OECS COUNTRIES

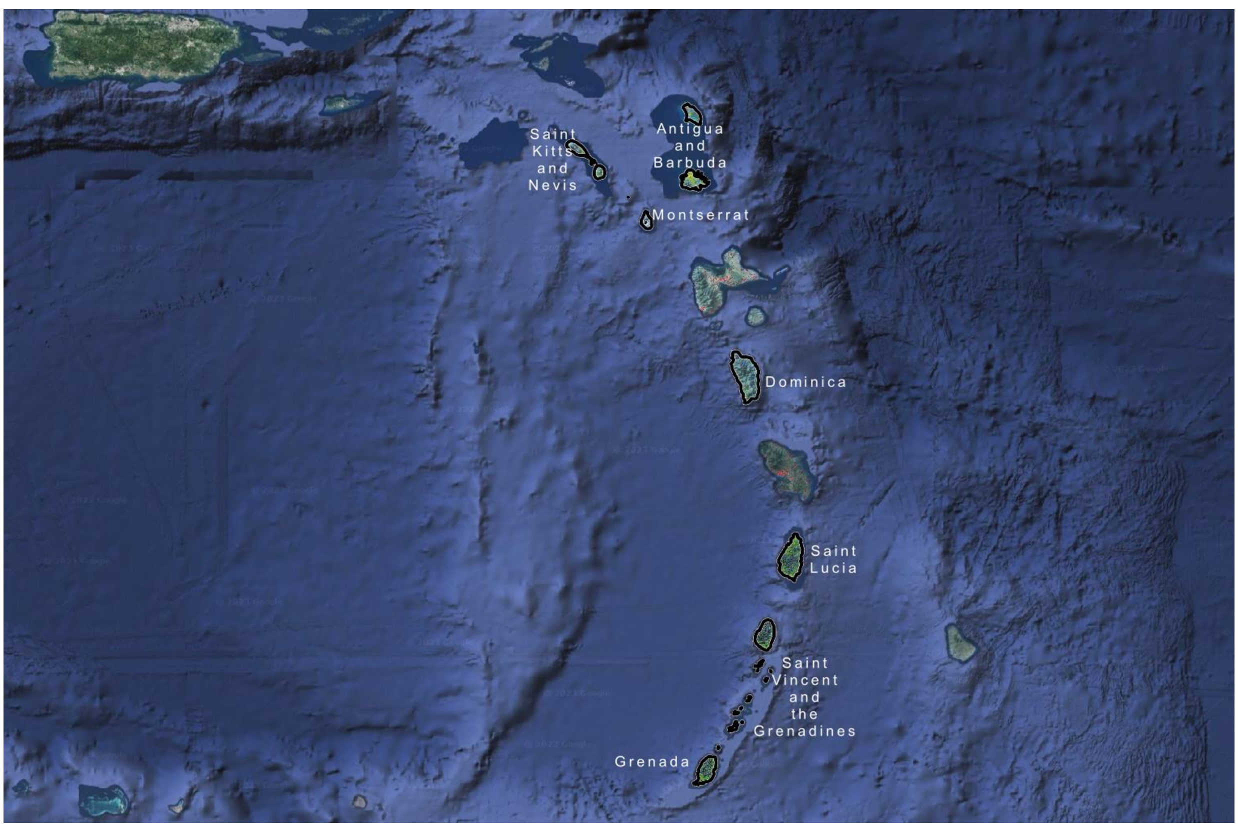
Screening of climate-related natural hazards

1. Introduction

The Organisation of Eastern Caribbean States (OECS) is an international inter-governmental organisation comprising of the small island States of Antigua and Barbuda, Commonwealth of Dominica, Grenada, Montserrat, Saint Kitts and Nevis, Saint Lucia and Saint Vincent and the Grenadines (*Map 1*).

These countries are characterized by volcanic islands, coral atolls, and rugged mountain ranges. Some islands are volcanic in origin and have peaks that rise above 1,000 meters. The terrain is generally rocky, with steep slopes leading down to the sea. The climate of the OECS countries is tropical, with temperatures ranging from 24°C to 32°C throughout the year. The islands receive an average of 2,000 to 2,500 mm of rainfall annually, with the wettest months being between June and November. Natural hazards are a significant concern for the OECS countries. The islands are among the most vulnerable to hydro-meteorological hazards such as hurricanes, floods, landslides, as well as geophysical hazards such as earthquakes and volcanic eruptions.

Map 1: OECS countries



Tropical cyclones phenomena (called *Hurricanes* in the N. Atlantic region) are the most important triggers of hazards in the region during the wet season. Damaging or destructive winds may reach speeds in excess of 300 km/h in the most intense systems. The combination of wind-driven waves and the low-pressure of a tropical cyclone can produce a coastal storm surge – a huge volume of water driven ashore at high speed and with immense force that can wash away structures in its path and cause significant damage to the coastal environment. Torrential rainfall results in flash-flooding, flooding, and potential landslides and mudslides. Their potential for wreaking havoc caused by those associated hazards is exacerbated by the length and width of the areas they affect, their intensity, frequency of occurrence and the vulnerability of the impacted areas. In 2017, category 5 hurricanes Irma and Maria stormed through the region, causing at least 3,191 deaths and a cumulative damage of USD 12 billion.

Seismic hazards are a significant concern for the OECS countries, as they are located in an active seismic zone along the boundary between the Caribbean and North American tectonic plates. Several OECS countries have experienced earthquakes in recent years, including a 5.7 magnitude earthquake in Dominica in 2020 and a 6.4 magnitude earthquake in Saint Lucia in 2007. In addition to earthquakes, the region is also at risk of tsunamis, which can be triggered by underwater earthquakes or landslides. In response to these hazards, the OECS has established a disaster management agency to coordinate emergency response and preparedness efforts across the region. The agency works closely with national governments, civil society organizations, and international partners to develop and implement disaster risk reduction strategies and response plans.

Data from the Emergency Events Database (EM-DAT) shows that during this period the OECS region incurred an estimated US$1.58 billion in total damages. The OECS countries are most vulnerable to dangerous hurricanes and tropical storms, which in the past resulted in the loss of life and irreparable damages to property and infrastructures. Natural disaster data from the OECS region published on the EMDAT database indicates 23 natural disaster events between 2002 to 2022, most of which (13) consist of tropical cyclone events. Each disaster challenges the institutional capacity and weakens public finances: on their own, these countries hardly have the financial resources to fund disaster risk management initiatives or huge reconstruction bills that follow natural disasters.

Disaster risk is usually not uniformly distributed across space, with poorer communities being typically more exposed. Risk is a function of the probability and intensity with which a hazard occurs, the exposure of people and assets to this hazard, and the vulnerability of these exposed people or assets. Hence, it is the result of an interaction between environmental processes and socioeconomic conditions. These socioeconomic conditions cause natural disasters to disproportionally affect the poor. Poorer households tend to reside in more disadvantaged and hazard-prone areas, have lower access to critical services like health, education and early warning systems, and they and their assets, like housing or livestock, are less well insured and less resilient to extreme adverse climate-related events (Hallegatte et al. 2018). Geography, environmental processes, and socioeconomic conditions play out hand in hand and need to be studied in great spatial detail when drawing up the risk profile of the country.

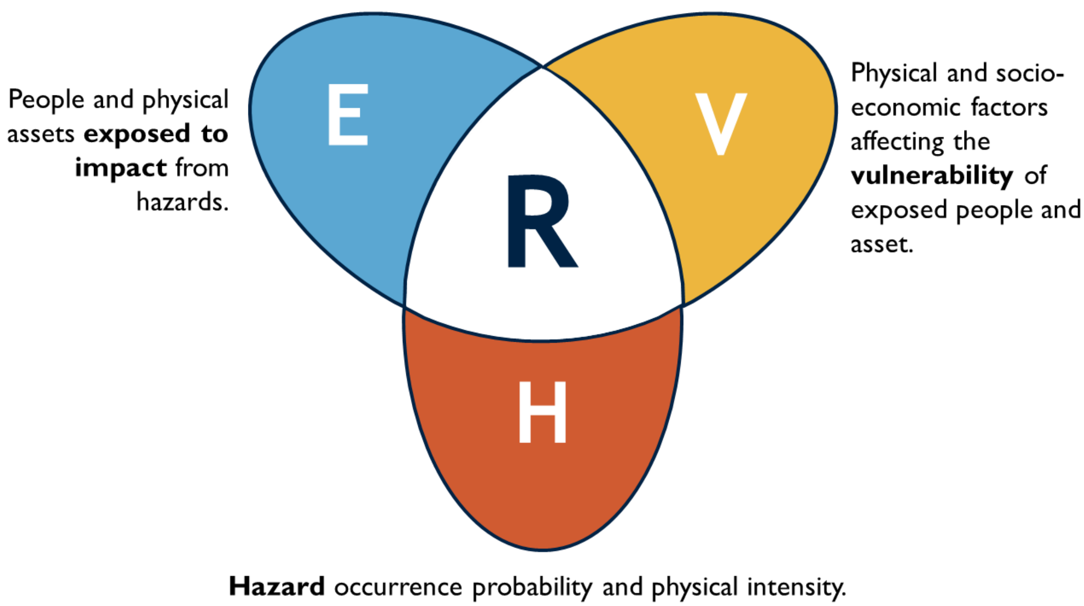
2. Defining Disaster Risk

Disaster risk is as the probability of a negative impact caused by a natural hazard. The Intergovernmental Panel on Climate Change (IPCC), following the main definitions of UNDRR, defines a natural hazard as the potential occurrence of a natural or human-induced physical event or trend that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources ([IPCC 2019 et al.](#)). Exposure describes the location of people and assets in an environment where they may be threatened by these natural hazards. People and assets may be exposed, yet not adversely impacted if they are not vulnerable. Vulnerability summarizes the propensity or predisposition to be adversely affected when exposure, measured by characteristics that favour a negative impact of a hazard if exposed to it. Together, hazard (***H***), exposure (***E***), and vulnerability (***V***) drive disaster risk (***R***) ([IPCC 2012](#)):

$$R=f(H, E, V)$$

- Example 1:
  Risk (*R*) from floods (*H*) over population (*E*) according to water depth/mortality function (*V*).

- Example 2:
  Risk (*R*) from strong winds (*H*) over built-up (*E*) according to wind/damage function (*V*).



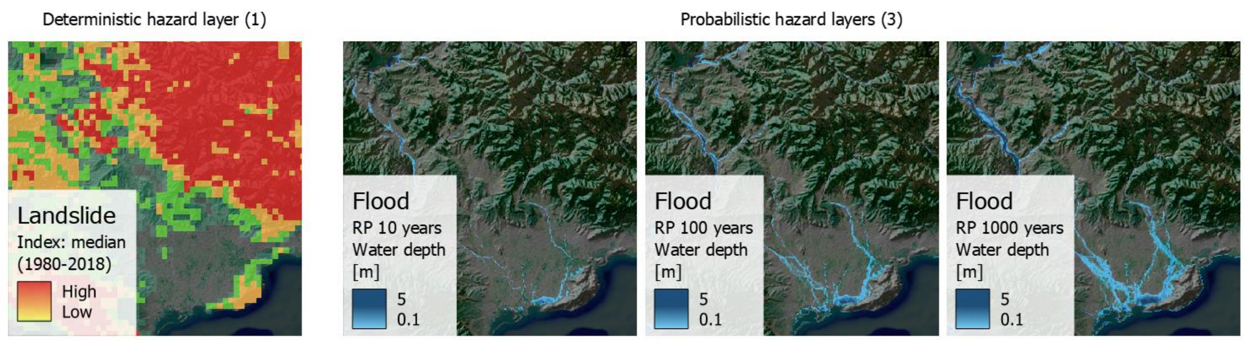
2.1. Hazard

A modelling approach for each of the included hazards needs to be selected. For the modelling of historical hazard (baseline), there are two options (*figure 1*). Hazard modelling can be either:

a. Deterministic, in the form of an individual geodata layer measuring the mean, median or maximum intensity of a hazard aggregating historical data and modelling. This is the case for landslide and drought hazard.

b. Probabilistic, in the form of multiple geodata layers, each representing a range of hazard physical intensities (e.g. water depth [m], wind speed [km/h]) corresponding to a specific occurrence frequency, measured as Return Period (RP), in years. This is the case for river flood, coastal flood and strong winds.

Figure 1: examples of individual deterministic hazard layer (landslide index) versus multiple probabilistic hazard layers (flood depth for three return periods of increasing intensity/decreasing frequency).

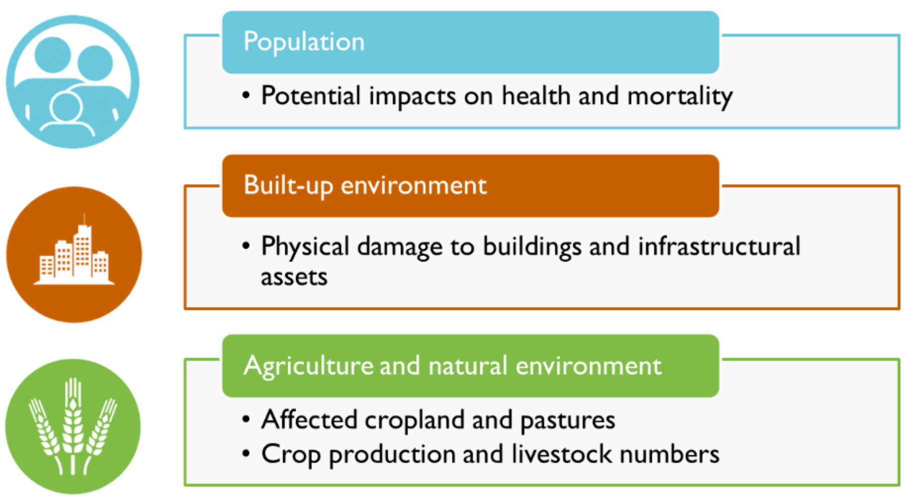


More details about the hazard models are provided in the annex.

2.2. Exposure

Exposure describes the location of people and assets that are prone to suffer an impact from natural hazards. We consider three exposure categories used as main indicators of risk, listed in *figure 2.*

Figure 2: exposure categories considered in the analysis



Each indicator is quantified by a specific spatial metric: population is described in terms of total count; built-up and agricultural land are measured in terms of area (hectares). Exposure datasets for the country are investigated with more detail in Section 3. Additional details are provided in the annex.

2.3. Vulnerability

Vulnerability comprises the conditions determined by physical, social, economic, and environmental factors or processes which increase the susceptibility (sensitivity) of an individual, a community, assets, or systems to the impacts of hazards (UNDRR). Two main components of vulnerability are typically accounted for in DRM assessments:

Impact model:

- Draws the relationship between the intensity of hazard and the degree of damage suffered by specific exposed categories; e.g., a flood depth of 0.5m is expected to cause a low degree of impact in terms of population mortality, while a 3m flood would cause severe impact.
- Impact models can be quantitative, providing an absolute or relative estimate of the damage (i.e., in USD terms or % of total value); or qualitative, classifying the impact in nominal categories.

Socio-economic conditions:

- Describe the differential susceptibility of exposed categories to suffer damage, i.e., areas under poverty conditions and high dependency rate are more likely to suffer damage compared to wealthy communities, under the same hazard event.
- Measured using spatial indices based on demographics (sex, age composition, dependency rate) and socioeconomic statistics (wealth, GDP and average salary, among others).
- Semi-quantitative metrics (index score; ranking)

The former is required to translate the physical intensity of a hazard into a measurable socioeconomic impact (damage or losses); the latter can be used to refine the risk output within the same exposure category. Not all exposure categories are affected in the same way by physical hazards - some hazards are more relevant for one category than another. The impact model needs to be aligned with the hazard intensity metric and the exposure category. For this reason, the availability of such models dictates the possible combinations of hazard and exposure categories. *Table 1* identifies which combinations are sustained by currently available impact models. Where no impact models are available, an exposure classification is produced based on literature studies on hazard thresholds.

Table 1: available Hazard, Exposure, and Vulnerability components

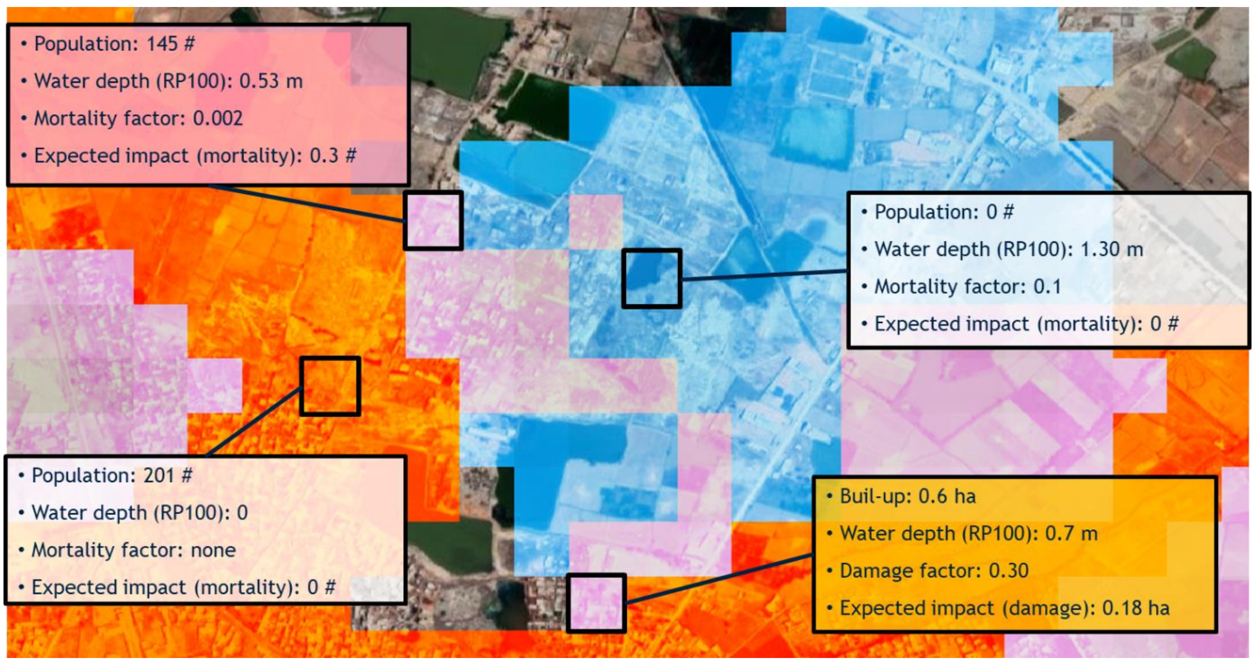
		Exposure Categories		
Hazards	Trigger	*Population* (Mortality)	*Built-up assets* (Physical damage)	*Agricultural land* (Production losses)
River flood *Water extent and depth*	Tropical cyclones	**Impact model**	**Impact model**	Exposure classification
Coastal flood *Water extent and depth*	Tropical cyclones	**Impact model**	**Impact model**	Exposure classification
Strong winds *Cyclone tracks and wind speed*	Tropical cyclones		Impact model	
Agricultural drought *Agricultural Stress Index*	Prolonged dry spell			Exposure classification

For this assessment, the vulnerability component is made of a set of global damage functions (algebraic equations) and quantitative impact classification (thresholds table) specific for each hazard type. More details about the impact models are given in the annex. The relative wealth index (presented in section 3.4) is used as proxy for socio-economic conditions and is provided alongside risk results, but it is not combined with it.

