Territorial analysis: Resilience to climate change at a glance

RÉGION GUADELOUPE

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 Guadeloupe

Total Area (square km)	*1 710*
Population	*400 114*
Percent Urbanization	*11*
GDP per capita	*N/A*
Debt as a percent of GDP	*N/A*
Unemployment Rate	*23*
Services as a percentage of GDP	*N/A*
Services as a percentage of workforce	*N/A*
Agriculture as a percentage of GDP	*N/A*
Agriculture as percentage of workforce	*N/A*
Percent Agriculture Land	*11,2*
Percent Forests	*40*
Human Development Index	*N/A*

Map of Guadeloupe

Figure 1: www.lonelyplanet.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 Région Guadeloupe is located in the **Leeward Islands** of the Lesser Antilles. Guadeloupe is centred on 16°10′ N Latitude and 61°57′ W Longitude and has a population of 395,000.

Guadeloupe is a volcanic archipelago including six inhabited islands. Grande-Terre and Basse-Terre, separated by a river-like channel, are the two main islands, claiming the majority of the land area of 1628 sq. km. The other four inhabited islands are Marie-Galante, Les Saintes (Terre-de-Haut and Terre-de-Bas) and Désirade. The highest peak at 1467 m is the Soufrière volcano on hilly Basse-Terre, whereas the low topography of Grande-Terre is largely characterised by flat land and gentle hills.

Relatively high rainfall levels as compared to evapotranspiration rates in Grande-Terre, combined with mostly fertile volcanic soils, means most of the island's natural vegetation consists of lush forests. Furthermore, thanks to its diverse topography, there are markedly diverse biomes in Guadeloupe (regionguadeloupe.fr).

Guadeloupe is well exposed to trade winds, which keep temperatures moderate at around 27°C, with a relative humidity of 79% (Météo France). The hot season (May to October) is characterized on average by 30 hot days (when day-time high temperatures are close to or exceed 31°C) and 39 hot nights (with night-time lows close to or above 24°C) on Basse-Terre, as well as by several heat waves. During the cool season (December to March), heat levels are comfortable and 33 cool nights (with lows below 19°C) occur on Basse-Terre on average.

The wet season spans May to November, largely coinciding with the Atlantic hurricane season. Across the six inhabited islands, the mean annual rainfall total varies from 1100 mm in the smallest islands, to 1400-1600 mm in Grande-Terre and from 1400-2600 mm in low-lying areas in Basse-Terre, and up to around 3,500 mm in the highest inhabited parts of Basse-Terre (Météo France, rcc.cimh.edu.bb). Extreme rainfall has the potential to trigger at least one flash flood per year, with the highest chances being between April and May, in August or between October and November. By contrast, spells of seven consecutive dry days tend to peak in frequency from January to May in the drier areas of the Leeward Islands, potentially limiting rainfed crop growth in the low-lying areas and smallest islands. Finally, impactful drought occurs on average once per 5 years during the dry season, and once every 12-14 years during the wet season, potentially impacting fresh water availability.

Sea turtle in Guadeloupe, Cousteau Underwater Reserve, Basse-Terre

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 Leeward 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.

