Customs and Excise Department, Ministry of Finance; and;
- The Planning/Economic Affairs Division, Ministry of Finance.

The collection of annual production and consumption data on primary fuels remains as a data gap for the GHG inventory compilation process. However, a number of the data gaps in the inventory compilation process are mainly a consequence of the existing challenges in technical and human resource capacity within the public sector generally. Until such capacity issues are fully resolved, challenges with data availability and quality will continue to surface in future inventory compilation exercises. Additionally, some gaps in data resulted from the passage of Hurricane Ivan and Tropical Storm Emily in 2004 and 2005 respectively, which caused the irretrievable loss of some emissions data required for inventory compilation.

Emission factors that are specific to the countries within the Caribbean region, and to the region at large, are still to be developed for use in emissions calculations. As such, many of the small island nations of the region have to resort to non-specific emission factors (international default, or from regions that may have some degree of comparability). However, filling this gap would be one of the objectives of the Regional Collaboration Centre of the UNFCCC for the Caribbean, based at the St. George's University.

Vulnerability and Adaptation Analyses

The INC indicated two major challenges in the V&A analysis for Grenada at the time, those being (1) the level of uncertainty of the climate scenarios and the socioeconomic dynamics that were used and (2) the incompleteness of the data sets necessary for rigorous analysis, through simulations of the natural processes, which therefore restricted the extent to which the results from initial analyses could be interpreted.

In respect of data and information, the INC identified existing gaps and made recommendations on how such information gaps can be addressed. These are presented in Table 69 adapted from the INC document. As a general rule, the INC urged for increased efforts to begin the robust collection of baseline data, to improve future analyses that would better guide national climate-resilient planning and development.

Table 69-Critical Data Gaps for Understanding Impact of Climate Change outlined in the INC, and the Status of Recommended Actions

SENSITIVE AREA	DATA REQUIRED	AVAILABILITY AT TIME OF INC	DATA LOCATION AND QUALITY	RECOMMENDED ACTIONS	STATUS OF ACTIONS
Ground water	Aquifer thickness (geology)	Very little	NAWASA	Development of comprehensive programme to investigate the ground water	NAWASA now has more detailed mapping of both surface and
	Aquifer boundaries **	Very little			
	Yields	Limited to a			

SENSITIVE AREA	DATA REQUIRED	AVAILABILITY AT TIME OF INC	DATA LOCATION AND QUALITY	RECOMMENDED ACTIONS	STATUS OF ACTIONS
		few sites		potential and to map out the ground water resource.	groundwater resources.
	Chemical composition	Limited to test sites			
Surface water	Stream flow	Available for Castaigne Bridge (1989-1990), Nianganfoix (1989-90); St. Marks (1989-1990); Marquis (1987-1988)♣	NAWASA/CMI Data records very short Some data missing from NAWASA	A project to collect stream flow data on a continuous basis must be established. Retrieve data from CMI to develop a total data set at a center responsible for Climate Change.	
	Temperature	Available for Pearls and Point Salines on a continuous basis	PSIA & Statistical Department The minimum period of 30 years is not available for any set of data	As the significant portion of agriculture is in the mountain regions, temperature and humidity data at these points should be collected.	Hydro-meteorological stations established in some regions to collect data on temperature, and an enhanced HydroMet Network has been proposed under DVRP.
	Precipitation	Available for many stations throughout the island	Much of the data is non-continuous Land Use Department	Research on hydrologic characteristics needed	The Land Use Division and NAWASA have scaled up their collaboration to ensure improvements to precipitation records from inland HydroMet stations under their responsibility.
	Catchment	All areas	Most data on		

SENSITIVE AREA	DATA REQUIRED	AVAILABILITY AT TIME OF INC	DATA LOCATION AND QUALITY	RECOMMENDED ACTIONS	STATUS OF ACTIONS
	areas and hydrologic characteristics	available	GIS NAWASA		
	Water demand, supply, shortage and quality	All data available	Good data		
Rainwater	Precipitation Evapo-transpiration				
Agriculture	Crop yield	Crop yield data not available for major crops	MOA, Statistical Dept. Commodity Boards	The Ministry of Agriculture should set up a monitoring project to collect a good data set on the yield for the major export crops	
	Annual crop production	Annual nutmeg, cocoa and banana production	The data is disjointed and is of moderate quality		
	Total annual acreage per crop	Not available			
	Damages by pests and diseases	Not available			
Coastal environment	Rates of beach erosion	Data available for 1984 onwards	National Science and Technology Council	The current beach monitoring project (UNESCO) should be continued and strengthened with capacity building	Grenada has re-established its beach monitoring programme under new terms of reference and stronger institutional backing as part of efforts to support the National ICZM Policy.

SENSITIVE AREA	DATA REQUIRED	AVAILABILITY AT TIME OF INC	DATA LOCATION AND QUALITY	RECOMMENDED ACTIONS	STATUS OF ACTIONS
	Storm surges and history				
	Tide properties	Tidal gages recently installed and data being collected	CPACC		
	State of mangrove and wetland areas	Some data is available	Land Use Department	Need to research previous work particularly from the colonial period	
	Health of corals				
	Geology, landforms, soil types				
Human Health	Records of communicable diseases	Good data for at least 25 years on most common diseases	Ministry of Health Good quality data	Need to create a digital form of the existing data. Need to research disease occurrence and various weather conditions	Current health data collection and reporting is paper-based at source, with later input into EpiInfo software (communicable diseases) and into Excel (non-communicable diseases). The lag does present some challenges for real-time data analysis. Some research has been conducted at the regional level to uncover climate-health correlations, but country-specific

SENSITIVE AREA	DATA REQUIRED	AVAILABILITY AT TIME OF INC	DATA LOCATION AND QUALITY	RECOMMENDED ACTIONS	STATUS OF ACTIONS
					analyses are limited by availability of requisite time series data.
	Vector breeding grounds		Public Health Department		
	Climate cycle	Available	MOH and Private Hospitals		
	Health Facilities	Available		Need to collect and document all the facilities available in the country	The Ministry of Health has maintained and updated this record as necessary.
Population	Current population Project population	Data available from previous census	Statistical Department Pre 1960 data suspect	The practice of regular census is sufficient	

At the time of the INC's publication, climate modelling in particular was a new and evolving science, and its practical applications were extremely limited for SIDS. As such, Grenada lacked specific climate change scenarios, which would have been the critical foundation for assessing future vulnerability.

These knowledge and policy gaps and translated into Grenada's inability to conduct the necessary, robust analyses required, especially at the sectoral level, in order to fully appreciate the extent of its exposure, sensitivity and adaptive capacity to climate change. Specific challenges that were raised in the INC included (Table 70):

Table 70-Challenges raised in the INC of Grenada

SECTOR	GAP

AGRICULTURE & FISHERIES	• Limited research/studies at the time on the potential impact of climate change on tropical crops, especially Grenada's cash/export crops (nutmeg, cocoa, bananas and spices). • Limited research/studies on the potential impact of climate change on the agricultural economy. • Limited knowledge of the extent to which carbon dioxide enhancement and natural plant adaptation would alleviate the negative effects on crop yields. • A lack of available studies on the relationships between fish production and climate in Grenada.
WATER RESOURCES	• Lack of understanding of the local interactions between climate, soil and vegetation and their impact on water resources availability. • Limited groundwater modelling for Carriacou. • Lack of mass diagrams of water consumption for Carriacou and Martinique.
HUMAN HEALTH	• The need for further research on correlations between health and climate and weather patterns in Grenada. • In particular, limited knowledge of the impact of environmental and climatic changes on vector-borne or respiratory diseases in Grenada.

Since the INC, several efforts have helped to amass and solidify regional and national technical capacities in conducting vulnerability and adaptation analyses, through a series of regional climate change initiatives (the CPACC, ACCC, MACC and SPACC), and subsequently through other regional, sub-regional (OECS) and national initiatives. Some specific achievements by these initiatives include:

- The establishment of the Caribbean Community Climate Change Centre (CCCCC), which co-ordinates regional climate change response; supports and implements activities geared towards regional adaptation and mitigation objectives, builds regional capacities through its projects, and guides CARICOM nation states on issues related to climate change and their participation in the international climate change dialogue.

- The advancement of climate modelling activities for Caribbean regional purposes, including: the downscaling of global model outputs for regional and national studies, preparation of climate scenarios for countries across the region, and the continued improvement of outputs based on modelling developments at the international level; by an established and growing cadre of regional climate scientists and modelling specialists.

- The establishment of dedicated, tertiary level studies in climate change, most prominently the Climate Change specialization of the Natural Resource and Environmental Management Master's degree, which is offered by the Centre for Resource Management and Environmental Studies (CERMES) at the University of the West Indies; and also the integration of climate change related courses and themes in other programmes and academic institutions. These developments have expanded awareness of and capacity for addressing climate change issues across the region.

- A series of vulnerability and capacity assessments conducted for different countries and priority socio-economic sectors since the INC, which continue to improve in methodology and results as data gaps are filled, more refined methodologies are applied and the necessary supporting capacities are built both within government and non-government sectors.
- The provision of some technical equipment and tools needed especially for data collection, collation and management; and training in the use of these.
- The establishment of a clearinghouse and repository (within the CCCCC) of climate change data, research, tools and information generated within or for the Caribbean region.

Even with the progress made, the region still has some way to go in terms of meeting its research and analysis intentions. Grenada is no different, as it faces continual challenges in these areas mainly due to limited domestic financial resources that are needed to support the technical activities, and to support personnel absorption and retention. These restrictions in turn affect activities such as the continuous and systematic collection and management of data, procurement and maintenance of equipment, and inter-agency co-ordination for environmental management issues (including climate change).

6.2.2 Constraints and Gaps Identified In the Second National Communication

This sub-section highlights those constraints and gaps identified in relation to the preparation of the Grenada's SNC. As such, it draws relevant points highlighted in the previous subcomponents of the SNC – particularly on Greenhouse Gas Inventories, Measures to Facilitate Adequate Adaptation to Climate Change and Measures to Mitigate Climate Change.

Greenhouse Gas (GHG) Inventories Reporting

Even with the improvements of data collection and availability for the preparation of national GHG inventories since the publication of the INC, some challenges remain. The limited availability and/or consistency of country-specific data (GHG – emission/sequestration activities and emissions factors; as well as non-GHG data such as annual population statistics) precluded the use of more detailed methodologies (Tiers 2 or 3) in preparing the GHG inventory for the SNC. This challenge with data also led to a heavy reliance on international statistical databases, time series extrapolation and proxy references – relying on data from other countries with similar relevant characteristics – to fill data gaps. This was the case for all of the GHG sectors assessed: Energy; Industrial Processes; Agriculture, Land Use and Forestry; and Waste. Specific sectoral concerns and the proposed recommendations for gap filling are reiterated below:

Energy

The activity data provided for energy consumption is currently not of high enough completeness to allow for estimates to be made based on country-specific data. Data gaps were filled using combinations of extrapolation, credible international datasets and expert judgement as appropriate.

The highest priority concern relates to the availability of data for fuel consumption, and many of the other concerns and recommendations for gap filling relate to this. Fuel consumption data across the time series is required to make accurate emission estimates across the energy sector, as opposed to using alternative data from UN statistics. The following is required:

- An annual official energy balance (this would allow estimates to be compiled using the Tier 1 reference approach).
- Fuel consumption by sector and type of fuel for the years being assessed. This has been provided for the year 2006 onwards, but is not fully complete for the SNC time series.

There is a need to further discern the international and domestic components accounted for within the aviation gasoline statistics currently collected and documented. It is recommended that a more accurate methodology, for estimating the amount of fuel used for domestic aviation relative to international, is undertaken in future inventory compilations.

Fuel consumed in maritime navigation was provided, but it is unclear how much of the fuel is used for domestic purposes and how much for international purposes. It is recommended that clarification is sought on the domestic / international split and that this information is incorporated into subsequent inventories.

Also necessary is more information on fuel consumption by plant (for each electricity plant and each industry) for the inventory years being assessed, and fuel analysis information showing average energy and carbon content of fuels.

In relation to emission factors, Tier 1 emission factors were used throughout the assessment. Detailed information on the characteristics of the energy industries – for example the technologies used, the age of the transport fleet and the use of catalytic converters would enable more accurate estimates to be made for the Energy sector.

Industrial Processes and Product Use

Data availability replays as a major issue in this sector, which required the use of proxy data, and thus filling these data gaps should be a priority for future emission estimates.

For the food and beverages industry, there is data to suggest Grenada is a significant producer of a variety of sugars, liquors, nutmeg, and cocoa, however no detailed production data is available. Nor is there sufficient export and import data to derive estimates of production.

In respect of the consumption of F-Gases, due to the lack of data on the imports/exports and content of hydrofluorocarbons (HFCs) in appliances, estimates have been derived by using proxy data. To improve the estimates of HFCs and SF_6 emissions, the amount used for recharging appliances and any quantities lost in disposal or destruction of gases would be beneficial and improve the estimates provided.

There may be emissions from the use of F-Gases in the electronics industry in cleaning and purging equipment. It is recommended that Grenada investigate possible sources and imports of perfluorocarbons (PFCs) for the electrical equipment industry.

Agriculture, Forestry and Other Land Use

Caution was raised with the uncertainty of emission estimates from this sector, largely because of the heavy dependence on international data and the lack of activity characterization in the data used. Similarly, the emission factors are based on international defaults (e.g. the Latin America Emissions Factor was used to estimate emissions from some agriculture activities) and include a variety of underlying assumptions.

The following recommendations in particular are considered to have a high priority for being addressed for future inventory activities:

- For livestock data, it is recommended that a livestock census is undertaken. This should ideally be at least every 5 years, and annual data would be estimated from this.
- Currently it is assumed that methane emission factors for manure management can be represented by an average Latin American emissions factor. This should be reviewed by local agriculture experts and amended as necessary.
- It is recommended (if relevant) that data regarding the use of synthetic fertilizers is obtained to determine the levels of nitrogen inputs to soils.
- It is recommended that land cover data is collected on a routine basis, so that this data can feed into the GHG inventory. This should consist of estimates of initial and final land use areas as well as the total area of land that is unchanged by category for each year of the inventory:
    - Forest land (unmanaged);
    - Forest land (managed) including the type of tree, and the age class if possible;
    - Grassland (rough grazing);
    - Grassland (improved);
    - Cropland;
    - Wetlands;
    - Settlements; and
    - Other land.
- It is recommended that forestland growing stock information is collected on a routine basis, so that this data can feed into the GHG inventory, reducing the need to use expert judgement.

Other issues flagged for attention where practical, mainly in respect of livestock, included:

- Currently it is assumed that manure management nitrous oxide emission factors can be represented by Latin American practices. This should be reviewed by local agriculture experts and amended as necessary.
- It is also assumed that nitrogen excretion rates for all animal categories are represented by Latin American livestock characteristics. If possible, country specific N excretion rates should be used for swine and cattle, to allow a Tier 2 method to be used.

Waste

Potential data gaps that have been flagged within the waste sector relate to biological treatment, whereas sources suggest that composting occurs in both residential and industrial contexts, although there is no formally available data. Similarly there is information to suggest incineration of clinical waste at two of Grenada's hospitals occurs, however no activity data is available.

High priority recommendations for addressing these and other data gaps include:

- Waste characterisation data is available for 2009 and the same split has been assumed for other years. It is recommended that this data is collected at least every 5 years.
- Waste generation rates have been obtained from various Grenada literature sources. It is recommended that this data is collected annually, so that any change over time can be reflected in the emission estimates.
- No data was made available on the wastewater treatment type used in Grenada for domestic and industrial/commercial wastewater. This information should be made readily available for future compilations.

Additionally, Tier 1 emission factors were used based on Caribbean regional values for emissions from landfills in the IPCC Waste Model. Also, a number of Tier 1 emission factors based on international data sets have been used in estimating emissions from wastewater. Studies to determine local/regional values would improve the accuracy of estimates. The following is a list of Tier 1 emission factors used in the wastewater, which could benefit from location specific data being used instead:

- Caribbean default values for landfill emissions;
- Wastewater generation from industrial processes; and
- Degradable organic component of residential and industrial/commercial wastewater.

Recommendations for filling gaps in activity data and improving accuracy of emissions estimates that has been started by the Energy Division. The recommendation of agencies and their potential roles is provided in Table 71 below.

Table 71-Agencies within Grenada and their potential responsibilities within a GHG Inventory system

Name of agency /stakeholder	Potential responsibility
Ministry of Finance and Energy	Providing an annual fuel balance and sectoral breakdown by sector
Ministry of Agriculture, Lands, Forestry and Fisheries	Undertaking an agricultural census every 5 years to ascertain the number of livestock and fertilizer use. In addition, a survey of land cover on a routine basis
The National Water and	Collection of data required for wastewater emission

Sewerage Authority (NAWASA)	calculations.
Grenada Solid Waste Management Authority (GSWMA)	Collection of data required for solid waste disposal and waste incineration (other than the sources identified in this report).
Princess Alice Hospital	Provision of waste incineration data to GSWMA
St George's Hospital	Provision of waste incineration data to GSWMA
Ministry of Finance and Energy	Collection of fuel use statistics in the energy sector.
Gravel, Concrete & Emulsion Production Corporation	Collection of cement clinker production data.
Grenada Chamber of Industry & Commerce	Collection of food production statistics (e.g. sugars, nutmeg).
Grenada Tourism Authority	Provide assistance to the Ministry of Finance and Energy on the allocation of fuel between domestic and international aviation.
Grenada Ports Authority	Provide assistance to the Ministry of Finance and Energy on the allocation of fuel between domestic and international navigation.

Measures to Facilitate Adequate Adaptation to Climate Change

The preparation of the subcomponent on Measures to Facilitate Adequate Adaptation to Climate Change also encountered similar data challenges which did not permit more quantitative methodologies, especially for priority sectors such as agriculture, water resources and health.

For the health sector, it was flagged that in the majority of instances the data is not collected according to geographic localities so it is very difficult to geo-reference the cases and identify the actual communities where they occur. The paucity of health and climate data makes it difficult to do a quantitative analysis of the impacts of climatic variables on climate sensitive disease outcomes.

For agriculture, detailed meteorological observations across the islands are needed to analyse the complexity of the micro-climates, in conjunction with specific, localized agriculture production and activity, in order to properly determine the impacts of climate on agricultural performance at high resolution.

6.2.3 Financials Gaps and Needs

According to the 2016 Adaptation Finance Gap Report, developing countries at large already face an *adaptation finance gap* – defined as the difference between the costs of, and thus the finance required, for meeting a given adaptation target and the amount of finance available to do so. Moreover, it is predicted that the gap will grow substantially without ambitious interventions (UNEP, 2016).

Furthermore, the costs of adaptation are likely to be two-to-three times higher than current global estimates by 2030, and potentially four-to-five times higher by 2050 (UNEP, 2016). However, more recent national and sectoral reports suggest a revised range of USD $140 billion to USD $300 billion by 2030 alone, and between USD $280 billion and USD $500 billion by 2050 (UNEP, 2016).

