Country analysis: Resilience to climate change at a glance

GRENADA CARRIACOU PETITE MARTINIQUE

KEY MESSAGES

Climate change risks

Increased hot season | Major hurricanes | Sea level rise | Warmer oceans | Increasing flash floods | Droughts

Temperatures will continue to rise. Further intensification of the hot season, high to extremely high heat impact potential by 2030, along with more frequent and more intense heat waves. The number of extreme heat events will increase roughly 15-fold by the 2020's and become a nearly year-long occurrence by the 2040s.

Major hurricanes: The frequency of category 4 and 5 hurricanes is expected to increase by 25%–30%. Storms are likely to become 2% to 11% stronger in terms of maximum wind speeds and possibly more frequent.

Continued sea level rise of 11 to 25cm. Rising sea levels combined with stronger winds during the strongest storms substantially increase the potential impact of storm surge and coastal inundation.

Warmer oceans along with steadily rising sea levels, even if global warming is halted in the foreseeable future.Trends in sea surface conditions include a projected rise of 0.77°C to 2.5°C by the end of the 21st century.

Rainfall: Changes in precipitation are more difficult to project; a slight decrease in total rainfall is anticipated, while single rain events will become more intense. Rainfall rates inside hurricanes could increase by up to 30%, increasing flash flood potential.

Droughts will become more prevalent. However, the trend may only become a major issue from the 2050s onwards.

Summary of key socio-economic indicators for Grenada

Total Area (square km)	*344*
Population	*112,200*
Percent Urbanization	*36.3*
GDP per capita	*US$ 15,100*
Debt as a percent of GDP	*70.4*
Unemployment Rate	*24*
Services as a percentage of GDP	*78*
Services as a percentage of workforce	*69*
Agriculture as a percentage of GDP	*6.8*
Agriculture as percentage of workforce	*11*
Percent Agriculture Land	*29,4*
Percent Forests	*50*
Human development Index value	*0,779*

Map of Grenada

Figure 1: www.worldatlas.com

This technical assistance operation is financed by the French Development Agency (AFD) and implemented by Expertise France, within the framework of the Adapt'Action facility. This facility, which began in May 2017, supports African countries, LDCs and SIDs in implementing their commitments under the Paris climate agreement, through financing studies and activities on capacity-building and technical assistance, especially in the adaptation sector.

OVERVIEW

The archipelagic, independent state of Grenada is composed mainly of three islands, namely Grenada, Carriacou, and Petite Martinique. It is centred on 11°58′ N Latitude, and 61°20′ W Longitude and is part of the **Windward Islands** chain **of the Lesser Antilles**. The Island of Grenada is 34 km long and 18km wide and the three islands taken together have a land area of 345 sq. km. In 2014, Grenada's population was estimated at 106,300.

The island is internationally renowned as the "Island of Spice" as it is the second largest exporter of nutmeg in the world. Generally, the country is characterised by mountainous terrain ringed by extensive coral reefs. The highest point, Mt. St. Catherine, lies 833 metres above sea level. Rich, volcanic soils and the elevated rainfall allow for dense rainforest over much of the inland regions of the island of Grenada, with a more drought-tolerant natural vegetation type in the southwest of the island, as in the Grenadines, which receive far less rainfall.

Grenada is exposed to trade winds, which keep temperatures moderate at around 27.5°C along the coastline, but with higher humidity and rainfall, as well as lower temperatures with increasing elevation. The hot season (May to October) is characterized on average by 31 hot days (when day-time high temperatures are close to or exceed 32°C) and 36 hot nights (with night-time lows above 26°C), as well as by several heat waves. During the cool season (December to March), heat levels are comfortable and 31 cool nights (with lows below 22.7°C) occur on average.

The average annual rainfall totals range from around 1150 mm in the extreme southwest to over 3000 mm at the higher elevations. Similar to the extreme southwest of Grenada, rainfall in the Grenadines (the two together forming the 'drier areas') is about 50% lower than in low-lying areas of the island of Grenada that are flanked by mountains. The wet season spans June to November, coinciding with the Atlantic hurricane season. Each of the wet season months totals around 150 mm in the extreme southwest of Grenada, but 200 mm or more in other areas of the island. Extreme rainfall has the potential to trigger one to two flash floods per year between June and December. By contrast, seven consecutive dry days occur frequently throughout much of the year in the drier areas except between June and August, limiting growth of sensitive crops to a narrow three-month period there. Finally, impactful drought occurs on average once per 6-7 years during the dry season, and once every 12 years in the wet season, potentially impacting fresh water availability, particularly in the drier areas.

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CLIMATE TRENDS AND PROJECTIONS

OECS, with CIMH, undertook an extensive analysis of the current trends and future projections of climate for the region was based on data from various meteorological services across the region, as well as future projections from regional circulation models (RCMs) developed by the Climate Studies Group of the University of the West Indies. In terms of priorities of relevance for the Windward Islands, these climate trends and projections (across a range of emissions scenarios: a low (Representative Concentration Pathway 2.6 – RCP2.6), mid-range (RCP4.5) and high (RCP8.5)), (see details page 8) point to the following risks.

PROJECTED HEAT TRENDS

Figure 2 shows that the increase in frequency of hot days and nights in the Leeward Islands is further accelerated into the 2020s, when frequency is eight-fold, to end up close to a 100% of all days in the year in most years during the 2040s. However, given the recent observed increase rate appears to be somewhat slower for hot days and hot nights, one might expect a delay in reaching a near 100% frequency.