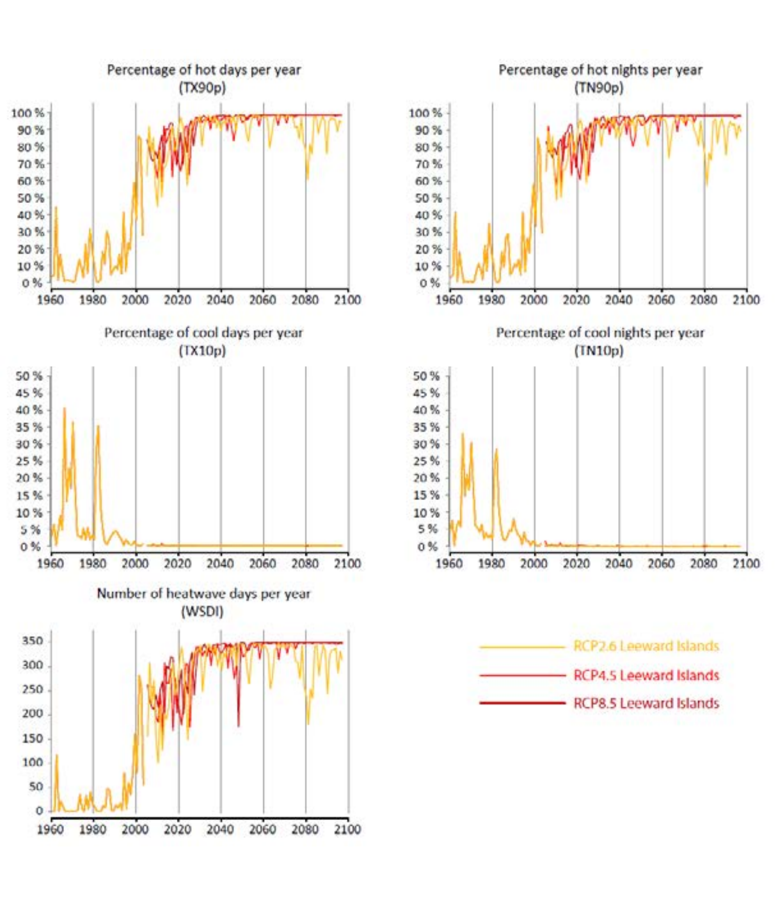


Figure 2
In the Leeward islands: Simulated annual trends in the percentage of hot days (TX90p, top left), hot nights (TN90p, top right), cool days (TX10p, middle left) and cool nights (TN10p, middle right) per year, as well as, trends in the annual number of heatwave days during long heat waves of at 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.

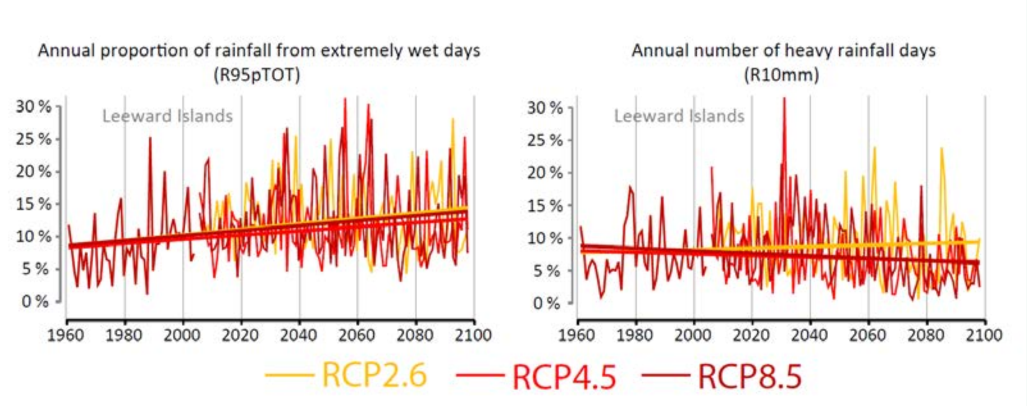


Figure 3

For the Leeward 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 tosuch 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.

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.

HEAT - AN UNDERESTIMATED HAZARD

Air temperature does not vary much between seasons and years in Guadeloupe. The heat – being moderated by a prevalent easterly breeze – has **historically** not been regarded as a major hazard but 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).

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

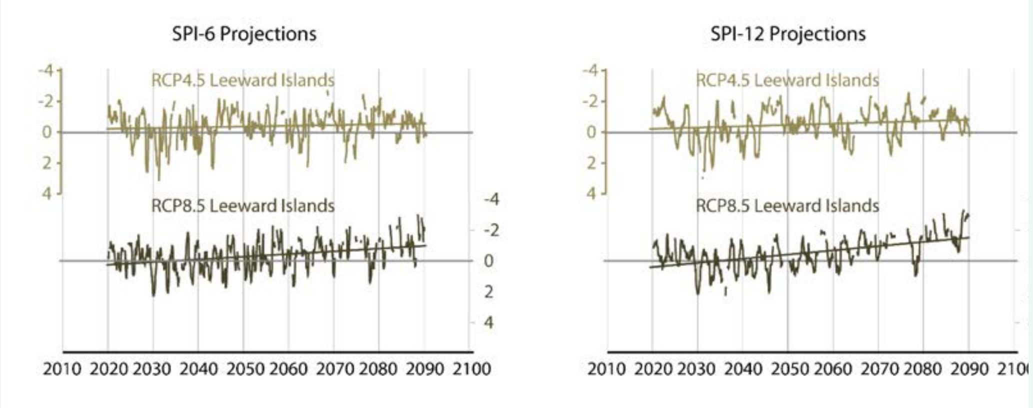


Figure 4

For the Leeward Islands: Simulated trends in the standardized precipitation index over six months (SPI-6, left) and twelve months (SPI-12, right) per year 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

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.