Adaptation is the primary mode that Grenada and other SIDS have adopted to address climate change at the national level. However, the costs of adaptation remain exceedingly high for SIDS nations like Grenada, which cannot afford to finance all of its adaptation needs from domestic investments alone. Additionally, while SIDS are typically the most considered beneficiaries for adaptation finance, the modalities for delivery or access are not always conducive, and some SIDS find themselves ineligible or beyond resource reach (UNEP, 2016).

Adaptation finance lingers as a resource challenge for Grenada, and for this reason, it is a priority area in Grenada's National Climate Change Adaptation Plan (NAP), and is presented as one of the NAP's five strategic pillars and one of 12 programmes of action. The NAP's review of the state of adaptation finance in Grenada (reflecting on performance in 2015 and 2016, where information and data were available) highlights the following:

- Grenada, particularly within recent years has been successful in attracting externally sourced investments in its climate change programme. In 2015, most (91%) of the capital budget for climate change was externally funded by bilateral and multilateral entities: 42% was in the form of grants and 49% as loans.
- Grenada is committed to financing adaptation domestically where possible. However, according to the CARICOM Declaration for Climate Action (CARICOM, 2015a), the government also stresses the need for improved and prioritised access to public, grant-based financial support to address climate change and its impacts. Further, adaptation is recognised as an additional development burden resulting from unchecked GHG emissions by large emitters. The responsibility for addressing adaptation therefore has to be borne in large part by these large emitters and not by diverting scarce local resources from ongoing development priorities like education, health and social development.
- **Grenada is a highly indebted country**. Grenada's fiscal and debt crisis in 2012-2013 featured a Debt-to-Gross Domestic Product (GDP) ratio reaching 109% in 2013 (Government of Grenada, 2016). This high Debt-to-GDP ratio, in addition to poor performance on other economic indicators resulted in the country undertaking austerity measures through debt restructuring and the implementation of a structural adjustment programme: its Home-Grown Economic Reform Programme under a Memorandum of Understanding with the International Monetary Fund [IMF] to access financial support in order to salvage a deteriorating economic situation. While these measures have reaped certain benefits in terms of reducing the Debt-to-GDP ratio (estimated at 93.2% for 2016) and realising cost savings of XCD 481 million in terms of debt service payments (Government of Grenada, 2016), these measures still leave the government with limited fiscal space to incur additional debt, whether concessional or not. Grenada's current Memorandum of Understanding with the IMF imposes restrictions on accessing debt finance

from third parties, which may in turn limit access to adaptation finance as concessional loans (IMF, 2015).

6.2.4 Technical and Capacity Gaps and Needs

Grenada has made significant strides in addressing technical and capacity needs related to climate change adaptation and mitigation since the INC, although some challenges persist; largely consequent of the aforementioned challenges with finance. These challenges are not specific to one sector but are cross-cutting and have manifested in various ways across the priority sectors for adaptation and mitigation. Furthermore, many of these challenges are inter-related and therefore have a compounding effect.

Human Resource Capacity

Typical of Caribbean SIDS, Grenada's human resource capacity is limited, and this is the case especially within the public sector, when matched against its workload and desired efficiency. However, the crux of the issue rests with the ability to absorb such expertise within the public sector. The limited availability of personnel or personnel time is one of the chief reasons for the challenges experienced with data and information, and the enforcement of policy and legislation cited repeatedly within the SNC. This limited capacity is considered to be the main climate finance readiness gap faced by Grenada, contributing to the country's limited absorptive capacity[62] (IMF, 2015).

The local Environment Division – the de facto base for public sector climate change operations – is modestly staffed, managing or at least involved in an extensive project portfolio including initiatives in climate change as well as other strategic or focal environmental areas. The burden of labour for some initiatives is shared with other Divisions and their line Ministries (e.g. the Ministry of Agriculture, Lands, Forestry and Fisheries; which will be heavily involved in environmental initiatives by nature of its responsibilities), but others rest squarely on the Environment Division's small technical team.

The human resource issues are further exacerbated by the recently imposed hiring restrictions implemented under the Homegrown Economic Reform Programme for the IMF, following the 2012-2013 economic crisis. Under the Programme, only three persons can be hired for every 10 persons leaving the public service (IMF, 2015). Such restrictions produce strained conditions within the Government service for the allocation of staff resources, at least for the immediate future while hiring restrictions remain in place. Personnel losses would be particularly felt from departing personnel with significant institutional memory and technical capacity.

[62] 'Absorptive capacity' can refer to the capacity of a country to absorb great amounts of aid in the medium term. A limited absorptive capacity may lead to delays in disbursement of aid (both grants and concessional loans) already committed for specific projects/uses (Reyes, Absorptive Capacity for Foreign Aid, 1990) - Grenada's National Climate Change Adaptation Plan.

Inter-agency collaboration has been the foremost strategy in addressing issues of human resource availability, capacity and overload in the environment sector. The recomposed National Climate Change Committee is one crucial example, drawing expertise and assistance from a number of government and non-government entities, with the flexibility of integrating other non-core personnel on an as-needed basis.

While inter-agency collaboration has eased some pressure compared to having to work *in silo,* the demand on these entities and their personnel is still high. Ideally, the Environment Division needs more staff members to adequately manage its responsibilities – local and international. Other sectors require a significant increase in staff complement to undertake the necessary research activities that support climate change related analyses and reporting. None of these increases are realistic in the short to medium term, given the prevailing economic regime, and the limited fiscal capacity of the country under 'normal' circumstances to support a larger civil servant base. As such, the quality and regularity of Grenada's international climate change and other environmental commitments will continue to be affected.

Data, Information and Research

Several sector assessments have addressed the general lack of data and information needed to adequately apply the types of rigorous methodologies recommended for GHG emissions, vulnerability, adaptation and mitigation analyses. In reality, the data demand on the public sector for empirical climate and environmental research is overwhelming. Beyond the human resource challenges which place significant limitations on the data collection and management systems that many agencies want to have in place, the technologies needed to facilitate these processes are often cost-prohibitive. Maintenance is also an issue, which is an often-neglected consideration in the procurement process – both in terms of the cost of maintenance, and availability of or access to the requisite skillsets for proper maintenance.

However, stakeholders are well aware of the importance of collecting and maintaining data of good quality that can be used for multiple purposes, and efforts are underway currently to address outstanding issues in some sectors (e.g. the proposed enhancements to Grenada's hydrometeorological network and the implementation of a new digital surveillance system in by the Ministry of Health and Social Security). Grenada has been extremely innovative in their attempts to fill data gaps, or at least to establish and maintain very robust baseline datasets for future research. Grenada has leveraged their participation in projects such as the EU-GCCA, Ridge-to-Reef initiative, ICCAS, RRACC and DVRP to acquire some of the technologies required to enhance their data management systems, and to build local capacity to maintain these systems.

Still, it is acknowledged that more is required, and some of the pertinent data and information needs, especially for the completion of future national communications, include:

- Localised climate and meteorological data to support climate impact or statistical analyses;
- Localised data in the health sector, with the correct geographic attribution of cases of climate-sensitive infections or diseases;
- Localised agricultural production and ecology data;

- The improvement of data services that would better allow for data sharing and use by other agencies, and as needed for detailed climate impacts assessments.

Policy, Legislation and Institutional Arrangements

The INC cited weak environmental policy and legislative co-ordination as an area to be addressed to better support climate change adaptation (Government of Grenada, 2000b). Since the INC, a number of policies and pieces of legislation were drafted (some formalised or enacted) which aim to provide the legal basis or supporting frameworks for adaptation and mitigation in Grenada, either through the encouragement of activities that contribute to these objectives (e.g. the National Energy Policy 2011, the National Water Policy 2007). For climate change specifically, a National Climate Change Policy and Action Plan was formalised in 2007 as a co-ordinating instrument to guide the execution and monitoring of a climate change programme that would tackle both adaptation and mitigation simultaneously (Government of Grenada, 2007), and is now being revised and updated in line with current national circumstances and priorities.

Some gaps still remain in the process of creating an enabling environment that promotes low carbon and climate resilient development. Policy and legislative ineffectiveness are quite often cited as a hindrance to furthering a number of development priorities and processes across the wider Caribbean region, including Grenada. Such ineffectiveness is typically rooted in the non-existence of the necessary legislation (e.g. the nation’s lack of specific Disaster Risk Management legislation), the retention of archaic or obsolete arrangements, the slow process of amending existing laws and policies, a lack of the general public’s knowledge or awareness (e.g. the extent of public awareness of the tax benefits applied to the purchase/import of renewable energy and energy efficient technologies), and the limited human resource capacity to properly implement or enforce them (e.g. challenges with the application or enforcement of the national building code).

6.3 INFORMATION ON FINANCIAL AND TECHNICAL RESSOURCES

The preparation of Grenada’s SNC to the UNFCCC was largely made possible by financial contribution from the Global Environment Facility (GEF) and technical assistance to the Government of Grenada from the United Nations Development Programme (UNDP) Office for Barbados and the OECS, acting as the implementing agency on behalf of GEF.

An independent firm was contracted by UNDP to prepare and submit the SNC and attending Subcomponent reports (presented as chapters in this compiled report). However, the Government of Grenada also committed time and resources to see the successful completion of the SNC over the entire preparation period. Financial and human resources were mainly contributed through the work and time of a Technical Officer within the Environment Division, within her capacity as the UNFCCC Operational Focal Point, and by extension the members of the National Climate Change Committee (NCCC), chaired by the UNFCCC's National Focal Point.

Further to these personnel, stakeholders from across the public and non-government sectors committed time to attend the meetings organised and hosted as part of the SNC preparation process, to provide information, data and reports (where available) that would support the assessments conducted, and to critically review and validate the technical outputs.

National commitment to broader climate change programming is evident in the various, concurrently running projects and programmes. These are being funded and/or implemented by international development partners operating under bi- and multilateral arrangements at national and regional levels; and the results of research, analysis and activity implementation under these programmes have fed into the SNC where appropriate. Chief of these projects/programmes and the key actors who funded, implemented and executed them are summarized in Table 72.

Table 72-Externally Funded Support of Grenada's National Climate Change Programming

Programme/Project	Timeframe	Implementing Agency(ies)	External Financing	Amount	Scale
DIRECT CLIMATE CHANGE FINANCING - NATIONAL					
Initial National Communication Enabling Activity – Phase 1	1999 - 2002	UNDP, GOG	GEF	USD 184,370	National
Initial National Communication Enabling Activity – Phase 2 (Top Up)	2001-2002	UNDP, GOG	GEF	USD 180,000	National
National Capacity Self-Assessment of Capacity Building Needs	2005 - 2006	UNDP, GOG	GEF	USD 200,000	National
Strategic Program for Climate Resilience (SPCR)	2012 - 2015	GOG	World Bank (Climate Investment Fund)	USD $8 M (Grant) USD $12 M (Concessional)	National
Integrated Climate Change Adaptation Strategies (ICCAS)	2012 - 2019 (Ongoing)	GIZ, UNDP, GOG	IKI, UNDP	€ 5.2 M	National
Reform of the Electricity Sector to Support Climate Policy	2014 - 2017 (Ongoing)	GIZ, GOG	IKI	€ 1.39 M	National

Programme/Project	Timeframe	Implementing Agency(ies)	External Financing	Amount	Scale
in Grenada (G-RESCP)					
DIRECT CLIMATE CHANGE FINANCING - REGIONAL					
Caribbean Planning for Adaptation to Climate Change (CPACC)	1997 - 2001	World Bank, OAS, CARICOM	GEF	USD $5.6 M	Regional
Adaptation to Climate Change in the Caribbean (ACCC)	2001 - 2004	World Bank, CARICOM	CIDA	CAD $3.5 M	Regional
Mainstreaming Adaptation to Climate Change in the Caribbean (MACC)	2003 - 2009	World Bank, CCCCC	GEF	USD $5 M	Regional
Review of the Economics of Climate Change in the Caribbean (RECC)	2010 - 2011	CCCCC, ECLAC	DFID (UK)		Regional
Intra-ACP GCCA (Global Climate Change Alliance) Programme – Caribbean Component	2011 - 2015	CCCCC	EU		Regional
Reduce Risks to Human & Natural Assets Resulting from Climate Change (RRACC) Project	2011 - 2016	OECS	USAID	USD $15.2 M	Sub-Regional (OECS)
Disaster Vulnerability Reduction Project (DVRP)	2011 - 2018 (Ongoing)	GOG, GOSVG	World Bank	USD $53 M	Sub-Regional
INDIRECT CLIMATE CHANGE FINANCING – NATIONAL AND REGIONAL					
Implementing a 'Ridge to Reef' Approach to Protecting Biodiversity and Ecosystem Functions within and Around Protected Areas	2014 - 2019 (Ongoing)	UNDP, GOG	GEF	USD $3.03 M	National
Caribbean Clean Energy Program (CARCEP)	2015 - 2020 (Ongoing)	Deloitte	USAID	USD $15 M	Regional
The Small Island Developing States (SIDS) Sustainable Energy Initiative - SIDS DOCK		AOSIS, UNDP	Denmark, Japan		Intra-Regional

Sources: (Thomas, 2005; CCCCC, n.d.; IKI, 2015; The World Bank, 2017)

GEF is highlighted in particular, having made significant financial contributions directly and indirectly to Grenada's national climate change programme since 1998/1999. In total, GEF commitment to and expenditure on Grenada's programming total USD $4.58 million in grant funding (two-thirds of this amount consists of the funds committed to the "Implementing a 'Ridge-to-Reef' Approach to Protecting Biodiversity and Ecosystem Functions within and Around Protected Areas" project); with another USD $3.67 million recorded in the pipeline for the "Climate Resilient Agriculture for Integrated Landscape Management" project which is in its concept stage (GEF, 2016).

More recently in terms of direct climate finance investment, Germany has mobilized and provided significant direct support (both finance and technical) to the national climate change programme. This has been achieved through the International Climate Initiative (IKI) of Germany's Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety; and projects have been implemented by German development agency - Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH in conjunction with the Government of Grenada. While Grenada is benefitting from eight projects being funded by IKI, two Grenada-specific projects include:

1. Reform of the Electricity Sector to Support Climate Policy in Grenada (G-RESCP), €1,395,000, being implemented by GIZ in conjunction with the Government of Grenada; and
2. Integrated Climate Change Adaptation Strategies (ICCAS), €4,206,000, being implemented by GIZ, UNDP and the Government of Grenada

Direct financial support arranged through other modalities – grant-loan combinations and concessionary loans – are mainly facilitated by the World Bank and the Caribbean Development Bank, providing budgetary support and financing for large capital or infrastructure projects infused with climate resilient objectives. One ongoing example would be the Disaster Vulnerability Reduction Project, which commenced in 2011, proposes a number of civil works in order to reduce the infrastructure vulnerability to natural hazards and climate change. The project is co-financed by the World Bank and the Climate Investment Fund up to USD 26.2 million (XCD70.7 million), including a grant of USD 8 million (XCD21.6 million) and is being co-ordinated by the Ministry of Finance of the Government of Grenada.

6.4 TECHNOLOGY TRANSFER

6.4.1 Technology Needs

Grenada recently completed some activities under the second phase of the Technology Needs Assessment (TNA) project, being implemented globally by the partnership between the United Nations Environment Programme and the Technical University of Denmark (the UNEP DTU Partnership).

Mitigation Technologies

Against a back-drop of preceding research and policy (e.g. the National Energy Policy, and the SIDS DOCK report on appropriateness of energy technologies for SIDS), three sectors: *energy, waste* and *transport* were selected as priority sectors for mitigation technology interventions, based on local expert judgement and the contribution of these sectors to the national emissions profile.

An original list of technology considerations were compiled based on the sectors selected, and ideas for sector and country-appropriate technologies were produced. From this list, some of the options were prioritised by local stakeholders using the Multi-Criteria Analysis method, based on criteria related to GHG reduction capacity, contribution to development, environmental benefits, readiness and maturity of technologies, and costs.

Adaptation Technologies

The *water resources sector* was selected as the priority focus for adaptation, in light of projections for highly variable or decreasing rainfall, with consequent implications for freshwater availability. Agriculture, tourism and domestic water supply were selected as priority sub-sectors, owing to their high dependence on freshwater availability. Such observations were highlighted in the Initial National Communication, and subsequently reiterated in the National Climate Change Policy (currently under review), the recently published National Adaptation Strategy and Action Plan (NASAP) for the water resources sector (Environmental Solutions Ltd., 2015), the Nationally Determined Contributions report and this Second National Communication.

6.4.2 Enabling Environments and Mechanisms for Technology Transfer

The technology transfer process has been encouraged and facilitated locally by key factors: calls for action by regional climate change programming, subsequent policy-driven interventions, legislative responses by government, the inputs to local projects and other initiatives by development partners and aid agencies, and increasing consumer demand upon observing local successes of technology uptake.

The inputs (especially financial / capital) from external partners are perhaps major deal-breakers, as SIDS face major challenges in technology procurement due to high, initial investment costs. Notable contributors to ongoing and previous projects include: GIZ; USAID; GEF; The World Bank; OAS; IDB; CDB; The EU (through the CCCCC, for the GCCA project) and Agencies within the UN (UNDP, UNEP).

Other bilateral arrangements with the Governments of countries such as Turkey, Japan, China and Finland, and local and regional public-private partnerships have also supported the technology transfer process.

The Government of Grenada has also strived to incentivize technology uptake – moreso in respect of RETs and EETs – amongst local households and companies, through the provision of tax exemptions (e.g. some RETs are VAT-exempted), and is further considering the establishment of feed-in-tariffs and an ESCO facility (Duncan 2015). To address some of these challenges, the Government of Grenada is spearheading reforms in specific areas, such as the new Electricity Supply Act (to encourage greater RET uptake and micro-independent power producer activity). Transport sector incentives and regulations are also being prioritised for assessment under the TNA, specifically looking at fuel tax, vehicle standards, public transport promotion and promotion of hybrid vehicles.

To further support technology transfer, recommendations geared towards building local capacity in technology design, development, assessment, installation, operation and maintenance have been put forward (IRENA, 2012; James, 2015; JICA & YONDEN, 2015). Local institutions such as the T. A. Marryshow Community College and the Grenada Solar Energy Technology Research Institute have been earmarked for these capacity building initiatives, through the development and introduction of relevant curricular and other programmes that would help to create a pool of trained and competent local talent to fill current gaps.