2.4. Risk

Now that all the core components have been defined, the risk estimate can be calculated. First, the Hazard and Exposure geodata are combined together in GIS environment, excluding from the analysis those areas where no hazard or no exposure is occurring. The spatial analysis is performed at the grid level, at a resolution matching that of the selected exposure layers. In our analysis, this is set to a common 90-metre grid[1]. The impact model translates the physical intensity unit of a specific hazard into a damage factor (0 to 1), which is then multiplied by the exposure layer to obtain the impacted share over the total exposed value (*figure 3*).

Figure 3: example of spatial combination of hazard, exposure, and vulnerability components. The flood hazard layer (blue) describing water extent and depth (m) is overlaid to the exposure layer (orange) describing population count and built-up area. Where they match, there is an impact (pink) which is calculated as the product of the total exposure and the damage factor, which is driven by the impact model: depth-mortality function in the case of population (top-left box), depth-damage function in the case of built-up (bottom-right box).



[1] The inclusion of all three components is required for a meaningful risk screening; evaluations based on hazard alone, such as the one proposed by ThinkHazard, cannot provide the same kind of information, nor the same level of detail and granularity.

When multiple probabilistic scenarios of hazard are available, the expected annual impact (EAI) is calculated by multiplying the impact from each event scenario with its exceedance probability ($1/RP_i - 1/RP_{i+1}$), and then summing up to one value. This is illustrated in *figure 4* below. The exceedance frequency curve shown in this figure highlights the relationship between the return period of each hazard and the estimated impact. The area below the curve represents the total annual damage considering all individual scenario probabilities.

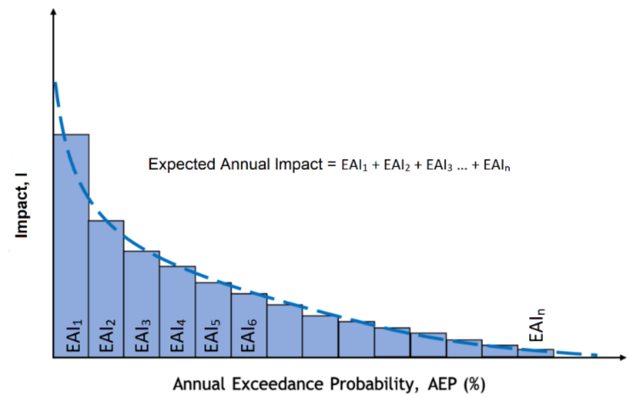
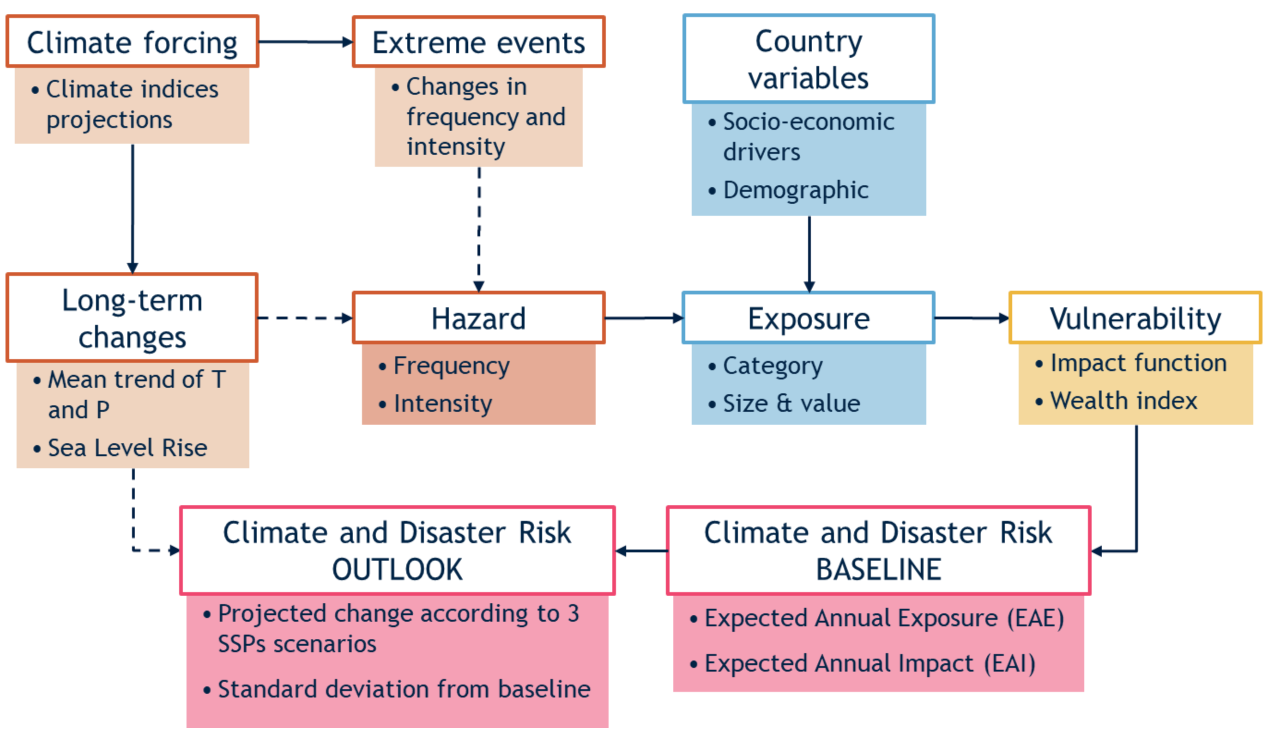


Figure 4: Computation of Annual Expected Impact of natural hazards in geospatial analytics

In the case of the OECS region, we focus on disaster risk from river, pluvial and coastal floods, strong winds (all combined into "tropical cyclone hazard") and droughts. Impact models are applied to calculate the expected annual impact of floods on population (mortality) and built-up assets (damaged area). Impact models are not available for agricultural land and crop types; instead, exposure is classified by hazard intensity categories. The vulnerability functions and parameters used to calculate the impacts on each dimension are explained in Annex 1. *Figure 5* summarizes the workflow of the analysis.

Figure 5: Workflow of the analysis



2.5. Hazard ranking and score combination

As last step, a synthetic qualitative risk index is produced for 1) tropical cyclone hazard, as combination of river floods, storm surges, landslides and strong winds; and 2) drought hazard. The ranking of numerical values of EAI and EAE into categorical risk classes is performed by first attributing a single score to each individual hazard contributing to tropical cyclone impacts, thus considering all exposure categories when more than one was assessed, and then combining each individual score into a composite ranking for the composite cyclone hazard.

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STEP 1
For each hazard:
      -  Normalize impact (EAI and EAI%) or exposure (EAE and EAE%) indicators
         on a 0-10 scale using null-filtered min and max
STEP 2
For each hazard:
      -  Combine normalized impact and exposure indicators using geomean
      -  Transform the 0-10 distribution into LOW-MEDIUM-HIGH ranks using the
         following criteria:
         x <= 3: Low
         3 < x <= 6: Medium
         X > 6: High
STEP 3
- Take the MAX between FL, CF, LS and SW normalized scores into: this is the
score for Tropical Cyclones.
- Transform the TC_rank 0-10 distribution into LOW-MEDIUM-HIGH ranks using the
same criteria as in Step 2
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3. Future climate

The forward-looking analysis uses future climate projections to explore how environmental risks could develop spatially across the OECS region. The assessment of future impacts of climate change are based on comparisons of baseline conditions (which can be either observed or simulated) against future scenarios of climate variability. The long-term averages of climate variables serve as the baseline conditions. Changes in projected values against this baseline are then interpreted future climate anomalies and used to project forward-looking disaster risks. Given that specific unit of measurement varies across climate indices, all changes against the baseline are expressed in terms of Standard Deviation (SD) of the anomaly compared to historical variability (E3CI, 2020). Data from climate models released under the IPCC Sixth Assessment Report (AR) framework (IPCC 2021a) are used to establish estimates of baseline and future projected climate anomalies. ARs are supported by coordinated climate modeling efforts referred to as Coupled Model Intercomparison Projects (CMIP). The analysis relies on CMIP6 data for modeling into the future, and takes into account four climate change scenarios, referred to as Shared Socioeconomic Pathways (SSPs) in CMIP6. These pathways cover the range of possible future scenarios of anthropogenic drivers of climate change by accounting for various future greenhouse gas emission trajectories, as well as a specific focus on carbon dioxide (CO_2) concentration trajectories (IPCC 2021b). The following scenarios are included in this analysis:

- **SSP1/RCP2.6**: emissions peak between 2040 and 2060, declining by 2100. This results in 3-3.5 °C of warming by 2100.
- **SSP2/RCP4.5**: emissions continue to increase through the end of the century, with resulting warming of 3.8-4.2 °C.
- **SSP3/RCP7.0**: models describe a large emission variability for this scenario. Warming in 2100 is estimated at 3.9-4.6 °C.
- **SSP5/RCP8.5:** high emissions scenario resulting in warming of 4.7-5.1 °C.

Each climate scenarios predicts different spatial patterns, resulting into a range of possible futures in terms of intensities, and frequencies of natural hazards. Key climate variables connected to the changing patterns of precipitation and temperature are collected from Copernicus Data Store and summarized in *Table 2.*

Table 2: Climate variables underlying climate projections

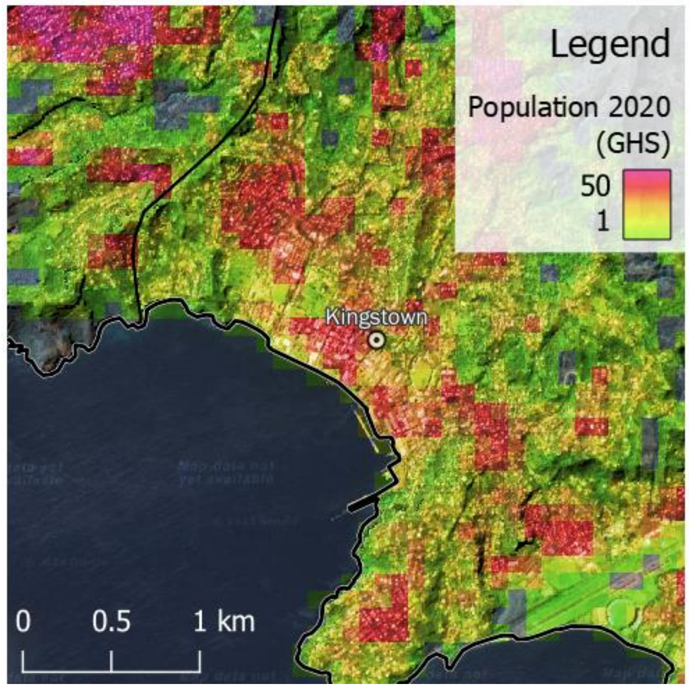
Hazard	Associated climate indices	Unit of measurement
River and pluvial floods	Rainfall > 10 mm	Days per year
	Consecutive wet days	Days per year
	Maximum 5-day precipitation	mm
	Extremely wet days	mm
Coastal floods	Sea Level Rise	cm
Drought	Consecutive dry days	Days per year
	Annual SPEI	Index

At the end, an aggregated score is produced to measure the change in terms of expected climate-related hazards. For each climate index, mean anomalies are calculated for two future periods (20y-time window): 2030 (2020-2040) and 2050 (2040-2060). The anomalies are standardised against historical baseline's standard deviation, then combined linearly to estimate the direction and intensity of change in terms of related hydrometeorological hazards.

4. Exposure datasets

4.1. Population

Whether an individual will be affected by a natural hazard depends on its location of residence. Especially for smaller-scale, well-defined extreme events such as floods or landslides, administrative unit-level population data (for instance census data) do not offer the necessary granularity to explore the precise settlement location of citizens and to study their exposure. Therefore, for this work, the high-resolution location of the population is plotted using the GHS POP 2020 population model, where each cell has a 90-meter resolution. *Map 2a* shows the distribution of the population across the country. High population densities are found primarily in the capital Santo Domingo (*Map 2b*), and urban centres such as Higuey, Gaspar Hernandez, San Pedro de Macoris.



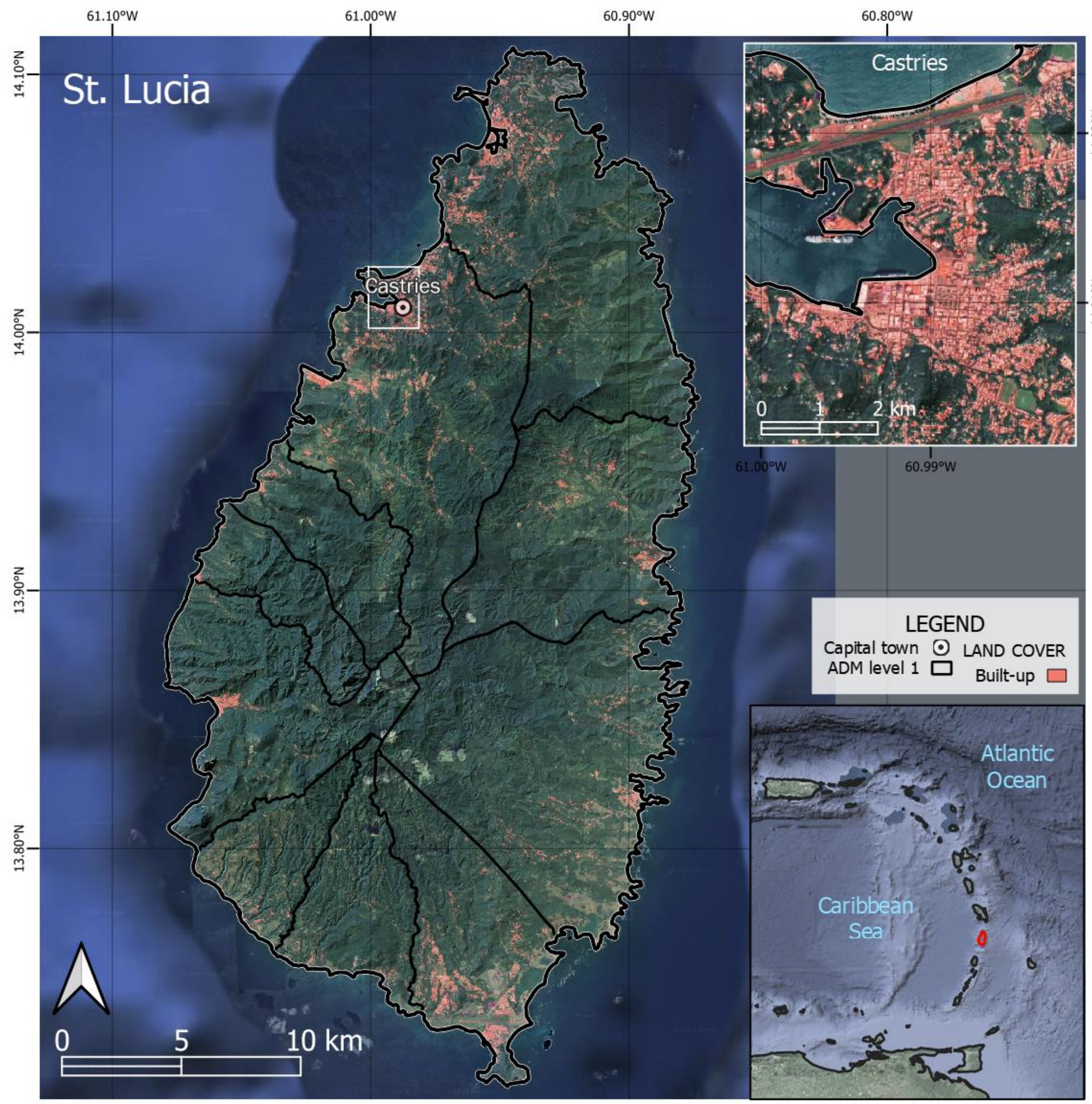
Map 2: GHS 2020 population model for Kingstown (SVG)

Caution in the interpretation of results is advised as projected population data has some limitations. We applied the constrained version of the model, which allocates population numbers proportionally to remotely sensed built-up density. This can generate model errors, particularly in mountainous environments, where populations are allocated to a limited number of built-up cells in valleys. This aggregation of population in valleys and allocation to specific cells might entail an overestimation of natural hazard risk in those areas, if affected. The aggregation of exposure and impacts at the level of administrative units partially compensates this error through the scaling of population estimates. However, a residual error cannot be ruled out.

4.2. Built-up Assets

Built-up assets include homes, industrial complexes, road infrastructure, facilities, among other infrastructure. For the analysis, 2019 World Settlement Footprint (WSF) data are employed. This is a high-resolution (10m) remotely sensed dataset which indicates whether each cell is primarily built up, as shown in *Map 3*.

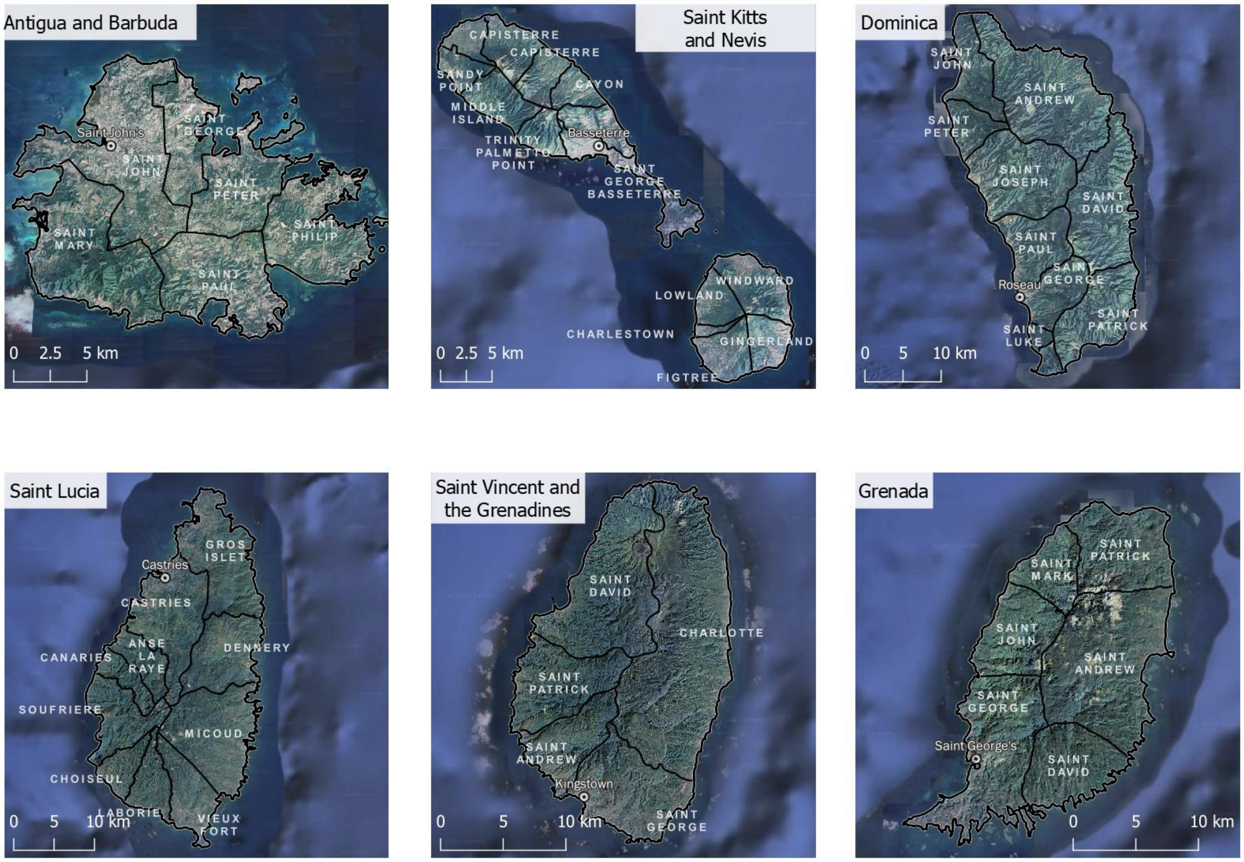
Map 3: WSF 2019 distribution of built-up area across LCA



4.3. Administrative boundaries

The OECS countries are small island states, with only one level of sub-national administrative division, shown in *Map 4* for the main island of each country. The boundaries have been sourced from GeoBoundaries and refer to a mix of years in the range 2017-2019. One level of sub-national boundaries is available (ADM1) and used to present the primary risk variables (EAI, EAE).