For **cool days and nights**, one can see that, from a 1961-1990 model baseline of 10% frequency, a decrease of over 75% was already noted by 1981-2010. This compares to observed decrease rate of over 60% for cool days and over 40% for cool nights.

Cool days and nights become virtually absent from the projected future as early as the 2020s.

Finally, looking at the number of days spent in **heat waves** of at least six consecutive days (the so-called warm spell duration index or WSDI), a remarkable increase is noted across all three scenarios, as well as, in the observations.

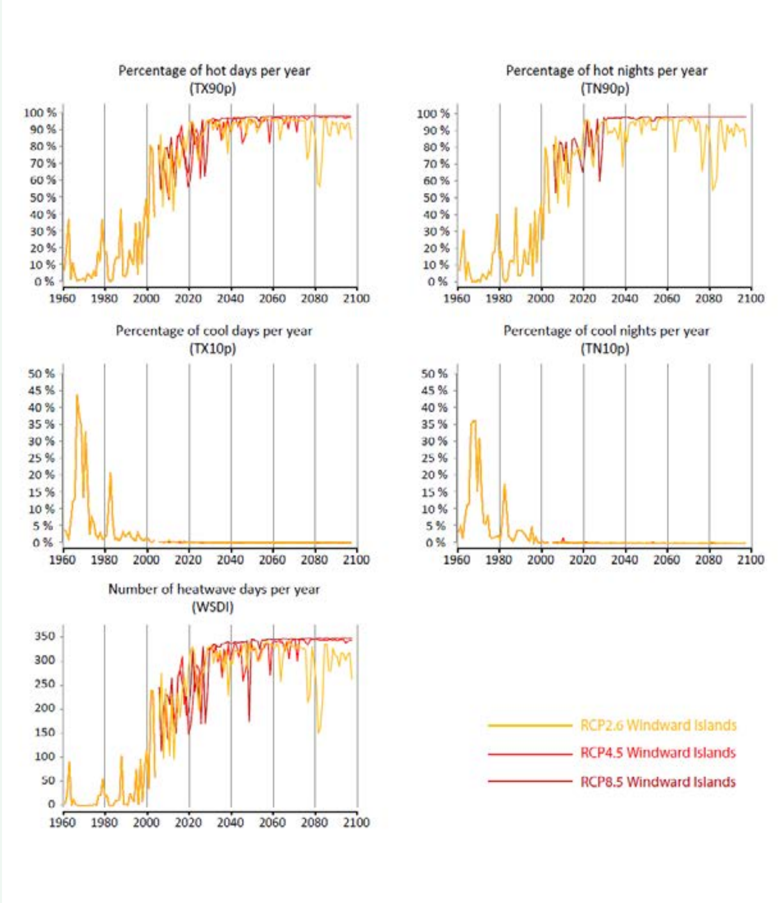


Figure 2

For the Windward Islands: simulated annual trends in the percentage of hot days (TX90p, top left), hot nights (TN90p, top right), cool days (TX10p, middle left) and cool nights (TN10p, middle right) per year -, as well as, trends in the annual number of heatwave days during long heat waves of at least six consecutive days (WSDI, bottom) from three downscaled projections.

Whereas the simulated baseline period only recorded 18 such heatwave days per year on average, the numbers had already increased fivefold by 1981-2010 to further increase roughly 15-fold by the 2020s and becoming a nearly yearlong occurrence by the 2040s.

It should be stressed that the strong simulated trends in the heat-related indices after around 1980 only corresponds well qualitatively with the strong observed trend. However, even with the downscaled projections overestimating the actual trends, hot days and hot nights will likely occur during most days of each year by mid-century, while cool days will likely disappear much sooner. Unfortunately, this committed future change seems to be mostly unavoidable, because the conclusion is valid no matter what RCP scenario is considered.

EXTREME RAINFALL

Projected Changes in Extreme rainfall

As can be seen from Figure 3, there are **no clear signals in projected trends of extreme rainfall.** Clearly, the year-to-year variability exceeds by far the long-term trend in both the proportion of annual rainfall totals from extremely wet days R95pTOT) and the number of days with heavy rainfall (R10mm). While the former appears to increase over time in all three scenarios, the R10mm decreases in both RCP4.5 and RCP8.5. However, if both trends do manifest, this means extreme rainfall will become less frequent, but even more intense. This means that the potential for flash flooding and related hazards may increase throughout the 21st Century, though changes may be hardly detectable by the 2020s and 2040s. An indication of such increasing flash flood potential towards 2100 comes from the fact that the RCP8.5 systematically projects fewer years with at least 5 days with heavy rainfall than RCP4.5 during the second half of the Century. The same is apparent when comparing RCP4.5 to RCP2.6. Indeed, the period 2050 to 2089 contains 19 years with at least 5 days with heavy rainfall in RCP2.6, versus 16 in RCP4.5 and only 10 in RCP8.5.

