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THE VARIOUS SHAPES OF THE INSULAR CARIBBEAN: POPULATION AND ENVIRONMENT

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When we look at a map, we expect to see the portrayed landmasses (e.g., countries) reflecting their actual sizes and shapes. If it is a thematic map; this is, a map that displays information about a specific theme; the different units are colored according to the information displayed (what is known as a choropleth map), or with symbols representing either quantitative or qualitative information (for example, a proportional symbol map). In the case of the insular Caribbean, logically, the Greater Antilles occupy a larger extent than the Lesser Antilles and the small islands in the northern Caribbean (Map 1). Oftentimes, geographic patterns displayed on regional maps are not easily discernible, particularly for those islands with smaller sizes (this will depend, of course, on the scale and extent of the map). This can be problematic because the information, and ultimately the message that wants to be conveyed through a map, can be overlooked or missed due to the inherent size differences.

There is a type of map that allows us to "redraw" conventional maps by varying the size and shape of the geographic units in relation to the quantity they represent. Such maps are called *cartograms*. Cartograms can be very effective in conveying messages that otherwise could be missed if mapped following the "true" geography (size and shape) of the mapped area. In the case of the insular Caribbean, it is possible then to visualize the Lesser Antilles in a larger size than the Greater Antilles if the data for the Lesser Antilles has higher values than that of the Greater Antilles. When interpreting a cartogram, it is important to keep in mind that geographic precision (i.e., geographic position, land size and shape) is not the focus of the map; these elements will, in fact, be distorted. What is important, and what makes cartograms useful, is to be able to easily identify geographic pattern and the message carried by the map by comparing and analyzing the sizes of the displayed geographic units. Such maps provide an alternative way of viewing and interpreting the mapped area.

In this Cartographic Essay we present a series of cartograms of the insular Caribbean that portray different themes about population, economy and the environment with the aim of presenting a regional "snapshot" of a variety of topics related to such themes. Our objective is to provide information that can allow the reader to make connections between the mapped topics and among the islands. Additionally, the cartograms present information that is related to, and further discussed in the articles that constitute this Special Issue.

We start the essay by displaying information about regional population dynamics, including total population, population change, urbanization, and population density (Maps 2 to 6). A look at these maps shows extreme differences within the region. In the case of total population, for example, numbers range from 11 million in Cuba, to only about 5,000 in Montserrat (Map 2). One phenomenon that characterizes most of the Caribbean countries is the high percentage of population living in urban areas. In 2010, more than half of the countries in the insular Caribbean had an urban population of more than 50%, and for some islands (like Anguilla and the Cayman Islands) urban population was 100% (Map 3). The region is also characterized by rapid rates of urbanization. For some islands, changes in urban population have been extraordinary, as in the case of Turks and Caicos (800% between 1980 and 2010), Haiti (345%), the British Virgin Islands (233%), and the Caiman Islands (229%). Regional change in urban population between 1980 and 2010 was, in fact, higher than the change in total population (81% change in urban population versus 40% change in total population) (Maps 4 and 5).

Population density provides a relation between size (available space) and number of persons which, in the case of many islands in the Caribbean, is critical. In a cartogram, when density values are taken into account, the population factor within the region presents a different picture: the smaller islands become larger and the larger islands smaller (Map 6). Population densities are generally higher in the Lesser Antilles than in the Greater Antilles (with the exception of Puerto Rico and Haiti). Regional population densities vary from 664.3 people/km^2 in Barbados to 31.0 in The Bahamas.

Another interesting density indicator in the region is the physiological density (Map 7). Physiological density represents the number of people per unit of arable land. This measure indicates the pressure of population over agricultural resources. A higher physiological density suggests that available agricultural lands are under more pressure than in those cases where values are lower. In the insular Caribbean, physiological densities vary from 41.0 in Turks and Caicos to 1.7 in Cuba. Even if land suitable for agriculture is not being used as such, this indicator gives an idea of the potential capacity of a country to supply food for its population, having implications concerning food security. In terms of agriculture and agricultural production, this is one, among other problems facing the region, as Barker (this issue) elaborates in his article.