ILES DES SAINTES, GUADELOUPE - *Photo : gsarda*

SOCIOECONOMIC CHARACTERISTICS

Population

Guadeloupe's population was estimated at 381,000 in 2019 with a decrease of -0.6% (IEDOM). In 2018, one quarter of the population was at least 60 years old. The life expectancy of women (84.4 years) is superior to that of men (77.3 years) (INSEE). The migratory deficit is growing, mainly due as a result of young people leaving to escape high unemployment and the absence of training opportunities in certain sectors in the territory. Since 2006, the birth rate in Guadeloupe has been declining. The average age of women on the birth of their first child was 30.4 in 2018. The index fertility rate was 2.03, after dropping to 1.74 in 2017 for reasons related to the information campaign carried out during the Zika virus epidemic.

Main Economic Drivers

After a slowdown in economic growth in 2018 (+1.5% compared to +3.4% for the first half of the year in 2017), the business climate, marked by labour disputes and a number of uncertainties, declined in 2019. From a sectoral point of view, tourism activity increased and revenues in the agri-food industry were satisfactory despite declining exports. After a good start to the year, business activity was somewhat lower in the building and public works sector. In the primary sector, difficulties persisted. Guadeloupe has the characteristics of a tertiary economy in which services are the main source of wealth creation, accounting for 83.9% of the total value added in 2014. Female employment is characterized by a higher proportion of women working in public administration, education, human health and social work, and other service activities. The differences between men and women are small in Guadeloupe in terms of professional activity. However, the generational effect is stronger for Guadeloupian women. Given the overrepresentation of single-parent families, young Guadeloupean women join the labour force significantly later than young Guadeloupean men. This gap has a greater impact on women aged 25 to 54. Unemployment mainly affects young working women (under 25) with an unemployment rate of 58%. In the context of persistent unemployment, some women are thus more likely than men to accept low-skilled

Table 1

Employed population by industry and gender

Profession	Women	Men
Operating farmers	576	2 404
Craftsmen, merchants, business leaders	5 163	11 238
Executives and higher intellectual professions	7 315	7 800
Intermediate professions	23 241	14 449
Employees	46 172	14 240
Labourers	6 080	27 745
Retired	39 908	31 112
Others without professional activity	84 101	72 772
All	212 556	181 761

or low-paid jobs rather than have no job at all. More than one employed woman in four is an unskilled employee (25.3 per cent), compared with 10.5 per cent of employed men (INSEE). In 2015, women employees in the private and semiprivate sector earned on average 11% less than men employees. Women are more often in poverty (45%) than men (37%). (INSEE)

Tourism

The increase in passenger traffic on the island slowed (+2.3% passengers excluding airport transit on the island after +4.6% in 2018). In addition, the hotel business recorded a 5% decline in the number of overnight stays, compared with a 3.5% increase in 2018, although levels remain well above those observed before 2017. At the same time, the number of cruise passengers fell significantly. This decrease follows the exceptional increase recorded in 2018 due to the repositioning of stopovers of liners, heavily impacted by hurricanes Irma and Maria.