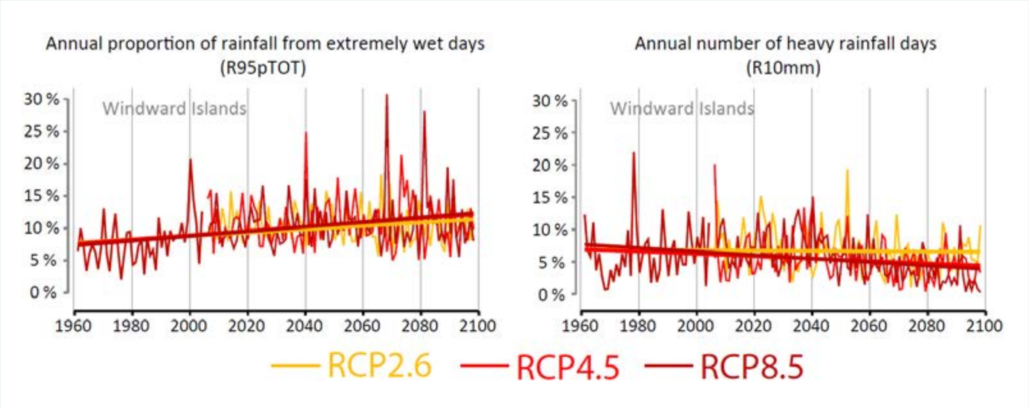


Figure 3

For the Windward Islands: Simulated annual trends in the percentage of the rainfall total from extremely wet days (i.e., days with rainfall above the 95th percentile only (Rp95TOT, left), the number of days with heavy rainfall (i.e. with at least 10 mm of rainfall – R10mm, right). Also plotted are the simulated trends in the duration (in days) of the longest dry spell (CDD, bottom). The results are shown for the RCP2.6, RCP4.5 and RCP8.5 downscaled projections.

Notes: The absence of significant simulated trends in Rp95TOT and R10mm indicates that flash flood potential may not significantly change in future. Also plotted are the simulated trends in the duration (in days) of the longest dry spell (CDD, bottom). The results are shown for the RCP2.6, RCP4.5 and RCP8.5 downscaled projections. Data source: projections provided by the Climate Studies Group Mona of the University of the West Indies – Mona Campus, Jamaica

DROUGHT

Drought has been and will remain an integral part of climate in the OECS region. This hazard, while physically dependent on both rainfall and evapotranspiration rates, is of lesser concern in the wetter islands with complex topography than in drier, low topography areas of the OECS region. However, where water consumption is intense due to high population density or high consumption by the islands' industries, the sensitivity of the environment and society to drought is significant.

Rainfall-Based Drought Indices

Meteorological drought can be defined as a deficit of rainfall over a period of several weeks to years.

When drier than normal conditions are significant and extend long enough to reduce the amount of available soil moisture, this can lead to crop wilting. Such droughts are called agricultural drought. If drought extends long enough to affect streams, rivers and water reservoirs above and below ground, one can refer to such droughts as hydrological drought. With reduced freshwater availability during prolonged hydrological drought, other socio-economic sectors start being affected, e.g. firefighting, household water provision, construction, tourism, etc. Such drought may be referred to as socio-economic drought.

Typically, reduced soil moisture and reduced flow in streams and small rivers takes anywhere between a number of weeks and about 6 months of rainfall deficits – i.e. **short-term drought** – to manifest. After 6 months of significant meteorological drought, stream flow in larger rivers and water levels in large reservoirs becomes affected. Finally, after about 9 to 12 months of rainfall deficits – i.e. **long-term drought** –, water levels in the largest surface reservoirs and in aquifers tend to lower and stream flow in the largest rivers tends to decrease.

Hence, a proxy for the different types of droughts should account for the different timescales involved. Furthermore, it should be scalable to the national context of water management. Its calculation should be possible given the climate record available within the territory.

HEAT - AN UNDERESTIMATED HAZARD

Air temperature does not vary much between seasons and years in Grenada. The heat – being moderated by a prevalent easterly breeze – has **historically** not been regarded as a major hazard but, at best, a discomfort at times. However, with rising temperatures year-round, a more pronounced heat season with more frequent and intense heatwaves are becoming a **new norm**. Heat discomfort and heat stress has started affecting society and the environment. Important impacts (supported by research findings from around the world, including tropical regions and, where references are given, Caribbean countries):

Human health: increased heat-related **mortality and morbidity** (suspected, but not measured in the territory– note that heatwaves are the deadliest weather-related hazard), in particular in persons with lower fitness; increased apathy and aggression; accelerated proliferation of vector borne diseases such as Dengue, etc. (e.g. Lowe et al., 2018).

Education: children's **learning ability** significantly decreases with increased heat exposure.

Energy: increased cooling demand and reduced efficiency in energy production.

National productivity: loss of hundreds of **man hours.**

Environment: exacerbation of **drought**; facilitation of **wildfires**; stress on **animal populations.**

Food security: crop failure due to wilting; severe heat stress related mortality and **morbidity in livestock** (e.g. Lallo et al., 2018).

One such proxy, recommended by the WMO is the Standardized Precipitation Index (SPI, McKee et al., 1993). The SPI is calculated as a normalized precipitation anomaly over 1 month to 48 months. Given that most droughts in the OECS are seasonal in nature, the most relevant indices are SPIs calculated over three-month (SPI-3), six-month (SPI-6) and twelve-month (SPI-12) periods. However, it is possible for rainfall deficits to exceed 12 months as was the case during the 2014 to 2016 Caribbean drought.

Finally, because freshwater availability from soils and surface reservoirs can be reduced due to enhanced evapotranspiration rates relative to rainfall, a similar index called the Standardized Precipitation Evapotranspiration Index (SPEI, Vicente-Serrano et al., 2010) can be very useful in monitoring drought. The index is constructed in the same way as the SPI and can therefore be calculated over any relevant time period (e.g. SPEI-3, SPEI-6 and SPEI-12). However, it offers the advantage of calculating a balance between rainfall (i.e. local water input onto the surface) and evapotranspiration (i.e. local water output from the surface).