High population totals and densities, and particularly increasing urban population, require and demand more materials and energy; a situation that can put increasing pressure on natural resources and the environment. Without proper management at different levels, these demands can put at risk and affect ecosystems and resources, as described in the case of agricultural lands, and as discussed by Heartsill Scalley (this issue) regarding management of urban sewage and freshwater resources. From another point of view, population trends, particularly urbanization, puts Caribbean inhabitants at risk, as it is in the case of exposure to natural hazards. This is especially true when increasing urbanization is not necessarily accompanied by enhancement in infrastructure and access to resources and services. Moreover, since urbanization occurs mostly in lowlands and coastal areas, it increases exposure and vulnerability to current hazard events (such as hurricanes, floods and tsunamis) and to those associated to potential climate change and sea level rise (Taylor and coauthors, this issue). Being hazard-prone, it is common that the region experiences the impacts of hazards and disasters (Map 8), yet disaster impacts differ within the region (Map 9). As López-Marrero and Wisner (this issue) discuss in their article, differences in disaster impacts result in part because of the human conditions in which a hazard develops into a disaster. Disaster outputs also reflect determinants of vulnerability and capacities, which include access to various natural, physical, economic, human, social, and political resources; resources that are not accessible equally to everyone in the region.

Proper ecosystem management and facilitating people's access to resources to enable them to cope with environmental change is critical, particularly within the context of the expected impacts of climate change. Uneven impacts of climate change are expected to occur within the insular Caribbean, as Taylor and co-authors (this issue) discuss in their article. Increases in natural hazards and disasters, and their effects on national economies and infrastructure are some potential impacts that can affect the development of countries in the region (Bueno e*t al*. 2008). Yet, not everyone will be impacted equally (Map 10); those countries with less capacity to resist, cope, and adapt to changes will suffer more, especially if their present condition is one of impoverishment and lack of resources, as is the case, for instance, of Haiti.

Another example of the potential impacts of climate change is related to freshwater resources (including water storage and availability) which are driven by regional climate patterns (Taylor and coauthors, this issue). Rainfall patterns already vary within the region because of different factors such as island position in relation to easterly winds, topography and island size (Map 11). There are already many islands with low rainfall that, along with other trends such as decreases of recharge surfaces for streams and aquifers (due to increasing paved/built up lands), affect water availability to the population (Heartsill Scalley, this issue). If to those conditions we add the effects of climate change, which include predictions of a drier climate (Taylor and coauthors, this issue), then problems of water availability and access to freshwater resources will be exacerbated.

Carbon dioxide (CO_2) emissions into the atmosphere contribute to global warming and climate change. Compared to global contributions, CO_2 emissions from the insular Caribbean are minimal. While regional CO_2 contributions are relatively small at the global scale, there is a large range of CO_2 emissions per capita in insular Caribbean countries (Map 12). The U.S. Virgin Islands, Trinidad and Tobago, and the former Netherlands Antilles are the countries with higher emissions per person. In fact, Trinidad and Tobago, the former Netherlands Antilles, and Aruba rank among the top-ten per capita emitters globally (Boden, Andres, and Marland 2009). The effects of high CO_2 emission levels within the local Caribbean region, and studies of its impacts on the local environment have only recently begun.

We finish this cartographic essay by showing two maps that display indicators of countries' development and achievement: Gross Domestic Product (GDP) per capita and Human Development Index (HDI). Using GDP per capita as an economic indicator, we can see the great disparity in economic terms within the region, from $54,827 in the Cayman Islands to $1,200 in Haiti (Map 13). The economy of a country can be related to potential environmental impacts in at least two ways. From one point of view, high economic means can result in higher purchasing power and consumerism, use of materials, and energy; all of which can negatively impact natural resources. Alternatively, having access to economic resources can allow investing in cleaner technologies and infrastructure that can be beneficial to natural resources and the environment. Moreover, access to economic resources can assist Caribbean inhabitants to better cope and adapt to changing environmental conditions, as is the case, for example, of disasters and freshwater resource management (López-Marrero and Wisner; Heartsill Scalley, this issue).

Economic resources alone are not always what drive sound environmental management practices and the way people cope with environmental changes; human resources and capacities need to be taken into consideration and invested in. The Human Development Index (HDI) is an alternative way to assess countries' development and achievements that goes beyond economic growth alone; it combines elements of health, knowledge, and income. In the insular Caribbean, Barbados is the country with the highest HDI, followed by Cuba. Haiti, in contrast, has the lowest index (Map 14). If one compares regional GDP per capita and HDI, there are some instances where there is a correspondence between both indicators, but there are other cases where this correspondence does not exist. One example of the latter case is Cuba, which is among the insular Caribbean countries with lowest GDP per capita, but high HDI. If one was to evaluate Cuba's performance on risks and disaster management by just looking at the economic indicator, for example, then one might conclude that Cuba will do very poorly because does not have the economic resources to anticipate, prepare, and respond to hazards and disaster events. Cuba's risk and disaster management is, however, impressive and loses of lives are minimal despite high occurrence of hazard events (refer to Maps 8 and 9). Cuba's success in risk reduction and disaster management has been achieved through an investment in human and social resources (López-Marrero and Wisner, this issue). This is just one example that shows how environmental management and promoting people's capacity to cope and adapt to environmental change requires an integrative, holistic approach that makes use of all possible resources available within a country, and among which and foremost, is their population.