Energy

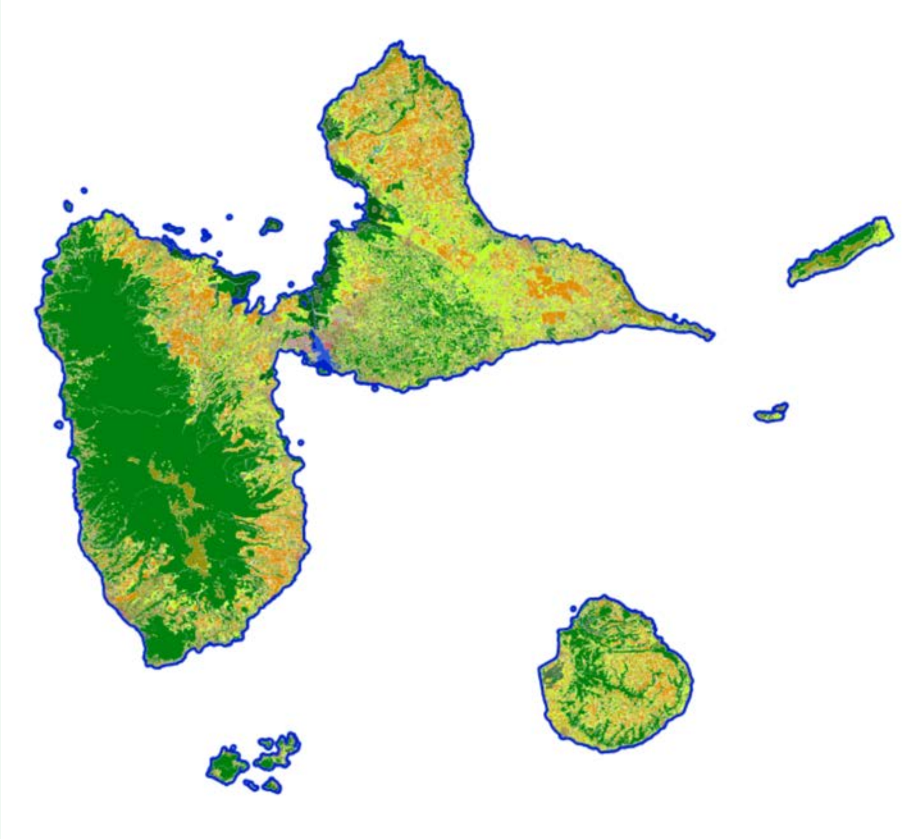
According to the Regional Observatory for Energy and Climate (OREC), Guadeloupe's energy consumption in 2018 amounted to 9,919 MWh, a decrease of 7.9% compared to 2017. In detail, imported resources represent 94.3% of the total. Fossil fuels accounted for 93.9% of this total, compared with 6.1% for local renewable energy sources.

Transport

Activity in the transportation sector, which has grown rapidly over the last five years, slowed down in 2019. Maritime freight traffic decreased (-4.4%) and passenger traffic remained stable. At the same time, air passenger traffic posted new records. In Guadeloupe, the transport and warehousing sector accounts for 5.2% of the total GDP. In 2020, the sector had 925 active establishments, with a majority of them operating in land transportation (72.3%).

Figure 4

Land use in Guadeloupe



(Source; DEAL Guadeloupe)

Land use

Guadeloupe is a region with an area of 1 628 km². The archipelago of Guadeloupe consists of two main islands, separated by a narrow sea arm, and three other islands: Marie-Galante, the archipelago of Les Saintes and Désirade, as well as a few islets.

Agriculture

In 2014, the agriculture, livestock, fisheries and aquaculture sector generated 1.9% of the wealth created in Guadeloupe (compared with 3.5% in 2002), with an added value estimated at €149.7 million. The sector accounted for 599 establishments in 2020 and 1.3% of salaried employment in 2019. Banana and sugar cane are the two main crops exported from Guadeloupe, occupying more than 50% of the usable agricultural land. Various other crops are grown, but occupy smaller areas. In 2019, revenues in the agriculture sector were still marked by the effects of the devastating passage of Hurricane Maria in 2017, which damaged many farms. In 2013, the farming population decreased by 12% compared to 2010, a proportion similar to the decrease in the number of farms. Women represented 24% of farm managers, co-operators and associates, a figure that increased by 10% over 3 years.

Health

In 2018, there were 6,561 healthcare professionals in Guadeloupe, 9.5% more than in 2017. This growth is due to the increase in the number of nurses. In 2017, Guadeloupe had 34 health care institutions, 4 of them with a maternity unit. The hospital offering is characterized by the historical importance of the private sector, which totals 22 establishments. Between 2017 and 2018, the fire that ravaged part of Pointe-à-Pitre university hospital directly impacted the healthcare facilities in Guadeloupe.