Projected Changes in Drought

Projected trends in drought are shown in Figure 4 for RCP4.5 and RCP8.5) from 2020 to 2090. Aside from a marked increase in heat exposure, the future projections also indicate that **drought will become more prevalent.** However, the trend may only clearly manifest from the 2050s onwards. An SPI value of around 0 is expected on average if rainfall totals are not changing from the 1961-1990 model climatology. However, in the RCP4.5 projection the SPI-6 shifts from close to 0 in the 2020s and 2030s to -0.6 and the SPI-12 from 0 to -1.4 – the latter value falling in the very dry category – in the 2070s and 2080s. Over the same periods in RCP8.5, the SPI-6 shifts from near 0 to -0.8 – moderately dry – and the SPI-12 from near 0 to -1.8, or **extremely dry on average** in the 2070s and 2080s. Those significant trends stand out even with the large interannual variability in both the SPI-6 and SPI-12.

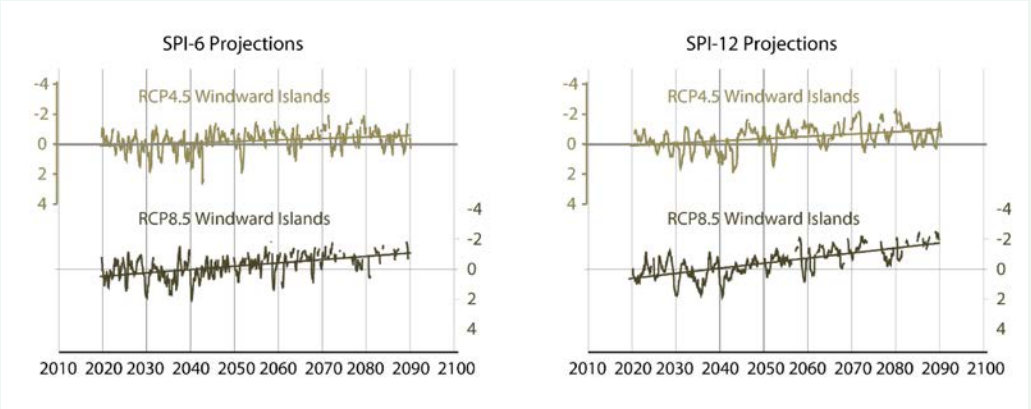


Figure 4

For the Windward Islands: Simulated trends in the standardized precipitation index over six months (SPI-6, left) and twelve months (SPI-12, right) per year on Windward Islands from the RCP4.5 and RCP8.5 downscaled projections.

Data source: projections provided by the Climate Studies Group Mona of the University of the West Indies – Mona Campus, Jamaica

EXTREME WET SPELLS - A PROXY FOR FLASH FLOOD POTENTIAL

The copious rainfall of Grenada occurs when spells of intense showers occur in a rapid succession over a small number of days and associated with weather disturbances. The recurring heavy rains during such **wet spells** can be beneficial for replenishing major water reservoirs. However, extremely intense showers often lead to flash flooding.

Flash floods occur when the rainfall accumulation rate exceeds the rate of soil infiltration and surface drainage. There are rainfall thresholds beyond which the occurrence of wet spells correlates well with the occurrence of flash flood across much of the Caribbean. Caribbean-wide, such **extreme wet spells** are defined as a three-day period during which the rainfall totals are among the top 1% (i.e. exceed the 99^{th} percentile) of all three-day rainfall totals in the historical record at a weather station (CSGM and CIMH, 2020).

While the flood record is incomplete and the number of recorded floods too low for robust statistical analysis, the use of extreme wet spell occurrence as a proxy for flash flood potential is validated regionally by similar findings in countries with a much larger sample of floods.

FUTURE CLIMATE PROJECTIONS - THE USE OF SCENARIOS AND CLIMATE MODELS

The most widely used tools to assess and simulate future or projected climates are **Global Climate Models** (GCMs, in academic circles referred to as General Circulation Models or Earth System Models). Such models can simulate to a great level of detail and reasonable accuracy how climate would behave around the world provided a scenario of socio-economic evolution or external physical factors would affect the energy balance of the earth's climate system. Three commonly used scenarios are the **RCP2.6** (a scenario based on a low carbon emissions future), **RCP4.5** (medium level of emissions) and **RCP8.5** (high emissions), elaborated by the Intergovernmental Panel on Climate Change (IPCC).

The major advantage of GCMs for the purpose of assessing how climate may change through time in future, is that they provide a **full spatio-temporal coverage** of earth's atmosphere. However, for the purposes of small island states in the OECS region, the spatial resolution is **far too coarse** to allow rigorous sub-regional analysis of future heat, drought and climate extremes. Island sub-regions such as the OECS are better served by **Regional Climate Models** (RCMs), which offer finer spatial resolutions. Among the CMIP-5 generation of projections run by a multitude of different GCMs and used in the IPCC's Fifth Assessment Report and many studies thereafter is the HadGEM2 GCM. To enable sub-regional analysis of trends in extremes, downscaled simulations can be performed using the **PRECIS regional climate** model.

Climate change may put pressures on our societies and environments by shifting them closer to or beyond the thresholds of their coping ranges. Therefore, climate projections are conceived to help provide the **scientific evidence base** for societies to adapt to climate change in future and hence build climate resilience for future generations. Such projections provide necessary insight to support **long term planning** for infrastructure, societal activities and the protection of environmental resources. In this climate profile, a special emphasis will be placed on two-time horizons: a **short-term horizon**, namely the 2020s (relevant within the current political context), and a **mid-term horizon**, namely the 2040s, relevant for infrastructure planning and many other societal and environmental systems.