Map 4: first level of administrative divisions for the main island of OECS countries



5. Results

5.1. Tropical cyclones

Tropical cyclones have been particularly devastating to the OECS countries. In 2004, Hurricane Ivan hit Grenada with the loss of around 39 lives and the destruction of housing, crops, and other national infrastructure. Moreover, this Hurricane led to substantial losses that were equivalent to approximately 148% of Grenada's GDP, with 90% of homes being damaged or destroyed, and business interruption for more than half of the touristic activities. Hurricane damage to Grenada's productive sectors led to an overall decline in economic growth from 9.5% in 2003 to -0.6% in 2004. In 2015, tropical storm Erika devastated Dominica, with torrential rains and mudslides wreaking significant casualties and damage to infrastructure. Thirty persons lost their lives and over 570 people were left homeless in Dominica. Damages from Erika were estimated at approximately USD 483 million, or approximately 97% of Dominica's GDP. The 2017 hurricane season was particularly severe: hurricane Irma, one of the most intense tropical cyclones on record, devastated Antigua's sister island Barbuda in September, where it is estimated that 90% of buildings were destroyed and 50% of the population were left homeless. Later in September, Hurricane Maria wreaked havoc on Dominica, as at least 30 people died in the hurricane and approximately 80% of buildings on the island were damaged or destroyed.

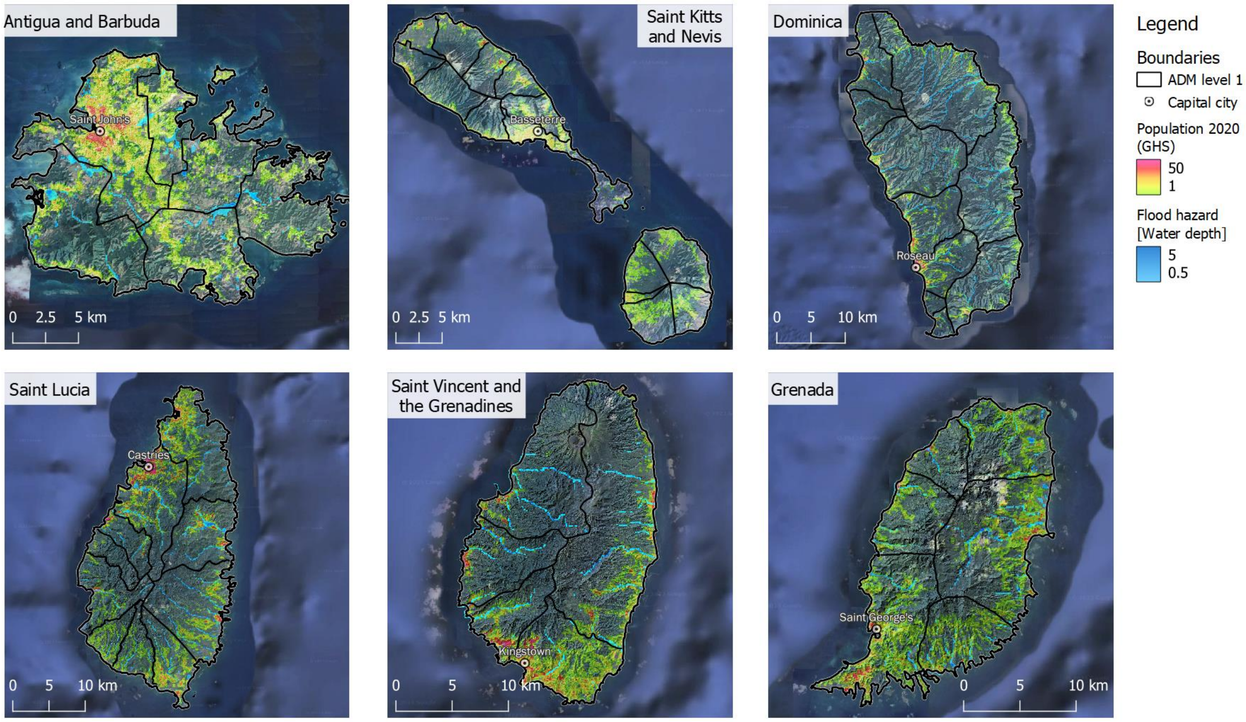
Following the combination of hazard, exposure and vulnerability as in *Table 1,* the Expected Annual Impact or Expected Annual Exposure values are presented for all individual hazards that, in the case of this tropical region, are most often triggered by tropical cyclones and related storm events: river and pluvial floods, storm surge and coastal floods, and strong winds.

5.1.1. Pluvial and River floods

Floods can have a major impact when they occur in areas with high density of vulnerable people, built-up assets or agricultural land. The river and coastal flood disaster risk mapping therefore provides a spatial profile of where the highest annual impact on population and built-up assets is expected under the current climate. *Map 5* captures the geographic distribution of flooding hazard for a river flooding event with a 100-year return period, according to the Fathom global model.

Combining the impact from probabilistic scenarios (5 to 1,000-year floods probability) with population exposure (*Map 6*) shows that the expected annual mortality risk from river and pluvial flooding is largest in the regions of Charlotte (VCT), St. George (DMA), Castries (LCA), St. Patrick (VCT), St. George (VCT) and St. Andrew (DMA). Chart 1 presents an aggregation of absolute (left axis) and relative (right axis) impact at subnational level. This somehow aligns with the recent records, which reports VCT and LCA as the most struck by flood disasters (over 30,000 people were affected during flash floods occurring in December 2013 in VCT, and almost 20,000 in LCA).

Map 5: Fluvial flood hazard across DR, Return Period 100 years



Map 6: Expected annual population impact of riverine (left) and coastal (right) floods – mortality and morbidity

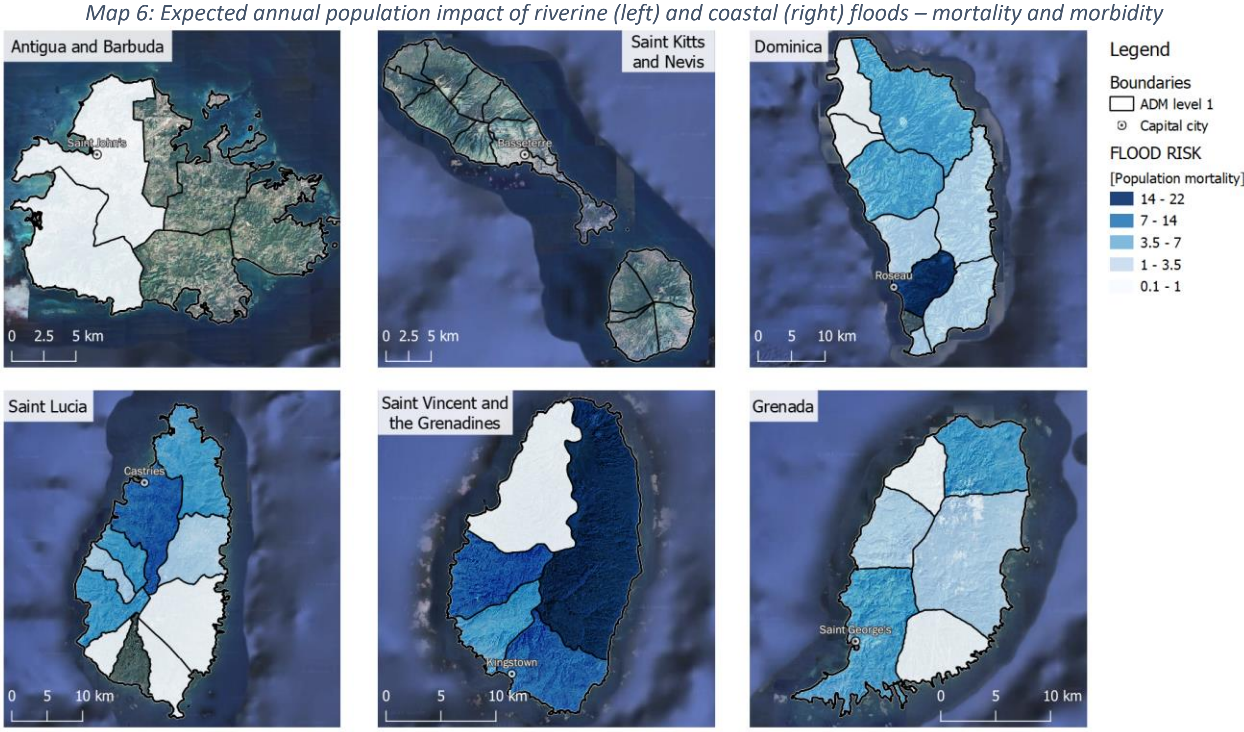
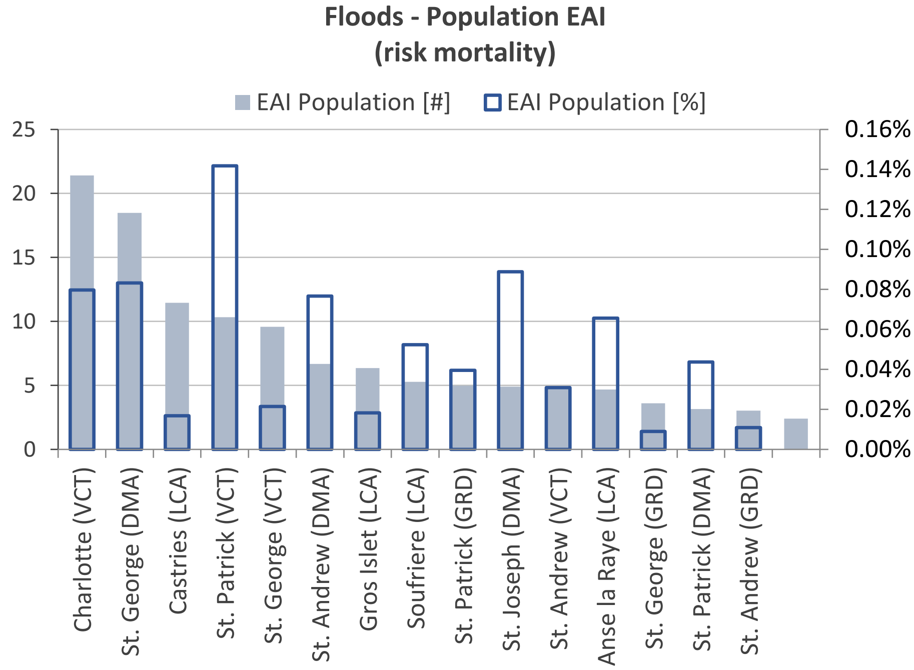


Chart 1: Expected Annual Impact on population (mortality) from river and pluvial flood events according to global models.



The floods damage pattern on built-up (*Map 7*) is similar to that of population, with the most exposed regions to river floods being Charlotte (VCT), St. Andrew (VCT), Castries (LCA), Soufriere (LCA), Gros Islet (LCA) and St. George (GRD). Chart 2 presents an aggregation of absolute (left axis) and relative (right axis) modelled impact at subnational level.

Map 7: Expected annual damage to built-up assets of riverine (left) and coastal (right) floods

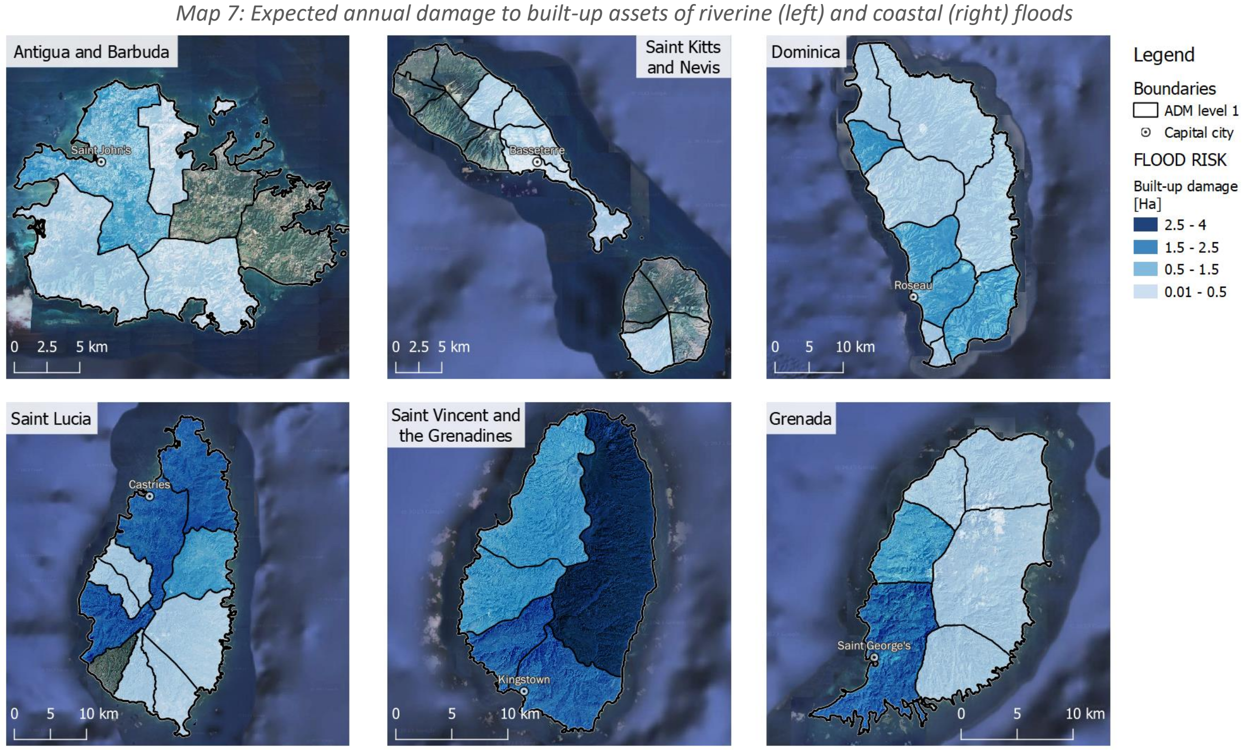
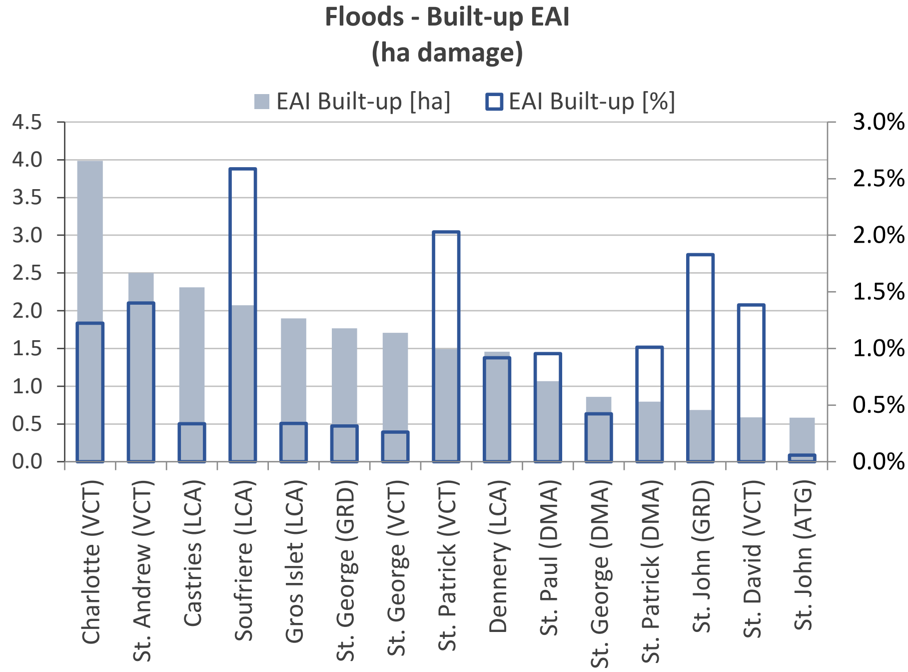
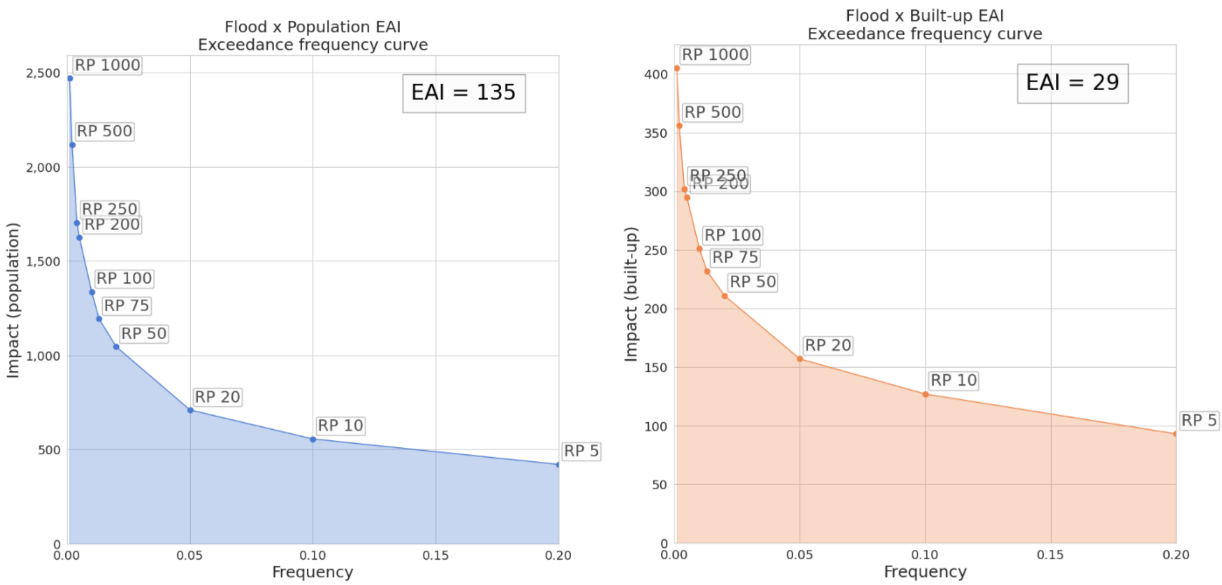


Chart 2: Expected Annual Impact on built-up asset (damage) from river and pluvial flood events according to global models.



Finally, the exceedance probability curves for population and built-up are presented for flood risk over population and built-up in *Chart 4*. The area below the curve represents the annual average impact from the combination of 10 individual impact scenarios.