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APPENDICES

APPENDIX I – Worksheet Technical Guidance

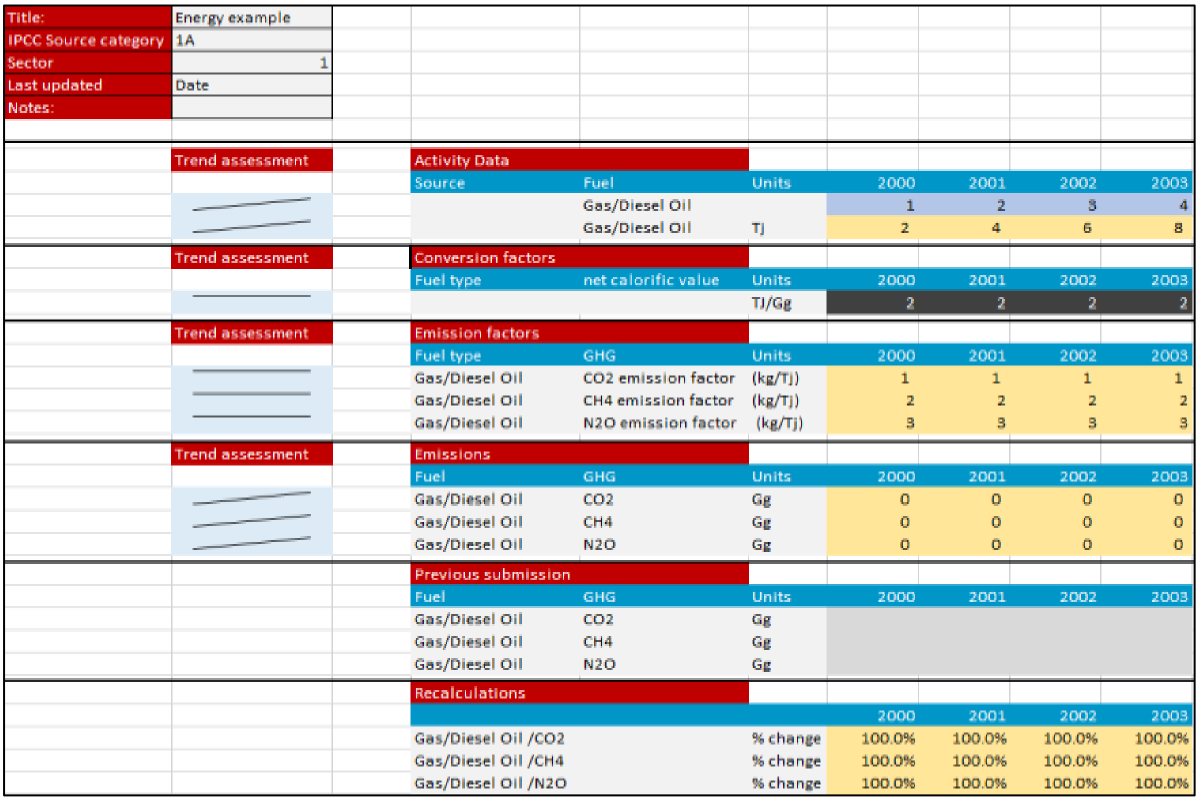
All emissions presented have been calculated using customised Excel worksheets, which, whilst not in line with the format of the worksheet templates that accompany the IPCC 2006 guidelines, operate according to the same methodological principles. The advantage to deviating from the IPCC 2006 worksheets, is the ability to add further quality controls, summaries, and analytical functions which serve to make the compilation process more fluid in future updates.

The majority of the worksheets follow a set format, with each 'tab' representing a source category. Each worksheet also has a 'QA' tab, documenting the contents of the worksheet, and its date of creation, in order to make each worksheet self-contained. In addition the QA tab contains the cell colour protocol, a colour scheme established the function of each cell can be easily identified.

Table A1 1- Cell protocol used within templates.

Cell Colour Protocol
Input data
Calculation /linked cells
Data sourced from another spreadsheet
Extrapolated / interpolated figure
Assumptions / assumed values
Conversion factors & constants
Checks

Each source category tab is laid out according to the following components; information/notes, activity data, conversion factors, emission factors, emissions, previous submission, recalculations. With each component occupying a specific block in the tab. These seven components make up the core structure of all the compilation spreadsheets and are shown in the example below:



Title:	Energy example								
IPCC Source category	1A								
Sector	1								
Last updated	Date								
Notes:									
	Trend assessment		Activity Data						
			Source	Fuel	Units	2000	2001	2002	2003
				Gas/Diesel Oil		1	2	3	4
				Gas/Diesel Oil	TJ	2	4	6	8
	Trend assessment		Conversion factors						
			Fuel type	net calorific value	Units	2000	2001	2002	2003
					TJ/Gg	2	2	2	2
	Trend assessment		Emission factors						
			Fuel type	GHG	Units	2000	2001	2002	2003
			Gas/Diesel Oil	CO2 emission factor	(kg/TJ)	1	1	1	1
			Gas/Diesel Oil	CH4 emission factor	(kg/TJ)	2	2	2	2
			Gas/Diesel Oil	N2O emission factor	(kg/TJ)	3	3	3	3
	Trend assessment		Emissions						
			Fuel	GHG	Units	2000	2001	2002	2003
			Gas/Diesel Oil	CO2	Gg	0	0	0	0
			Gas/Diesel Oil	CH4	Gg	0	0	0	0
			Gas/Diesel Oil	N2O	Gg	0	0	0	0
			Previous submission						
			Fuel	GHG	Units	2000	2001	2002	2003
			Gas/Diesel Oil	CO2	Gg				
			Gas/Diesel Oil	CH4	Gg				
			Gas/Diesel Oil	N2O	Gg				
			Recalculations						
						2000	2001	2002	2003
			Gas/Diesel Oil /CO2		% change	100.0%	100.0%	100.0%	100.0%
			Gas/Diesel Oil /CH4		% change	100.0%	100.0%	100.0%	100.0%
			Gas/Diesel Oil /N2O		% change	100.0%	100.0%	100.0%	100.0%

Figure A1 1- An example of a typical template format.

The last two components; previous submission & recalculations, are intended to be used in future updates, with the previous submission a space to hold the data for the last inventory year, and the recalculations to automatically identify any changes by comparing the previous data to the new emission data created in the update and placed in the block directly above. In this manner, it is intended all recalculations are firmly documented and the potential for error propagation is reduced.

APPENDIX II – Key Category Analysis and Uncertainties

An uncertainty analysis is viewed as a means to help prioritise national efforts to reduce the uncertainty of inventories in the future, and guide decisions on methodological choice. Uncertainty within a national inventory can arise from a variety of sources such as; lack of completeness within the methodology, lack of representativeness of the data, measurement error, or the use of emission models. The IPCC guidelines define two approaches to quantify the uncertainty, Approach 1 uses simple error propagation equations, whilst Approach 2 uses more complex Monte Carlo analysis. No quantified uncertainty analysis has been undertaken in regards to the Inventory presented in this report. A qualitative analysis of uncertainty based upon knowledge of the activity data and methodology used has been undertaken and is detailed in the table below:

Table A2 1 - Qualitative analysis of uncertainties.

IPCC source category	Comments	Estimated uncertainty level

IPCC source category		Comments	Estimated uncertainty level
Domestic aviation	1A3aii	The activity data is estimated from a bottom up methodology in which no parameters are variable over time.	HIGH
Domestic navigation and fishing	1A3dii	The activity data used is incomplete, and gapfilling has been used to estimate consumption for the earlier portion of the time series.	HIGH
Agriculture/Forestry/Fishing	1A4c	An error was identified within the activity used, and had to be adjusted. This points to a potentially high level of uncertainty.	HIGH
Product uses as substitute for ozone depleting substances	2F	The methodology used means the emissions data derived is not representative of national circumstances	HIGH
Forest land Remaining Forest land	3B1a	This source category is subject to a lack of data and parameters, meaning estimates are generally reliant on gapfilling.	HIGH
Domestic Wastewater Treatment and Discharge	4D1	Certain parameters do not have the necessary variability required in the methodology and have been kept constant, leading to potential uncertainty.	HIGH
Stationary combustion in manufacturing industries and construction	1A2	The activity data used within this source category is incomplete for two fuels burned and gapfilling has been used to complete the time series as a result, without detailed knowledge as to whether that fuel has been burnt across the earlier portion of the time series. However the emissions from these fuels only make a minor contribution to the overall totals for the source category.	MEDIUM
Commercial/institutional	1A4a	The activity data is incomplete in regards to gas/diesel oil, with gapfilling techniques used to complete the majority of the time series, without detailed knowledge as to whether that fuel has been burnt across the earlier portion of the time series.	MEDIUM
Biomass burning in croplands	3C1b	This source category is subject to a lack of completeness, as it is recognise there is likely more crop types that undergo burning practices, than currently accounted for.	MEDIUM
Biomass Burning in Forest Lands	3C1a	This source category is subject to a lack of completeness, and is reliant of gapfilling techniques.	MEDIUM

IPCC source category		Comments	Estimated uncertainty level
Solid waste disposal	4A	This source category uses an IPCC verified model, however some of the key country specific inputs are considered uncertain.	MEDIUM
Electricity and Heat Production	1A1a	The activity data used within this source category is complete across the time series, and is representative.	LOW
Road transportation	1A3b	The activity data used within this source category is complete across the time series, and is representative.	LOW
Residential stationary combustion	1A4b	The activity data used is complete with some exceptions and can be considered representative.	LOW
Enteric fermentation	3A1	The activity data is complete and representative of the source category.	LOW
Manure management	3A2	The activity data is complete and representative of the source category.	LOW
Direct N2O Emissions from Managed Soils	3C4	The activity data is complete and representative of the source category.	LOW
Indirect N2O Emissions from Managed Soils	3C5	The activity data is complete and representative of the source category.	LOW

It is good practice to identify those categories that have the greatest contribution to overall inventory uncertainty in order to make the most efficient use of available resources. By identifying these 'key categories' in the national inventory, inventory compilers can prioritise their efforts and improve their overall estimates. Two approaches have been defined in the IPCC 2006 guidelines; approach 1 and approach 2. In Approach 1, a simplistic methodology is applied assessing both the base year and latest inventory year in terms of level and contribution. Key categories are identified using a pre-determined cumulative emissions threshold. Under the IPCC 2006 guidelines, this threshold is set so key categories are those that, when summed together in descending order of magnitude, add up to 95 percent of the total level. Approach 2, is only applicable if category and parameter uncertainties are available, however is arguably more comprehensive as key categories are determined according to their contribution to uncertainty. Due to the limitations in deriving uncertainty values for specific parameters, an Approach 1 methodology was utilised.

Key category analysis for the base year (2000), and for the latest available inventory year (2014). Analysis for level in both 2000 and 2014 was performed in addition to analysis for contribution to trend. Key categories common across all test are: 1A1a (electricity and heat production), 1A2 (stationary combustion in manufacturing industries and construction), 1A3b (road transportation), 1A3dii (domestic navigation and fishing), 3A1 (enteric fermentation), 4A (solid waste disposal), 4D1 (domestic wastewater treatment and discharge). The full analysis is detailed in the tables below:

Table A2 2 - Approach 1 level assessment for the year 2000 (key categories are highlighted in green)

IPCC category	Emission source	GHG	2000 emission estimate Gg CO_2 eq	Absolute 2000 emission estimate Gg CO_2 eq	2000 Level assessment %	Cumulative total of level %
1A1a	Electricity and Heat Production	CO_2	77.46	77.46	28.48%	28.48%
1A3b	Road transportation	CO_2	74.76	74.76	27.49%	55.97%
1A4b	Residential stationary combustion	CO_2	26.31	26.31	9.67%	65.64%
4D1	Domestic Wastewater Treatment and Discharge	CH_4	20.88	20.88	7.68%	73.32%
4A	Solid waste disposal	CH_4	18.82	18.82	6.92%	80.24%
1A3dii	Domestic navigation and fishing	CO_2	10.53	10.53	3.87%	84.12%
3A1	Enteric fermentation	CH_4	9.15	9.15	3.36%	87.48%
1A4a	Commercial/institutional	CO_2	6.88	6.88	2.53%	90.01%
1A4c	Agriculture/Forestry/Fishing	CO_2	5.83	5.83	2.14%	92.15%
1A2	Stationary combustion in manufacturing industries and construction	CO_2	5.71	5.71	2.10%	94.25%
3C4	Direct N_2O Emissions from Managed Soils	N_2O	3.54	3.54	1.30%	95.55%
1A3b	Road transportation	N_2O	2.43	2.43	0.89%	96.44%
3A2	Manure management	CH_4	2.31	2.31	0.85%	97.29%
4D1	Domestic Wastewater Treatment and Discharge	N_2O	1.45	1.45	0.53%	97.83%
2F	Product uses as substitute for ozone depleting substances	F-gases	1.38	1.38	0.51%	98.34%
1A4b	Residential stationary combustion	CH_4	1.29	1.29	0.48%	98.81%
3C5	Indirect N_2O Emissions from Managed Soils	N_2O	1.13	1.13	0.42%	99.23%
1A3b	Road transportation	CH_4	0.61	0.61	0.23%	99.46%
3A2	Manure management	N_2O	0.42	0.42	0.15%	99.61%
1A3dii	Domestic navigation and fishing	N_2O	0.29	0.29	0.11%	99.72%
1A4b	Residential stationary combustion	N_2O	0.21	0.21	0.08%	99.79%
1A1a	Electricity and Heat Production	N_2O	0.19	0.19	0.07%	99.86%
1A1a	Electricity and Heat Production	CH_4	0.08	0.08	0.03%	99.89%

IPCC category	Emission source	GHG	2000 emission estimate	Absolute 2000 emission estimate	2000 Level assessment	Cumulative total of level
			Gg CO_2 eq	Gg CO_2 eq	%	%
1A3dii	Domestic navigation and fishing	CH_4	0.07	0.07	0.02%	99.91%
1A3ai	Domestic aviation	CO_2	0.05	0.05	0.02%	99.93%
1A2	Stationary combustion in manufacturing industries and construction	N_2O	0.05	0.05	0.02%	99.95%
1A2	Stationary combustion in manufacturing industries and construction	CH_4	0.03	0.03	0.01%	99.96%
3C1b	Biomass burning in croplands	CH_4	0.02	0.02	0.01%	99.97%
1A4c	Agriculture/Forestry/Fishing	CH_4	0.02	0.02	0.01%	99.98%
1A4a	Commercial/institutional	CH_4	0.02	0.02	0.01%	99.98%
3C1a	Biomass Burning in Forest Lands	CH_4	0.01	0.01	0.01%	99.99%
1A4c	Agriculture/Forestry/Fishing	N_2O	0.01	0.01	0.01%	99.99%
1A4a	Commercial/institutional	N_2O	0.01	0.01	0.00%	100.00%
3C1a	Biomass Burning in Forest Lands	N_2O	0.01	0.01	0.00%	100.00%
3C1b	Biomass burning in croplands	N_2O	0.00	0.00	0.00%	100.00%
1A3ai	Domestic aviation	N_2O	0.00	0.00	0.00%	100.00%
1A3ai	Domestic aviation	CH_4	0.00	0.00	0.00%	100.00%
3B1a	Forest land Remaining Forest land	CO_2	0.00	0.00	0.00%	100.00%

Table A2 3 - Approach 1 level assessment for the year 2014 (key categories are highlighted in green)

IPCC category	Emission source	GHG	2014 emission estimate Gg CO_2 eq	Absolute 2014 emission estimate Gg CO_2 eq	2014 Level assessment %	Cumulative total of level %
1A1a	Electricity and Heat Production	CO_2	127.83	127.83	31.44%	31.44%
1A3b	Road transportation	CO_2	102.25	102.25	25.15%	56.59%
2F	Product uses as substitute for ozone depleting substances	F-gases	58.32	58.32	14.34%	70.93%
1A4b	Residential stationary combustion	CO_2	21.52	21.52	5.29%	76.22%
4D1	Domestic Wastewater Treatment and Discharge	CH_4	21.86	21.86	5.38%	81.60%
4A	Solid waste disposal	CH_4	20.86	20.86	5.13%	86.73%
3A1	Enteric fermentation	CH_4	9.41	9.41	2.32%	89.04%
1A3dii	Domestic navigation and fishing	CO_2	9.75	9.75	2.40%	91.44%
1A4a	Commercial/institutional	CO_2	9.70	9.70	2.39%	93.83%
1A2	Stationary combustion in manufacturing industries and construction	CO_2	4.58	4.58	1.13%	94.95%
3C4	Direct N_2O Emissions from Managed Soils	N_2O	3.93	3.93	0.97%	95.92%
1A4c	Agriculture/Forestry/Fishing	CO_2	3.19	3.19	0.78%	96.70%
3A2	Manure management	CH_4	3.09	3.09	0.76%	97.46%
1A3b	Road transportation	N_2O	3.05	3.05	0.75%	98.21%
4D1	Domestic Wastewater Treatment and Discharge	N_2O	1.79	1.79	0.44%	98.65%
3C5	Indirect N_2O Emissions from Managed Soils	N_2O	1.24	1.24	0.31%	98.96%
1A3b	Road transportation	CH_4	0.73	0.73	0.18%	99.14%
3A2	Manure management	N_2O	0.54	0.54	0.13%	99.27%
1A1a	Electricity and Heat Production	N_2O	0.31	0.31	0.08%	99.35%
1A4b	Residential stationary combustion	CH_4	1.68	1.68	0.41%	99.76%
1A3dii	Domestic navigation and fishing	N_2O	0.30	0.30	0.07%	99.83%
1A1a	Electricity and Heat Production	CH_4	0.13	0.13	0.03%	99.86%

IPCC category	Emission source	GHG	2014 emission estimate	Absolute 2014 emission estimate	2014 Level assessment	Cumulative total of level
			Gg CO_2 eq	Gg CO_2 eq	%	%
1A3dii	Domestic navigation and fishing	CH_4	0.07	0.07	0.02%	99.88%
1A3ai	Domestic aviation	CO_2	0.05	0.05	0.01%	99.90%
1A2	Stationary combustion in manufacturing industries and construction	N_2O	0.05	0.05	0.01%	99.91%
3C1b	Biomass burning in croplands	CH_4	0.04	0.04	0.01%	99.92%
1A4b	Residential stationary combustion	N_2O	0.25	0.25	0.06%	99.98%
1A2	Stationary combustion in manufacturing industries and construction	CH_4	0.03	0.03	0.01%	99.98%
1A4a	Commercial/institutional	CH_4	0.03	0.03	0.01%	99.99%
1A4a	Commercial/institutional	N_2O	0.02	0.02	0.00%	100.00%
1A4c	Agriculture/Forestry/Fishing	CH_4	0.01	0.01	0.00%	100.00%
1A4c	Agriculture/Forestry/Fishing	N_2O	0.01	0.01	0.00%	100.00%
3C1b	Biomass burning in croplands	N_2O	0.00	0.00	0.00%	100.00%
1A3ai	Domestic aviation	N_2O	0.00	0.00	0.00%	100.00%
1A3ai	Domestic aviation	CH_4	0.00	0.00	0.00%	100.00%
3C1a	Biomass Burning in Forest Lands	CH_4	0.00	0.00	0.00%	100.00%
3C1a	Biomass Burning in Forest Lands	N_2O	0.00	0.00	0.00%	100.00%
3B1a	Forest land Remaining Forest land	CO_2	0.00	0.00	0.00%	100.00%

Table A2 4 - Approach 1 trend assessment for 2000 and 2014 (key categories are highlighted in green).