SOCIOECONOMIC CHARACTERISTICS

Population

Grenada's total population was estimated at 109,374 in 2014 (Government of Grenada, 2015b) with the majority between the ages of 15 and 55. Based on the data from 2011, there was a near-equal gender ratio; 50.5% males, and 49.5% females (Government of Grenada, 2015a). The average life expectancy rose from 73 in 2008 to 76 years in 2013. In 2013 life expectancy for females was 79 years, which is higher than that recorded for males, i.e. 74 years (Government of Grenada, 2017).

Main economic drivers

In the past two decades, Grenada's economy has switched from being agriculture based to a service-based one. During these same two decades, the country's economy has shown steady growth, with an average annual rate of 3.4% (IDB, 2013). However, Hurricanes Ivan and Emily, along with the recent global economic climate, have caused major setbacks. Table 2 shows the sectoral contributions to GDP during the year 2013.

Tourism

In 2014, it was estimated that tourism directly contributed XCD$154.4 million to Grenada's economy (World Travel and Tourism Council, 2015). As an island in the Caribbean, Grenada offers a traditional "sun, sand and sea" destination. However, it has recently expanded its tourism through the development of ecotourism, heritage tourism and "edu-tourism". In 2018, there were a total of 528,637 visitors to Grenada of whom 160,975 were defined as stay-over visitors. The main countries of origin for stay-over visitors are the USA (61,422), other Caribbean countries (27,000), the UK (22,753), Canada (13,784) and others (36,016) (ECCB, 2018). In 2015, Grenada's tourism sector directly supported 3,550 jobs (8.7% of total employment). Most of these employees were female, accounting for 11.1% of the total female population, compared to males, who accounted for 6.7% of the total male population (Grenada Statistics Department, 2016).

Table 1

Population and Gender by Parish 2011
(Government of Grenada, 2011)

PARISH	MALE	FEMALE	TOTAL
Rest of St. George	17568	17550	**35118**
St. Andrew	13467	13036	**26503**
St. David	6465	6412	**12877**
St. Patrick	5316	5187	**10503**
St. John	4356	4110	**8466**
Carriacou and Petite Martinique	2866	2795	**5661**
St. Mark	2304	2102	**4406**
Town of St. George	1556	1577	**3133**
Total	**53898**	**52769**	**106667**

Table 2

Contribution to GDP by industry (%) in 2013 and projections for 2014 *(Government of Grenada, 2017)*

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

Energy

Grenada's energy mix is dominated by imported fossil fuels (from Venezuela under the PetroCaribe Agreement), which account for over 98% of nation's energy; the remainder is from renewable sources (CARICOM, 2015a; National Renewable Energy Laboratory, 2015). These fuels are used primarily for transportation, electricity generation and cooking. The largest consumers of energy, with just over 84%, are the small commercial and residential sectors (Government of Grenada, 2017).

Transport

International and domestic air transport in Grenada falls under the purview of the Grenada Airports Authority (GAA) and is facilitated by the Maurice Bishop International Airport and Lauriston Airport. There are several ports scattered across the country which facilitate maritime transport. The main port in Grenada is the Port of St. George's, which accommodates both cargo and cruise vessels. Public transportation is currently operated by privately-owned buses which service a number of routes. Private transportation, through purchase or rental, is available for both residents and visitors. In 2009 there were an estimated 26,400 registered vehicles with a historic average increase of approximately 1,200 vehicles per year over the decade prior (Government of Grenada, 2011d).

Land use

As can be seen in Figure 5 all except artificial areas were shown to have decreased in size between 2000 and 2010.

Agriculture

Grenada is known in the Caribbean as the Island of Spice, reflecting the importance of spices, especially nutmeg and mace, to its economy. Nutmeg is also critical to the island's culture and was once the main source of livelihoods and economic benefits for the country's rural population (Government of Grenada, 2010). However, Hurricanes

Table 3

Employed population by industry and Gender
(Government of Grenada, 2011)

ECONOMIC SECTORS	MALE	FEMALE	TOTAL
Wholesale and Retail Trade	*2951*	*3272*	***6223***
Construction	*4238*	*202*	***4440***
Education	*1097*	*2700*	***3797***
Public administration and defence	*1864*	*1747*	***3611***
Agriculture, Forestry and Fishing	*2785*	*604*	***3389***
Accommodation and food service activities	*864*	*1550*	***2414***
Transportation and storage	*1885*	*410*	***2295***
Manufacturing	*1243*	*713*	***1956***
Human health and social work activities	*285*	*1519*	***1804***
Administrative and support service activities	*1009*	*757*	***1766***
Financial and insurance activities	*375*	*733*	***1108***
Activities of households	*87*	*915*	***1002***
Other service activities	*390*	*498*	***888***
Professional, scientific and technical activities	*237*	*370*	***607***
Arts, entertainment and recreation	*389*	*189*	***578***
Information and communication	*324*	*226*	***550***
Water	*317*	*64*	***381***
Electricity	*193*	*71*	***264***
Real estate activities	*27*	*26*	***53***
Mining and Quarrying	*20*	*18*	***38***
Activities of extraterritorial organisations and bodies	*14*	*23*	***37***
Not stated	*2199*	*2000*	***4199***
Total	***22793***	***18607***	***41400***