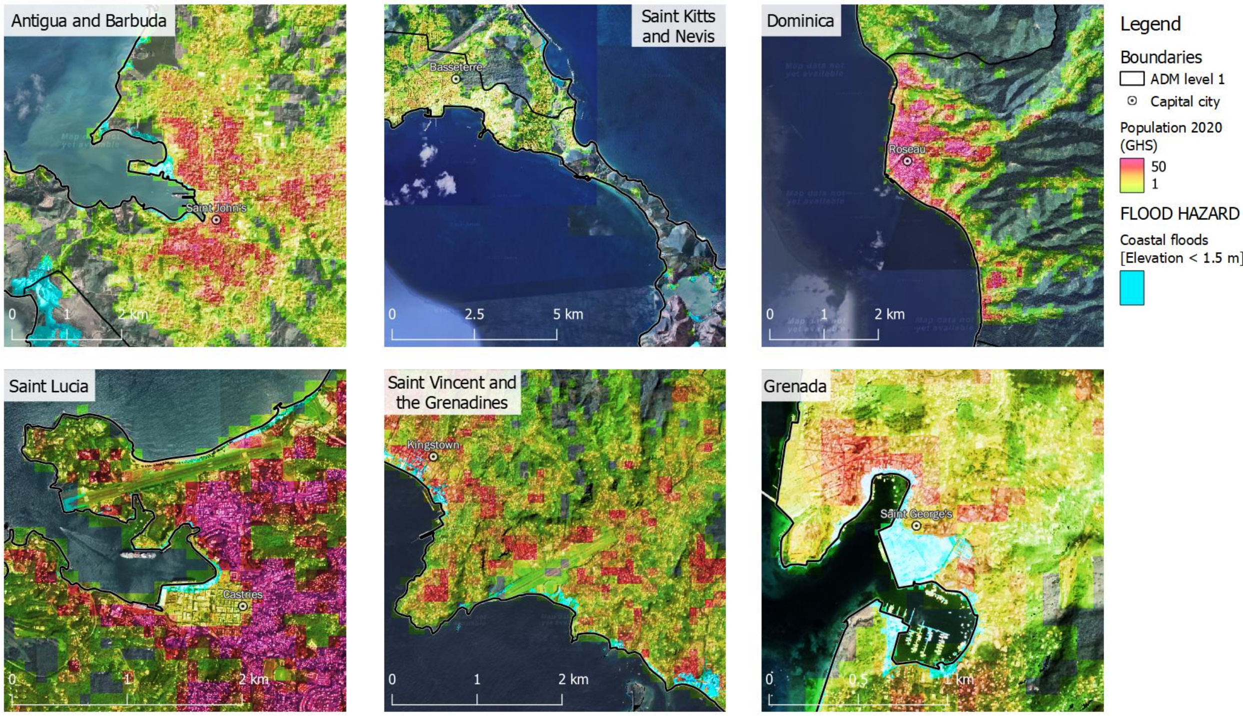
Chart 3: Exceedance Frequency curves for Flood risk over population (left) and built-up (right).



5.2. Coastal floods

Depiction of coastal hazard for the OECS country reveals the location that are exposed to storm surge events up to 1.5 over mean sea level. *Map 8* focuses on the most densely inhabited areas in each country (capital town).

Map 8: Coastal flood hazard across OECS countries – exposure to water level of 1.5 meters, focus on area around capital town



The charts 2 and 3 show the top 15 subnational units in terms of population located below 1.5 meters from mean sea level, meaning they are exposed to storm surge events with a Return Period between 50 and 200 years. The analysis is produced for the whole region using the 30-meters digital elevation model FABDEM. For the islands of LCA, VCT and GRD, an additional 5-meters model produced by CHARIM is used to estimate population exposure. The high-resolution model offers a much better representation of floodable areas, as shown in annex. The most exposed are LCA, GRD and VCT, whereas DMA and MSR shows almost no exposure.

Chart 4: Expected Annual Exposure of population to coastal flood events – 30 m DEM analysis

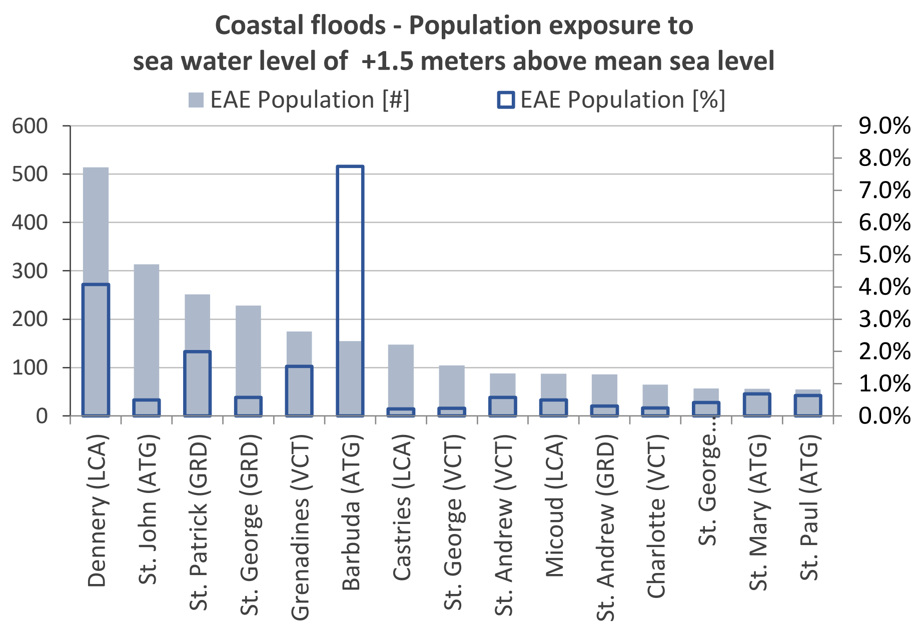
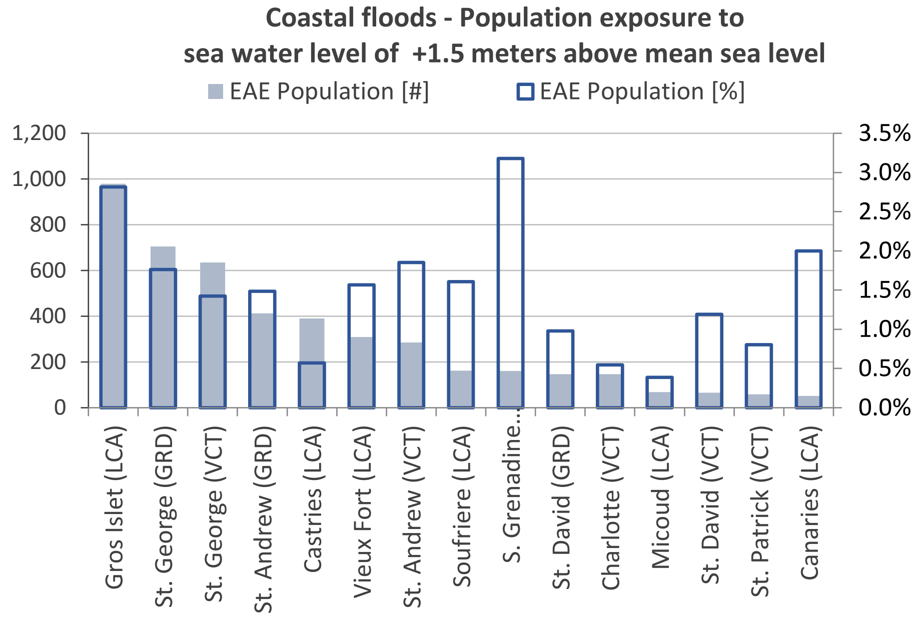
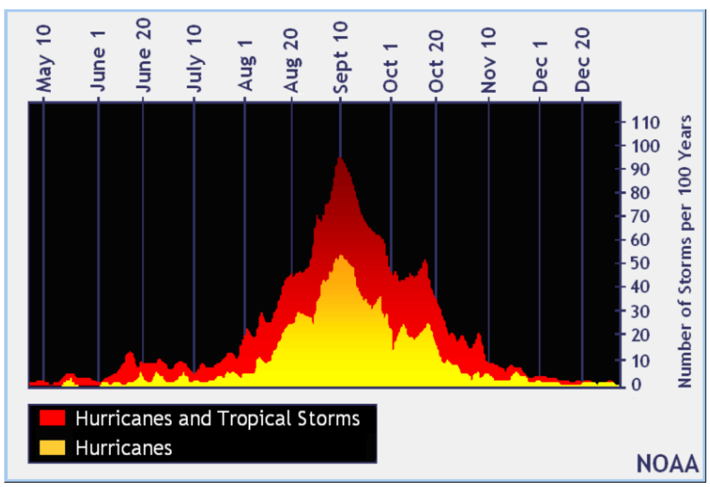


Chart 5: Expected Annual Exposure of population to coastal flood events – 5 m DEM analysis for LCA, VCT and GRD



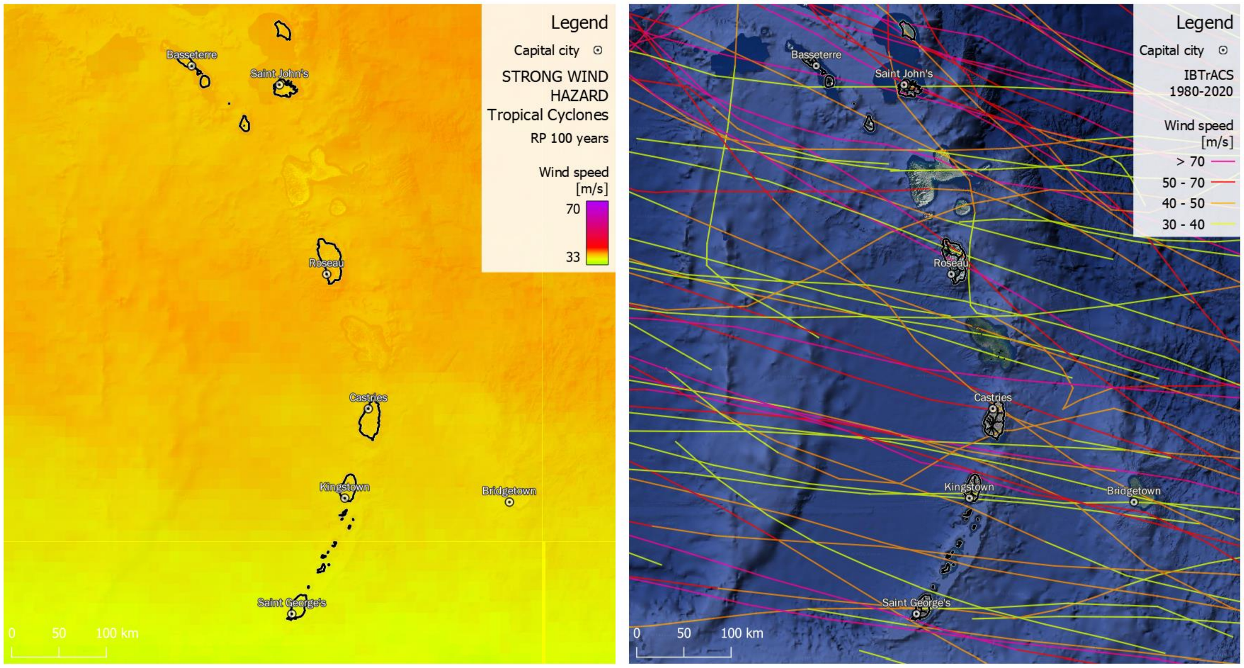
5.2.1. Strong wind

The OECS region has seen numerous tropical cyclones events. The STORM 2022 dataset combined with the IBTrACS v4 database help identify them in terms of direction and wind intensity (*Map 9)*. Most events move from SE to NW, affecting the OECS countries with high intensity wind before decreasing in intensity while moving along the North West path. Over the last 20 years, the OECS countries have experienced a total of 46 tropical cyclones. The majority of these storms occurred between June and November, during the Atlantic hurricane season.

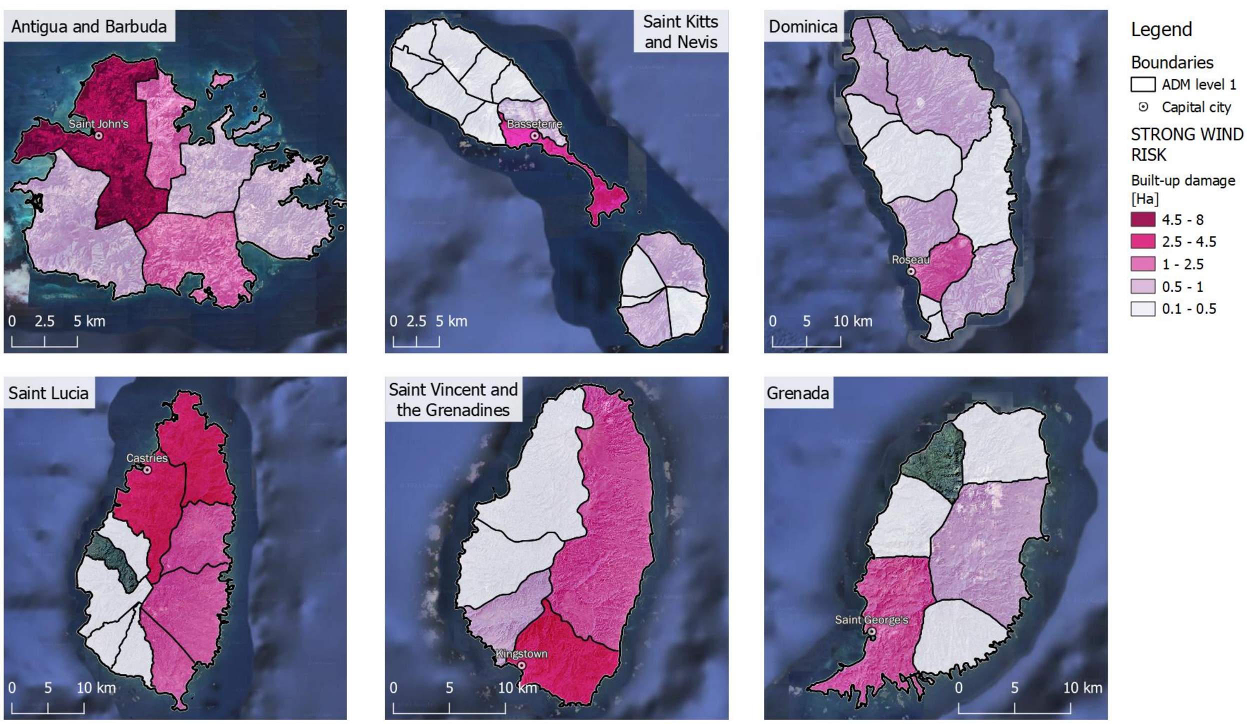


The frequency of tropical cyclones varied from year to year, with the most active year being 2017, which saw 6 storms affecting the region (National Hurricane Center, the Caribbean Disaster Emergency Management Agency). The intensity of tropical cyclones also varied, with some storms reaching category 5. Hurricane Irma in 2017 was also the most intense storm to affect the OECS countries in the last 20 years.

Map 9: Strong wind hazard from hurricanes across OECS region

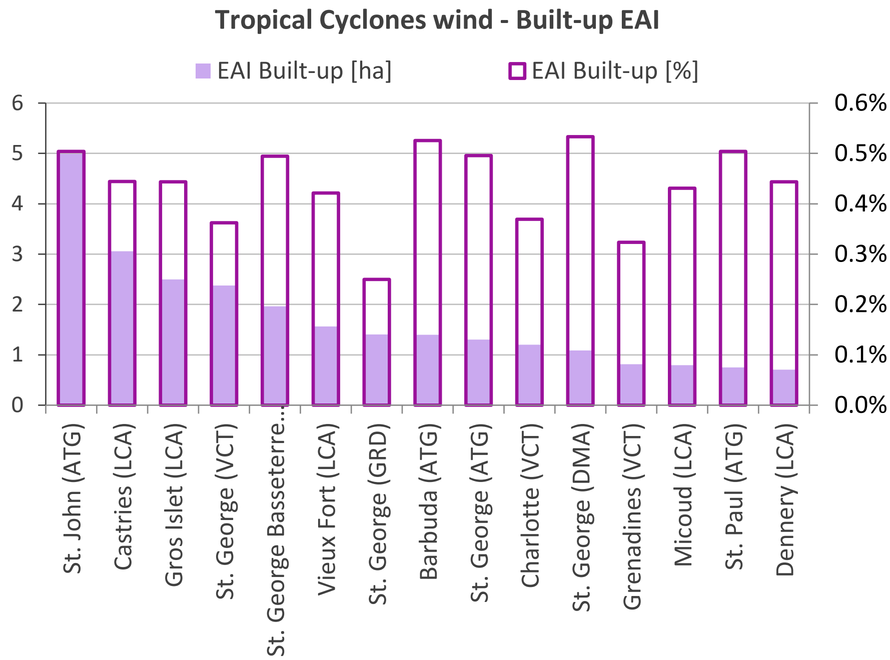


Map 10: Expected Annual Impact on built-up from strong wind hazard during tropical cyclone events across OECS region



When measuring the risk in terms of expected annual damage from strong winds over built-up, the model produces a damage up to 20% of houses destroyed for the scenario RP 100 years, while the scenario RP 500 years goes up to 32% in most locations. The most exposed to damage according to the model is Antigua and Barbuda, with around 0.5% of built-up (around 5 hectares) being at risk if being destructed by cyclones every year. Nonetheless, these seem to underrepresent the read devastation that was recorded during recent events, which reached 80%-90% housing destruction in some places – yet considering the combination of hazards triggered by the cyclone.

Chart 6: Expected Annual Impact over built-up land (ha of land exposed) to strong wind during cyclone events



5.3. Drought

Drought is an inherent feature of climate variability in the OECS region, but its negative effects on agricultural production and environment have recently increased due to the effect of ENSO and Climate Change in recent decades (Payano-Almanzar et al. 2018). In the Caribbean, two of the worst droughts on record (i.e. the 2009-10 and 2014-16) occurred within the last period of 10 years of observations (Trotman et al., 2010). According to OECS climate report (2020), the average drought impact potential has often been moderate during the dry season, and slight or moderate during the wet season. The 20 years of observations since 1999 show an increase in long-term drought impact potential over the 20 preceding years in both the Leeward and Windward Islands. No robust change has been seen in the frequency of short-term drought since the late 1970s.

The assessment of drought frequency and impacts is performed with a variety of indices, among them the remote-sensed Agricultural Stress Index (ASI), the self-calibrating Palmer Drought Severity Index (PDSI) and the Standard Precipitation-Evapotranspiration Index (SPEI). *Maps 10* captures how agricultural land has been affected by drought stress during the primary cropping seasons according to ASI: over a 37-year baseline (1984-2021), it shows the share of period during which at least 30% of cropland area extent was exposed to agricultural drought stress. This index relies on FAO data and remote-sensed crop images, and as such it cannot properly represent small scale agriculture. In the case of VCT and GRD, not cropland is identified by the FAO dataset.