Table 2

Land use in Guadeloupe

	Size	Unit
Total area	1 710	*km²*
Density of population	294.3	*persons per km²*
Land area	1 690	*km²*
percentage of total area	98.8	*%*
Water surface	20	*km²*
percentage of total area	1.2	*%*
Agricultural land	440	*km²*
percentage of total area	25.7	*%*
Arable land	210	*km²*
percentage of total area	12.3	*%t*
Permanent crops	30	*km²*
percentage of total area	1.8	*%*
Permanent meadows and pastures	200	*km²*
percentage of total area	11.7	*%*
Forest area	793	*km²*
percentage of total area	46.4	*%*
Other land	457	*km²*
percentage of total area	26.7	*%*

VULNERABILITY OF SECTORS AND TERRITORIES 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. Most OECS Member States 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 desalination 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. Speciality 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 livelihoods, 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 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 all 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 structures 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 (see also the food security section on fisheries). The major future impacts of sea level rise (SLR) facing the OECS region include coastal erosion, reduction of land space - including urban space - near coastlines, and saline intrusion into soils and aquifers. Forecasts of coastal erosion impacts on tourism activity within CARICOM member countries point to 30% of coastal tourism infrastructure being affected by a 1m shoreline retreat (SLR) and 60% by a 100 m shoreline retreat.

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.

HEALTH

Extreme weather, coupled with higher temperatures and changes in rainfall, will impact the region's population both directly and indirectly. Heat stress, for example, induces dehydration and has been linked to chronic kidney disease in agricultural and construction workers, and has the potential to increase respiratory and cardiovascular disease risks. Storms and hurricanes can cause death and lead to flooding with significant effects on crop production, water quality and water-borne illnesses. Additionally, increased morbidity and mortality of water-borne illnesses, mental health effects of extreme events, and impacts of cardiovascular and respiratory conditions are all subject to climate stress. The region's aging population is also vulnerable to increased heat stress. Disease outbreaks closely associated with the climatic conditions of the Eastern Caribbean include those transmitted by certain mosquito species. Temperature is an important determinant of biting rate and mosquito development. Precipitation provides habitats for the aquatic stages of the mosquito life cycle and strongly influences vector distribution. Changes in climate are already altering the spatial and temporal dynamics of dengue ecology, potentially increasing vector ranges, lengthening the duration of vector activity, and increasing the mosquito's infectious period. Dengue is endemic to Guadeloupe; already expanding globally, and is likely to continue increasing as dengue vectors reproduce more quickly and bite more frequently at higher temperatures. This is also the case with chikungunya, which has affected several countries in the last 10 years. Other climate-related public health issues include harmful sargassum algal blooms and Saharan dust which could have serious implications for human health.

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. Figures 5 and 6 below shows the number of people affected by key natural hazards (Source: World Bank Climate Change Portal) and the frequency distribution of natural hazards. A summary of the general profile of Guadeloupe's vulnerability to climate change was published in 2018 in the Regional assessment (Figure 7). The 3 main areas analysed presenting different vulnerabilities are socio-economic conditions, population and natural environment. Land use planning, biodiversity, tourism, health, fisheries and the overall economy of the region are emerging as the top critical risks (in red), while water resource quality is also identified as a significant risk. These risks are located on the map illustrating the SRCAE (regional climate, air and energy scheme).