Ivan and Emily (2004 and 2005) destroyed 90% of the nutmeg trees, resulting in Grenada's market share of nutmeg dropping from around 25% of the world nutmeg trade in the early 2000's to roughly 3% after 2005, and it has still not fully recovered (ProTrade Consult and International Economics, 2015). Despite this, 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. This decline in nutmeg has somewhat supplemented the increase in exports of cocoa and cocoa preparations and, more recently, fish (IDB, 2013). In 2014 fish products and crops were the primary exports for Grenada, contributing 69.9% to overall exports (ECCB, 2016b). Agriculture in Grenada is now characterised by small-scale, family-run farms. In 1977, Agriculture contributed 20% to Grenada's GDP, however by the end of the century it had fallen to just over 6% (ECCB, 2016a). In 2014 the sector was estimated to account for only 5.82% of GDP, which was mainly from "Other Crops" (all produce except for bananas and nutmeg) (ECCB, 2016a). In 2008, the agriculture and fisheries sectors combined contributed almost 9% of total employment (Caribbean Development Bank, 2008).

Health

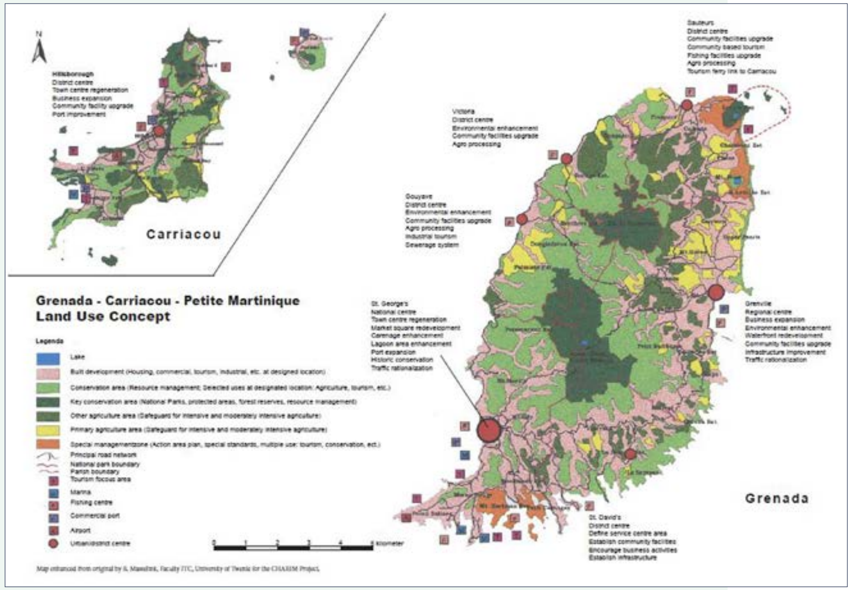
There are currently seven hospitals in operation, four of which are public-owned (Government of Grenada, 2013), six district health centres and thirty medical stations across the island (Ministry of Health, 2016). Private entities and non-governmental organisations also exist which provide health services and contribute to national health (Government of Grenada, 2017). The Environmental Health Division also provides public health services, such as water quality; vector monitoring and control; food safety investigation; waste management; monitoring, investigation, control and evaluation of the spread of infectious diseases; and controlling the spread of hazardous materials (Ministry of Health, 2016).

Table 4

Changes in Land use in Grenada
(Government of Grenada, 2017)

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	

LAND USE IN GRENADA



VULNERABILITY OF SECTORS TO CLIMATE RISKS

WATER RESOURCES

The trend indicating a decrease in the extents of water-related ecosystems is observable in all OECS Member States (except Grenada) that report information on SDG 6 achievements. In terms of water stress, the most critical situation is currently observed in St. Kitts and Nevis with a water stress index of 51%, followed by St. Lucia with an index of 14%. The rest of the islands are not under critical water stress, although the current situation can change drastically as the impacts of climate change mainly affect water resources. There is still a lack of information concerning the impacts of climate change on water resources in OECS Member States, as well as on the identification of possible conflicts of use that may occur in the future if climate change further affects water resource systems resulting in increased scarcity. Nevertheless, some of the Eastern Caribbean islands are already water-stressed for at least part of the year. Some of them currently rely heavily on desalinization or unsustainable abstraction of groundwater resources, especially to serve the tourism industry. Changes in temperature, rainfall and extreme events will inevitably lead to reductions in water availability and quality, as a result both of damage to service infrastructure and reduced water quality through siltation of streams and rivers via landslides and destructive floods.

AGRICULTURE AND FOOD SECURITY

Agriculture is a critical sector in the economies and livelihoods of many of the countries in the Eastern Caribbean, although the region still relies heavily on food imports to meet local needs, at a significant cost. The sector comprises primarily rain-fed, small-scale subsistence farms growing multiple crops such as yams, sweet potatoes, and various vegetables such as peppers. There are also some large commercial farms focused on export crops such as banana and plantain, coconut, citrus, mango, and avocado. Specialty crops such as nutmeg, cinnamon, ginger and cloves are also important export earners for some islands such as Grenada. Other important grown crops are tropical fruit, coconut, cocoa, vegetables, herbs, tree crops and cut flowers.

Livestock production, likewise, is a basic source of food security for local populations in the Caribbean. Cattle, pigs, chickens, and goats are widely produced across the region, as are dairy foods. The sector is integral to rural ivelihoods, providing food, materials, income and mechanical power for pulling carts and ploughing fields. Most of the livestock production follows a similar dynamic to that of agriculture, with 14 small-scale subsistence and commercial producers catering primarily to a domestic market. However, recent efforts to diversify the agricultural industry in response to climate change and global markets have supported livestock exports.