A note about the data and cartograms

The geographic database used to develop the cartograms was generated with the open-source, on-line software ScapeToad <http://scapetoad.choros.ch/>. The data used to develop the geographic database was collected from various secondary sources. Data appeared in aggregated forms (at the country level) in the various data sources used, consequently it was not possible to provide disaggregated data for different islands that are grouped, such as Antigua and Barbuda, the Cayman Islands, the Bahamas, Saint Kitts and Nevis, Trinidad and Tobago, the British Virgin Islands, the U.S. Virgin Islands, and the former Netherlands Antilles. There were cases where data did not exist for some countries, usually for those islands that are overseas departments, non-independent states, or overseas territories. This was the case for the following cartograms: Physiological Density, GDP per capita, and HDI. In those cases, the name of the islands was included in the cartogram to show their relative position, but no land masses where displayed associated to the names.

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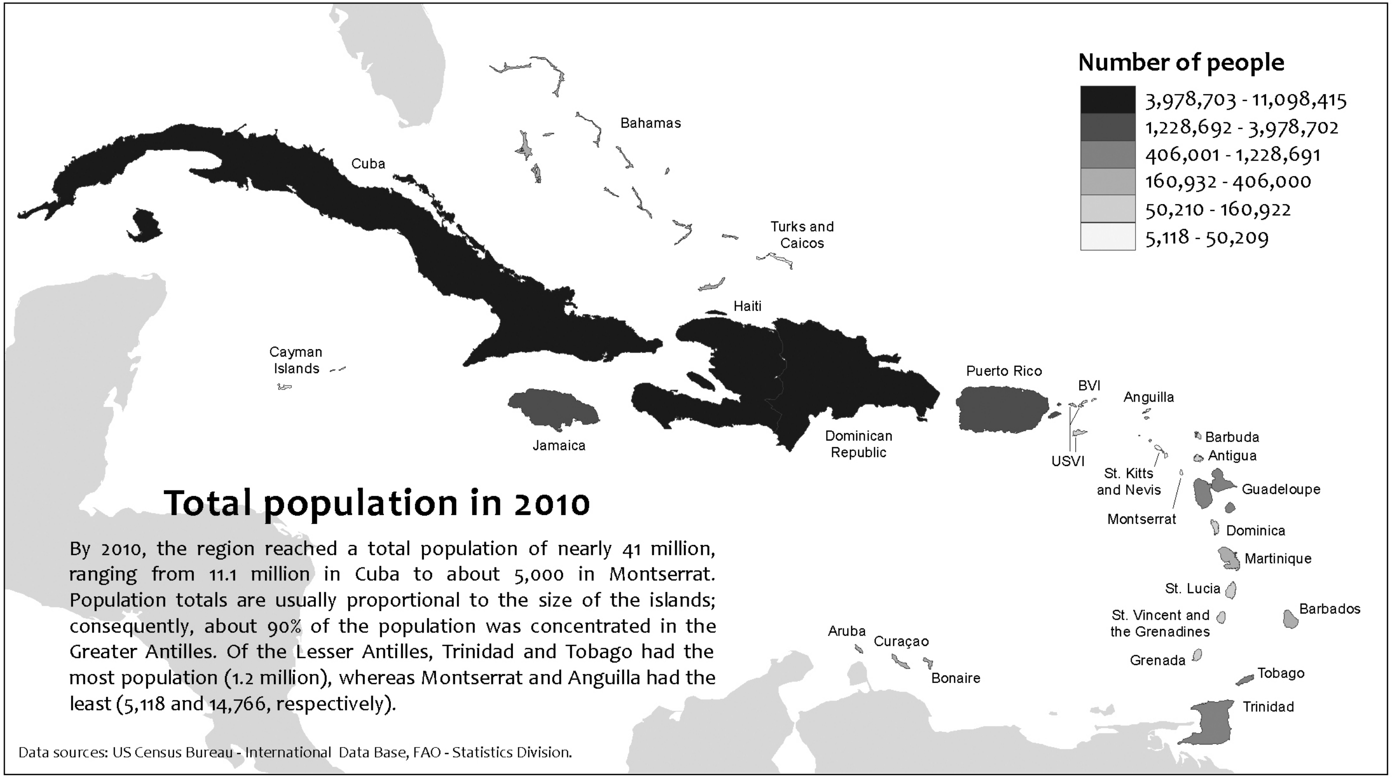
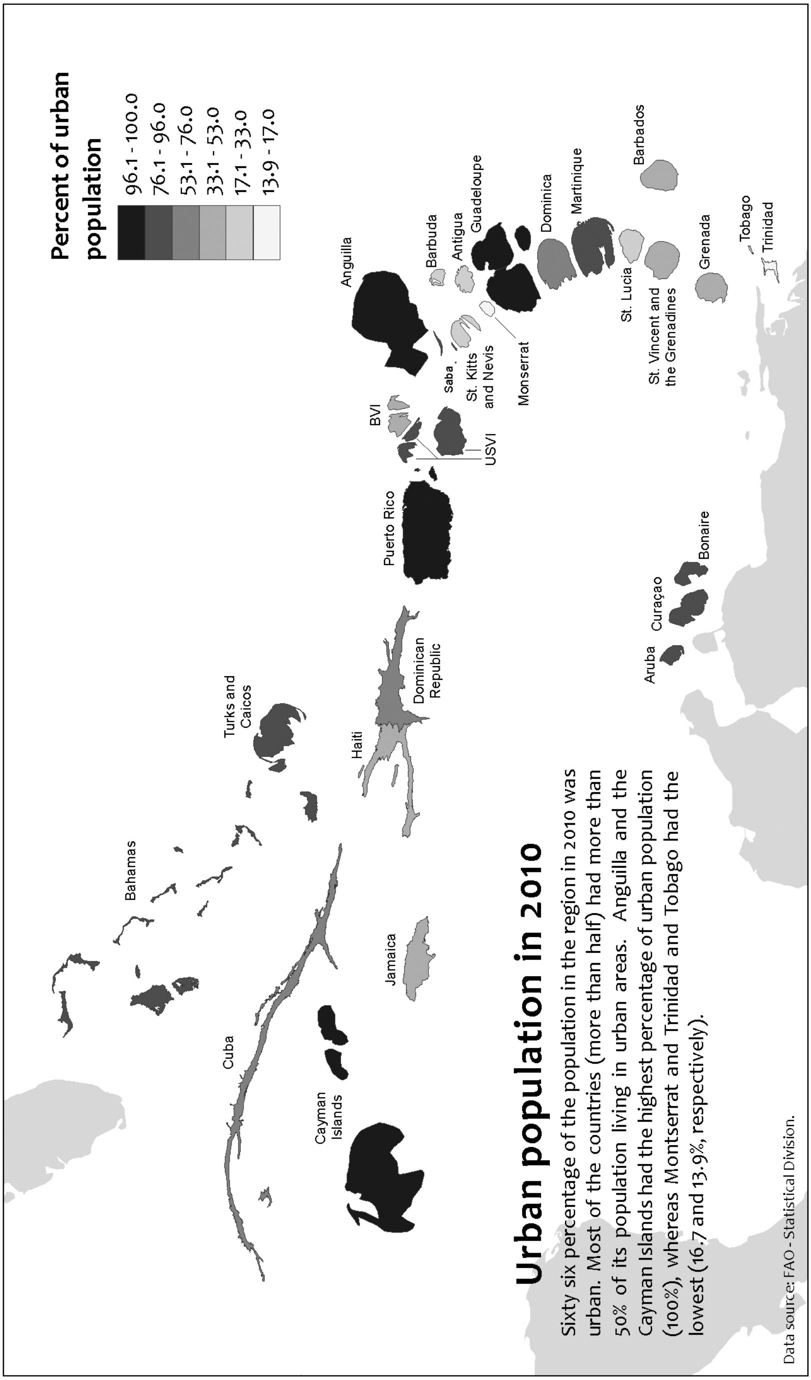
Map 1. A conventional map of the insular Caribbean displaying actual island size and geographic shape.