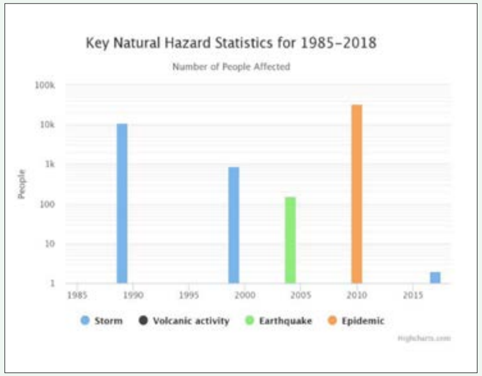


Figure 5: Number of People Affected by Key Natural Hazards in Guadeloupe

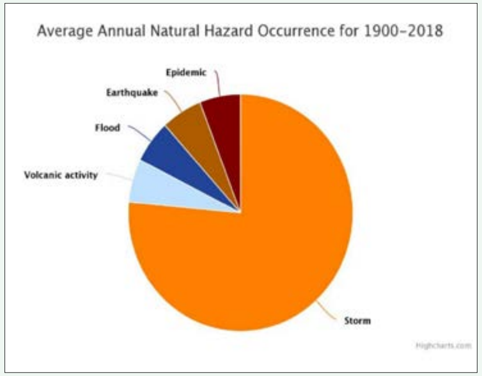


Figure 6: Frequency distribution of natural hazards in Guadeloupe

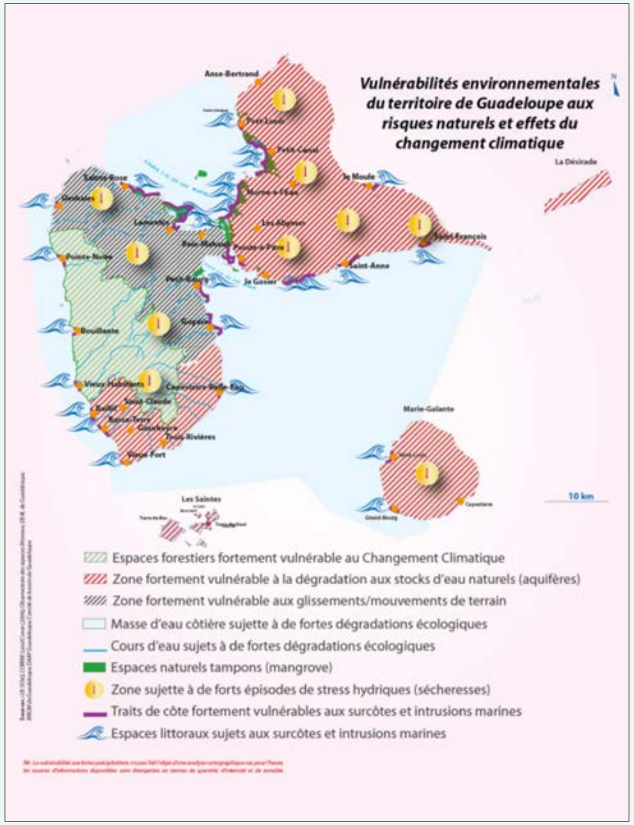


Figure 7: Environmental vulnerability to climate change of the territory of Guadeloupe.
Source Schéma Régional Air Climat Energie (SRCAE Guadeloupe -2012).

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 the case for the Petit-Bourg station on the windward side of Grande-Terre, which is a wet area. However, Météo France possesses much more daily data than was available for the project, meaning the research could be refined to community scales.
- 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 or sea level rise at the OECS regional level, let alone the Guadeloupe island level.
- 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, Guadeloupe. However, not much is known or measured with respect to heat impacts on Guadeloupe's society and environment.

Data and information gaps

- The Petit-Bourg record of daily weather observations available to the project spans 37 years. This makes the climatological analysis robust for the windward slopes of Basse-Terre with respect to extreme rainfall, and for low-lying areas across the island with respect to heat, dry spells and drought. However, since extreme rainfall occurrence is a smaller-scale physical process and extreme rainfall occurrence is typically enhanced by pronounced topography, data records of daily rainfall for other areas on Basse-Terre, areas on Grande-Terre and the 4 smaller inhabited islands would be beneficial to assess flash flood potential there. Note, however, that Météo France is developing an operational flood alert system for Guadeloupe.
- 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 Guadeloupe. 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

Guadeloupe is an integral part of France as a Region, as well as a territory of the European Union, therefore not directly submitting documents under the UNFCCC and other International Agreements for its Territory.

A first French national plan for adaptation to climate change (2011-2015) was produced. During its development, the French Outermost Regions (OR), including Guadeloupe, were consulted in order to ensure that the recommendations developed addressed the challenges faced by the OR. As a result, the National Plan includes their needs even though it does not address them specifically. Regional adaptation guidelines to implement the national plan were published under the provisions of French Law 2010-88 of July 2010.

The **Regional Climate, Air and Energy Scheme** (SRCAE) for Guadeloupe, published in December 2012, analysed the vulnerability of the island to climate change and identified priority adaptation actions to be implemented by 2020-2050. The SRCAE is providing a reference framework to ensure consistency in policies implemented in the field of sustainable development, energy and adaptation to climate change. It includes measure for land use planning and protection; adaptation and protection of resources; governance; improving knowledge; cooperation; professionalization; communication, information and awareness raising.

Relevant Programmes / Projects

SELECTED PROGRAMME / PROJECT	VALUE (USD)	DONOR	YEAR	IMPLEMENTING AGENCY
Càyoli; a project to protect the natural environment of the Grand Port Maritime of Guadeloupe, develop ecological value, and promote sustainable uses and economic activities in relation to coastal zones. The Càyoli initiative plans to develop and implement tangible, targeted solutions for the restoration of coastal island ecosystems.	€4m seed funding (initial)	Public funds	Started in 2016 Over 15 years	Coraïbes SARL for the Grand Port Maritime Guadeloupe (GPMG)

KEY RESOURCES

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🔗 **WorldStat Info** Guadeloupe.

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