Fisheries will be severely impacted by climate variability and change, as the associated impacts of rising seas and extreme weather events alter the productivity of aquatic habitats and the distribution and productivity of marine fish species. These changes are threat multipliers to existing stressors on the sector, including overfishing, loss of habitat, pollution, coral bleaching, and the proliferation of invasive species.

TOURISM

Tourism is essential to the economy of the Eastern Caribbean, contributing substantially to territorial GDP and serving as a source of employment across the region. Tourism relies on critical, government-owned infrastructure such as airports and seaports serving travel between islands, as well as on coastal communication systems, utilities and roads. Tourism also depends on a range of privately-owned infrastructure, including hotels and other beach facilities as well as boats for ocean activities and vehicles for land transportation. All this infrastructure is vulnerable both to rising sea levels and damage from floods and storm surge, and more directly to the impacts of hurricanes and other extreme events.

COASTAL RESOURCES

Coastal zones in the Eastern Caribbean are highly vulnerable to changes brought about by climate-change forces such as rising sea levels, warming ocean temperatures, increasing ocean acidity, and the impact of storms. Rapid coastal erosion and increased salinization of coastal areas, as well as impacts on coral bleaching, have immediate impacts. Vulnerability is also increased through inappropriate land use planning and badly designed coastal works such as constructions built right on the coast, too close to the beach, hard longitudinal coastal defences on upper beaches (seawalls, revetments), hard cross-shore coastal structures (jetties, groynes), and reclamation of wetlands and mangroves. Built infrastructure, including roads, settlements, hotels and coastal defences, as well as sand mining and other resource extraction and coastal activities have jeopardized the coast and contributed to the destruction of important living resource systems, such as coral reefs, mangroves and seagrass beds.

TRANSPORT SECTOR AND BUILT ENVIRONMENT

Sea level rise, shifting temperatures and precipitation patterns are climatic changes to baseline conditions that affect transport and housing — and especially the people living there. These changes can lead to more frequent or more severe droughts, floods, tropical storms and storm surge, and should be considered in road and housing design, siting, materials selection, construction, use, and maintenance. Roads and housing, especially permanent structures, need to be designed to reduce exposure and sensitivity to climate variability and change. Improperly or poorly constructed housing presents one of the greatest risks associated with climate hazards, leaving inhabitants highly vulnerable. Relocation of settlements may become necessary due to gradual impacts such as sea level rise; however, many questions remain on the relocation issue. In many cases managing for greater uncertainty and risk associated with potential extreme conditions rather than past historical trends should be applied. This type of focus on risk analysis and management is commonly applied by the financial and insurance industries and can also be used in assessing proposed development activities.

IMPACTS OF RAPID-ONSET EXTREME EVENTS

Most of the Eastern Caribbean is made up of small island developing states. When an extreme event happens, it is therefore likely to overwhelm an entire country or territory because of its small size and have an outsize impact on national GDP. Emergency services are likely to be overwhelmed, while critical infrastructure serving the entire country may be significantly damaged or destroyed. The devastation is likely to be debilitating without outside support to address the immediate needs of the population. Figure 6 et 7 show the number of people affected by key natural hazards between 1985 and 2018 (Source: World Bank Climate Change Portal).

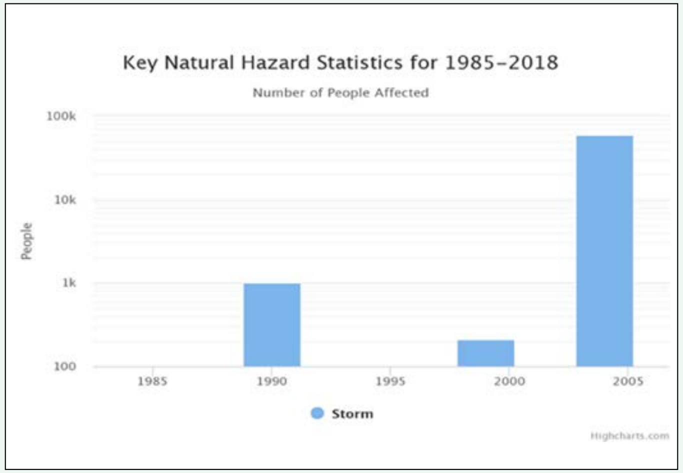


Figure 6

Number of people affected by key natural hazards in Grenada.

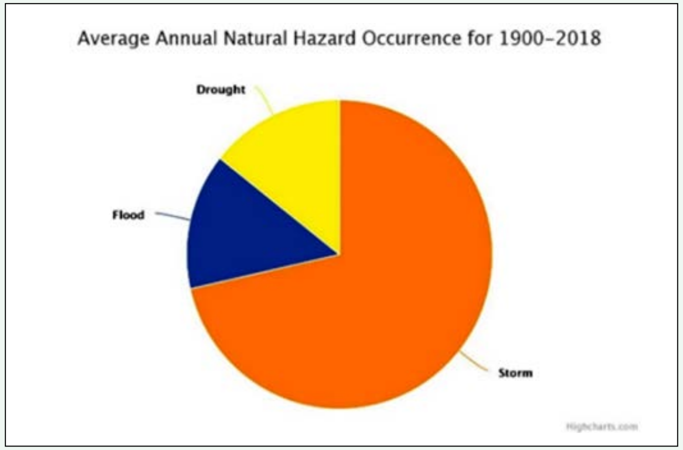


Figure 7

Frequency distribution of natural hazards in Grenada.