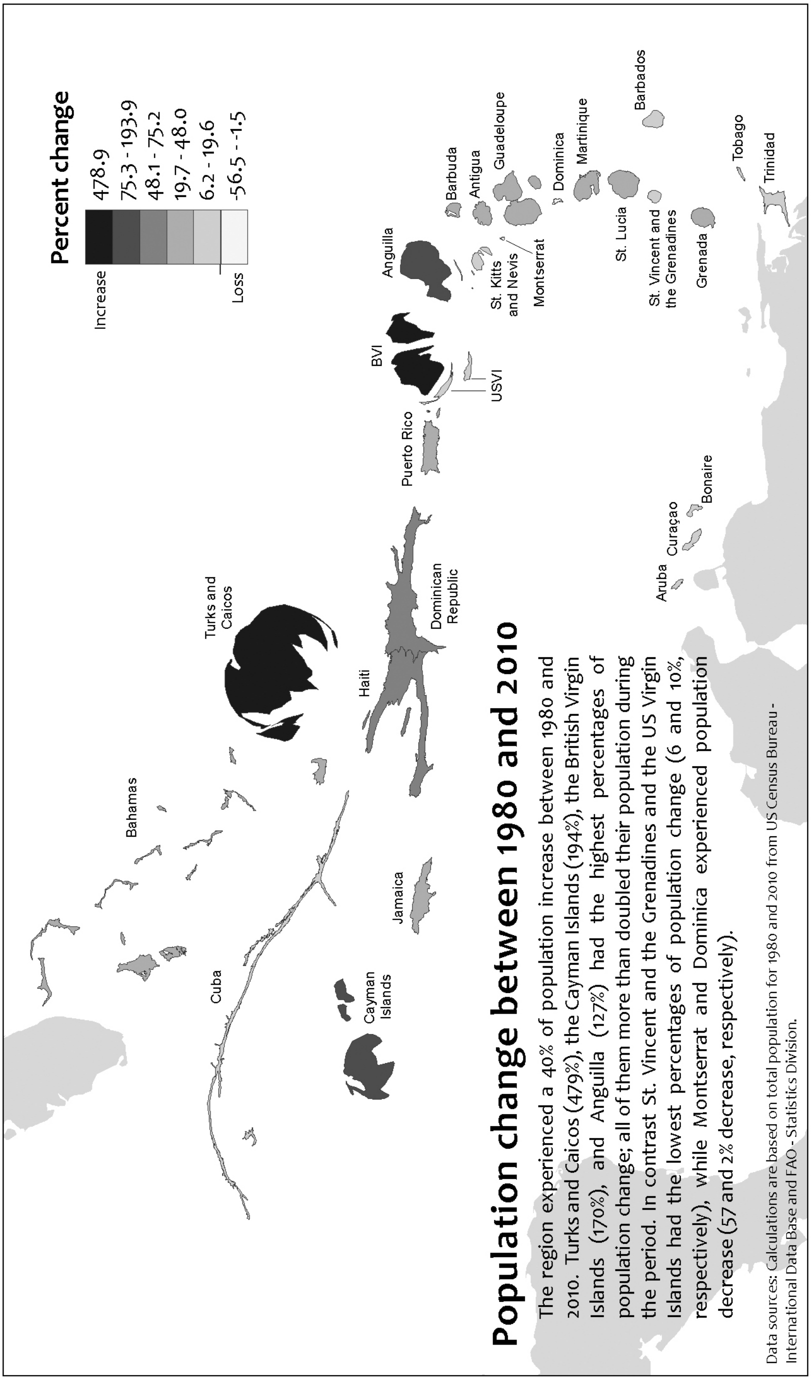
Map 2. Total population in the insular Caribbean in 2010.