IPCC category	Emission source	GHG	Absolute 2000 emission estimate	Absolute 2014 emission estimate	2014 trend assessment	Contribution to trend	Cumulative total of trend
			Gg CO_2 eq	Gg CO_2 eq	%	%	%
2F	Product uses as substitute for ozone depleting substances	F-gases	1.38	58.32	0.09	41.17%	41.17%
1A4b	Residential stationary combustion	CO_2	26.31	21.52	0.03	13.03%	54.20%
1A1a	Electricity and Heat Production	CO_2	77.46	127.83	0.02	8.80%	63.01%
4D1	Domestic Wastewater Treatment and Discharge	CH_4	20.88	21.86	0.02	6.86%	69.86%
1A3b	Road transportation	CO_2	74.76	102.25	0.02	6.97%	76.84%
4A	Solid waste disposal	CH_4	18.82	20.86	0.01	5.33%	82.17%
1A3dii	Domestic navigation and fishing	CO_2	10.53	9.75	0.01	4.38%	86.56%
1A4c	Agriculture/Forestry/Fishing	CO_2	5.83	3.19	0.01	4.05%	90.60%
3A1	Enteric fermentation	CH_4	9.15	9.41	0.01	3.12%	93.72%
1A2	Stationary combustion in manufacturing industries and construction	CO_2	5.71	4.58	0.01	2.90%	96.62%
1A4b	Residential stationary combustion	CH_4	1.29	1.68	0.00	0.19%	96.81%
3C4	Direct N_2O Emissions from Managed Soils	N_2O	3.54	3.93	0.00	0.99%	97.80%
1A3b	Road transportation	N_2O	2.43	3.05	0.00	0.42%	98.22%
1A4a	Commercial/institutional	CO_2	6.88	9.70	0.00	0.43%	98.65%
3C5	Indirect N_2O Emissions from Managed Soils	N_2O	1.13	1.24	0.00	0.33%	98.98%
4D1	Domestic Wastewater Treatment and Discharge	N_2O	1.45	1.79	0.00	0.28%	99.26%
3A2	Manure management	CH_4	2.31	3.09	0.00	0.27%	99.53%
1A4b	Residential stationary combustion	N_2O	0.21	0.25	0.00	0.05%	99.58%

IPCC category	Emission source	GHG	Absolute 2000 emission estimate Gg CO_2 eq	Absolute 2014 emission estimate Gg CO_2 eq	2014 trend assessment %	Contribution to trend %	Cumulative total of trend %
1A3b	Road transportation	CH_4	0.61	0.73	0.00	0.14%	99.72%
1A3dii	Domestic navigation and fishing	N_2O	0.29	0.30	0.00	0.10%	99.81%
3A2	Manure management	N_2O	0.42	0.54	0.00	0.06%	99.88%
1A1a	Electricity and Heat Production	N_2O	0.19	0.31	0.00	0.02%	99.90%
1A3ai	Domestic aviation	CO_2	0.05	0.05	0.00	0.02%	99.92%
1A3dii	Domestic navigation and fishing	CH_4	0.07	0.07	0.00	0.02%	99.94%
1A2	Stationary combustion in manufacturing industries and construction	N_2O	0.05	0.05	0.00	0.02%	99.95%
1A4c	Agriculture/Forestry/Fishing	CH_4	0.02	0.01	0.00	0.01%	99.97%
1A4c	Agriculture/Forestry/Fishing	N_2O	0.01	0.01	0.00	0.01%	99.98%
1A2	Stationary combustion in manufacturing industries and construction	CH_4	0.03	0.03	0.00	0.01%	99.99%
1A1a	Electricity and Heat Production	CH_4	0.08	0.13	0.00	0.01%	99.99%
1A4a	Commercial/institutional	N_2O	0.01	0.02	0.00	0.00%	100.00%
1A4a	Commercial/institutional	CH_4	0.02	0.03	0.00	0.00%	100.00%
3C1b	Biomass burning in croplands	CH_4	0.02	0.04	0.00	0.00%	100.00%
1A3a	Domestic aviation	N_2O	0.00	0.00	0.00	0.00%	100.00%
3C1b	Biomass burning in croplands	N_2O	0.00	0.00	0.00	0.00%	100.00%
1A3ai	Domestic aviation	CH_4	0.00	0.00	0.00	0.00%	100.00%
3C1a	Biomass Burning in Forest Lands	CH_4	0.01	0.00	0.00	0.00%	100.00%
3C1a	Biomass Burning in Forest Lands	N_2O	0.01	0.00	0.00	0.00%	100.00%
3B1a	Forest land Remaining Forest land	CO_2	0.00	0.00	0.00	0.00%	100.00%

APPENDIX III - Inventory Sectoral Tables

Decision 17/CP.8 '*Guidelines for the preparation of national communications from Parties not included in Annex I to the Convention'* contains multiple recommendations on the presentation of inventories within national communications. Clause 22 of the annex to this Decision states:

'*Each non-Annex I Party is encouraged to use tables 1 and 2 of these guidelines in reporting its national GHG inventory, taking into account the provisions established in paragraphs 14 to 17 above. In preparing those tables, Parties should strive to present information which is as complete as possible. Where numerical data are not provided, Parties should use the notation keys as indicated.*'

Tables 1 and 2 are designed to enable the transparent reporting of emissions data without the application of global warming potentials, in contrast with the data presented in the main body of this report. These tables have been adapted to account for the fact the source categories supplied within the Decision refer to the Revised 1996 IPCC Guidelines, which has now been superseded by the 2006 IPCC Guidelines. In addition, these tables require the use of notation keys which are used to signify the status of a source category, when an emission value is not reported. The notations keys used are as follows:

- NE –'Not estimated' - Emissions and/or removals occur but have not been estimated or reported.
- IE –'Included elsewhere' - Emissions and/or removals for this activity or category are estimated and included in the inventory but not presented separately for this category.
- NA –'Not applicable' - The activity or category exists but relevant emissions and removals are considered never to occur. Such cells are normally shaded in the reporting tables.
- NO –'Not occurring' - An activity or process does not exist within a country.

The tables below refer to the years 2000, 2005, 2010 and 2014. Grey cells indicate that emissions do not need to be provided for that source category and GHG combination. The data for F-gases has been presented as both HFCs and SF_6 combined, in terms of CO_2 equivalents, due to the methodology used to derive these estimates. Non-direct GHGs (NO_x, CO, NMVOCs and SO_2) have not been estimated and hence have not been added to sectoral tables. It therefore should be assumed that all Non-direct GHGs are classified as 'NE', not estimated, across the IPCC sectors shown below, except in cases where the notation key 'NO', not occurring is used. In these cases the notation key 'NO' also applies to all non-direct GHGs.

Table A3 1- Emissions & removals of the main GHGs for the year 2000.

Greenhouse gas source and sink categories	CO2 emissions (Gg)	CO2 removals (Gg)	CH4 (Gg)	N2O (Gg)
Total national emissions and removals (excluding MEMO)	207.53	0.00	2.13	0.03
1. Energy	227.69		0.08	0.0113
A. Fuel combustion (Sectoral approach)	227.69		0.08	0.0113
1. Energy industries	77.46		0.003	0.0006
a. Main Activity Electricity and Heat Production	77.46		0.003	0.0006
b. Petroleum Refining	NO		NO	NO
c. Manufacture of Solid Fuels and Other Energy Industries	NO		NO	NO
2. Manufacturing industries and construction	5.71		0.001	0.000159
3. Transport	105.51		0.03	0.009685
a. Civil Aviation	20.22		0.0001	0.000566
i. International Aviation (International Bunkers) (MEMO)	20.16		0.0001	0.001
ii. Domestic Aviation	0.05		0.0000004	0.000002
b. Road Transportation	74.76		0.02	0.01
c. Railways	NO		NO	NO
d. Water-borne Navigation	10.53		0.003	0.001
i. International Water-borne Navigation (MEMO)	NE		NE	NE
ii. Domestic Water-borne Navigation	10.53		0.003	0.001
4. Other sectors	39.02		0.05	0.001
a. Commercial/Institutional	6.88		0.001	0.00004
b. Residential	26.31		0.05	0.001
c. Agriculture/Forestry/Fishing/Fish Farms	5.83		0.001	0.00005
5. Non-Specified	NO		NO	NO
B. Fugitive emissions from fuels	NO		NO	NO
1. Solid fuels	NO		NO	
2. Oil and natural gas	NO		NO	NO
C. Carbon Dioxide Transport and Storage	NO			
2. Industrial processes	NO		NO	NO

Greenhouse gas source and sink categories	CO2 emissions (Gg)	CO2 removals (Gg)	CH4 (Gg)	N2O (Gg)
A. Mineral Industry	NO		NO	NO
B. Chemcial Industry	NO		NO	NO
C. Metal Industry	NO		NO	NO
D. Non-Energy Products from Fuels and Solvent Use	NO		NO	NO
E. Electronics Industry	NO		NO	NO
F. Product Uses as Substitutes for Ozone Depleting Substances				
G. Other Product Manufacture and Use	NO		NO	NO
H. Other	NO		NO	NO
3. Agriculture, Forestry, and Other Land Use	0.00	0.00	0.46	0.02
A. Livestock			0.46	0.00
1. Enteric Fermentation			0.37	
2. Manure Management			0.09	0.001
B. Land	0.00	0.00		
1. Forest Land	0.00	0.00		
a. Forest Land Remaining Forest Land	0.00	0.00		
b. Land Converted Forest Land	NE	NE		
2. Cropland	NE	NE		
3. Grassland	NE	NE		
4. Wetlands	NO	NO		
5. Settlements	NE	NE		
6. Other Land	NO	NO		
C. Aggregate Sources and Non-CO2 Emission Sources on Land	0.00		0.001	0.02
1. Emissions from Biomass Burning	0.00		0.001	0.00002
a. Biomass Burning in Forest lands	NE		0.001	0.00002
b. Biomass Burning in Croplands	NE		0.001	0.000002
c. Biomass Burning in Grasslands	NO		NO	NO
d. Biomass Burning in All Other Land	NO		NO	NO
2. Liming	NE			
3. Urea Application	NE			

Greenhouse gas source and sink categories	CO2 emissions (Gg)	CO2 removals (Gg)	CH4 (Gg)	N2O (Gg)
4. Direct N2O Emissions from Managed Soils				0.01
5. Indirect N2O Emissions from Managed Soils				0.004
6. Indirect N2O Emissions from Manure Management				NE
7. Rice Cultivations			NO	
8 Other (please specify)			NO	NO
D. Other	NO		NO	NO
4. Waste	NA		1.59	0.005
A. Solid waste disposal	NA		0.75	
B. Biological Treatment of Solid Waste			NE	NE
C. Waste incineration	NE		NE	NE
1. Waste Incineration	NE		NE	NE
2. Open Burning of Waste	NE		NE	NE
D. Wastewater Treatment and Discharge			0.84	0.005
1. Domestic Wastewater Treatment and Discharge			0.84	0.005
2. Industrial Wastewater Treatment and Discharge			IE	IE
E. Other (please specify)			NO	NO
5. Other	NO		NO	NO
A. Indirect N2O Emissions from the Atmospheric Deposition of Nitrogen on NOx and NH3				NO
B. Other (please specify)	NO	NO	NO	NO
CO2 from Biomass Combustion for Energy Production (INFORMATION ITEM)	18.81			

Table A3 2- Emissions of F-gases for the year 2000.

Greenhouse gas source and sink categories	HFCs (GgCO2e)				PFCs (Gg)		
	HFC-23	HFC - 134	Other	SF6 (GgCO2e)	CF4	C2F6	Other
Total national emissions and removals (excluding MEMO)			1.38		NE	NE	NE
1. Energy							
A. Fuel combustion (Sectoral approach)							
1. Energy industries							
a. Main Activity Electricity and Heat Production							
b. Petroleum Refining							
c. Manufacture of Solid Fuels and Other Energy Industries							
2. Manufacturing industries and construction							
3. Transport							
a. Civil Aviation							
i. International Aviation (International Bunkers) (MEMO)							
ii. Domestic Aviation							
b. Road Transportation							
c. Railways							
d. Water-borne Navigation							
i. International Water-borne Navigation (MEMO)							
ii. Domestic Water-borne Navigation							
4. Other sectors							
a. Commercial/Institutional							
b. Residential							
c. Agriculture/Forestry/Fishing/Fish Farms							
5. Non-Specified							
B. Fugitive emissions from fuels							
1. Solid fuels							

Greenhouse gas source and sink categories	HFCs (GgCO2e)			SF6 (GgCO2e)	PFCs (Gg)		
	HFC-23	HFC - 134	Other		CF4	C2F6	Other
2. Oil and natural gas							
C. Carbon Dioxide Transport and Storage							
2. Industrial processes			1.38		NE	NE	NE
A. Mineral Industry							
B. Chemical Industry	NO	NO	NO	NO	NO	NO	NO
C. Metal Industry	NO	NO	NO	NO	NO	NO	NO
D. Non-Energy Products from Fuels and Solvent Use							
E. Electronics Industry	NO	NO	NO	NO	NO	NO	NO
F. Product Uses as Substitutes for Ozone Depleting Substances			1.38		NE	NE	NE
G. Other Product Manufacture and Use	NO	NO	NO	NO	NO	NO	NO
H. Other							
3. Agriculture, Forestry, and Other Land Use							
A. Livestock							
1. Enteric Fermentation							
2. Manure Management							
B. Land							
1. Forest Land							
a. Forest Land Remaining Forest Land							
b. Land Converted Forest Land							
2. Cropland							
3. Grassland							
4. Wetlands							
5. Settlements							
6. Other Land							
C. Aggregate Sources and Non-CO2 Emission Sources on Land							
1. Emissions from Biomass Burning							
a. Biomass Burning in Forest lands							
b. Biomass Burning in Croplands							

Greenhouse gas source and sink categories	HFCs (GgCO2e)			SF6 (GgCO2e)	PFCs (Gg)		
	HFC-23	HFC - 134	Other		CF4	C2F6	Other
c. Biomass Burning in Grasslands							
d. Biomass Burning in All Other Land							
2. Liming							
3. Urea Application							
4. Direct N2O Emissions from Managed Soils							
5. Indirect N2O Emissions from Managed Soils							
6. Indirect N2O Emissions from Manure Management							
7. Rice Cultivations							
8 Other (please specify)							
D. Other							
4. Waste							
A. Solid waste disposal							
B. Biological Treatment of Solid Waste							
C. Waste incineration							
1. Waste Incineration							
2. Open Burning of Waste							
D. Wastewater Treatment and Discharge							
1. Domestic Wastewater Treatment and Discharge							
2. Industrial Wastewater Treatment and Discharge							
E. Other (please specify)							
5. Other							
A. Indirect N2O Emissions from the Atmospheric Depostion of Nitrogen on NOx and NH3							
B. Other (please specify)							
CO2 from Biomass Combustion for Energy Production (INFORMATION ITEM)							

Table A3 3-Emissions & removals of the main GHGs for the year 2005.

Greenhouse gas source and sink categories	CO2 emissions (Gg)	CO2 removals (Gg)	CH4 (Gg)	N2O (Gg)
Total national emissions and removals (excluding MEMO)	243.38	-177.42	2.16	0.04
1. Energy	263.54		0.05	0.0125
A. Fuel combustion (Sectoral approach)	263.54		0.05	0.0125
1. Energy industries	93.23		0.004	0.0008
a. Main Activity Electricity and Heat Production	93.23		0.004	0.0008
b. Petroleum Refining	NO		NO	NO
c. Manufacture of Solid Fuels and Other Energy Industries	NO		NO	NO
2. Manufacturing industries and construction	6.22		0.001	0.000179
3. Transport	120.00		0.03	0.011306
a. Civil Aviation	20.22		0.0001	0.000566
i. International Aviation (International Bunkers) (MEMO)	20.16		0.0001	0.001
ii. Domestic Aviation	0.05		0.0000004	0.000002
b. Road Transportation	89.25		0.03	0.01
c. Railways	NO		NO	NO
d. Water-borne Navigation	10.53		0.003	0.001
i. International Water-borne Navigation (MEMO)	NE		NE	NE
ii. Domestic Water-borne Navigation	10.53		0.003	0.001
4. Other sectors	44.10		0.01	0.000
a. Commercial/Institutional	7.15		0.001	0.00004
b. Residential	30.48		0.01	0.000
c. Agriculture/Forestry/Fishing/Fish Farms	6.47		0.001	0.00005
5. Non-Specified	NO		NO	NO
B. Fugitive emissions from fuels	NO		NO	NO
1. Solid fuels	NO		NO	
2. Oil and natural gas	NO		NO	NO
C. Carbon Dioxide Transport and Storage	NO			
2. Industrial processes	NO		NO	NO

Greenhouse gas source and sink categories	CO2 emissions (Gg)	CO2 removals (Gg)	CH4 (Gg)	N2O (Gg)
A. Mineral Industry	NO		NO	NO
B. Chemical Industry	NO		NO	NO
C. Metal Industry	NO		NO	NO
D. Non-Energy Products from Fuels and Solvent Use	NO		NO	NO
E. Electronics Industry	NO		NO	NO
F. Product Uses as Substitutes for Ozone Depleting Substances				
G. Other Product Manufacture and Use	NO		NO	NO
H. Other	NO		NO	NO
3. Agriculture, Forestry, and Other Land Use	0.00	-177.42	0.47	0.02
A. Livestock			0.47	0.00
1. Enteric Fermentation			0.37	
2. Manure Management			0.10	0.001
B. Land	0.00	-177.42		
1. Forest Land	0.00	-177.42		
a. Forest Land Remaining Forest Land	0.00	-177.42		
b. Land Converted Forest Land	NE	NE		
2. Cropland	NE	NE		
3. Grassland	NE	NE		
4. Wetlands	NO	NO		
5. Settlements	NE	NE		
6. Other Land	NO	NO		
C. Aggregate Sources and Non-CO2 Emission Sources on Land	0.00		0.001	0.02
1. Emissions from Biomass Burning	0.00		0.001	0.00000
a. Biomass Burning in Forest lands	NE		0.000	0.00000
b. Biomass Burning in Croplands	NE		0.001	0.000002
c. Biomass Burning in Grasslands	NO		NO	NO
d. Biomass Burning in All Other Land	NO		NO	NO
2. Liming	NE			
3. Urea Application	NE			

Greenhouse gas source and sink categories	CO2 emissions (Gg)	CO2 removals (Gg)	CH4 (Gg)	N2O (Gg)
4. Direct N2O Emissions from Managed Soils				0.01
5. Indirect N2O Emissions from Managed Soils				0.004
6. Indirect N2O Emissions from Manure Management				NE
7. Rice Cultivations			NO	
8 Other (please specify)			NO	NO
D. Other	NO		NO	NO
4. Waste	NA		1.64	0.006
A. Solid waste disposal	NA		0.79	
B. Biological Treatment of Solid Waste			NE	NE
C. Waste incineration	NE		NE	NE
1. Waste Incineration	NE		NE	NE
2. Open Burning of Waste	NE		NE	NE
D. Wastewater Treatment and Discharge			0.85	0.006
1. Domestic Wastewater Treatment and Discharge			0.85	0.006
2. Industrial Wastewater Treatment and Discharge			IE	IE
E. Other (please specify)			NO	NO
5. Other	NO		NO	NO
A. Indirect N2O Emissions from the Atmospheric Depostion of Nitrogen on NOx and NH3				NO
B. Other (please specify)	NO	NO	NO	NO
CO2 from Biomass Combustion for Energy Production (INFORMATION ITEM)	21.08			

Table A3 4- Emissions of F-gases for the year 2005.