Map 11: Drought hazard for agricultural land across OECS countries during the primary cropping season

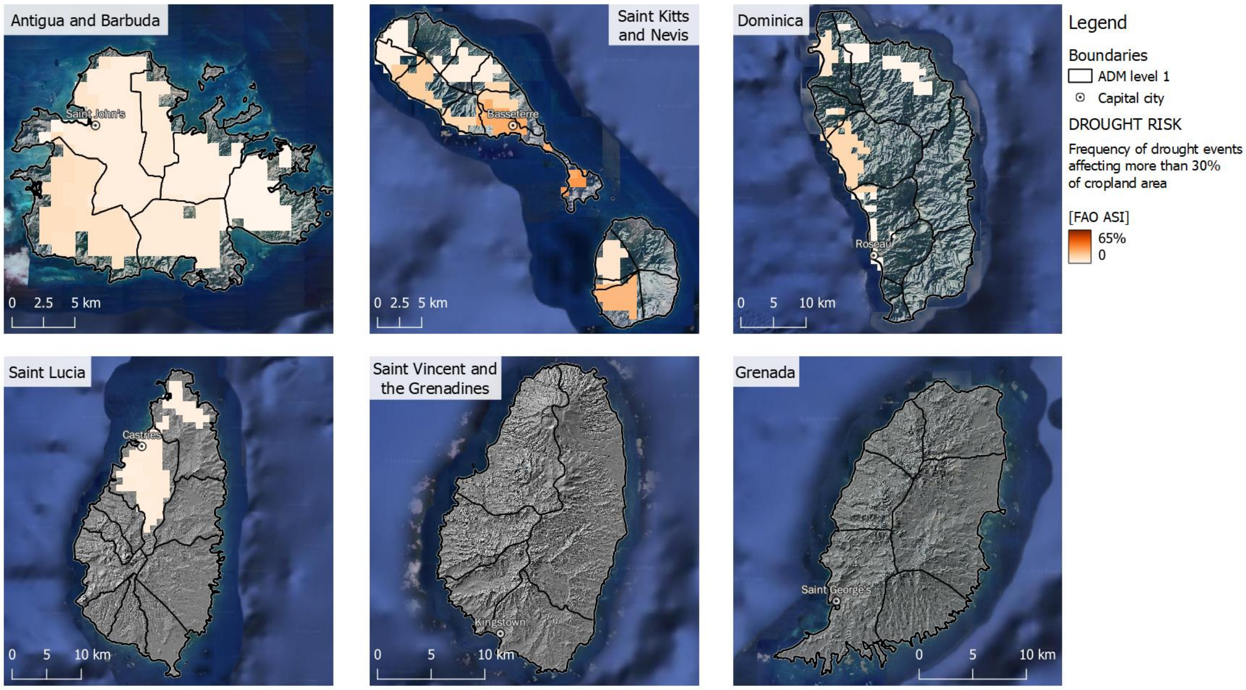
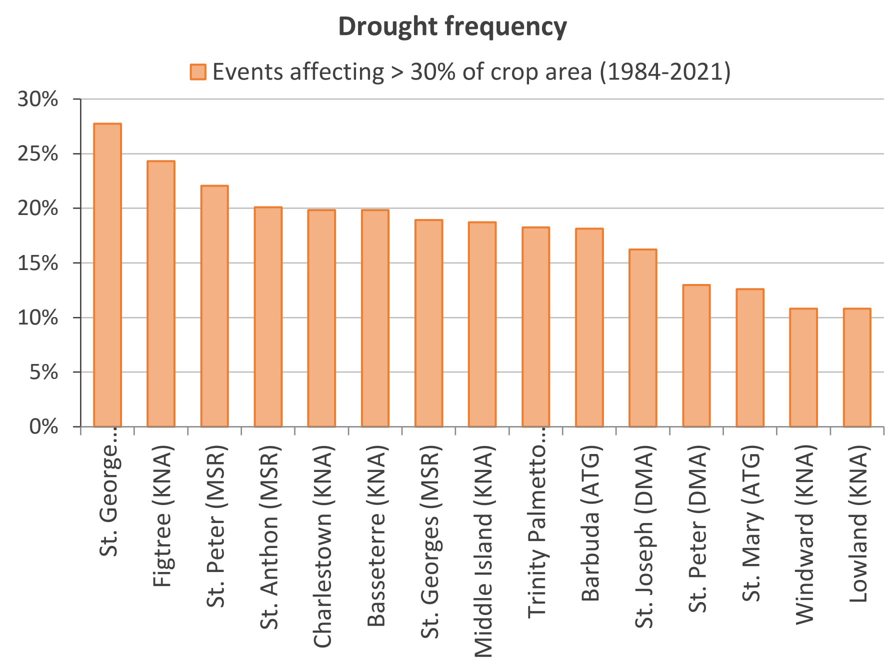


Chart 7 shows the frequency of drought events by subnational unit. KNA and MSR appear to be the two countries most frequently affected by drought events, as dry spells impact is much higher in smaller and less rugged islands, due to their limited natural water storage capacity.

Chart 7: Frequency of drought events over agricultural land (ha of land exposed) according to FAO ASI dataset 1984-2021.



The following figures present the PDSI and SPEI indicators for the whole region in the last 70 years (1951-2021) and for each country in the last 25 years (1996-2021). The direction of the change agrees between the two indices, with the last 10-15 years showing decreasing water availability in the region and individual countries. Please note that the small size of the countries compared to the rough resolution of the data (0.5° degrees for PDSI, 1° degree for SPEI) may result in large uncertainties compared to the aggregated regional average.

Figure 6: Self-calibrating Palmer Drought Severity Index (scPDSI) across OECS region, 1951-2022

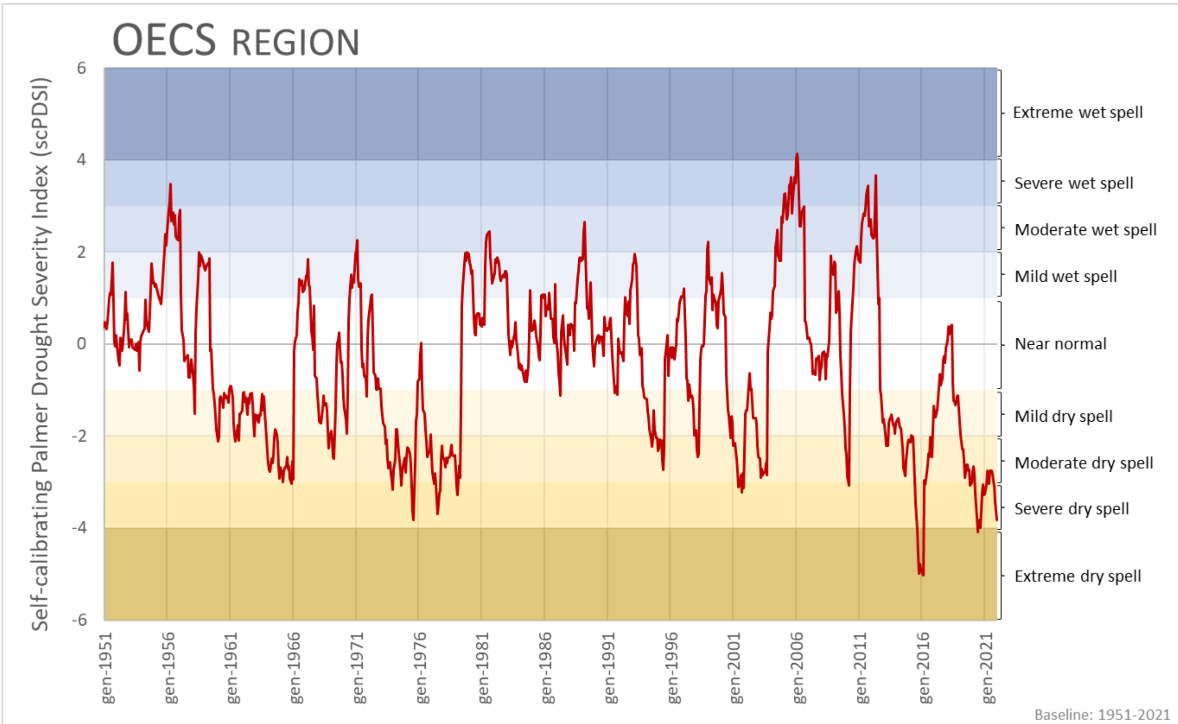
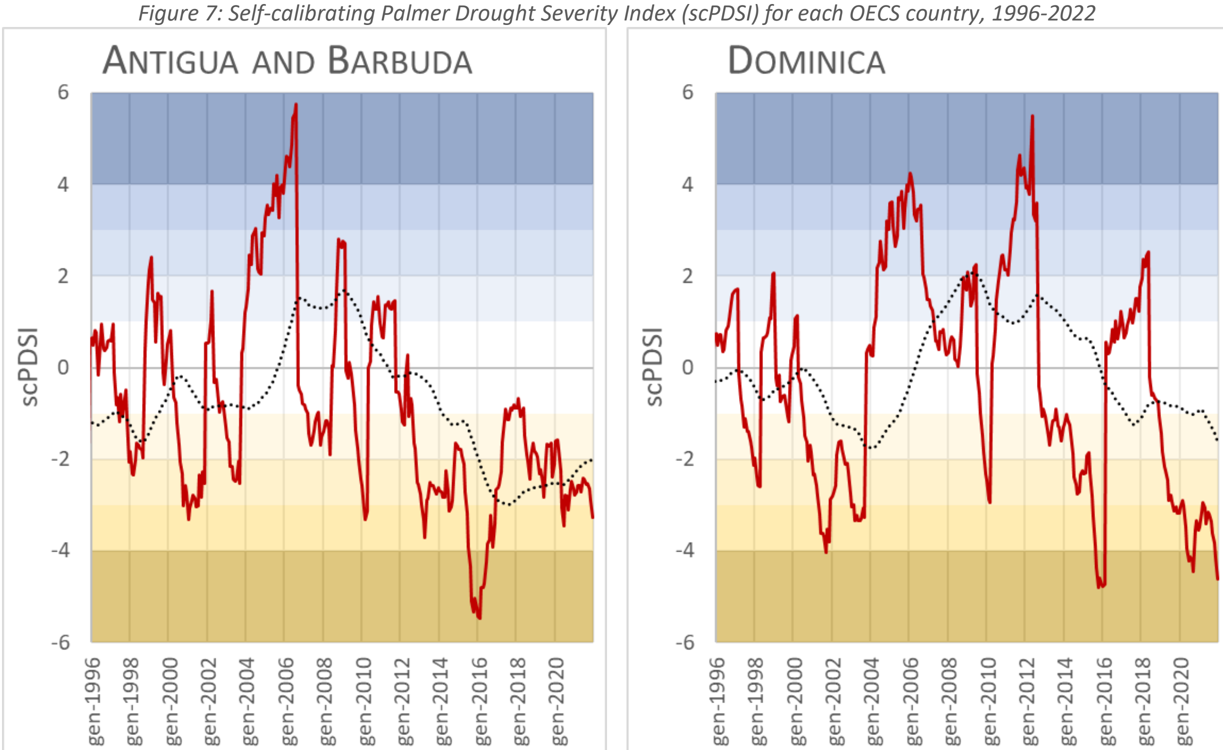
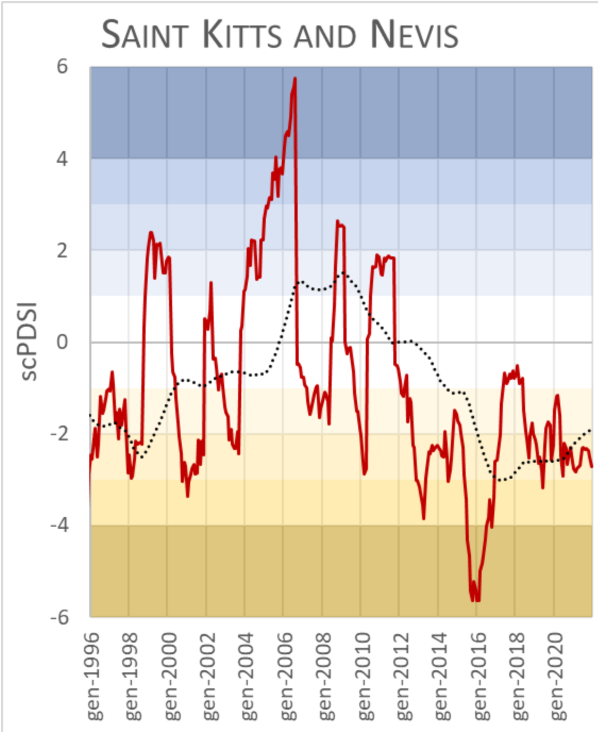
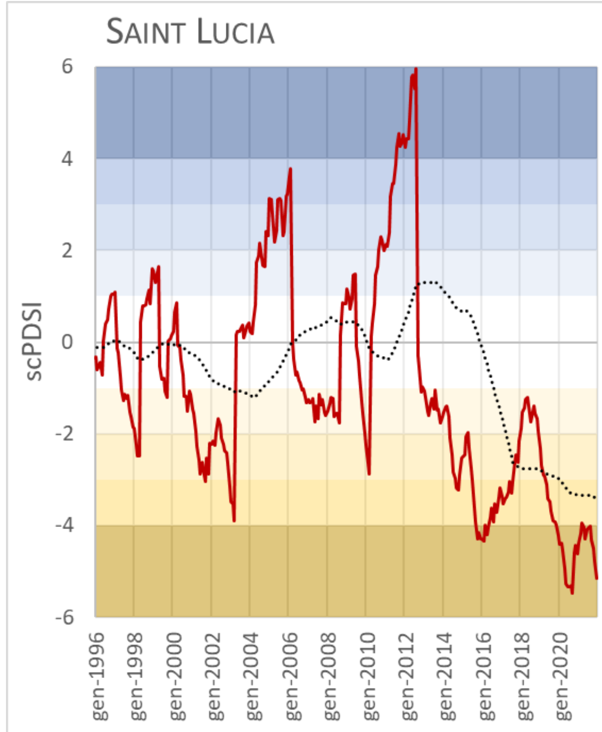
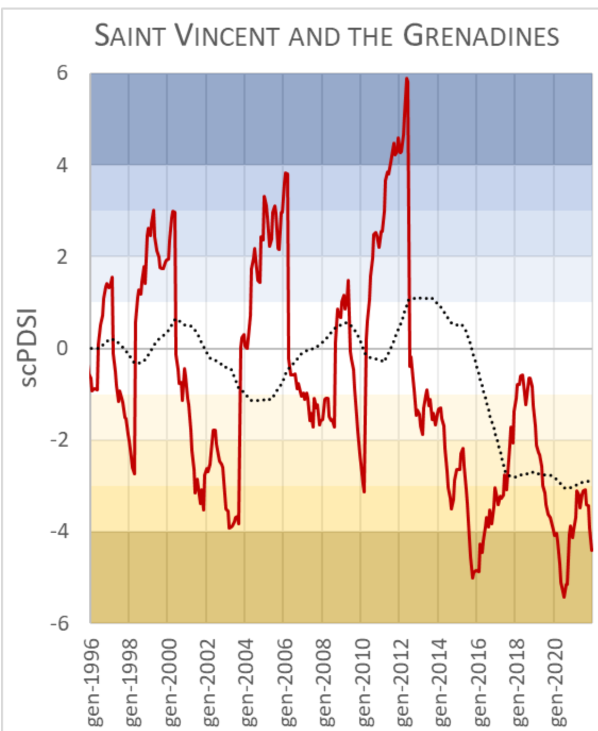


Figure 7: Self-calibrating Palmer Drought Severity Index (scPDSI) for each OECS country, 1996-2022




SAINT KITTS AND NEVIS
scPDSI
6
4
2
0
-2
-4
-6
gen-1996
gen-1998
gen-2000
gen-2002
gen-2004
gen-2006
gen-2008
gen-2010
gen-2012
gen-2014
gen-2016
gen-2018
gen-2020


SAINT LUCIA
scPDSI
6
4
2
0
-2
-4
-6
gen-1996
gen-1998
gen-2000
gen-2002
gen-2004
gen-2006
gen-2008
gen-2010
gen-2012
gen-2014
gen-2016
gen-2018
gen-2020


SAINT VINCENT AND THE GRENADINES
scPDSI
6
4
2
0
-2
-4
-6
gen-1996
gen-1998
gen-2000
gen-2002
gen-2004
gen-2006
gen-2008
gen-2010
gen-2012
gen-2014
gen-2016
gen-2018
gen-2020

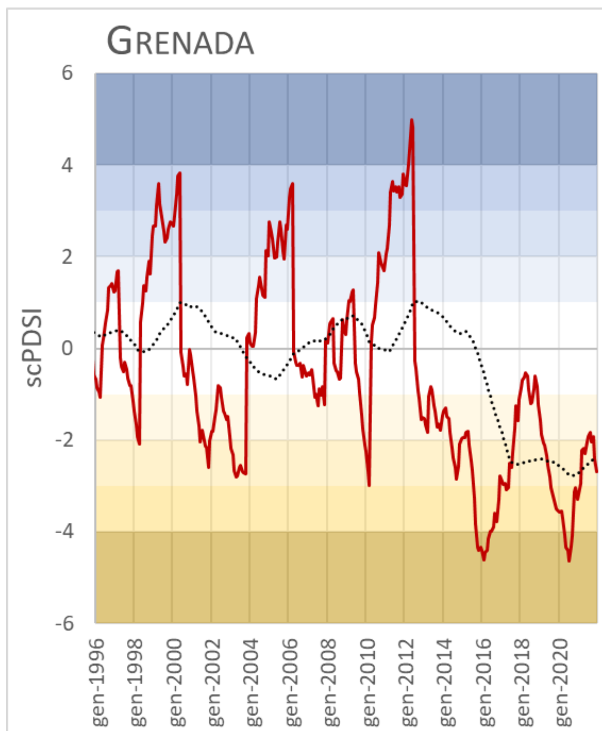

GRENADA
scPDSI
6
4
2
0
-2
-4
-6
gen-1996
gen-1998
gen-2000
gen-2002
gen-2004
gen-2006
gen-2008
gen-2010
gen-2012
gen-2014
gen-2016
gen-2018
gen-2020

Figure 8: Standardized Precipitation-Evapotranspiration Index (SPEI) –12 months across the OECS region, 1951-2022