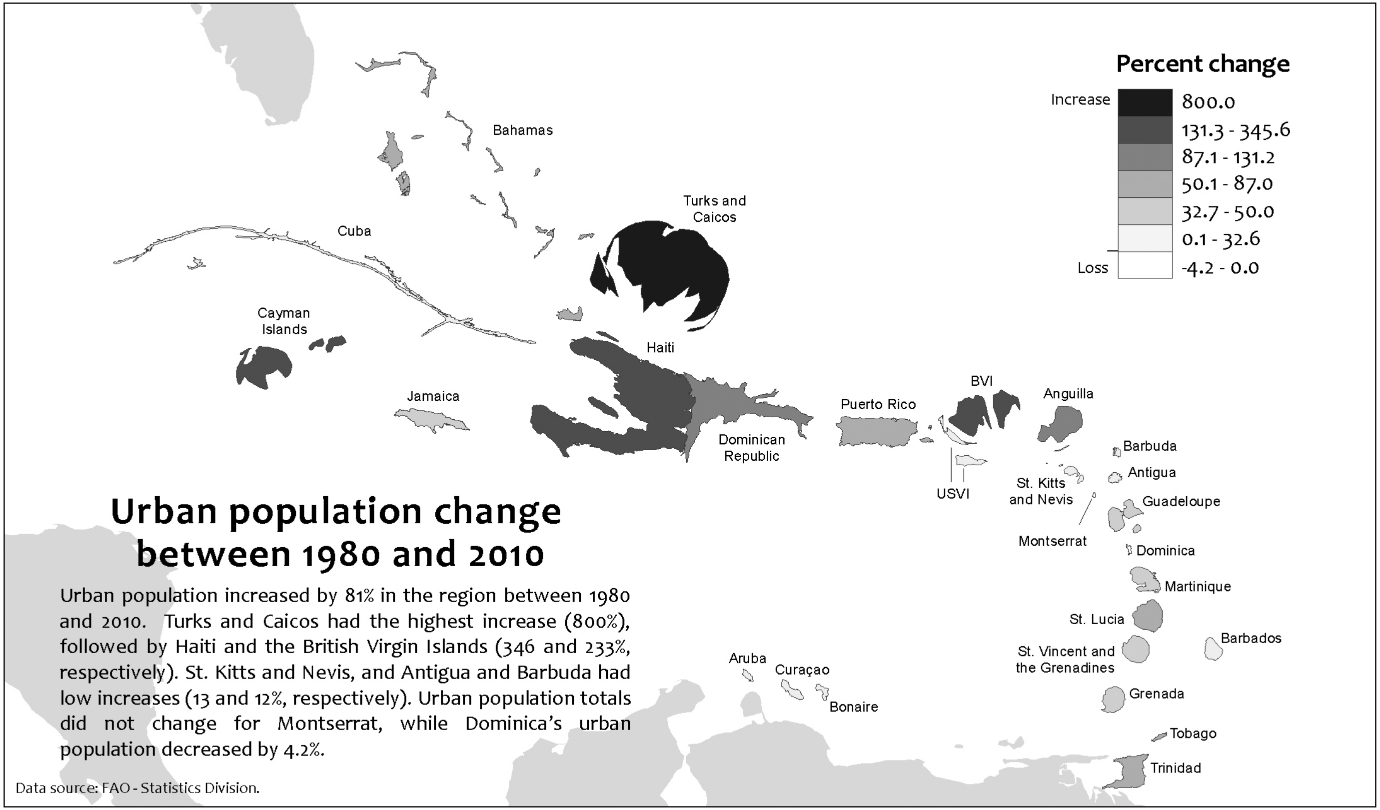
Map 3. Urban population in the insular Caribbean in 2010.



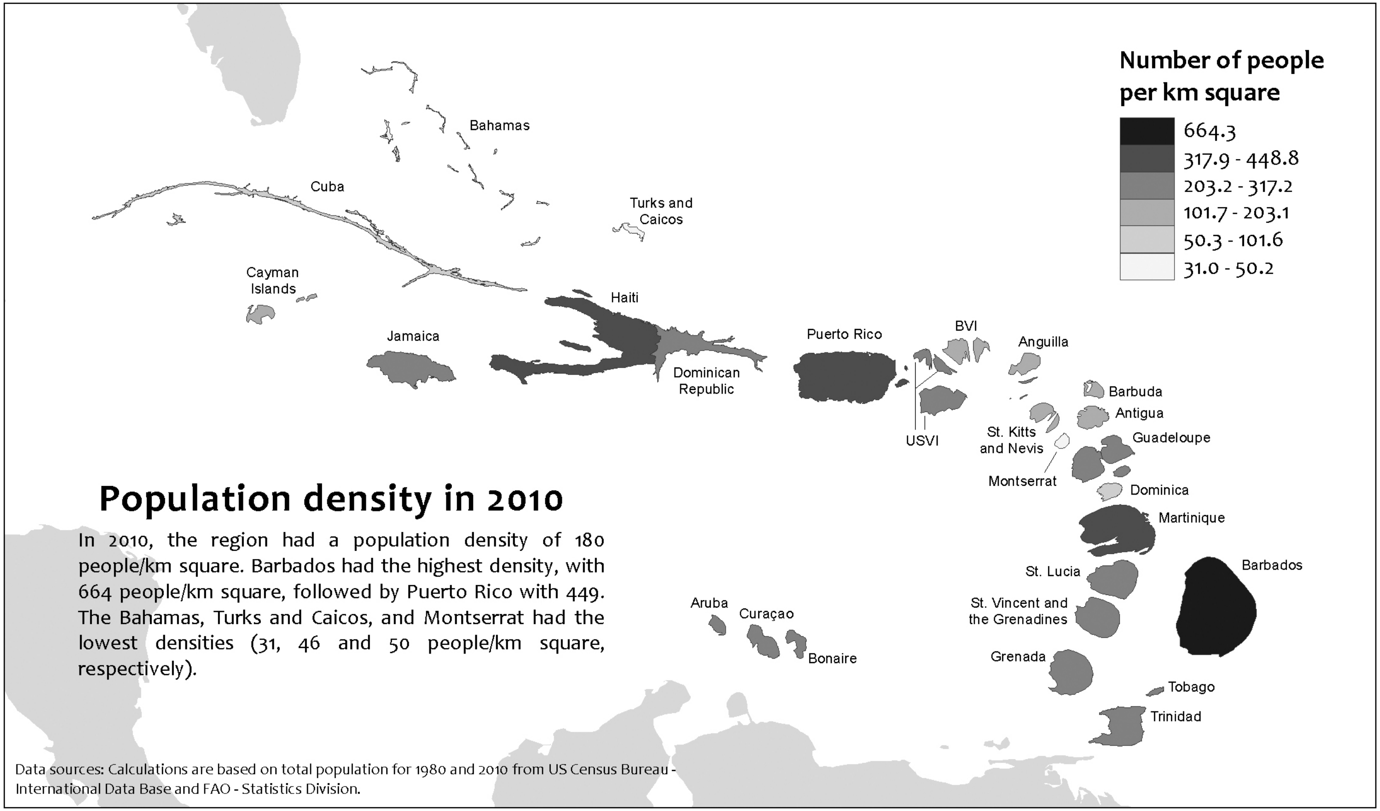
Map 4. Population change in the insular Caribbean between 1980 and 2010.