Greenhouse gas source and sink categories	HFCs (GgCO2e)				PFCs (Gg)		
	HFC-23	HFC - 134	Other	SF6 (GgCO2e)	CF4	C2F6	Other
Total national emissions and removals (excluding MEMO)	10.88				NE	NE	NE
1. Energy							
A. Fuel combustion (Sectoral approach)							
1. Energy industries							
a. Main Activity Electricity and Heat Production							
b. Petroleum Refining							
c. Manufacture of Solid Fuels and Other Energy Industries							
2. Manufacturing industries and construction							
3. Transport							
a. Civil Aviation							
i. International Aviation (International Bunkers) (MEMO)							
ii. Domestic Aviation							
b. Road Transportation							
c. Railways							
d. Water-borne Navigation							
i. International Water-borne Navigation (MEMO)							
ii. Domestic Water-borne Navigation							
4. Other sectors							
a. Commercial/Institutional							
b. Residential							
c. Agriculture/Forestry/Fishing/Fish Farms							
5. Non-Specified							
B. Fugitive emissions from fuels							
1. Solid fuels							
2. Oil and natural gas							
C. Carbon Dioxide Transport and Storage							

Greenhouse gas source and sink categories	HFCs (GgCO2e)			SF6 (GgCO2e)	PFCs (Gg)		
	HFC-23	HFC - 134	Other		CF4	C2F6	Other
2. Industrial processes			10.88		NE	NE	NE
A. Mineral Industry							
B. Chemical Industry	NO	NO	NO	NO	NO	NO	NO
C. Metal Industry	NO	NO	NO	NO	NO	NO	NO
D. Non-Energy Products from Fuels and Solvent Use							
E. Electronics Industry	NO	NO	NO	NO	NO	NO	NO
F. Product Uses as Substitutes for Ozone Depleting Substances			10.88		NE	NE	NE
G. Other Product Manufacture and Use	NO	NO	NO	NO	NO	NO	NO
H. Other							
3. Agriculture, Forestry, and Other Land Use							
A. Livestock							
1. Enteric Fermentation							
2. Manure Management							
B. Land							
1. Forest Land							
a. Forest Land Remaining Forest Land							
b. Land Converted Forest Land							
2. Cropland							
3. Grassland							
4. Wetlands							
5. Settlements							
6. Other Land							
C. Aggregate Sources and Non-CO2 Emission Sources on Land							
1. Emissions from Biomass Burning							
a. Biomass Burning in Forest lands							
b. Biomass Burning in Croplands							
c. Biomass Burning in Grasslands							
d. Biomass Burning in All Other Land							

Greenhouse gas source and sink categories	HFCs (GgCO2e)			SF6 (GgCO2e)	PFCs (Gg)		
	HFC-23	HFC - 134	Other		CF4	C2F6	Other
2. Liming							
3. Urea Application							
4. Direct N2O Emissions from Managed Soils							
5. Indirect N2O Emissions from Managed Soils							
6. Indirect N2O Emissions from Manure Management							
7. Rice Cultivations							
8 Other (please specify)							
D. Other							
4. Waste							
A. Solid waste disposal							
B. Biological Treatment of Solid Waste							
C. Waste incineration							
1. Waste Incineration							
2. Open Burning of Waste							
D. Wastewater Treatment and Discharge							
1. Domestic Wastewater Treatment and Discharge							
2. Industrial Wastewater Treatment and Discharge							
E. Other (please specify)							
5. Other							
A. Indirect N2O Emissions from the Atmospheric Depostion of Nitrogen on NOx and NH3							
B. Other (please specify)							
CO2 from Biomass Combustion for Energy Production (INFORMATION ITEM)							

Table A3 5-Emissions & removals of the main GHGs for the year 2010.

Greenhouse gas source and sink categories	CO2 emissions (Gg)	CO2 removals (Gg)	CH4 (Gg)	N2O (Gg)
Total national emissions and removals (excluding MEMO)	289.01	0.00	2.23	0.04
1. Energy	301.67		0.05	0.0133
A. Fuel combustion (Sectoral approach)	301.67		0.05	0.0133
1. Energy industries	137.90		0.006	0.0011
a. Main Activity Electricity and Heat Production	137.90		0.006	0.0011
b. Petroleum Refining	NO		NO	NO
c. Manufacture of Solid Fuels and Other Energy Industries	NO		NO	NO
2. Manufacturing industries and construction	7.89		0.001	0.000193
3. Transport	126.18		0.03	0.011854
a. Civil Aviation	12.72		0.0001	0.000356
i. International Aviation (International Bunkers) (MEMO)	12.67		0.0001	0.000
ii. Domestic Aviation	0.05		0.0000004	0.000002
b. Road Transportation	104.20		0.03	0.01
c. Railways	NO		NO	NO
d. Water-borne Navigation	9.26		0.002	0.001
i. International Water-borne Navigation (MEMO)	NE		NE	NE
ii. Domestic Water-borne Navigation	9.26		0.002	0.001
4. Other sectors	29.70		0.01	0.000
a. Commercial/Institutional	4.81		0.001	0.00003
b. Residential	21.71		0.01	0.000
c. Agriculture/Forestry/Fishing/Fish Farms	3.19		0.000	0.00003
5. Non-Specified	NO		NO	NO
B. Fugitive emissions from fuels	NO		NO	NO
1. Solid fuels	NO		NO	
2. Oil and natural gas	NO		NO	NO
C. Carbon Dioxide Transport and Storage	NO			
2. Industrial processes	NO		NO	NO

Greenhouse gas source and sink categories	CO2 emissions (Gg)	CO2 removals (Gg)	CH4 (Gg)	N2O (Gg)
A. Mineral Industry	NO		NO	NO
B. Chemical Industry	NO		NO	NO
C. Metal Industry	NO		NO	NO
D. Non-Energy Products from Fuels and Solvent Use	NO		NO	NO
E. Electronics Industry	NO		NO	NO
F. Product Uses as Substitutes for Ozone Depleting Substances				
G. Other Product Manufacture and Use	NO		NO	NO
H. Other	NO		NO	NO
3. Agriculture, Forestry, and Other Land Use	0.00	0.00	0.50	0.02
A. Livestock			0.49	0.00
1. Enteric Fermentation			0.37	
2. Manure Management			0.12	0.002
B. Land	0.00	0.00		
1. Forest Land	0.00	0.00		
a. Forest Land Remaining Forest Land	0.00	0.00		
b. Land Converted Forest Land	NE	NE		
2. Cropland	NE	NE		
3. Grassland	NE	NE		
4. Wetlands	NO	NO		
5. Settlements	NE	NE		
6. Other Land	NO	NO		
C. Aggregate Sources and Non-CO2 Emission Sources on Land	0.00		0.001	0.02
1. Emissions from Biomass Burning	0.00		0.001	0.00000
a. Biomass Burning in Forest lands	NE		0.000	0.00000
b. Biomass Burning in Croplands	NE		0.001	0.000003
c. Biomass Burning in Grasslands	NO		NO	NO
d. Biomass Burning in All Other Land	NO		NO	NO
2. Liming	NE			
3. Urea Application	NE			

Greenhouse gas source and sink categories	CO2 emissions (Gg)	CO2 removals (Gg)	CH4 (Gg)	N2O (Gg)
4. Direct N2O Emissions from Managed Soils				0.01
5. Indirect N2O Emissions from Managed Soils				0.004
6. Indirect N2O Emissions from Manure Management				NE
7. Rice Cultivations			NO	
8 Other (please specify)			NO	NO
D. Other	NO		NO	NO
4. Waste	NA		1.68	0.006
A. Solid waste disposal	NA		0.82	
B. Biological Treatment of Solid Waste			NE	NE
C. Waste incineration	NE		NE	NE
1. Waste Incineration	NE		NE	NE
2. Open Burning of Waste	NE		NE	NE
D. Wastewater Treatment and Discharge			0.86	0.006
1. Domestic Wastewater Treatment and Discharge			0.86	0.006
2. Industrial Wastewater Treatment and Discharge			IE	IE
E. Other (please specify)			NO	NO
5. Other	NO		NO	NO
A. Indirect N2O Emissions from the Atmospheric Depostion of Nitrogen on NOx and NH3				NO
B. Other (please specify)	NO	NO	NO	NO
CO2 from Biomass Combustion for Energy Production (INFORMATION ITEM)	22.49			

Table A3 6-Emissions of F-gases for the year 2010.

Greenhouse gas source and sink categories	HFCs (GgCO2e)			SF6 (GgCO2e)	PFCs (Gg)		
	HFC-23	HFC - 134	Other		CF4	C2F6	Other
Total national emissions and removals (excluding MEMO)			36.92		NE	NE	NE
1. Energy							
A. Fuel combustion (Sectoral approach)							
1. Energy industries							
a. Main Activity Electricity and Heat Production							
b. Petroleum Refining							
c. Manufacture of Solid Fuels and Other Energy Industries							
2. Manufacturing industries and construction							
3. Transport							
a. Civil Aviation							
i. International Aviation (International Bunkers) (MEMO)							
ii. Domestic Aviation							
b. Road Transportation							
c. Railways							
d. Water-borne Navigation							
i. International Water-borne Navigation (MEMO)							
ii. Domestic Water-borne Navigation							
4. Other sectors							
a. Commercial/Institutional							
b. Residential							
c. Agriculture/Forestry/Fishing/Fish Farms							
5. Non-Specified							
B. Fugitive emissions from fuels							
1. Solid fuels							
2. Oil and natural gas							
C. Carbon Dioxide Transport and Storage							

Greenhouse gas source and sink categories	HFCs (GgCO2e)			SF6 (GgCO2e)	PFCs (Gg)		
	HFC-23	HFC - 134	Other		CF4	C2F6	Other
2. Industrial processes			36.92		NE	NE	NE
A. Mineral Industry							
B. Chemical Industry	NO	NO	NO	NO	NO	NO	NO
C. Metal Industry	NO	NO	NO	NO	NO	NO	NO
D. Non-Energy Products from Fuels and Solvent Use							
E. Electronics Industry	NO	NO	NO	NO	NO	NO	NO
F. Product Uses as Substitutes for Ozone Depleting Substances			36.92		NE	NE	NE
G. Other Product Manufacture and Use	NO	NO	NO	NO	NO	NO	NO
H. Other							
3. Agriculture, Forestry, and Other Land Use							
A. Livestock							
1. Enteric Fermentation							
2. Manure Management							
B. Land							
1. Forest Land							
a. Forest Land Remaining Forest Land							
b. Land Converted Forest Land							
2. Cropland							
3. Grassland							
4. Wetlands							
5. Settlements							
6. Other Land							
C. Aggregate Sources and Non-CO2 Emission Sources on Land							
1. Emissions from Biomass Burning							
a. Biomass Burning in Forest lands							
b. Biomass Burning in Croplands							
c. Biomass Burning in Grasslands							
d. Biomass Burning in All Other Land							

Greenhouse gas source and sink categories	HFCs (GgCO2e)				PFCs (Gg)		
	HFC-23	HFC - 134	Other	SF6 (GgCO2e)	CF4	C2F6	Other
2. Liming							
3. Urea Application							
4. Direct N2O Emissions from Managed Soils							
5. Indirect N2O Emissions from Managed Soils							
6. Indirect N2O Emissions from Manure Management							
7. Rice Cultivations							
8 Other (please specify)							
D. Other							
4. Waste							
A. Solid waste disposal							
B. Biological Treatment of Solid Waste							
C. Waste incineration							
1. Waste Incineration							
2. Open Burning of Waste							
D. Wastewater Treatment and Discharge							
1. Domestic Wastewater Treatment and Discharge							
2. Industrial Wastewater Treatment and Discharge							
E. Other (please specify)							
5. Other							
A. Indirect N2O Emissions from the Atmospheric Depostion of Nitrogen on NOx and NH3							
B. Other (please specify)							
CO2 from Biomass Combustion for Energy Production (INFORMATION ITEM)							

Table A3 7-Emissions & removals of the main GHGs for the year 2014.

Greenhouse gas source and sink categories	CO2 emissions (Gg)	CO2 removals (Gg)	CH4 (Gg)	N2O (Gg)
Total national emissions and removals (excluding MEMO)	278.87	0.00	2.32	0.04
1. Energy	292.83		0.11	0.0138
A. Fuel combustion (Sectoral approach)	292.83		0.11	0.0138
1. Energy industries	127.83		0.005	0.0010
a. Main Activity Electricity and Heat Production	127.83		0.005	0.0010
b. Petroleum Refining	NO		NO	NO
c. Manufacture of Solid Fuels and Other Energy Industries	NO		NO	NO
2. Manufacturing industries and construction	4.58		0.001	0.000158
3. Transport	126.01		0.03	0.011646
a. Civil Aviation	14.01		0.0001	0.000392
i. International Aviation (International Bunkers) (MEMO)	13.96		0.0001	0.000
ii. Domestic Aviation	0.05		0.0000004	0.000002
b. Road Transportation	102.25		0.03	0.01
c. Railways	NO		NO	NO
d. Water-borne Navigation	9.75		0.003	0.001
i. International Water-borne Navigation (MEMO)	NE		NE	NE
ii. Domestic Water-borne Navigation	9.75		0.003	0.001
4. Other sectors	34.41		0.07	0.001
a. Commercial/Institutional	9.70		0.001	0.00007
b. Residential	21.52		0.07	0.001
c. Agriculture/Forestry/Fishing/Fish Farms	3.19		0.000	0.00003
5. Non-Specified	NO		NO	NO
B. Fugitive emissions from fuels	NO		NO	NO
1. Solid fuels	NO		NO	
2. Oil and natural gas	NO		NO	NO
C. Carbon Dioxide Transport and Storage	NO			
2. Industrial processes	NO		NO	NO

Greenhouse gas source and sink categories	CO2 emissions (Gg)	CO2 removals (Gg)	CH4 (Gg)	N2O (Gg)
A. Mineral Industry	NO		NO	NO
B. Chemical Industry	NO		NO	NO
C. Metal Industry	NO		NO	NO
D. Non-Energy Products from Fuels and Solvent Use	NO		NO	NO
E. Electronics Industry	NO		NO	NO
F. Product Uses as Substitutes for Ozone Depleting Substances				
G. Other Product Manufacture and Use	NO		NO	NO
H. Other	NO		NO	NO
3. Agriculture, Forestry, and Other Land Use	0.00	0.00	0.50	0.02
A. Livestock			0.50	0.00
1. Enteric Fermentation			0.38	
2. Manure Management			0.12	0.002
B. Land	0.00	0.00		
1. Forest Land	0.00	0.00		
a. Forest Land Remaining Forest Land	0.00	0.00		
b. Land Converted Forest Land	NE	NE		
2. Cropland	NE	NE		
3. Grassland	NE	NE		
4. Wetlands	NO	NO		
5. Settlements	NE	NE		
6. Other Land	NO	NO		
C. Aggregate Sources and Non-CO2 Emission Sources on Land	0.00		0.001	0.02
1. Emissions from Biomass Burning	0.00		0.001	0.00000
a. Biomass Burning in Forest lands	NE		0.000	0.00000
b. Biomass Burning in Croplands	NE		0.001	0.000003
c. Biomass Burning in Grasslands	NO		NO	NO
d. Biomass Burning in All Other Land	NO		NO	NO
2. Liming	NE			
3. Urea Application	NE			

Greenhouse gas source and sink categories	CO2 emissions (Gg)	CO2 removals (Gg)	CH4 (Gg)	N2O (Gg)
4. Direct N2O Emissions from Managed Soils				0.01
5. Indirect N2O Emissions from Managed Soils				0.004
6. Indirect N2O Emissions from Manure Management				NE
7. Rice Cultivations			NO	
8 Other (please specify)			NO	NO
D. Other	NO		NO	NO
4. Waste	NA		1.71	0.006
A. Solid waste disposal	NA		0.83	
B. Biological Treatment of Solid Waste			NE	NE
C. Waste incineration	NE		NE	NE
1. Waste Incineration	NE		NE	NE
2. Open Burning of Waste	NE		NE	NE
D. Wastewater Treatment and Discharge			0.87	0.006
1. Domestic Wastewater Treatment and Discharge			0.87	0.006
2. Industrial Wastewater Treatment and Discharge			IE	IE
E. Other (please specify)			NO	NO
5. Other	NO		NO	NO
A. Indirect N2O Emissions from the Atmospheric Depostion of Nitrogen on NOx and NH3				NO
B. Other (please specify)	NO	NO	NO	NO
CO2 from Biomass Combustion for Energy Production (INFORMATION ITEM)	23.05			

Table A3 8-Emissions of F-gases for the year 2014.