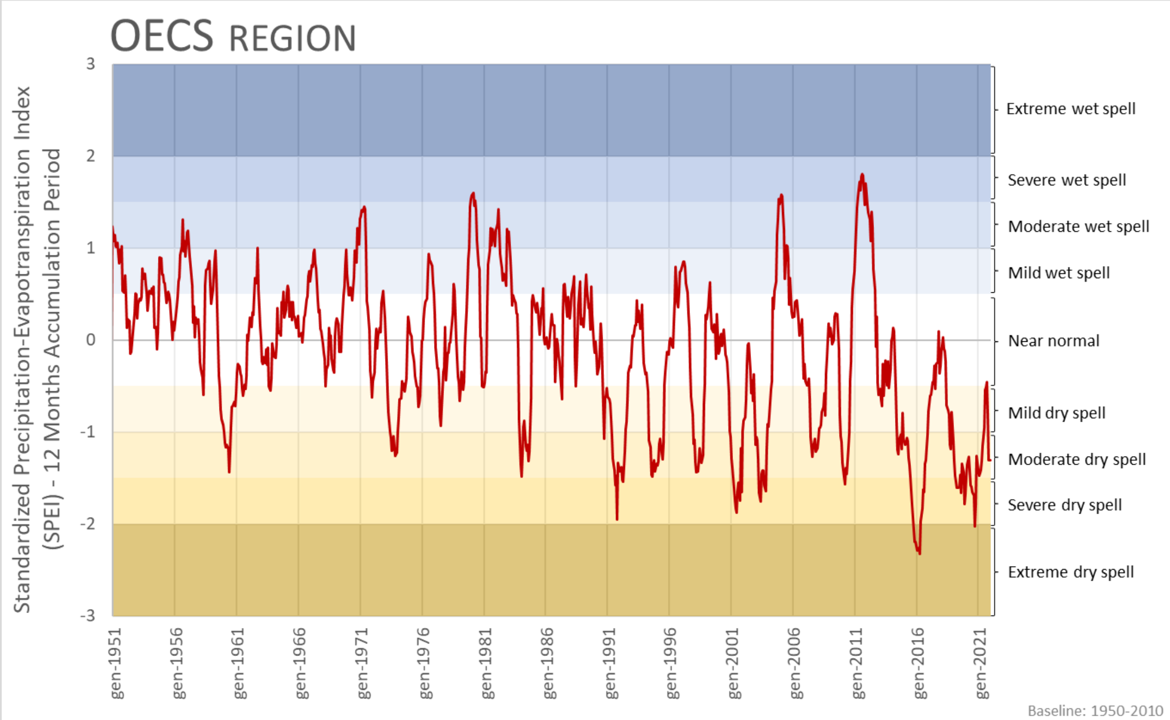
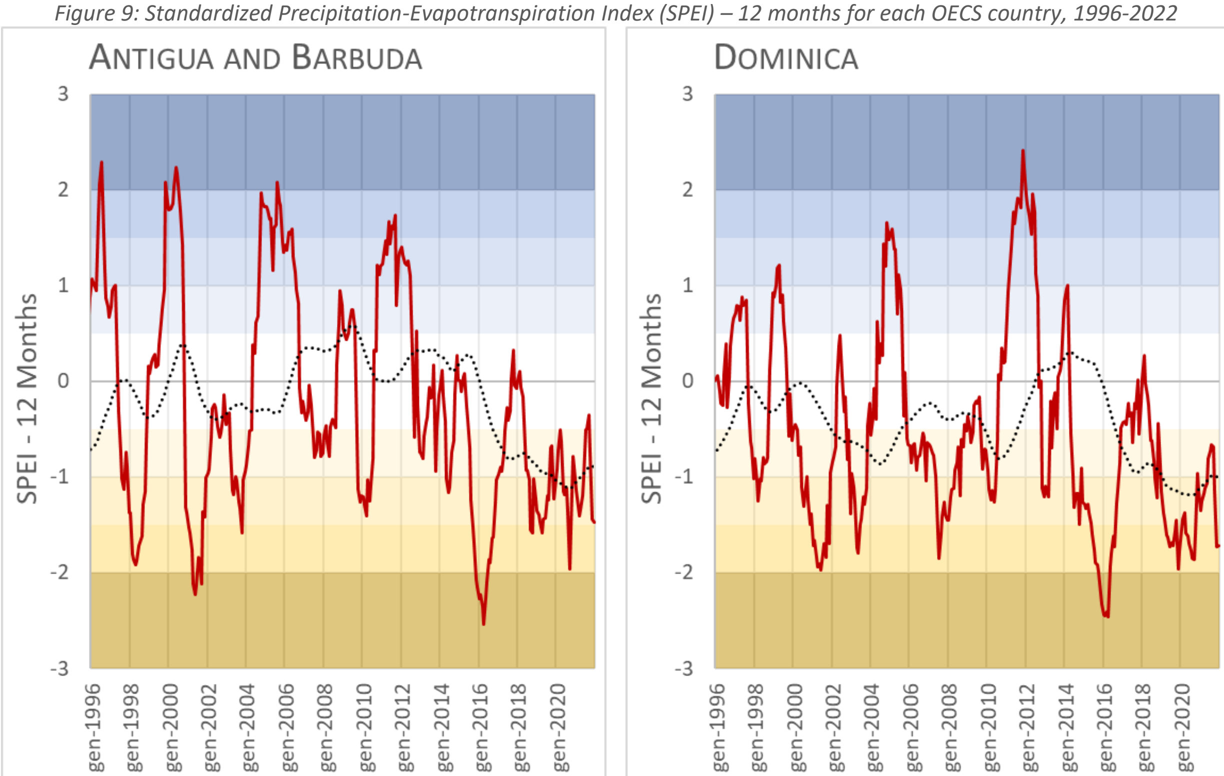
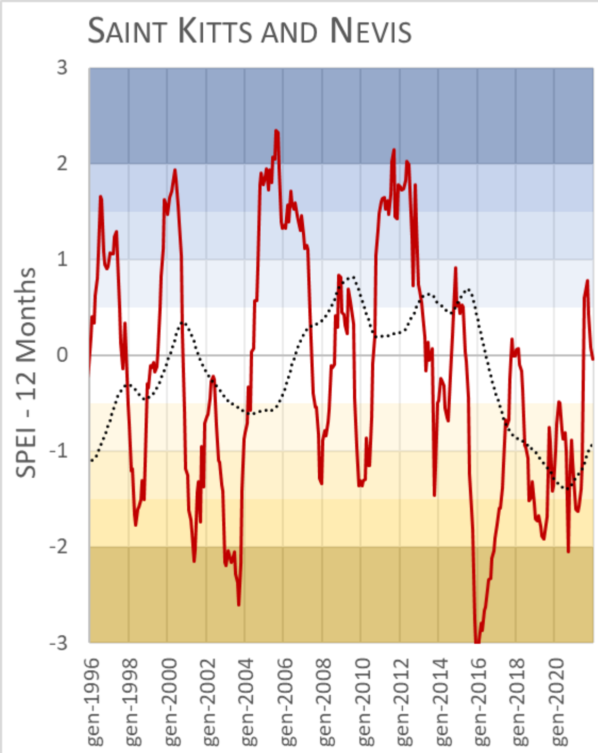
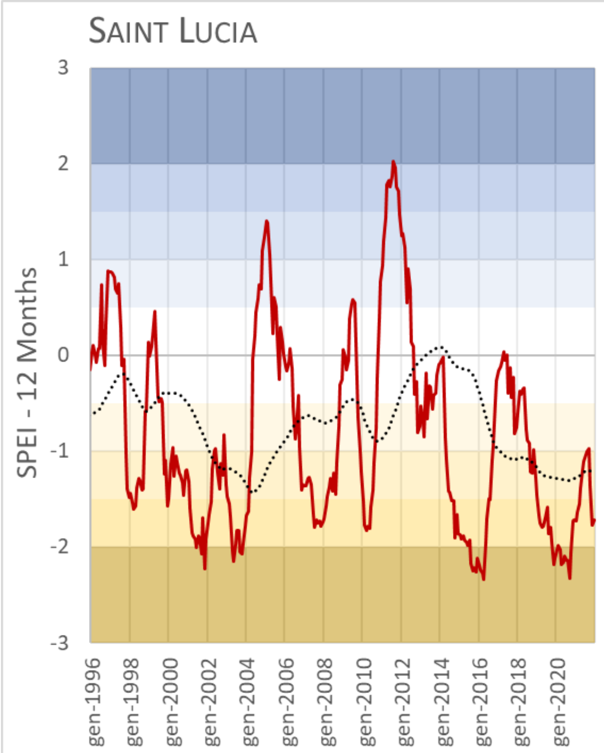
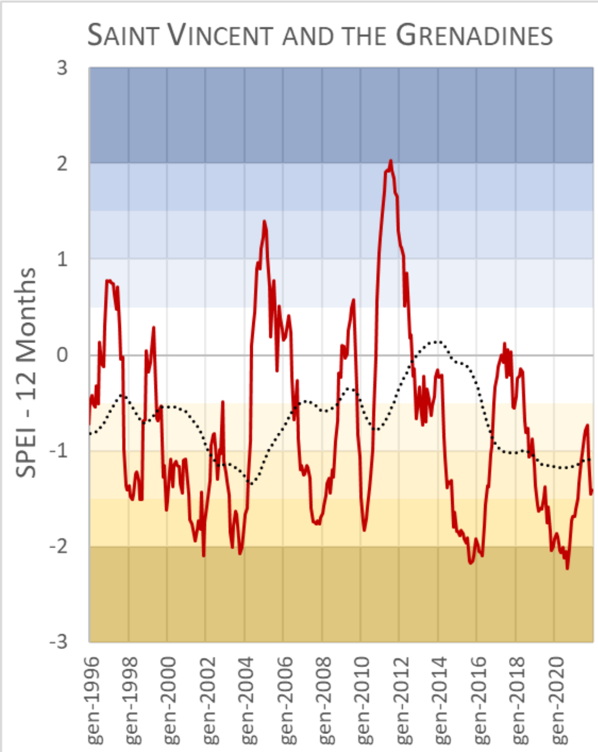


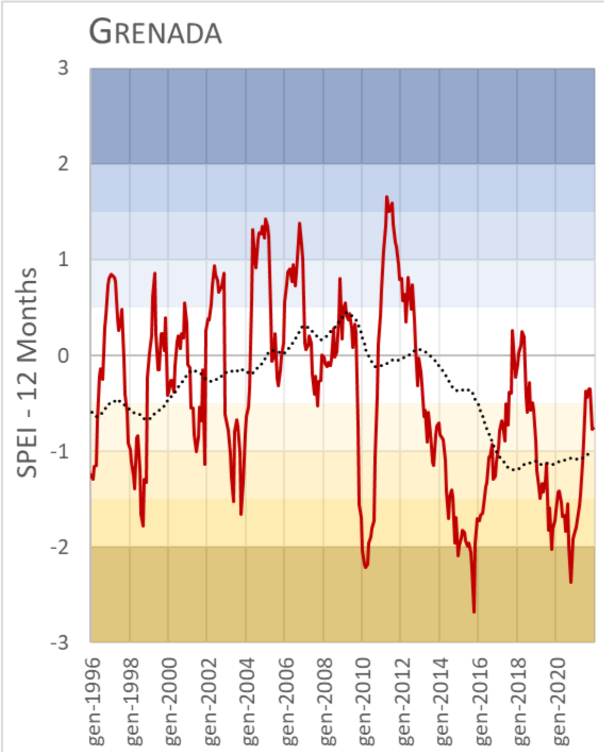
Figure 9: Standardized Precipitation-Evapotranspiration Index (SPEI) – 12 months for each OECS country, 1996-2022




Saint Kitts and Nevis
SPEI - 12 Months
3
2
1
0
-1
-2
-3
gen-1996
gen-1998
gen-2000
gen-2002
gen-2004
gen-2006
gen-2008
gen-2010
gen-2012
gen-2014
gen-2016
gen-2018
gen-2020


Saint Lucia
SPEI - 12 Months
3
2
1
0
-1
-2
-3
gen-1996
gen-1998
gen-2000
gen-2002
gen-2004
gen-2006
gen-2008
gen-2010
gen-2012
gen-2014
gen-2016
gen-2018
gen-2020


Saint Vincent and the Grenadines
SPEI - 12 Months
3
2
1
0
-1
-2
-3
gen-1996
gen-1998
gen-2000
gen-2002
gen-2004
gen-2006
gen-2008
gen-2010
gen-2012
gen-2014
gen-2016
gen-2018
gen-2020


Grenada
SPEI - 12 Months
3
2
1
0
-1
-2
-3
gen-1996
gen-1998
gen-2000
gen-2002
gen-2004
gen-2006
gen-2008
gen-2010
gen-2012
gen-2014
gen-2016
gen-2018
gen-2020

5.4. Risk ranking

Risk rankings produced considering the impact from individual hazards on multiple exposure categories are shown in *Table 3* (Regional level) and *table 4 (*Province level*)* according to the criteria explained in paragraph 2.5: tropical cyclone risk score is aggregated as the maximum of the river/pluvial flood, coastal flood and strong wind risk score.

Table 3: Risk scores for individual hazards at country level

COUNTRY	RIVER / PLUVIAL FLOOD	COASTAL FLOOD	STRONG WIND	TROPICAL CYCLONES	DROUGHT
Antigua and Barbuda	LOW	HIGH	HIGH	HIGH	HIGH
Dominica	HIGH	LOW	HIGH	HIGH	MEDIUM
Grenada	MEDIUM	MEDIUM	LOW	MEDIUM	LOW
Montserrat	LOW	LOW	HIGH	HIGH	HIGH
Saint Kitts and Nevis	LOW	LOW	HIGH	HIGH	HIGH
Saint Lucia	HIGH	HIGH	HIGH	HIGH	MEDIUM
Saint Vincent and the Grenadines	HIGH	MEDIUM	MEDIUM	HIGH	LOW

6. Climatology and future hazard scenarios

OECS countries are located within the tropics and has a relatively mild tropical climate. […] The Caribbean is one of the most vulnerable regions to climate change and its consequences, such as warmer summers, increased number of extreme events, water scarcity, loss of marine biodiversity, rising sea level, disease outbreaks, heat shocks, and others. One of the most important sources of climate variability in the region is the El Niño Southern Oscillation (ENSO) (Giannini et al., 2000). The historical temperature and rainfall record in the OECS further suggest strong correlation between strong El Niño events and temperature as well as the frequency of heatwaves and, to a certain extent, dry spells. Future climate scenarios provided by the National Meteorological Office (ONAMET) suggest that the total number of tropical cyclones may decrease towards the end of the century. However, it is likely that cyclones will become more intense (an increase in wind speed of 2–11% for a mid-range scenario), meaning that the most intense events (category 4 and 5) will become more frequent. It is also likely that average precipitation rates within 100 km of the storm centre will increase – by a maximum of about 10% per degree of warming [WHO, 2021].

6.1. Hazard projections: climate indices

The climate indices associated with presented natural hazards are discussed as follows. Each of the map figures uses the same layout: the grid data for the historical mean over the baseline period 1995-2014 is shown in the top left, and the average for each of the 10 regions on the bottom left. The second, third and fourth columns represent the projected anomalies for the climate variables under low emission scenario SSP1 – 2.6 (second column), medium emission scenario SSP2 – 4.5 (third column), and high emission scenario SSP5 – 8.5 (fourth column). The top row shows the gridded standardised anomalies derived from CMIP6 for our time horizon 2041-2060, and the bottom row shows the mean for each region. Below the maps, for each climate variable, the historical variation during the baseline period is shown, together with the projected future anomalies for the three SSPs.

6.2. Rainfall indices

Four climate indices are assessed to estimate the change in extreme rainfall trends, which could ultimately affect flood and landslide hazards: annual number of consecutive wet days (CWD, *Figure 6*), annual days of rainfall with over 10mm of precipitation (R10mm, *Figure 7*), maximum precipitation over five days (Rx5day, *Figure 8*), precipitation amounts during extremely wet days (R99p, *Figure 9*). Projected sea level rise (SLR, *Figure 10*) is considered in relation to coastal floods.

The historical baseline of precipitation variables show wetter conditions in the north-western and south-eastern Caribbean both in terms of rainfall duration (*CWD*) but also in term of intensity (*R10mm*, *Rx5day*, *R99p*). According to projections, the southern OECS region will see an overall decrease in terms of precipitation duration and intensity by mid-century, while the western OECS region will expect a slight increase. The severity of rainfall reduction is larger for the high-emission scenario (SSP5-8.5) and moving towards the end of the century, while it remains much closer within the boundaries of historical variability for the low emission scenario (SSP1-2.6). Interestingly, extreme precipitation may become more frequent in the north and centre of the OECS region before decreasing after mid-century. The general direction of change for these indices suggests that flood events triggered by precipitation might see a slight decrease in frequency and intensity.

Figure 10: Climate indices - Consecutive Wet Days (days/year) for OECS region

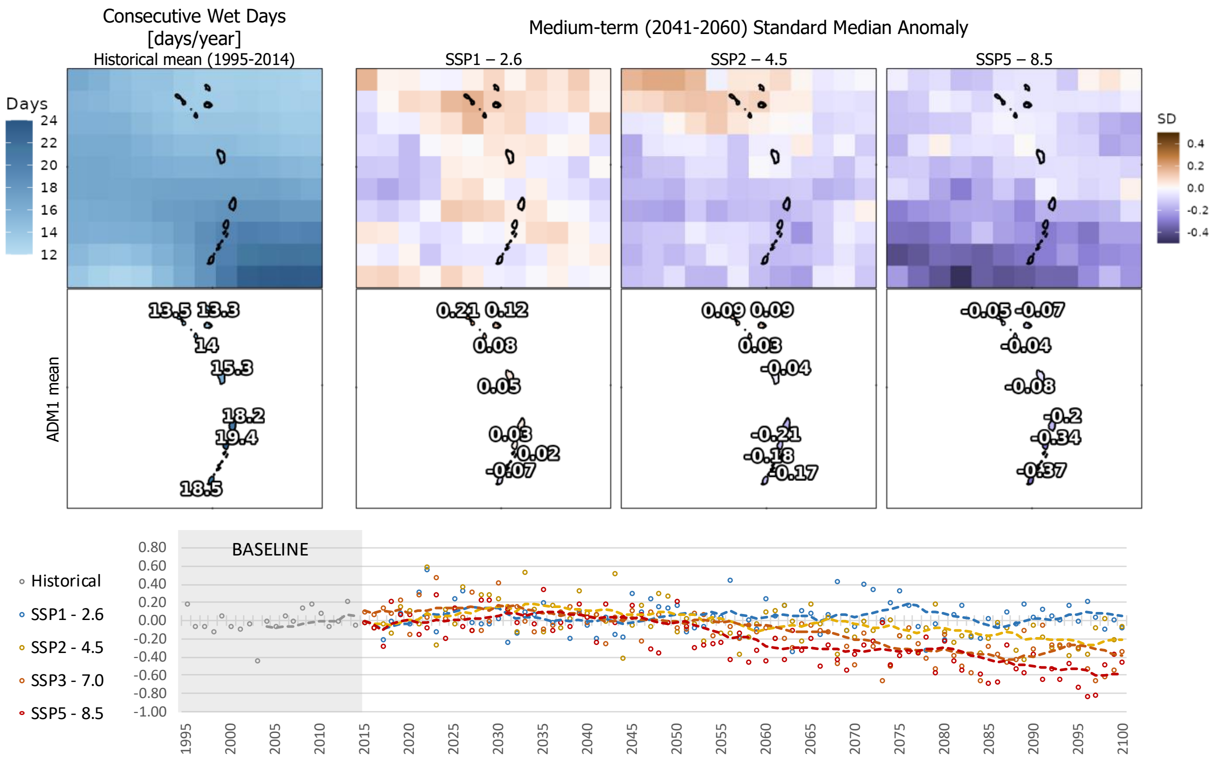


Figure 11: Climate indices - Rainfall over 10mm (days/year) for OECS region

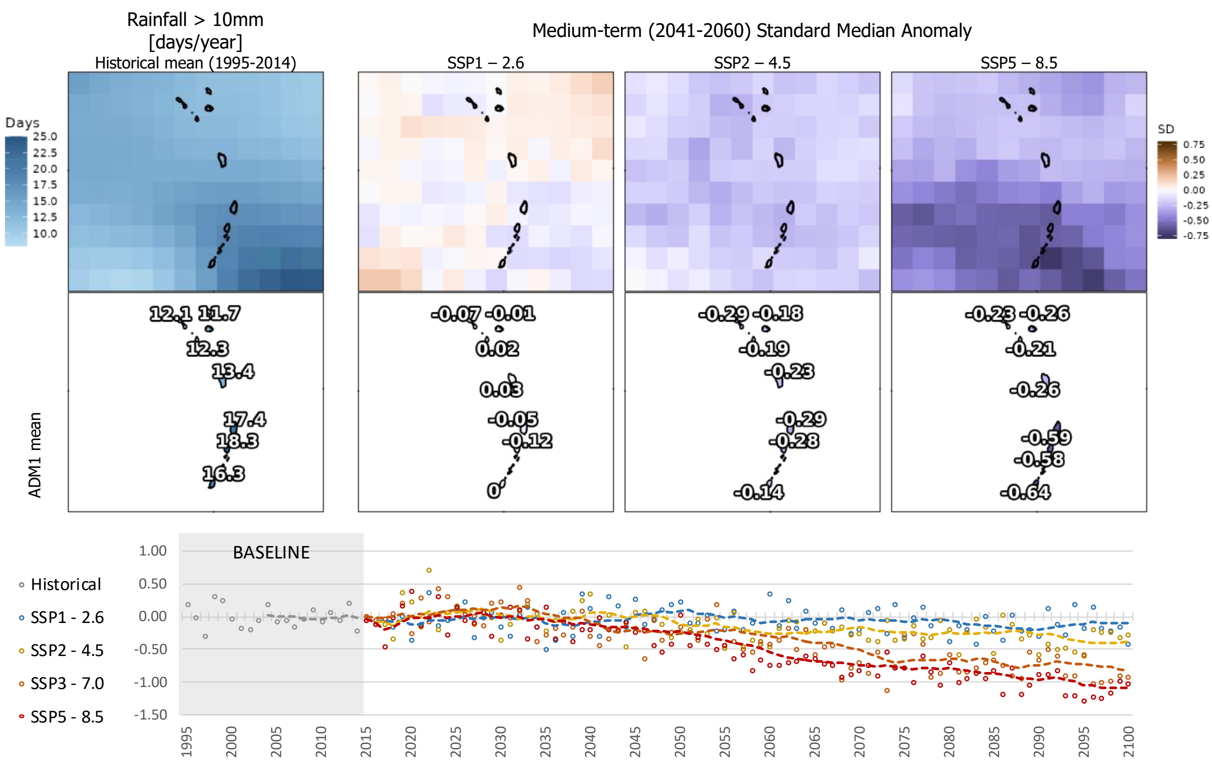


Figure 12: Climate indices - Maximum 5-day Precipitation (mm/year) for OECS region