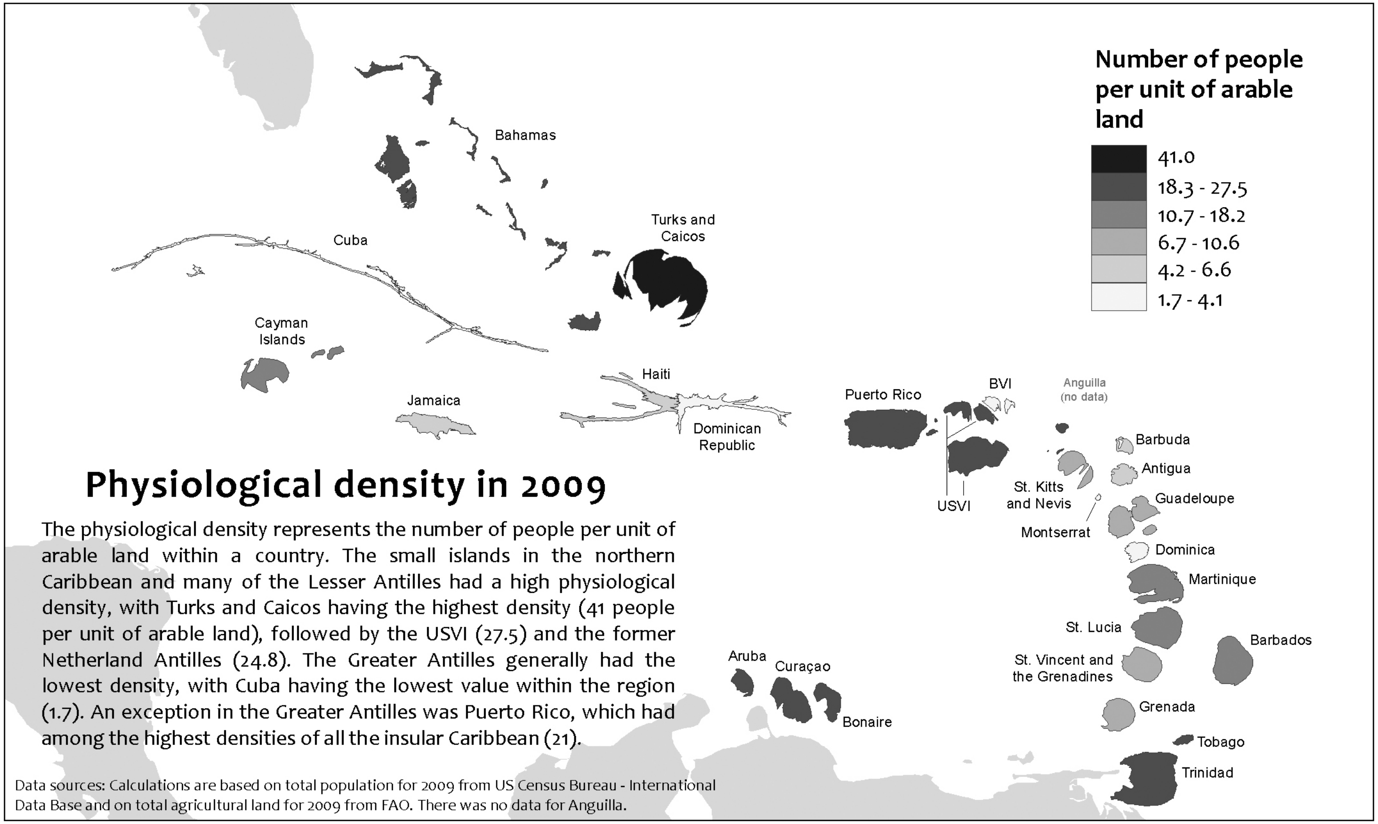
Map 5. Urban population change in the insular Caribbean between 1980 and 2010.