Greenhouse gas source and sink categories	HFCs (GgCO2e)				PFCs (Gg)		
	HFC-23	HFC - 134	Other	SF6 (GgCO2e)	CF4	C2F6	Other
Total national emissions and removals (excluding MEMO)			58.32		NE	NE	NE
1. Energy							
A. Fuel combustion (Sectoral approach)							
1. Energy industries							
a. Main Activity Electricity and Heat Production							
b. Petroleum Refining							
c. Manufacture of Solid Fuels and Other Energy Industries							
2. Manufacturing industries and construction							
3. Transport							
a. Civil Aviation							
i. International Aviation (International Bunkers) (MEMO)							
ii. Domestic Aviation							
b. Road Transportation							
c. Railways							
d. Water-borne Navigation							
i. International Water-borne Navigation (MEMO)							
ii. Domestic Water-borne Navigation							
4. Other sectors							
a. Commercial/Institutional							
b. Residential							
c. Agriculture/Forestry/Fishing/Fish Farms							
5. Non-Specified							
B. Fugitive emissions from fuels							
1. Solid fuels							
2. Oil and natural gas							
C. Carbon Dioxide Transport and Storage							

Greenhouse gas source and sink categories	HFCs (GgCO2e)			SF6 (GgCO2e)	PFCs (Gg)		
	HFC-23	HFC - 134	Other		CF4	C2F6	Other
2. Industrial processes			58.32		NE	NE	NE
A. Mineral Industry							
B. Chemical Industry	NO	NO	NO	NO	NO	NO	NO
C. Metal Industry	NO	NO	NO	NO	NO	NO	NO
D. Non-Energy Products from Fuels and Solvent Use							
E. Electronics Industry	NO	NO	NO	NO	NO	NO	NO
F. Product Uses as Substitutes for Ozone Depleting Substances			58.32		NE	NE	NE
G. Other Product Manufacture and Use	NO	NO	NO	NO	NO	NO	NO
H. Other							
3. Agriculture, Forestry, and Other Land Use							
A. Livestock							
1. Enteric Fermentation							
2. Manure Management							
B. Land							
1. Forest Land							
a. Forest Land Remaining Forest Land							
b. Land Converted Forest Land							
2. Cropland							
3. Grassland							
4. Wetlands							
5. Settlements							
6. Other Land							
C. Aggregate Sources and Non-CO2 Emission Sources on Land							
1. Emissions from Biomass Burning							
a. Biomass Burning in Forest lands							
b. Biomass Burning in Croplands							
c. Biomass Burning in Grasslands							
d. Biomass Burning in All Other Land							

Greenhouse gas source and sink categories	HFCs (GgCO2e)				PFCs (Gg)		
	HFC-23	HFC - 134	Other	SF6 (GgCO2e)	CF4	C2F6	Other
2. Liming							
3. Urea Application							
4. Direct N2O Emissions from Managed Soils							
5. Indirect N2O Emissions from Managed Soils							
6. Indirect N2O Emissions from Manure Management							
7. Rice Cultivations							
8 Other (please specify)							
D. Other							
4. Waste							
A. Solid waste disposal							
B. Biological Treatment of Solid Waste							
C. Waste incineration							
1. Waste Incineration							
2. Open Burning of Waste							
D. Wastewater Treatment and Discharge							
1. Domestic Wastewater Treatment and Discharge							
2. Industrial Wastewater Treatment and Discharge							
E. Other (please specify)							
5. Other							
A. Indirect N2O Emissions from the Atmospheric Depostion of Nitrogen on NOx and NH3							
B. Other (please specify)							
CO2 from Biomass Combustion for Energy Production (INFORMATION ITEM)							

APPENDIX IV - Scenario Analysis Methodology

The future scenario analysis of Grenada's emissions until 2030 have been undertaken as part of preparation of the country's INDC (September 2015), and updated for Grenada's Second National Communication. The analysis assesses the likely future projected GHG emissions and removal scenarios based on five individual scenarios;

Business as Usual (BAU) – The BAU scenario has been updated for this report based on the scenario developed for the country's INDC submission. The scenario outlines the expected GHG emissions trajectory accounting for normal execution of operations without the uptake of any additional mitigation of GHGs. The scenario is based on projected energy consumption, GDP, and population growth.

Table 73-Emissions 2010 – 2030 by sector for Second National Communication INDC BAU scenario

Sector	Sub-sector	Sector name	Units (Gg CO_2e) per Year																
			2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
ENERGY	1A1a	Electricity & heat	128	137	140	143	146	149	152	155	158	162	165	169	172	176	180	184	188
	1A2	Stationary combustion in manufacturing ind. & constr.	5	5	5	5	6	6	6	6	6	6	7	7	7	7	7	7	7
	1A3a	Domestic aviation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1A3b	Road transport	106	106	106	106	106	106	106	106	106	106	106	106	106	106	106	106	106
	1A3d	Domestic navigation and fishing	10	10	11	11	12	13	13	13	14	14	14	15	15	15	16	16	16
	1A4a	Commercial/institutional	10	10	10	11	12	12	12	13	13	13	14	14	14	15	15	15	16
	1A4b	Residential stationary combustion	23	24	25	26	28	29	30	31	31	32	33	34	34	35	36	37	37
	1A4c	Agriculture/Forestry/Fishing	3	3	3	4	4	4	4	4	4	4	5	5	5	5	5	5	5
IPPU	2F	Product uses as substitute for ozone depleting substances	58	60	63	66	69	73	75	76	78	80	82	84	86	88	89	91	93
AFOLU	3A	Enteric fermentation	9	10	10	11	11	12	12	12	13	13	13	14	14	14	14	15	15
	3B	Manure management	4	4	4	4	4	5	5	5	5	5	5	5	5	5	6	6	6
	3Da	Direct N_2O emissions from managed soils	4	4	4	4	5	5	5	5	5	5	6	6	6	6	6	6	6
	3Db	Indirect N_2O Emissions from managed soils	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2
	3F	Field burning of agricultural residues	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3C1a	Biomass burning - Forest	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3C1b	Biomass burning - Cropland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WASTE	5A	Solid waste disposal	21	22	22	23	24	24	25	25	25	26	26	27	27	27	28	28	28
	5D1	Domestic Wastewater Treatment and Discharge	24	24	24	24	24	24	24	24	25	25	25	25	25	25	25	25	25
TOTAL			**407**	**420**	**430**	**440**	**451**	**462**	**470**	**478**	**486**	**494**	**502**	**510**	**518**	**526**	**534**	**542**	**551**

INDC Scenario – The INDC scenario has been developed based on Grenada's climate target outlining a 30% reduction of GHG emissions by 2025 compared to 2010, and 40% reduction by 2030 compared to 2010 as specified in the INDC (Government of Grenada, 2015). This target remains the same for the updated inventory reported in this report.

With Existing Measures (WEM) scenario – The WEM scenario has been estimated based on quantified emissions reductions of actions deemed to be either under implementation, or in an advanced planning stage. Additional details on the quantification of these mitigation actions are included in Appendix 3.

Table 74-Emissions reductions of WEM climate actions (2014 - 2030)

SECTOR	Units (Gg CO_2e) per Year																
	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
ID 30 - Mt. St. Catherine Geothermal energy	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	77	77	77	77	77	77
ID 33 - Solar farm	NE	NE	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
ID 36 - Solar system (Korean funded)	NE	NE	NE	0	0	0	0	0	0	0	0	NE	NE	NE	NE	NE	NE
TOTAL	**0**	**0**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**78**	**78**	**78**	**78**	**78**	**78**

With Additional Measures (WAM) scenario – The WAM scenario has been estimated based on quantified emissions reductions of actions deemed to be possible in the medium to long-term such as additional geothermal energy developments. Additional details on the quantification of these mitigation actions are included in Appendix 3.

Table 75-Impact of WAM climate actions (2014 - 2030)

SECTOR	Units (Gg CO_2e) per Year																
	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
ID 32 - Electric Vehicles	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
ID 34 - Wind power	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	9
ID 37 - LED public lighting	NE	NE	NE	NE	NE	NE	0	0	0	0	0	0	0	0	0	0	0
ID 39 - G-Hydro In-Conduit hydropower development	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	0	0	0	0	0
ID 40 - PV systems	NE	NE	NE	1	3	4	6	7	9	10	11	13	14	16	17	19	20
ID 54 - Petite Martinique off grid solar PV system	NE	NE	NE	0	0	0	0	1	1	1	1	1	1	1	1	1	1
ID 56 - 15 MW additional geothermal	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	77	77	77	77	77	77
TOTAL	**0**	**0**	**0**	**2**	**3**	**5**	**6**	**8**	**9**	**11**	**12**	**91**	**92**	**94**	**95**	**97**	**108**

With Potential Measures (WPM) scenario – The WPM scenario has been estimated based on quantified emissions reductions of actions deemed to be possible in the medium to long-term through development of an integrated solid waste management system including capture of landfill gas.

Table 76-Impact of WPM climate actions (2014 – 2030)

SECTOR	Units (Gg CO_2e) per Year																
	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
ID 45 - Biogas and agricultural processor systems	NE	NE	NE	NE	NE	NE	1	1	1	1	1	1	1	1	1	1	1
ID 55 - Integrated solid waste management	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	19	20	21	22	23	25
ID 57 - 10 MW additional wind power	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	46
TOTAL	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**1**	**1**	**20**	**21**	**22**	**24**	**25**	**72**

APPENDIX V - Mitigation Action Savings Quantification Methods and Assumptions

Grid Decarbonisation

Emission reductions from renewable electricity generation are calculated assuming the replacement of diesel generation. Approximately 98% of Grenada's electricity generation (through GRENLEC) is met through diesel generation (Energy Transition Initiative, 2015).

For energy efficiency and transport mitigation actions such as the use of electric vehicles, emission reductions are estimated based on a changing electricity emission factor to account for the projected uptake of renewable energy in Grenada. Doing so eliminates the risk of double-counting emission reductions from the decarbonisation of the grid until 2030. The electric emission factor under a constant and changing emission factor are presented in more detail in **Error! Reference source not found.** below.

Table 77-Grenada projected electricity emission factor 2014 - 2030

SECTOR	SCENARIO	Units (tCO_2e/MWh) per Year																
		2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Constant electricity emission factor	Displacing BAU diesel generation	0.5821	0.5771	0.5771	0.5771	0.5771	0.5771	0.5771	0.5771	0.5771	0.5771	0.5771	0.5771	0.5771	0.5771	0.5771	0.5771	0.5771
Changing electricity emission factor	Accounts for uptake of renewables	0.5821	0.5771	0.5731	0.5670	0.5611	0.5555	0.5500	0.5448	0.5397	0.5349	0.5302	0.2326	0.2343	0.2361	0.2380	0.2400	0.2101

Electric Vehicle (EV) Charging Infrastructure

Grenada's electrification rate of over 99.5% of households and characteristics as a small island state could make the island well suited for more range-restricted vehicles such as electric vehicles, in particular if combined with sufficient generation of renewable electricity. Consequently, for the sake of the electric vehicle mitigation action presented in this report, assuming an uptake of 1% of vehicles by 2025, and 5% by 2030, a sufficient provision of EV charging infrastructure is assumed to adequately mitigate range anxiety and enable domestic uptake of EVs.

Solar PV Projects

Uptake of solar PV in Grenada is primarily addressed through the WAM mitigation action 'PV systems'. This is the case for all residential and commercial PV installations, unless treated as a separate policy by the Government of Grenada or GRENLEC. This is the case for the 11 solar farms incorporated in the 'Solar farm' mitigation action where GRENLEC installed solar PV at eleven sites in Grand Anse, Queen's Park and Plains in 2016, as well as the independent off grid solar PV system including battery storage for the island of Petite Martinique off the coast of Grenada.

APPENDIX VI - Policies and Programmes that Mitigate Greenhouse Gas Emissions

Name of the mitigation action	Status [idea, planning phase, under implementation]	Implementing institution	Duration (20XX-20YY)	Sector[1] and subsector (if applicable)	Scope [e.g. national, regional, city-wide]	Quantitative targets (both GHG-related and non-GHG impacts, as applicable)	GHGs covered
ID 30 - Mt. St. Catherine Geothermal Energy	*Under implementation*	*Government of Grenada; Geothermal Energy Project Management Unit (GPMU)*	*2015-2030*	*Energy supply, renewable energy*	*National*	*Reduction of 77.0 Gg CO_2e by 2030*	*CO_2*
	Objective of the mitigation action						
	The objective of this mitigation action is to reduce emissions from fossil fuel powered electricity generation plants by fostering renewable energy generation through the development of a geothermal energy site at Mt. St. Catherine, and reduce Grenada's dependence on imported diesel fuel for electricity generation.						
	Brief description and activities planned under the mitigation action						
	The mitigation action will achieve the objectives through a comprehensive programme of measures to remove barriers and accomplish the development of a geothermal energy generation site at Mt. St. Catherine. *Financial Component: In 2017, a grant was approved by the Caribbean Development Bank (CDB) to develop a roadmap for geothermal energy generation, and build capacity for the planning and implementation of geothermal energy in Grenada.* *As stated by the country's INDC, Grenada does not currently use any international market mechanisms, but is willing to explore the potential of such market mechanisms, as well as other mechanisms under the UNFCCC demonstrating adequate environmental integrity.* *Technical support component: The project incorporates the provision of technical consultancy to the Geothermal Energy Project Management Unit (GPMU) under a 24-month period (2017-19).*						
	Estimated outcomes and estimated emission reductions						
	The development of the geothermal energy site is expected to achieve an emissions reduction of 77.0 Gg CO_2e by 2030, assuming the plant is completed in 2025.						

	Methodologies and assumptions						
	The quantification of this mitigation action assumes the geothermal energy site is completed in 2025. The impact of this mitigation action was estimated assuming an installed capacity of 15MW. The expected generation was estimated to 8,670 MWh/MW installed capacity based on data from another geothermal energy site on the Caribbean island of Saba (http://energeia.nl/nieuws/541432-1607/rapport/BINARY/rapport). Consequently, the annual generation at the site was estimated to 130,050 MWh/annually. *Emission reductions were estimated assuming a replacement of diesel generated electricity currently generated on the island, with an emission factor of 0.589 tCO_2e/MWh.*						
	General description of the monitoring and reporting system						
	Due to the initial stage of implementation, no additional information is currently available regarding the mitigation action's MRV system.						
	Action X Key indicators used						
Name of the indicator	**Unit**	**Indicator baseline value**	**Indicator target value**	**Year baseline and target value relate to**	**Progress to date**	**Progress to date year**	**Datasets & sources**
	Progress indicators						
Installed capacity	*MW*	*0*	*15*	*2015*	*0*	*2017*	*Government of Grenada, 2017*
	Indicators related to GHG impacts						
Replacement of diesel generated electricity	MWh	0	130,050	2015	0	2017	Government of Grenada, 2017
	Indicators related to sustainable development						
Full time employment (FTEs) following completion	FTEs	0	32	2015	0	2017	Government of Grenada, 2017
Affordable and clean energy	US$ / kWh	US$ 0.34/kWh	NE	2015	NE	NE	Energy Transition Initiative, 2015 and

							Government of Grenada, 2017

Name of the mitigation action	Status [idea, planning phase, under implementation]	Implementing institution	Duration (20XX-20YY)	Sector[1] and subsector (if applicable)	Scope [e.g. national, regional, city-wide]	Quantitative targets (both GHG-related and non-GHG impacts, as applicable)	GHGs covered
ID 32 - Electric vehicles	*Under implementation*	*Government of Grenada; GRENLEC*	*2014-2030*	*Energy, road transport*	*National*	*Reduction of 0.5 Gg CO_2e by 2030*	*CO_2*
	Objective of the mitigation action						
	The objective of this mitigation action is to reduce the consumption of fossil fuels in the road transport subsector through increased uptake of electric vehicles.						

	Brief description and activities planned under the mitigation action						
	The mitigation action will achieve the objectives through measures such as the EV pilot programme developed by GRENLEC, and the removal of barriers to increase uptake of EVs in the private sector. *Financial Component: The development of this mitigation action primarily relies on private capital to increase uptake of EVs in the private sector.* *Technical support component: The project currently does not incorporate the provision of any foreign technical support.*						
	Estimated outcomes and estimated emission reductions						
	The increased uptake of EVs is estimated to reduce emissions by 0.5 Gg CO_2e by 2030.						
	Methodologies and assumptions						
	The quantification of this mitigation action assumes a general decarbonisation of the electricity grid until 2030. *Due to the size of the island of Grenada, no additional investments into EV infrastructure are currently included in this mitigation action.*						
	General description of the monitoring and reporting system						
	No formalised monitoring and reporting systems have been developed for this mitigation action beyond a general assessment of the number of EVs currently operating in Grenada.						
	Action X Key indicators used						
Name of the indicator	**Unit**	**Indicator baseline value**	**Indicator target value**	**Year baseline and target value relate to**	**Progress to date**	**Progress to date year**	**Datasets & sources**
	Progress indicators						
Percent of cars that are EVs	*Percent*	*0%*	*5%*	*2013*	*0.04%*	*2017*	*Government of Grenada, 2017*
	Indicators related to GHG impacts						
Percent of cars that are EVs	*Percent*	*0%*	*5%*	*2013*	*0.04%*	*2017*	*Government of Grenada, 2017*
	Indicators related to sustainable development						
Reduced NO_x	Tonnes of NO_x	0	NE	2013	NE	2017	*Government of Grenada,*

emissions							*2017*
Reduced PM_{10} emissions	Tonnes of PM_{10}	0	NE	2013	NE	2017	*Government of Grenada, 2017*

Name of the mitigation action	Status [idea, planning phase, under implementation]	Implementing institution	Duration (20XX-20YY)	Sector[1] and subsector (if applicable)	Scope [e.g. national, regional, city-wide]	Quantitative targets (both GHG-related and non-GHG impacts, as applicable)	GHGs covered
ID 33 - Solar farm	*Implemented*	*GRENLEC*	*2015-2016*	*Energy supply, renewable energy*	*City-wide*	*Reduction of 0.9 Gg CO_2e by 2030*	*CO_2*
	Objective of the mitigation action						
	The objective of this mitigation action is to reduce emissions from fossil fuel powered electricity generation plants through the development of 11 solar PV sites at Grand Anse, Queen's Park, and Plains in 2016.						
	Brief description and activities planned under the mitigation action						
	The mitigation action will achieve the objectives through a comprehensive programme of measures to ensure continued use of installed solar PV. *Financial Component: No additional funding is required for this implemented mitigation action* *Technical support component: The project did not include any additional technical support.*						
	Estimated outcomes and estimated emission reductions						
	The development of the 11 solar PV sites is expected to achieve an emissions reduction of 0.9 Gg CO_2e by 2030.						
	Methodologies and assumptions						
	The quantification of this mitigation action assumes an installed capacity of 0.937MW. The expected generation was estimated to 1,546 MWh annually. *Emission reductions were estimated assuming a replacement of diesel generated electricity currently generated on the island, with an emission factor of 0.589 tCO_2e/MWh.*						
	General description of the monitoring and reporting system						
	As the mitigation action has already been implemented, no additional information is available regarding the development of an MRV system for this action.						
	Action X Key indicators used						
Name of the	**Unit**	**Indicator**	**Indicator target**	**Year**	**Progress**	**Progress to**	**Datasets & sources**

indicator		baseline value	value	baseline and target value relate to	to date	date year	
	Progress indicators						
Installed capacity	*MW*	*0*	*0.937*	*2015*	*0.937*	*2017*	*GRENLEC, 2017*
	Indicators related to GHG impacts						
Installed capacity	*MW*	*0*	*0.937*	*2015*	*0.937*	*2017*	*GRENLEC, 2017*
	Indicators related to sustainable development						
Full time employment (FTEs) following completion	FTEs	0	NE	2015	NE	2017	Government of Grenada, 2017