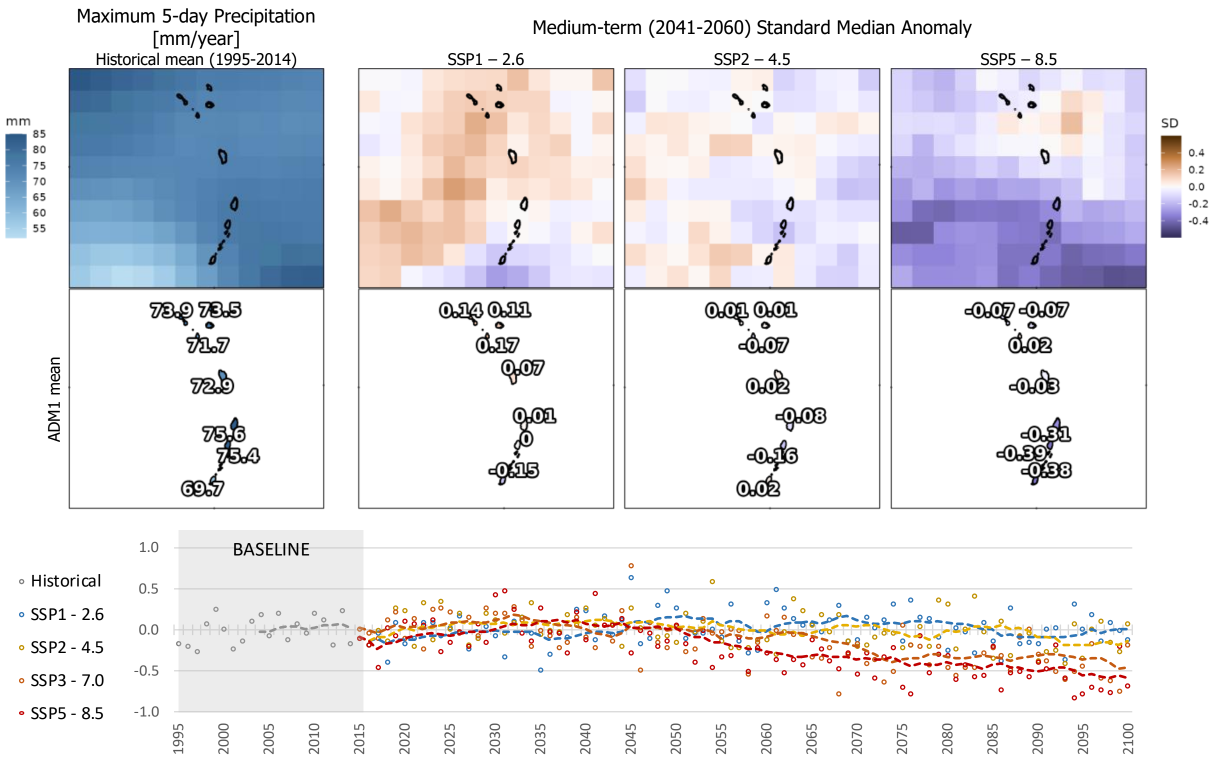
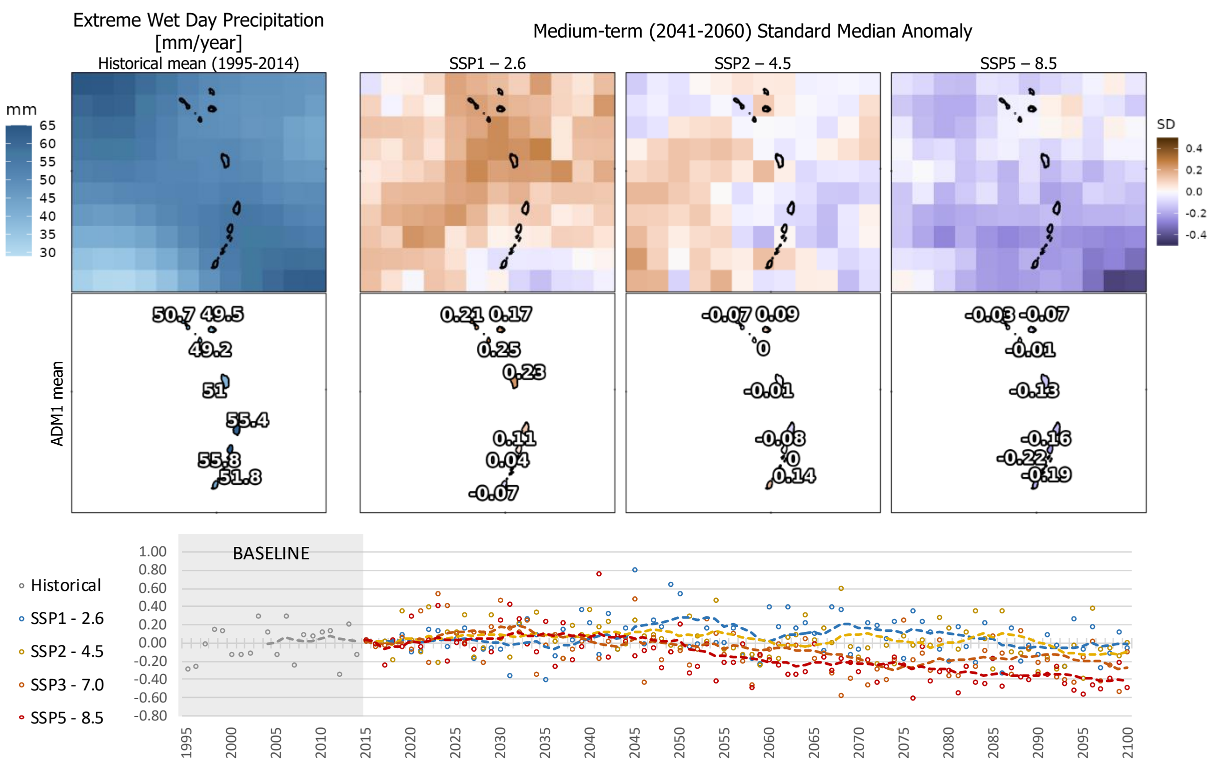


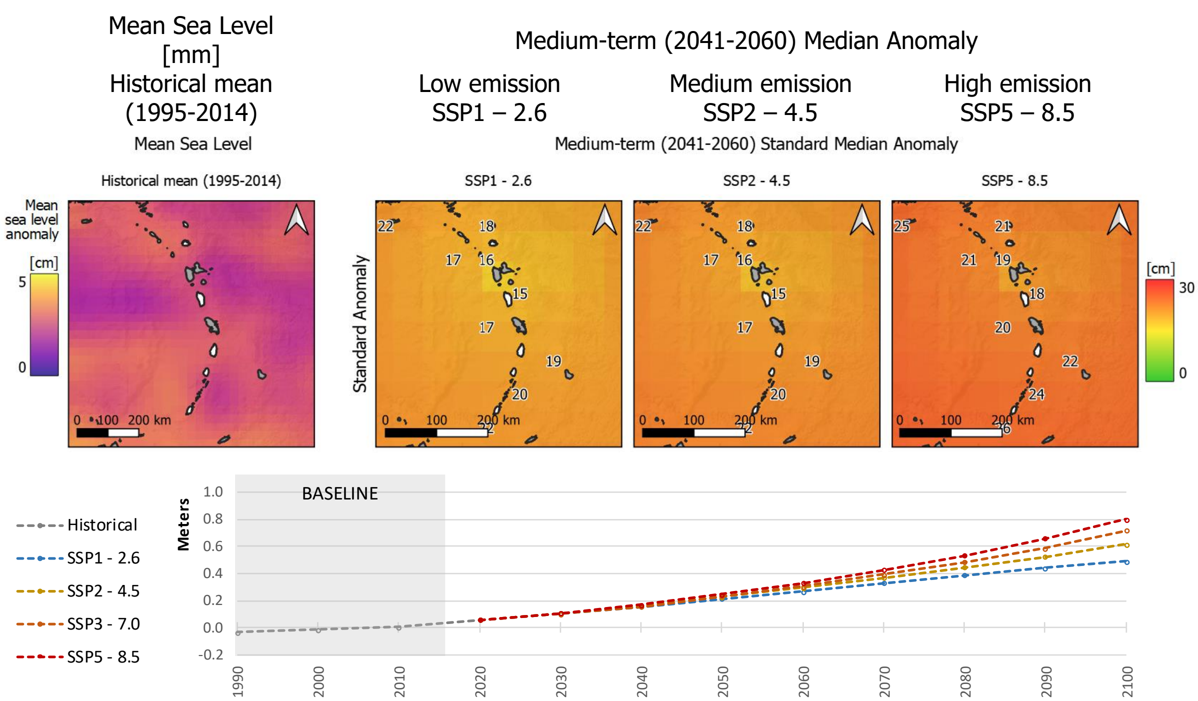
Figure 13: Climate indices - Extreme Wet Day Precipitation (mm/year) for OECS region



6.3. Sea level rise

Being made of small island states, sea level rise is a point of serious concerns for the OECS region. The relatively long response times to global warming mean that sea level will continue to rise for a considerable time after any reduction in emissions. By mid-century, a rise of mean sea level of at least 15 to 20 cm is expected under any emission scenarios. By the end of the century, however, sea level could rise by 40 cm to 80 cm for the scenarios SSP1-2.6 and SSP5-8.5, respectively, posing threats to all coastal perimeters. Increasing mean sea level will make storm surge events more impactful in terms of inland inundation, and may ultimately cause irreversible coastal erosion and land loss.

Figure 14: Climate indices - Average Sea Level Rise (cm)

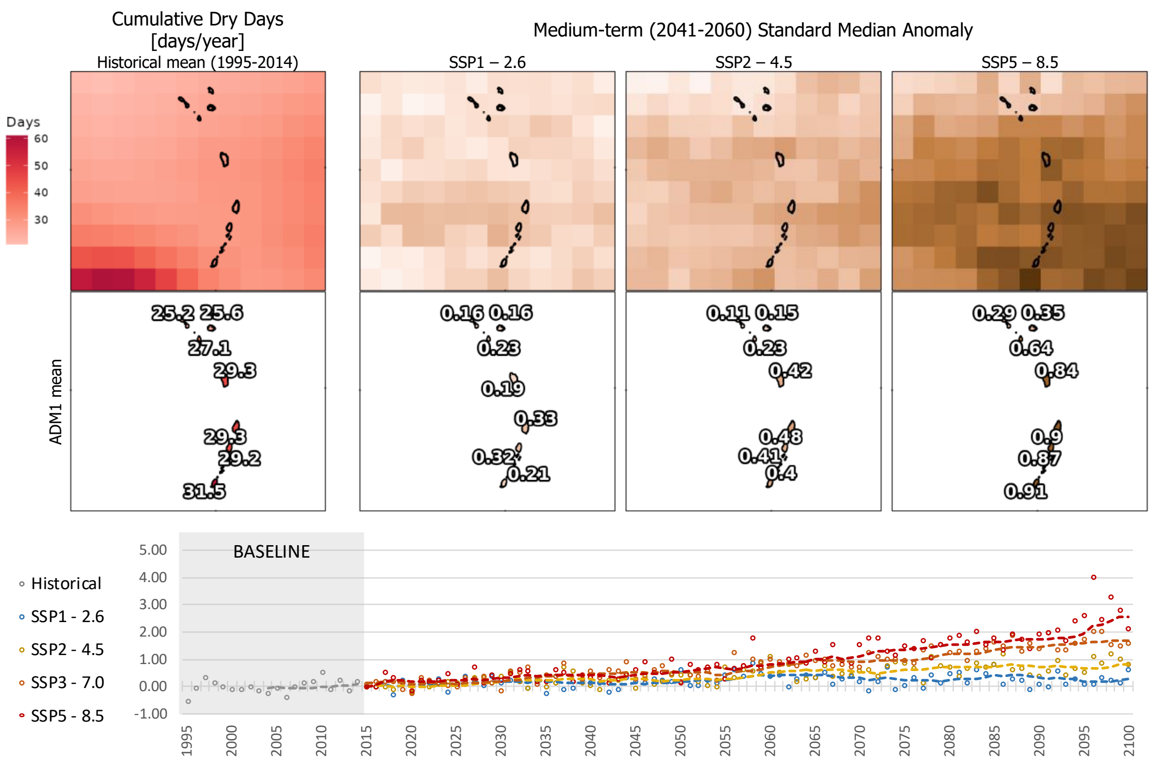


6.4. Drought indices

Two variables underpin the projection of changes in drought patterns: the *number of consecutive dry days per year* (CDD, *Figure 11*), and the *12-month Standardized Precipitation-Evapotranspiration Index* (SPEI, *Figure 12*). The SPEI has been found to be closely related to drought impacts on ecosystems, crop, and water resources, and has been designed to take into account both precipitation and potential evapotranspiration in determining drought [World Bank 2022]. It is important to note that negative SPEI values indicate drier than normal conditions, while positive values indicate wetter than normal conditions. The mapping ensembles for these drought-related variables follow a similar design to the precipitation-related variables, again with the 1995-2014 period as a historical baseline.

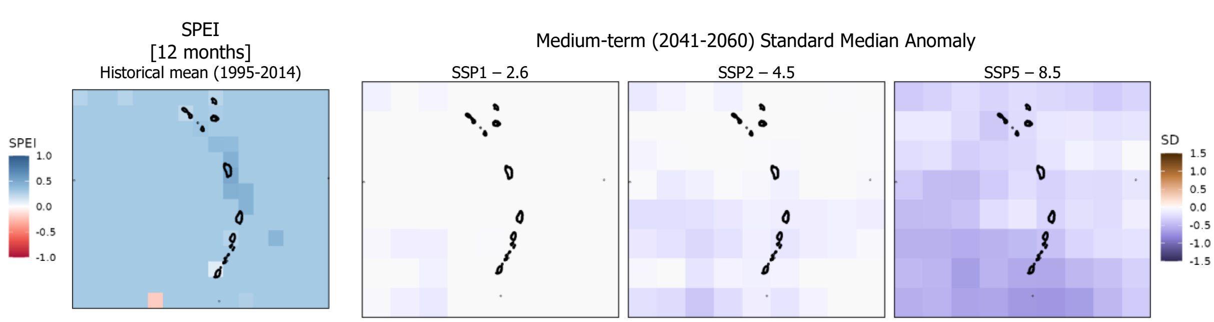
The impact potential of dry spells is much higher on smaller islands and in areas with low topography, due to their limited natural water storage capacity. The events are more likely to occur during the second half of the dry season (i.e. March to May). The historical baseline shows that the OECS region has around 30 consecutive dry days/year. The climate index projections suggest that these regions could experience a relatively increase in the length of dry periods, especially in the centre and south.

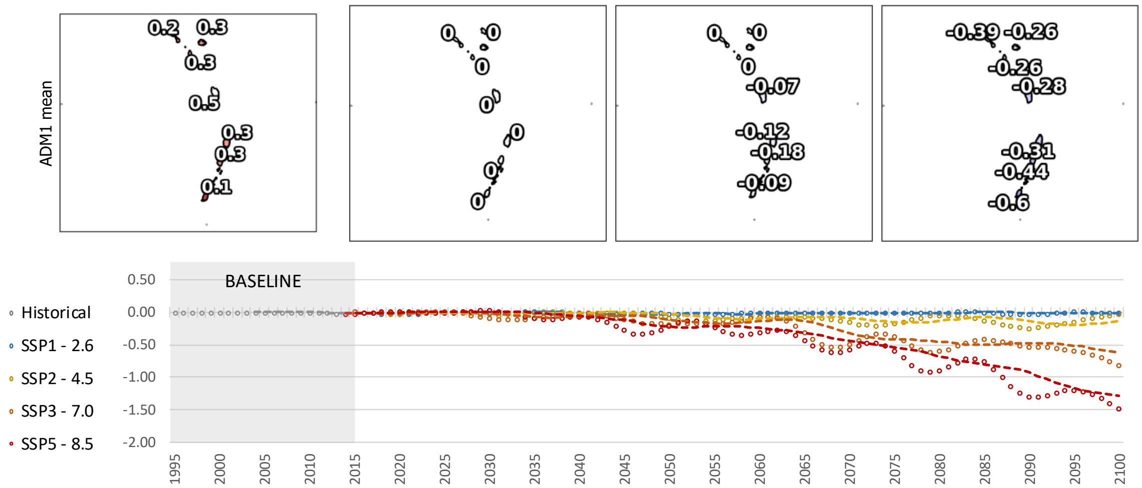
Figure 15: Climate indices – Consecutive Dry Days for OECS region



A complementary spatial picture of future water availability is depicted by the SPEI, which shows small negative values for the baseline and very little change in terms of future anomaly under any emission scenarios, with more significative reductions in the southern-central part of the region under the high emission scenario SSP5 - 8.5. This suggests no major changes in terms of water availability and agricultural drought patterns for the period 2041-2060 compared to the 1995-2014 baseline, yet inter-annual variability cannot be ruled out, particularly during strong El Nino years. The frequency of dry spells are likely to increase in the second half of the century.

Figure 16: Climate indices – Standard Precipitation-Evapotranspiration Index for OECS region





6.5. Tropical cyclones

There is low confidence in projections of changes in tropical cyclone genesis, location, tracks, duration, or areas of impact [IPCC, 2020]. Based on the level of consistency among models, and physical reasoning, it is likely that tropical cyclone related rainfall rates will increase with greenhouse warming. However, it is likely that the global frequency of tropical cyclones will either decrease or remain essentially unchanged. An increase in mean tropical cyclone maximum wind speed is likely, although increases may not occur everywhere in the tropics. In the North Atlantic basin, it can be expected that wind-induced damage potential from the strongest storms could further increase as compared to present-day. The combination of rising sea levels (virtually certain – see sub-section below) and stronger winds around category 4 and 5 hurricanes (medium confidence), the impact potential of storm surge and coastal inundation greatly increases (high confidence) [Knutson et al. 2019]. Additionally, the STORM dataset projections show no substantial change in the Caribbean region.

6.6. Expected climate change impact on hydrometeorological hazards

In conclusion, the analysis of extreme climate indices anomalies over future periods and considering multiple emission scenarios suggests:

- Small decrease in extreme precipitation events that can trigger river and pluvial floods;
- Increase of mean sea level which will trigger more frequent coastal floodings and erosion, especially under high-emission scenarios;
- Small to moderate decrease in freshwater availability due to prolonged dry spells, posing threat especially in smaller, low-topography islands (ATG, KNA);
- The expected change of tropical cyclones impact is small/uncertain for the Caribbean region [Bloemendaal et al, 2022]. There might be a decrease in the frequency tropical cyclones, with an increase in terms of event intensity i.e. wind speed and precipitation [WHO, 2021].