Gaps in research and information

Although significant progress has been made to collate the available historical records of climate and hazards, there are still large variations in the needs and quality of research, information, and data.

Research gaps

- Analyses allowing a robust description of the climatology, variability, extremes and trends at any location are possible if long, good quality data records of (sub-)daily weather observations are available. This was, to a large extent, the case for the Maurice Bishop International Airport (MBIA) station at Grenada's south-western tip of Point Salines, an area known to be much drier than much of the island of Grenada. However, no sufficiently long daily data records are available for any other location on Grenada or anywhere in the Grenadines. Therefore, comprehensively assessing the nature of climate hazards for communities in other areas of the island of Grenada and for the Grenadines is an immense challenge.
- Some knowledge has been gathered since the 1990s on drivers of drought, excessive rainfall and tropical cyclones in the Caribbean as a whole. However, little information is available on the drivers of heat, extreme rainfall, sea level rise at the OECS regional level, let alone the national level in Grenada.
- Knowledge on the impacts of and risk associated with hurricanes, sea level rise and rising ocean temperatures engendering coral reef bleaching in the Caribbean is relatively well established. In addition, recent efforts have led to some advancement in mapping flash flood/flooding and drought as hazards and risk factors to socio-economic sectors in the Caribbean and, by extension, Grenada. However, not much is known or measured with respect to heat impacts on the country's society and environment.

Data and information gaps

- The MBIA airport record of daily weather observations exceeds 30 years in length. This makes the climatological analysis robust for the low-lying, drier areas with respect to heat- and drought-/dryness-related hazards. However, since extreme rainfall occurrence is a smaller-scale, highly variable physical process and extreme rainfall occurrence is typically enhanced by pronounced topography, data records of daily rainfall for the wetter portions of the island and for the drier Grenadines would be beneficial to assess flash flooding across the island.
- Much more so than weather observation data, socio-economic and environmental impact data with respect to climate-related hazards beyond tropical cyclones and sea level rise are scant in the Caribbean, let alone Grenada. While in-depth data mining has not been done, regional experience teaches that this is particularly the case for heat impacts. Apart from sea level rise, heat is the one hazard that has already intensified and that we are most confident will continue to intensify. Therefore, in future, heat impacts on public health, agriculture, water, education, energy and labour need to be observed and archived and data sets made available for research, so as to determine the different dimensions of risk from excessive heat exposure.

CLIMATE CHANGE POLICY PRIORITIES IN TERMS OF ADAPTATION

Grenada is a full participating Member Sate of both the Organisation of Eastern Caribbean States (OECS) and the Caribbean Community (CARICOM), and a signatory to the UNFCCC and the Paris Agreement.

- The Grenada **National Climate Change Policy** builds on the foundation laid by the first National Climate Change Strategy and Action Plan which was updated in 2016.
- A **National Climate Change Adaptation Plan** (NAP 2017), a comprehensive 5-year plan (2017-2021), was then formulated "taking advantage of recent studies as well as ensuring alignment with ongoing processes such as the development of **Grenada's Second National Communication** and the **National Sustainable Development Plan 2030.**" The policy aims to achieve an empowered Grenadian population capable of managing the risks from climate change with emphasis on pursuing a low-carbon development pathway and building resilience at the individual, community and national levels. It is composed of different multi-sectoral programmes of action. The NAP vision is: **A resilient nation that continuously adapts to climate change by reducing its vulnerability through comprehensive adaptation strategies.** It consists of 12 programmes of action with 14 corresponding goals, and 20 indicators.
- The first Grenada **Nationally Determined Contribution** (NDC) (2016) was submitted on 21 September 2016 and the Second NDC on 30 November 2020. The Second NDC confirms the nation's target for reducing national greenhouse gas emissions by 40% of the 2010 emission levels by 2030; to be done through interventions in the energy including transport, waste, forestry, and industrial processes and product use (IPPU) sectors and by **leveraging mitigation co-benefits of adaptation actions.**

Selected adaptation interventions

SELECTED PROGRAMME / PROJECT	*VALUE (USD)*	*DONOR*	*YEAR*	*IMPLEMENTING AGENCY*
'Ridge to Reef' project to support Grenada's compliance with a number of agreed international environmental management and conservation strategies, policies and plans (e.g. MDGs and Aichi targets and goals).	US$ 15,426,822	GEF	2014-2020	UNDP
Climate Resilient Water Sector in Grenada: Systemic Climate Change Resilience in Grenada's Water Sector, by applying a Multi-level Approach, Addressing the Resilience at the level of Water Governance, Users, and the Water Supply System.	€ 42 million (approx. 35 million from GCF)	GCF BMU IKI Grenada Development Bank (GDB)	2019- 2025	Government of Grenada (MoFE) GIZ
Strengthen the Climate Risk Management Framework in the 16 CARIFORUM member countries, including Grenada.	€12-million project (Regional)	EU GCCA+	2019-2022	CCCCC (Belmopan)
Restoration and Community Co-Management of Mangroves (RECOMM).	N.A.	GFC GIZ	2014 - ongoing	Ministry of Climate Resilience, the Environment, Forestry, Fisheries, Disaster Management.
Disaster Vulnerability and Climate Risk Reduction / Additional Financing to the Regional Disaster Vulnerability Reduction Project (RDVRP) in Grenada.	US$ 8.0 million	World Bank PPCR GRANT	2011-2017	

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