Name of the mitigation action	Status [idea, planning phase, under implementation]	Implementing institution	Duration (20XX-20YY)	Sector[1] and subsector (if applicable)	Scope [e.g. national, regional, city-wide]	Quantitative targets (both GHG-related and non-GHG impacts, as applicable)	GHGs covered
ID 36 - Solar system (Korean funded)	*Implemented*	*GRENLEC*	*2015-2016*	*Energy supply, renewable energy*	*National*	*Reduction of 0.0 Gg CO_2e by 2030*	*CO_2*
	Objective of the mitigation action						
	The objective of this mitigation action is to reduce emissions from fossil fuel powered electricity generation plants through the development of off-grid solar PV solutions (incl. battery storage) funded by the Republic of Korea.						
	Brief description and activities planned under the mitigation action						
	The mitigation action will achieve the objectives through a comprehensive programme of measures to ensure the use of installed solar PV in rural communities. *Financial Component: No additional funding is required for this implemented mitigation action*						
	Estimated outcomes and estimated emission reductions						
	The development of the 24kW off-grid solar PV solutions for off-grid households is expected to save approximately 23 tCO_2e annually between 2016 and 2024 during the lifetime of the batteries.						
	Methodologies and assumptions						
	The quantification of this mitigation action assumes an installed capacity of 0.024 MW. The expected generation was estimated to 40 MWh annually. *Emission reductions were estimated assuming a replacement of diesel generated electricity currently generated on the island, with an emission factor of 0.589 tCO_2e/MWh.*						
	General description of the monitoring and reporting system						
	As the mitigation action has already been implemented, no additional information is available regarding the development of an MRV system for this action.						
	Action X Key indicators used						

Name of the indicator	Unit	Indicator baseline value	Indicator target value	Year baseline	Progress to date	Progress to date year	Datasets & sources

				and target value relate to			
	Progress indicators						
Installed capacity	*MW*	*0*	*0.024*	*2015*	*0.024*	*2017*	*GRENLEC, 2017*
	Indicators related to GHG impacts						
Installed capacity	*MW*	*0*	*0.024*	*2015*	*0.024*	*2017*	*GRENLEC, 2017*
	Indicators related to sustainable development						
NE	NE	NE	NE	NE	NE	NE	NE

Name of the mitigation action	Status [idea, planning phase, under implementation]	Implementing institution	Duration (20XX-20YY)	Sector[1] and subsector (if applicable)	Scope [e.g. national, regional, city-wide]	Quantitative targets (both GHG-related and non-GHG impacts, as applicable)	GHGs covered
ID 34 - Wind power	*Planned*	*GRENLEC*	*2015-2030*	*Energy supply, renewable energy*	*National*	*Reduction of 9.3 Gg CO_2e by 2030*	*CO_2*
	Objective of the mitigation action						
	The objective of this mitigation action is to reduce emissions from fossil fuel powered electricity generation plants through the development of 2 MW wind turbines by 2030.						
	Brief description and activities planned under the mitigation action						
	The mitigation action will achieve the objectives through a comprehensive programme of measures to promote the development of small scale, hurricane-proofed wind generators. *Financial Component: The mitigation action has currently not managed to acquire sufficient funding for final development.* *Technical support component: The project does not include any additional technical support.*						
	Estimated outcomes and estimated emission reductions						
	The development of 2 MW wind turbines is expected to achieve an emissions reduction of 9.3 Gg CO_2e by 2030.						
	Methodologies and assumptions						
	The quantification of this mitigation action assumes an installed capacity of 2 MW. The expected generation was estimated to 15,770 MWh annually based on the development of wind generators on the island of Bonaire. *Emission reductions were estimated assuming a replacement of diesel generated electricity currently generated on the island, with an emission factor of 0.589 tCO_2e/MWh.*						
	General description of the monitoring and reporting system						
	Due to the initial stage of implementation, no additional information is currently available regarding the mitigation action's MRV system.						

	Action X Key indicators used							
Name of the indicator	**Unit**	**Indicator baseline value**	**Indicator target value**	**Year baseline and target**	**Progress to date**	**Progress to date year**	**Datasets & sources**	

				value relate to			
	Progress indicators						
Installed capacity	*MW*	*0*	*2*	*2015*	*0*	*2017*	*GRENLEC, 2017*
	Indicators related to GHG impacts						
Installed capacity	*MW*	*0*	*2*	*2015*	*0*	*2017*	*GRENLEC, 2017*
	Indicators related to sustainable development						
Full time employment (FTEs) following completion	FTEs	0	NE	2015	NE	2017	Government of Grenada, 2017

Name of the mitigation action	Status [idea, planning phase, under implementation]	Implementing institution	Duration (20XX-20YY)	Sector[1] and subsector (if applicable)	Scope [e.g. national, regional, city-wide]	Quantitative targets (both GHG-related and non-GHG impacts, as applicable)	GHGs covered
ID 37 - LED public lighting	*Planned*	*Government of Grenada, GRENLEC*	*2015-2030*	*Energy supply, energy efficiency*	*National*	*Reduction of 0.2 Gg CO_2e by 2030*	*CO_2*
	Objective of the mitigation action						
	The objective of this mitigation action is to increase the energy efficiency of public street lighting through increased uptake of LED lighting until 2030.						
	Brief description and activities planned under the mitigation action						
	The mitigation action will achieve the objectives through a comprehensive programme of measures to ensure replacement of older conventional public lighting with LED public lighting, assuming a target of 1% by 2020, and 15% by 2030. *Financial Component: No funding has currently been acquired for this mitigation action.* *Technical support component: The project does not include any additional technical support.*						
	Estimated outcomes and estimated emission reductions						
	The increased uptake of LED public street lighting is expected to achieve an emissions reduction of 0.2 Gg CO_2e by 2030.						
	Methodologies and assumptions						
	The quantification of this mitigation action assumes the replacement of 2,337 conventional street light fixtures in 2030 by LED street lights, achieving an energy saving of approximately 819 MWh annually. *The quantification of this mitigation action assumes a general decarbonisation of the electricity grid until 2030.*						
	General description of the monitoring and reporting system						
	Due to the initial stage of implementation, no additional information is currently available regarding the mitigation action's MRV system.						
	Action X Key indicators used						
Name of the indicator	**Unit**	**Indicator baseline value**	**Indicator target value**	**Year baseline and target**	**Progress to date**	**Progress to date year**	**Datasets & sources**

				value relate to			
	Progress indicators						
Numbed of installed LED light fixtures	*Number of LED light fixtures*	*0*	*2,337*	*2015*	*0*	*2017*	*GRENLEC, 2017*
	Indicators related to GHG impacts						
Energy reduction	*MWh*	*0*	*819*	*2015*	*0*	*2017*	*GRENLEC, 2017*
	Indicators related to sustainable development						
Reduced NO_x emissions	Tonnes of NO_x	0	NE	2015	NE	2017	*Government of Grenada, 2017*
Reduced PM_{10} emissions	Tonnes of PM_{10}	0	NE	2015	NE	2017	*Government of Grenada, 2017*

Name of the mitigation action	Status [idea, planning phase, under implementation]	Implementing institution	Duration (20XX-20YY)	Sector[1] and subsector (if applicable)	Scope [e.g. national, regional, city-wide]	Quantitative targets (both GHG-related and non-GHG impacts, as applicable)	GHGs covered
ID 39 - G-Hydro In-Conduit hydropower	*Planned*	*GRENLEC*	*2015-2030*	*Energy supply, renewable energy*	*Regional*	*Reduction of 0.4 Gg CO_2e by 2030*	*CO_2*
	Objective of the mitigation action						
	The objective of this mitigation action is to reduce emissions from fossil fuel powered electricity generation plants through the development of 0.2 MW G-Hydro In-Conduit hydropower by 2030.						
	Brief description and activities planned under the mitigation action						
	Financial Component: No funding has currently been acquired for this mitigation action. *Technical support component: The project does not include any additional technical support.*						
	Estimated outcomes and estimated emission reductions						
	The development of 0.2 MW In-Conduit hydropower is expected to achieve an emissions reduction of 0.4 Gg CO_2e by 2030.						
	Methodologies and assumptions						
	The quantification of this mitigation action assumes an installed capacity of 0.2MW. The expected generation was estimated to 600 MWh annually. *Emission reductions were estimated assuming a replacement of diesel generated electricity currently generated on the island, with an emission factor of 0.589 tCO_2e/MWh.*						
	General description of the monitoring and reporting system						
	Due to the initial stage of implementation, no additional information is currently available regarding the mitigation action's MRV system.						
	Action X Key indicators used						

Name of the indicator	Unit	Indicator baseline value	Indicator target value	Year baseline and target value relate to	Progress to date	Progress to date year	Datasets & sources
	Progress indicators						

Installed capacity	*MW*	*0*	*0.2*	*2015*	*0.0*	*2017*	*GRENLEC, 2017*
	Indicators related to GHG impacts						
Annual generation	*MWh*	*0*	*600*	*2015*	*0*	*2017*	*GRENLEC, 2017*
	Indicators related to sustainable development						
Full time employment (FTEs) following completion	FTEs	0	NE	2015	NE	2017	Government of Grenada, 2017

Name of the mitigation action	Status [idea, planning phase, under implementation]	Implementing institution	Duration (20XX-20YY)	Sector[1] and subsector (if applicable)	Scope [e.g. national, regional, city-wide]	Quantitative targets (both GHG-related and non-GHG impacts, as applicable)	GHGs covered
ID 40 - PV systems	*Planned*	*GRENLEC*	*2015-2030*	*Energy supply, renewable energy*	*National*	*Reduction of 20 Gg CO_2e by 2030*	*CO_2*
	Objective of the mitigation action						
	The objective of this mitigation action is to reduce emissions from fossil fuel powered electricity generation plants through the development of 21.79MW solar PV in Grenada by 2030.						
	Brief description and activities planned under the mitigation action						
	Financial Component: No funding has currently been acquired for this mitigation action. *Technical support component: The project does not include any additional technical support.*						
	Estimated outcomes and estimated emission reductions						
	The development of an additional 21.79 MW solar PV in Grenada is expected to achieve an emissions reduction of 20 Gg CO_2e by 2030.						
	Methodologies and assumptions						
	The quantification of this mitigation action assumes an installed capacity of 21.79 MW. The expected generation was estimated to 33,868 MWh annually. *Emission reductions were estimated assuming a replacement of diesel generated electricity currently generated on the island, with an emission factor of 0.589 tCO_2e/MWh.*						
	General description of the monitoring and reporting system						
	Due to the initial stage of implementation, no additional information is currently available regarding the mitigation action's MRV system.						
	Action X Key indicators used						
Name of the indicator	**Unit**	**Indicator baseline value**	**Indicator target value**	**Year baseline and target value**	**Progress to date**	**Progress to date year**	**Datasets & sources**

				relate to			
	Progress indicators						
Installed capacity	*MW*	*0*	*21.79*	*2015*	*0.0*	*2017*	*GRENLEC, 2017*
	Indicators related to GHG impacts						
Annual generation	*MWh*	*0*	*33,868*	*2015*	*0.0*	*2017*	*GRENLEC, 2017*
	Indicators related to sustainable development						
Full time employment (FTEs) following completion	FTEs	0	NE	2015	NE	2017	Government of Grenada, 2017

Name of the mitigation action	Status [idea, planning phase, under implementation]	Implementing institution	Duration (20XX-20YY)	Sector[1] and subsector (if applicable)	Scope [e.g. national, regional, city-wide]	Quantitative targets (both GHG-related and non-GHG impacts, as applicable)	GHGs covered
ID 54 - Petite Martinique off grid solar PV system	*Planned*	*GRENLEC*	*2015-2030*	*Energy supply, renewable energy*	*Regional*	*Reduction of 1.0 Gg CO_2e by 2030*	*CO_2*
	Objective of the mitigation action						
	The objective of this mitigation action is to reduce emissions from fossil fuel powered electricity generation plants through the development of an off-grid solar PV system including energy storage on the island of Petite Martinique off the coast of Grenada.						
	Brief description and activities planned under the mitigation action						
	Financial Component: No funding has currently been acquired for this mitigation action, but it is currently estimated that solar PV is price competitive with BAU diesel generation on Petite Martinique due to the cost of fuel on the island. *Technical support component: The project does not include any additional technical support.*						
	Estimated outcomes and estimated emission reductions						
	The development of the 1.0 MW solar PV off grid system including energy storage on the island of Petite Martinique is expected to achieve an emissions reduction of 1.0 Gg CO_2e by 2030.						
	Methodologies and assumptions						
	The quantification of this mitigation action assumes an installed capacity of 1.0 MW. The expected generation was estimated to 1,668 MWh annually. *Emission reductions were estimated assuming a replacement of diesel generated electricity currently generated on Petite Martinique, with an emission factor of 0.589 tCO_2e/MWh.*						
	General description of the monitoring and reporting system						
	Due to the initial stage of implementation, no additional information is currently available regarding the mitigation action's MRV system.						
	Action X Key indicators used						

Name of the indicator	Unit	Indicator baseline value	Indicator target value	Year baseline	Progress to date	Progress to date year	Datasets & sources

				and target value relate to			
	Progress indicators						
Installed capacity	*MW*	*0*	*1.0*	*2015*	*0.0*	*2017*	*GRENLEC, 2017*
	Indicators related to GHG impacts						
Annual generation	*MWh*	*0*	*1,668*	*2015*	*0.0*	*2017*	*GRENLEC, 2017*
	Indicators related to sustainable development						
Reduced NO_x emissions	Tonnes of NO_x	0	NE	2015	NE	2017	*Government of Grenada, 2017*
Reduced PM_{10} emissions	Tonnes of PM_{10}	0	NE	2015	NE	2017	*Government of Grenada, 2017*
Affordable and clean energy	US$ / kWh	US$ 0.34/kWh	NE	2015	US$ 0.34/kWh	2017	Energy Transition Initiative, 2015 and Government of Grenada, 2017

Name of the mitigation action	**Status [idea, planning phase, under implementation]**	**Implementing institution**	**Duration (20XX-20YY)**	**Sector[1] and subsector (if applicable)**	**Scope [e.g. national, regional, city-wide]**	**Quantitative targets (both GHG-related and non-GHG impacts, as applicable)**	**GHGs covered**
ID 56 – 15 MW additional geothermal energy	*Proposed*	*Government of Grenada; Geothermal Energy Project Management Unit (GPMU)*	*2020-2030*	*Energy supply, renewable energy*	*National*	*Reduction of 77.0 Gg CO_2e by 2030*	*CO_2*
	Objective of the mitigation action						
	The objective of this mitigation action is to reduce emissions from fossil fuel powered electricity generation plants by fostering renewable energy generation through the development of an additional 15 MW geothermal energy in Grenada, beyond the currently implemented project at Mt. St. Catherine.						
	Brief description and activities planned under the mitigation action						
	Financial Component: No funding has currently been acquired for this mitigation action. *Technical support component: The project does not include any additional technical support.*						
	Estimated outcomes and estimated emission reductions						
	The development of the geothermal energy site is expected to achieve an emissions reduction of 77.0 Gg CO_2e by 2030, assuming the plant is completed in 2025.						
	Methodologies and assumptions						
	The quantification of this mitigation action assumes the geothermal energy site is completed in 2025. The impact of this mitigation action was estimated assuming an installed capacity of 15MW. The expected generation was estimated to 8,670 MWh/MW installed capacity based on data from another geothermal energy site on the Caribbean island of Saba (http://energeia.nl/nieuws/541432-1607/rapport/BINARY/rapport). Consequently, the annual generation at the site was estimated to 130,050 MWh/annually. *Emission reductions were estimated assuming a replacement of diesel generated electricity currently generated on the island, with an emission factor of 0.589 tCO_2e/MWh.*						
	General description of the monitoring and reporting system						

	Due to the initial stage of implementation, no additional information is currently available regarding the mitigation action's MRV system.						
	Action X Key indicators used						
Name of the indicator	**Unit**	**Indicator baseline value**	**Indicator target value**	**Year baseline and target value relate to**	**Progress to date**	**Progress to date year**	**Datasets & sources**
	Progress indicators						
Installed capacity	*MW*	*0*	*15*	*2015*	*0*	*2017*	*Government of Grenada, 2017*
	Indicators related to GHG impacts						
Replacement of diesel generated electricity	MWh	0	130,050	2015	0	2017	Government of Grenada, 2017
	Indicators related to sustainable development						
Full time employment (FTEs) following completion	FTEs	0	32	2015	0	2017	Government of Grenada, 2017
Affordable and clean energy	US$ / kWh	US$ 0.34/kWh	NE	2015	NE	NE	Energy Transition Initiative, 2015 and Government of Grenada, 2017

Name of the mitigation action	**Status** **[idea, planning phase, under implementation]**	**Implementing institution**	**Duration (20XX-20YY)**	**Sector[1] and subsector (if applicable)**	**Scope** **[e.g. national, regional, city-wide]**	**Quantitative targets (both GHG-related and non-GHG impacts, as applicable)**	**GHGs covered**
ID 45 - Biogas	*Planned*	*Government*	*2015-2030*	*Waste*	*National*	*Reduction of 1.3 Gg*	*CH_4*

and agricultural processor systems		*of Grenada*		*management, renewable energy*		*CO_2e by 2030*	
	Objective of the mitigation action						
	The objective of this mitigation action is to reduce methane emissions arising from landfilling of biodegradable waste through the development of local small-scale biogas installations.						
	Brief description and activities planned under the mitigation action						
	Financial Component: No funding has currently been acquired for this mitigation action. *Technical support component: The project does not include any additional technical support.*						
	Estimated outcomes and estimated emission reductions						
	The development of the biogas installations is expected to achieve an emissions reduction of 1.3 Gg CO_2e by 2030.						
	Methodologies and assumptions						
	Emission reductions were estimated assuming a replacement of diesel generated electricity currently generated on the island, with an emission factor of 0.589 tCO_2e/MWh, and reduced methane emissions.						
	General description of the monitoring and reporting system						
	Due to the initial stage of implementation, no additional information is currently available regarding the mitigation action's MRV system.						
	Action X Key indicators used						
Name of the indicator	**Unit**	**Indicator baseline value**	**Indicator target value**	**Year baseline and target value relate to**	**Progress to date**	**Progress to date year**	**Datasets & sources**
	Progress indicators						
Annual generation	*MWh*	*0*	*NE*	*2015*	*0.0*	*2017*	*GRENLEC, 2017*
	Indicators related to GHG impacts						
Annual generation	*MWh*	*0*	*NE*	*2015*	*0.0*	*2017*	*GRENLEC, 2017*
	Indicators related to sustainable development						
Full time	FTEs	0	NE	2015	NE	2017	Government of Grenada,

employment (FTEs) following completion							2017

Name of the mitigation action	Status [idea, planning phase, under implementation]	Implementing institution	Duration (20XX-20YY)	Sector[1] and subsector (if applicable)	Scope [e.g. national, regional, city-wide]	Quantitative targets (both GHG-related and non-GHG impacts, as applicable)	GHGs covered
ID 55 - Integrated solid waste management	*Proposed*	*Government of Grenada*	*2015-2030*	*Waste management, renewable energy*	*National*	*Reduction of 24.6 Gg CO_2e by 2030*	*CH_4*
	Objective of the mitigation action						
	The objective of this mitigation action is to reduce methane emissions from landfilling of biodegradable waste through collection of landfill gas.						
	Brief description and activities planned under the mitigation action						
	Financial Component: No funding has currently been acquired for this mitigation action. *Technical support component: The project does not include any additional technical support.*						
	Estimated outcomes and estimated emission reductions						
	Collection of landfill gas is estimated to achieve an emissions reduction of 24.6 Gg CO_2e by 2030.						
	Methodologies and assumptions						
	Emission reductions are estimated using the 2006 IPCC waste model.						
	General description of the monitoring and reporting system						
	Due to the initial stage of implementation, no additional information is currently available regarding the mitigation action's MRV system.						