Assuming that the exposure component remains static, *Table 5* summarizes the change in risk considering the effect of climate change on hazard frequency and intensity. We keep a precautionary approach, that means we do not lower the current risk score in case of hazard decreasing trends that are within the baseline variability, such occurs with the extreme precipitation and flood hazard indices, and with the cyclone-related scenarios, which are surrounded by large uncertainrit. In general, two risks are safely expected to increase in the region: coastal floods, which will undoubtedly threaten the coastal community in low-laying areas due to global sea level rise, especially during hurricanes; and drought events, due to general decrease trend of precipitation indices. Proper disaster and climate adaptation measures (relocation of exposed asset, increase of water storing capacity) could help mitigate the most severe risks over the long term.

Table 4: expected change in risk scores for individual hazards at country level

COUNTRY	RIVER / PLUVIAL FLOOD	COASTAL FLOOD	STRONG WIND	TROPICAL CYCLONES	DROUGHT
Antigua and Barbuda	NO CHANGE	INCREASE	NO CHANGE	NO CHANGE	INCREASE
Dominica	NO CHANGE	INCREASE	NO CHANGE	NO CHANGE	INCREASE
Grenada	NO CHANGE	INCREASE	NO CHANGE	NO CHANGE	INCREASE
Montserrat	NO CHANGE	INCREASE	NO CHANGE	NO CHANGE	INCREASE
Saint Kitts and Nevis	NO CHANGE	INCREASE	NO CHANGE	NO CHANGE	INCREASE
Saint Lucia	NO CHANGE	INCREASE	NO CHANGE	NO CHANGE	INCREASE
Saint Vincent and the Grenadines	NO CHANGE	INCREASE	NO CHANGE	NO CHANGE	INCREASE

7. Annex

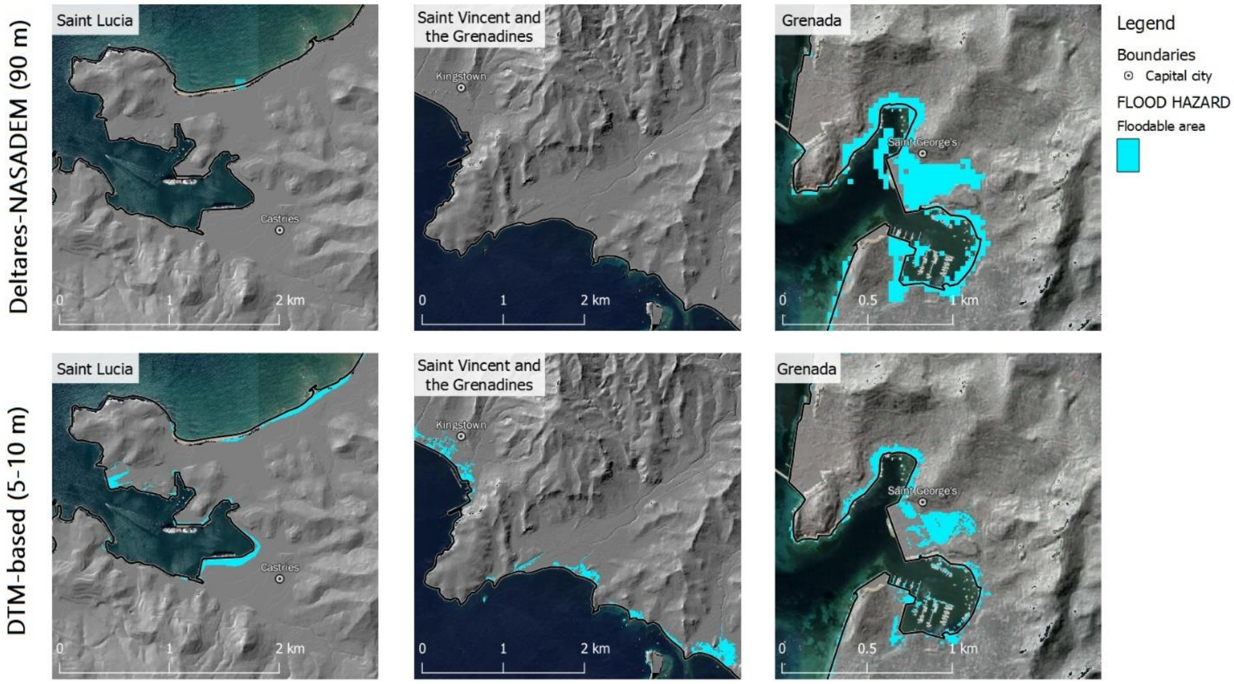
7.1. Hazard models

7.1.1. Fluvial floods

Name	Fathom flood hazard maps v2
Source	Fathom
Hazard process	Fluvial flood
Resolution	90 m
Analysis type	Probabilistic
Frequency type	Return Period (10 RPs)
Time reference	Baseline (1989-2018)
Intensity metric	Water depth [m]
License	Commercial (acquired by World Bank)
Notes	"Undefended scenario" option is selected for the analysis.

7.1.2. Coastal floods / Storm surges

Name	Aqueduct flood hazard maps	Land exposed to coastal floods (elevation < 1.5 m)
Source	Deltares	GFDRR-CHARIM
Hazard process	Coastal flood and Sea level rise	Land below 1.5 m of elevation above mean sea level
Resolution	90 m	5-30 m
Analysis type	Probabilistic	Deterministic
Frequency type	Return Period (2 RPs)	Equal to RP100-250
Time reference	Baseline (2018) and Projections (SSP5)	
Intensity metric	Water depth [m]	Water extent area
License	Open data	Open data
Notes	Based on 90m NASADEM	Based on: • CHARIM high-res DTM (5 to 10 m resolution) for LCA, SVG and GRD. • FABDEM DTM (30 m resolution) for ATG, DMA and KNA).



7.1.3. Agricultural droughts

Name	Agricultural Stress Index (ASI)
Source	FAO
Hazard process	Agricultural drought
Resolution	1 km
Analysis type	Deterministic (remote sensing)
Frequency type	Occurrence frequency
Time reference	Baseline (1984-2020)
Intensity metric	Percentage of crop and pasture land affected by drought conditions across baseline period.
License	Open data
Notes	Aggregated from annual data scale.

7.1.4. Strong wind

Name	Strong wind hazard scenarios
Source	IBtRACS v4, GAR2015
Hazard process	Strong wind gusts during tropical cyclones
Resolution	10 km
Analysis type	Probabilistic
Frequency type	Return Period (3 RPs)
Time reference	Baseline (1981-2010)
Intensity metric	3-sec wind gust speed at 10m over surface (Km/h)
License	Open data

7.2. Exposure models

7.2.1. Population

Name	Global Human Settlement Layer
Source	EU Joint Research Center
Format	Raster grid
Resolution	100 m
Time reference	2020
Metric	Population count
License	Open
Notes	Constrained to built-up (2020)

7.2.2. Built-up

Name	World Settlement Footprints
Source	ESA
Format	Raster grid
Resolution	10 m
Time reference	2019
Metric	Presence of built-up (binary)
License	Open

7.2.3. Land cover and land use

Name	ESA WorldCover
Source	VITO and consortium for ESA
Format	Raster
Resolution	10 m
Time reference	2020
Metric	Land cover classes
License	Open

7.3. Climate scenarios

Climate indices are produced from CMIP6 climate data obtained via:

- **Copernicus CDS**: Extreme climate indices
- **World Bank Climate Change Knowledge portal:** CCKP and Global datasets

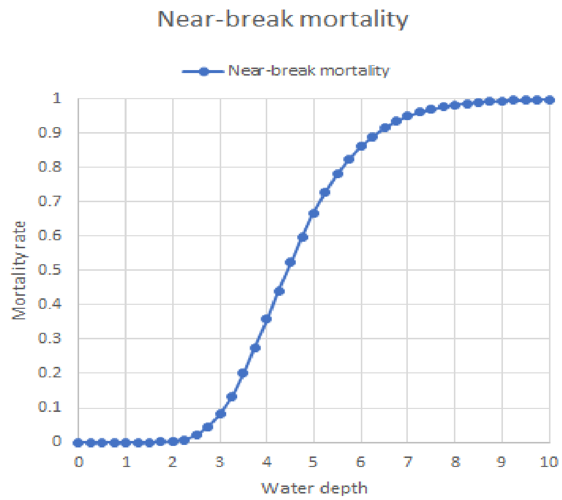
7.4. Vulnerability functions, thresholds, and calculations

7.4.1. Floods (river and coastal)

Population: Generalized mortality function for people located close to dam break (Jonkman et al. 2008)

Approximated by:

$$y = \frac{0.985}{1 + e^{(6.32 - 1.412x)}}$$

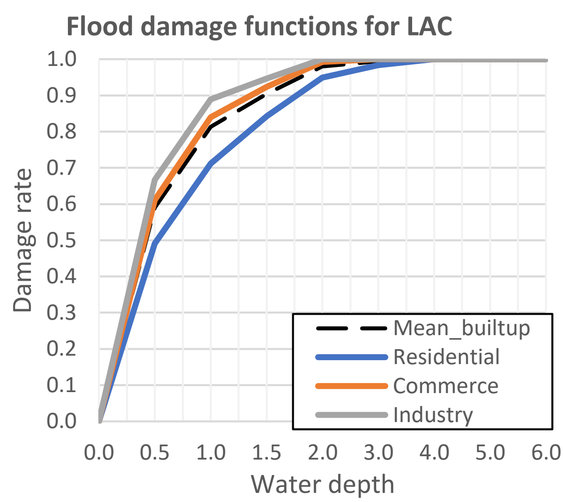


Built-up: regionalized (continent) impact function for land cover categories (Huizinga et al. 2017)

- Mean function for built-up area classes, including residential and industrial categories

Approximated by:

$$y = 0.9981 - 0.9946 * e^{-1.71x}$$

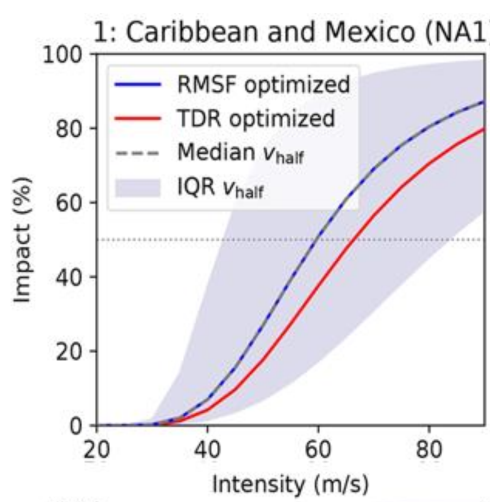


7.4.2. Strong wind

Built-up: Generalized impact model from Emanuel 2011, Elliot et al. 2015, Sealy & Strobl 2017 – regionally elaborated in Climada.

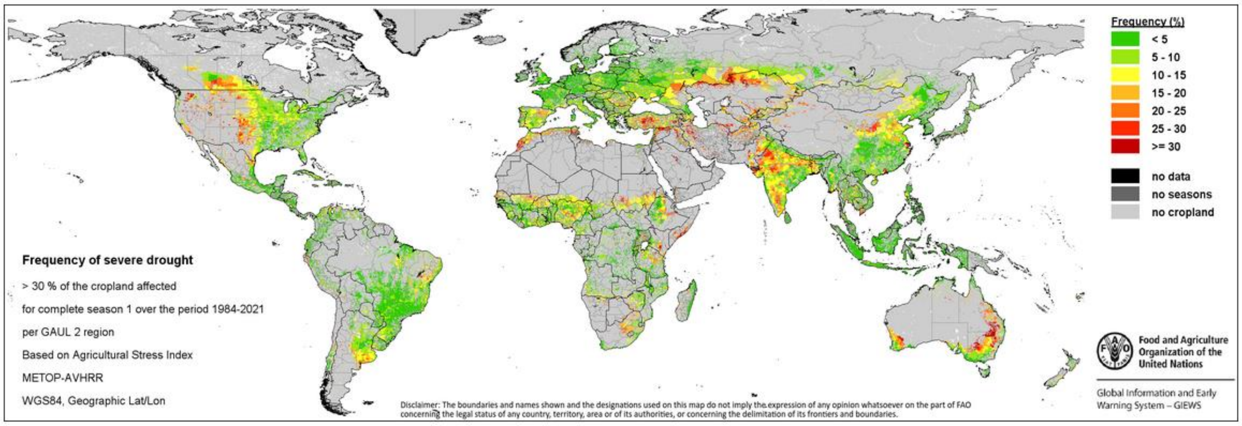
$$f_{ij} = \frac{v_{ij}^3}{1 + v_{ij}^3}, \quad v_{ij} = \frac{\max(v_{ij} - v_{\text{thresh}}, 0)}{v_{\text{half}} - v_{\text{thresh}}},$$

Region	Vhalf_median	Vhalf_mean	Vthres
NA1	59.6	71.7	25.7



7.4.3. Drought (water stress on agriculture)

Agriculture: FAO ASIS classification; frequency of impact over >30% of cropland area.



7.5. Subnational risk ranking

Subnational	Country	Population [#]	Built-up area [ha]	Inland flood	Coastal flood	Strong wind	Tropical cyclones	Drought
Saint George	Antigua and Barbuda	9,795	262	LOW	LOW	HIGH	HIGH	MEDIUM
Saint John	Antigua and Barbuda	63,165	990	LOW	MEDIUM	HIGH	HIGH	MEDIUM
Saint Mary	Antigua and Barbuda	8,220	124	LOW	LOW	HIGH	HIGH	HIGH
Saint Paul	Antigua and Barbuda	8,629	148	LOW	LOW	HIGH	HIGH	MEDIUM
Saint Peter	Antigua and Barbuda	5,341	111	LOW	LOW	HIGH	HIGH	MEDIUM
Saint Philip	Antigua and Barbuda	3,286	103	LOW	LOW	HIGH	HIGH	LOW
Redonda	Antigua and Barbuda	-	-	LOW	LOW	LOW	LOW	LOW
Barbuda	Antigua and Barbuda	2,000	266	LOW	HIGH	HIGH	HIGH	HIGH
Saint Andrew	Dominica	8,704	75	MEDIUM	LOW	HIGH	HIGH	LOW
Saint David	Dominica	5,697	39	LOW	LOW	MEDIUM	MEDIUM	LOW
Saint George	Dominica	22,194	204	MEDIUM	LOW	HIGH	HIGH	LOW
Saint John	Dominica	7,248	86	LOW	LOW	HIGH	HIGH	MEDIUM
Saint Joseph	Dominica	5,515	66	LOW	LOW	HIGH	HIGH	HIGH
Saint Luke	Dominica	1,761	15	LOW	LOW	HIGH	HIGH	LOW
Saint Mark	Dominica	1,812	17	MEDIUM	LOW	HIGH	HIGH	LOW
Saint Patrick	Dominica	7,192	79	LOW	LOW	HIGH	HIGH	LOW
Saint Paul	Dominica	11,158	111	LOW	LOW	HIGH	HIGH	MEDIUM
Saint Peter	Dominica	1,360	17	MEDIUM	LOW	MEDIUM	MEDIUM	HIGH
Saint Andrew	Grenada	27,807	175	LOW	LOW	LOW	LOW	LOW
Saint David	Grenada	15,011	59	LOW	LOW	LOW	LOW	LOW
Saint George	Grenada	40,043	563	LOW	LOW	LOW	LOW	LOW
Saint John	Grenada	7,626	38	LOW	LOW	LOW	LOW	LOW
Saint Mark	Grenada	3,973	23	LOW	LOW	LOW	LOW	LOW
Saint Patrick	Grenada	12,592	61	LOW	MEDIUM	LOW	MEDIUM	LOW
Southern Grenadine Islands	Grenada	5,040	223	LOW	LOW	LOW	LOW	LOW
Christ Church Nichola Town	Saint Kitts and Nevis	2,884	25	LOW	LOW	MEDIUM	MEDIUM	MEDIUM
Saint Anne Sandy Point	Saint Kitts and Nevis	3,093	39	LOW	LOW	MEDIUM	MEDIUM	MEDIUM
Saint George Basseterre	Saint Kitts and Nevis	13,711	398	LOW	LOW	HIGH	HIGH	HIGH
Saint George Gingerland	Saint Kitts and Nevis	3,378	47	LOW	LOW	HIGH	HIGH	LOW
Saint James Windward	Saint Kitts and Nevis	2,305	78	LOW	LOW	HIGH	HIGH	HIGH
Saint John Capisterre	Saint Kitts and Nevis	4,339	35	LOW	LOW	MEDIUM	MEDIUM	MEDIUM
Saint John Figtree	Saint Kitts and Nevis	4,617	111	LOW	LOW	HIGH	HIGH	HIGH
Saint Mary Cayon	Saint Kitts and Nevis	3,338	47	LOW	LOW	HIGH	HIGH	MEDIUM
Saint Paul Capisterre	Saint Kitts and Nevis	2,126	23	LOW	LOW	MEDIUM	MEDIUM	LOW
Saint Paul Charlestown	Saint Kitts and Nevis	2,529	51	LOW	LOW	MEDIUM	MEDIUM	HIGH
Saint Peter Basseterre	Saint Kitts and Nevis	5,705	136	LOW	LOW	MEDIUM	MEDIUM	HIGH
Saint Thomas Lowland	Saint Kitts and Nevis	2,761	54	LOW	LOW	HIGH	HIGH	HIGH

Saint Thomas Middle Island	Saint Kitts and Nevis	2,388	25	LOW	LOW	MEDIUM	MEDIUM	HIGH
Trinity Palmetto Point	Saint Kitts and Nevis	2,576	41	LOW	LOW	HIGH	HIGH	HIGH
Anse la Raye	Saint Lucia	7,104	32	LOW	LOW	MEDIUM	MEDIUM	MEDIUM
Castries	Saint Lucia	68,049	688	MEDIUM	LOW	HIGH	HIGH	MEDIUM
Choiseul	Saint Lucia	6,463	69	LOW	LOW	MEDIUM	MEDIUM	LOW
Dennery	Saint Lucia	12,606	159	LOW	HIGH	MEDIUM	HIGH	LOW
Gros Islet	Saint Lucia	34,792	563	LOW	LOW	HIGH	HIGH	MEDIUM
Laborie	Saint Lucia	6,027	76	LOW	LOW	MEDIUM	MEDIUM	LOW
Micoud	Saint Lucia	17,612	184	LOW	LOW	MEDIUM	MEDIUM	LOW
Soufriere	Saint Lucia	10,081	80	MEDIUM	LOW	MEDIUM	MEDIUM	LOW
Vieux Fort	Saint Lucia	19,677	371	LOW	LOW	MEDIUM	MEDIUM	LOW
Canaries	Saint Lucia	2,601	11	LOW	LOW	LOW	LOW	LOW
Saint Anthon	Montserrat	1	0	LOW	LOW	LOW	LOW	HIGH
Saint Georges	Montserrat	-	-	LOW	LOW	LOW	LOW	HIGH
Saint Peter	Montserrat	5,062	65	LOW	LOW	HIGH	HIGH	HIGH
Charlotte	Saint Vincent and the Grenadines	26,826	326	HIGH	LOW	MEDIUM	HIGH	LOW
Saint Andrew	Saint Vincent and the Grenadines	15,426	178	MEDIUM	LOW	LOW	MEDIUM	LOW
Saint David	Saint Vincent and the Grenadines	5,544	42	LOW	LOW	LOW	LOW	LOW
Saint George	Saint Vincent and the Grenadines	44,631	656	LOW	LOW	MEDIUM	MEDIUM	LOW
Saint Patrick	Saint Vincent and the Grenadines	7,280	74	HIGH	LOW	LOW	HIGH	LOW
Grenadines	Saint Vincent and the Grenadines	11,341	251	LOW	LOW	LOW	LOW	LOW