	Action X Key indicators used						
Name of the indicator	**Unit**	**Indicator baseline value**	**Indicator target value**	**Year baseline and target value relate to**	**Progress to date**	**Progress to date year**	**Datasets & sources**
	Progress indicators						
Landfill gas capture	*tCH_4*	*0*	*NE*	*2015*	*0.0*	*2017*	*Government of Grenada, 2017*

	Indicators related to GHG impacts						
Landfill gas electricity generation	*MWh*	*0*	*NE*	*2015*	*0.0*	*2017*	*Government of Grenada, 2017*
	Indicators related to sustainable development						
Full time employment (FTEs) following completion	FTEs	0	NE	2015	NE	2017	Government of Grenada, 2017

Name of the mitigation action	Status [idea, planning phase, under implementation]	Implementing institution	Duration (20XX-20YY)	Sector[1] and subsector (if applicable)	Scope [e.g. national, regional, city-wide]	Quantitative targets (both GHG-related and non-GHG impacts, as applicable)	GHGs covered
ID 57 - Additional 10 MW wind power	*Proposed*	*GRENLEC*	*2025-2030*	*Energy supply, renewable energy*	*National*	*Reduction of 46.4 Gg CO_2e by 2030*	*CO_2*
	Objective of the mitigation action						
	The objective of this mitigation action is to reduce emissions from fossil fuel powered electricity generation plants through the development of an additional 10 MW wind turbines by 2030.						
	Brief description and activities planned under the mitigation action						
	Financial Component: The mitigation action has currently not managed to acquire sufficient funding for final development. *Technical support component: The project does not include any additional technical support.*						
	Estimated outcomes and estimated emission reductions						
	The development of an additional 10 MW wind turbines is expected to achieve an emissions reduction of 46.4 Gg CO_2e by 2030.						
	Methodologies and assumptions						
	The quantification of this mitigation action assumes an additional installed capacity of 10 MW by 2030 beyond the 10 MW already addressed above. This would utilise 60% of the potential (20MW) of wind power in Grenada identified by the Energy Transitions Initiative in 2015. The expected generation was estimated to 78,850 MWh annually based on the development of wind generators on the island of Bonaire. *Emission reductions were estimated assuming a replacement of diesel generated electricity currently generated on the island, with an emission factor of 0.589 tCO_2e/MWh.*						
	General description of the monitoring and reporting system						
	Due to the initial stage of implementation, no additional information is currently available regarding the mitigation action's MRV system.						

	Action X Key indicators used						
Name of the indicator	**Unit**	**Indicator baseline value**	**Indicator target value**	**Year baseline and target**	**Progress to date**	**Progress to date year**	**Datasets & sources**

				value relate to			
	Progress indicators						
Installed capacity	*MW*	*0*	*10*	*2015*	*0*	*2017*	*GRENLEC, 2017*
	Indicators related to GHG impacts						
Installed capacity	*MW*	*0*	*10*	*2015*	*0*	*2017*	*GRENLEC, 2017*
	Indicators related to sustainable development						
Full time employment (FTEs) following completion	FTEs	0	NE	2015	NE	2017	Government of Grenada, 2017

ID	Name of the mitigation action	Mitigation priority	Status [idea, planning phase, under implementation]	Implementing institution	Duration (20XX-20YY)	Sector[1] and subsector (if applicable)	Scope [e.g. national, regional, city-wide]	Quantitative targets (both GHG-related and non-GHG impacts, as applicable)	GHGs covered	Description
4	*Reforestation efforts under*	*Low*	*Proposed*	*Ministry of Agriculture,*	*NE*	*AFOLU*	*National*	*NE*	*CO_2*	*Reforestation efforts under Pilot*

ID	Name of the mitigation action	Mitigation priority	Status [idea, planning phase, under implementation]	Implementing institution	Duration (20XX-20YY)	Sector[1] and subsector (if applicable)	Scope [e.g. national, regional, city-wide]	Quantitative targets (both GHG-related and non-GHG impacts, as applicable)	GHGs covered	Description
	PPCR projects (watershed component)			*Forestry & Fisheries*						*Program for Climate Resilience (PPCR)*
5	*GCCA – OECS Project (land use policy devt. Infrastructure)*	*Low*	*Proposed*	*Ministry of Agriculture, Forestry & Fisheries*	*NE*	*AFOLU*	*National*	*NE*	CO_2	*Land use policy and infrastructure as part of Global Climate Change Alliance and Organisation of Eastern Caribbean States project*
6	*Mangrove reforestation*	*Low*	*Proposed*	*Ministry of Agriculture, Forestry & Fisheries*	*NE*	*AFOLU*	*National*	*NE*	CO_2	*Reforestation of mangrove forests*
7	*Forestry policy and protected areas system plan*	*Low*	*Proposed*	*Ministry of Agriculture, Forestry & Fisheries*	*NE*	*AFOLU*	*National*	*NE*	CO_2	*Development of forestry policy and system plan for protected areas*
8	*Acquisition of lands for public projects and programmes*	*Low*	*Proposed*	*Government of Grenada, Ministry of Finance & Energy, GRENLEC, Ministry of*	*NE*	*AFOLU*	*National*	*NE*	CO_2	*Acquisition of lands for planned public projects and programmes*

ID	Name of the mitigation action	Mitigation priority	Status [idea, planning phase, under implementation]	Implementing institution	Duration (20XX-20YY)	Sector[1] and subsector (if applicable)	Scope [e.g. national, regional, city-wide]	Quantitative targets (both GHG-related and non-GHG impacts, as applicable)	GHGs covered	Description
				Agriculture Forestry & Fisheries						
9	*Declare a RAMSAR site and conduct national awareness of wetland resources*	*Low*	*Proposed*	*Ministry of Agriculture, Forestry & Fisheries*	*NE*	*AFOLU*	*Regional*	*NE*	*CO_2*	*Declaration of wetland site as RAMSAR site, combined with a national awareness campaign*
10	*Propagated 7,000 seedlings (species for coastal stabilization, agroforestry and reforestation)*	*Low*	*Proposed*	*Ministry of Agriculture, Forestry & Fisheries*	*NE*	*AFOLU*	*National*	*NE*	*CO_2*	*Coastal stabilization, reforestation and agroforestry through planting of 7,000 seedlings*
11	*Implement Grenada's Aligned National Action Plan (UNCCD)*	*Low*	*Proposed*	*Government of Grenada*	*NE*	*NA*	*National*	*NE*	*CO_2*	*Implementation of Grenada's Aligned National Action Plan*
12	*Encourage the practice of zero grazing and semi-intensive*	*Low*	*Proposed*	*Ministry of Agriculture, Forestry & Fisheries*	*NE*	*AFOLU*	*National*	*NE*	*CO_2*	*Promotion of zero grazing and semi-intensive management*

ID	Name of the mitigation action	Mitigation priority	Status [idea, planning phase, under implementation]	Implementing institution	Duration (20XX-20YY)	Sector[1] and subsector (if applicable)	Scope [e.g. national, regional, city-wide]	Quantitative targets (both GHG-related and non-GHG impacts, as applicable)	GHGs covered	Description
	management systems									*systems in the agriculture sector*
13	*Nursery development, seedling propagation, reforestation*	*Low*	*Proposed*	*Ministry of Agriculture, Forestry & Fisheries*	*NE*	*AFOLU*	*National*	*NE*	CO_2	*Development of plant nurseries, seedling propagation and reforestation*
14	*Designation of protected areas*	*Low*	*Proposed*	*Ministry of Agriculture, Forestry & Fisheries*	*NE*	*AFOLU*	*National*	*NE*	CO_2	*Designation of protected nature conservation areas*
15	*Develop mechanisms for the management of bush overgrowth in the bush-fire prone areas*	*Low*	*Proposed*	*Ministry of Agriculture, Forestry & Fisheries*	*NE*	*AFOLU*	*National*	*NE*	CO_2	*Development of mechanisms for the management of bush overgrowth in fire prone areas*
17	*Implement programme for mainstreaming climate smart agriculture in the agribusiness sector*	*Low*	*Proposed*	*Ministry of Agriculture, Forestry & Fisheries*	*NE*	*AFOLU*	*National*	*NE*	CO_2, CH_4, N_2O	*Mainstreaming of climate smart agriculture*
18	*Promotion of*	*Low*	*Proposed*	*Ministry of*	*NE*	*AFOLU*	*National*	*NE*	CO_2	*Promotion of*

ID	Name of the mitigation action	Mitigation priority	Status [idea, planning phase, under implementation]	Implementing institution	Duration (20XX-20YY)	Sector[1] and subsector (if applicable)	Scope [e.g. national, regional, city-wide]	Quantitative targets (both GHG-related and non-GHG impacts, as applicable)	GHGs covered	Description
	agroforestry practices so that nutmeg trees are protected by higher trees			*Agriculture, Forestry & Fisheries*						*alternative agroforestry practices to reduce damages to nutmeg plantations*
19	*Promote organic mulch*	*Low*	*Proposed*	*Ministry of Agriculture, Forestry & Fisheries*	*NE*	*AFOLU*	*National*	*NE*	CO_2, CH_4, N_2O	*Promotion of organic mulch in agriculture*
20	*Adoption of no-burn agricultural practices*	*Low*	*Proposed*	*Ministry of Agriculture, Forestry & Fisheries*	*NE*	*AFOLU*	*National*	*NE*	CO_2, N_2O	*Adoption of no-burn agricultural practices*
21	*Controls on agrochemical use*	*Low*	*Proposed*	*Ministry of Agriculture, Forestry & Fisheries*	*NE*	*AFOLU*	*National*	*NE*	CO_2	*Control of agrochemical use*
22	*Organic mix cocoa plantations*	*Low*	*Proposed*	*Ministry of Agriculture, Forestry & Fisheries*	*NE*	*AFOLU*	*National*	*NE*	CO_2	*Promotion of organic and mixed cocoa plantations*
23	*Soil conservation practices such as contour farming and grass barriers*	*Low*	*Proposed*	*Ministry of Agriculture, Forestry & Fisheries*	*NE*	*AFOLU*	*National*	*NE*	CO_2	*Promotion of soil conservation practices such as contour farming and grass barriers*

ID	Name of the mitigation action	Mitigation priority	Status [idea, planning phase, under implementation]	Implementing institution	Duration (20XX-20YY)	Sector[1] and subsector (if applicable)	Scope [e.g. national, regional, city-wide]	Quantitative targets (both GHG-related and non-GHG impacts, as applicable)	GHGs covered	Description
25	*Agriculture biogas systems*	*Low*	*Proposed*	*Ministry of Agriculture, Forestry & Fisheries*	*NE*	*AFOLU, Energy*	*National*	*NE*	CH_4	*Increased uptake of biogas systems in agriculture sector*
26	*Compositing and permaculture activities*	*Low*	*Proposed*	*Ministry of Agriculture, Forestry & Fisheries*	*NE*	*AFOLU, Waste*	*National*	*NE*	CH_4, N_2O	*Promotion of compositing and permaculture*
27	*Expand organic waste recycling (composting)*	*Low*	*Proposed*	*Government of Health*	*NE*	*Waste*	*National*	*NE*	CH_4, N_2O	*Expanding organic waste composting*
28	*Stabled dairy goats with cut-and-carry fodder*	*Low*	*Proposed*	*Ministry of Agriculture, Forestry & Fisheries*	*NE*	*AFOLU*	*National*	*NE*	CH_4, N_2O	*Changed agricultural practices in dairy goat rearing*
29	*Improve the nutrition regime through the establishment of better pastures and forage banks*	*Low*	*Proposed*	*Ministry of Agriculture, Forestry & Fisheries*	*NE*	*AFOLU*	*National*	*NE*	CH_4, N_2O	*Improved pastures and forage banks*
30	*Mt. St. Catherine Geothermal Energy*	*See separate table above*								
31	*Energy supply*	*High*	*Under*	*Ministry of*	*NE*	*Energy*	*National*	*NE*	CO_2	*Development of*

ID	Name of the mitigation action	Mitigation priority	Status [idea, planning phase, under implementation]	Implementing institution	Duration (20XX-20YY)	Sector[1] and subsector (if applicable)	Scope [e.g. national, regional, city-wide]	Quantitative targets (both GHG-related and non-GHG impacts, as applicable)	GHGs covered	Description
	act and other accompanying legislation		*implementation*	*Finance & Energy*						*enabling policy for deployment of renewable energy*
32	*Electric Vehicles*	*See separate table above*								
33	*Solar farms*	*See separate table above*								
34	*Wind power*	*See separate table above*								
35	*Bulb replacement project*	*High*	*Proposed*	*Ministry of Finance & Energy, GRENLEC*	*NE*	*Energy*	*National*	*NE*	*CO_2*	*Replacement of conventional lightbulbs with LED alternatives*
36	*Solar PV (Korean funded)*	*See separate table above*								
37	*LED public lighting*	*See separate table above*								
38	*Energy sector reform to further expand on renewables*	*High*	*Under implementation*	*Ministry of Finance & Energy, GRENLEC, Government of Grenada*	*NE*	*Energy*	*National*	*NE*	*CO_2*	*Development of enabling policy for increased uptake of renewable energy*
39	*G-Hydro In-Conduit Hydropower*	*See separate table above*								
40	*PV systems*	*See separate table above*								
41	*INDC document*	*High*	*Implemented*	*Government of Grenada*	*NE*	*NA*	*National*	*NE*	*CO_2, CH_4,*	*Completed development of*

ID	Name of the mitigation action	Mitigation priority	Status [idea, planning phase, under implementation]	Implementing institution	Duration (20XX-20YY)	Sector[1] and subsector (if applicable)	Scope [e.g. national, regional, city-wide]	Quantitative targets (both GHG-related and non-GHG impacts, as applicable)	GHGs covered	Description
									N_2O	*Grenada's INDC document*
42	*Installation of solar powered pumps*	*Medium*	*Proposed*	*Ministry of Finance & Energy*	*NE*	*Energy*	*National*	*NE*	CO_2	*Promotion of solar powered water pumps*
43	*Use of PV for processing activities (GEF SGP Grenada)*	*Medium*	*Proposed*	*Ministry of Finance & Energy*	*NE*	*Energy*	*National*	*NE*	CO_2	*Promotion of solar PV for processing activities*
44	*Solar dryers (cocoa farming)*	*Medium*	*Proposed*	*Government of Grenada, GRENLEC, Ministry of Agriculture, Forestry & Fisheries*	*NE*	*Energy*	*National*	*NE*	CO_2	*Development of solar driers for the drying of cocoa beans*
45	*Biogas and agricultural processor systems*	*See separate table above*								
48	*Proposal to develop biogas plant for one of the largest distilleries*	*Medium*	*Proposed*	*Ministry of Finance & Energy*	*NE*	*Energy*	*National*	*NE*	CO_2, CH_4	*Development of a biogas plant at one of the largest distilleries in Grenada*
49	*CDB project to*	*Medium*	*Proposed*	*Government of*	*NE*	*Waste*	*National*	*NE*	CH_4,	*Project designed to*

ID	Name of the mitigation action	Mitigation priority	Status [idea, planning phase, under implementation]	Implementing institution	Duration (20XX-20YY)	Sector[1] and subsector (if applicable)	Scope [e.g. national, regional, city-wide]	Quantitative targets (both GHG-related and non-GHG impacts, as applicable)	GHGs covered	Description
	address waste issues	*um*		*Health*					*N_2O*	*address existing waste issues, potentially funded through the CDB.*
50	*Waste streaming and categorisation*	*Medium*	*Proposed*	*Government of Health*	*NE*	*Waste*	*National*	*NE*	*CH_4, N_2O*	*Waste streaming and categorisation*
51	*Waste-to-Energy plant*	*High*	*Proposed*	*Government of Health, GRENLEC, Government of Grenada*	*NE*	*Waste*	*National*	*NE*	*CO_2, CH_4, N_2O*	*Proposed development of 40,000 tonnes per annum state of the art Waste-to-Energy plant. Feasibility studies undertaken.*
52	*Development of Coastal Zone Legislation*	*Low*	*Proposed*	*Government of Grenada*	*NE*	*AFOLU*	*National*	*NE*	*CO_2*	*Development of Coastal Zone legislation*
53	*Initiation of National Climate Change Adaptation Plan (NAP) process*	*Low*	*Planned*	*Government of Grenada*	*NE*	*NA*	*National*	*NE*	*CO_2*	*Initiation of NAP process*
54	*Petite Martinique Solar PV system*	*See separate table above*								

ID	Name of the mitigation action	Mitigation priority	Status [idea, planning phase, under implementation]	Implementing institution	Duration (20XX-20YY)	Sector[1] and subsector (if applicable)	Scope [e.g. national, regional, city-wide]	Quantitative targets (both GHG-related and non-GHG impacts, as applicable)	GHGs covered	Description
55	*Integrated solid waste management*	*See separate table above*								
56	*15 MW additional geothermal energy*	*See separate table above*								
57	*10 MW additional wind power*	*See separate table above*								

APPENDIX VII - Co-benefits of Climate Actions

Table 78-Co-benefits assessment of Grenada's mitigation actions

MITIGATION ACTION	Economic	Health			Natural capital				Social capital		
	Increased economic competitiveness	Improved air quality	Improved lifestyle and exercise	Reduced accidents	Positive impact on biodiversity	Reduced soil pollution	Reduced waste generation	Reduced water pollution	Improved communities	Positive equity impact	Poverty alleviation
ID 30 - Mt. St. Catherine Geothermal energy	3	2	0	0	1	1	0	1	1	1	0
ID 33 - Solar farm	3	3	0	0	2	1	0	1	2	3	2
ID 36 - Solar system (Korean funded)	3	3	0	0	2	1	0	1	2	3	2
ID 32 - Electric Vehicles	2	3	0	0	2	0	1	1	2	2	1
ID 34 - Wind power	3	3	0	0	-1	1	0	1	2	2	1
ID 37 - LED public lighting	1	1	0	1	0	0	0	0	3	3	0
ID 30 - G-Hydro In-Conduit hydropower	3	3	0	0	0	1	0	0	2	1	1
ID 40 - PV systems	3	3	0	0	2	1	0	1	2	3	2
ID 54 - Petite Martinique off grid solar PV system	3	3	0	0	2	1	0	1	2	3	2
ID 56 - 15 MW additional geothermal	3	2	0	0	1	1	0	1	1	1	0
ID 45 - Biogas and agricultural processor systems	2	1	0	1	1	2	2	2	2	2	1
ID 55- Integrated solid waste management	1	1	0	0	1	3	3	2	2	1	1
10 MW additional wind power	3	3	0	0	-1	1	0	1	2	2	1

Colour legend	Strong benefit	Moderate benefit	Light benefit	Neutral	Light adverse effect	Strong adverse effect