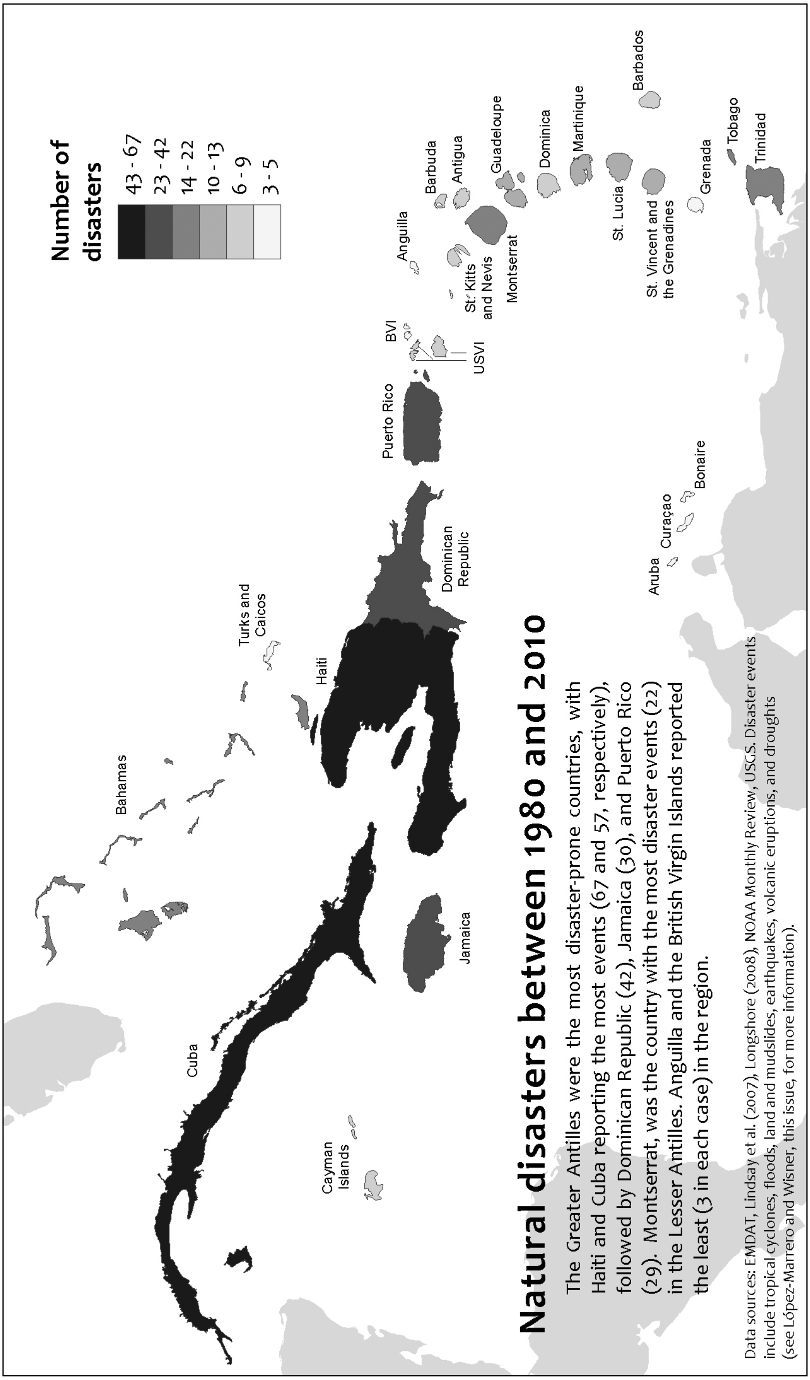
Map 6. Population density in the insular Caribbean in 2010.



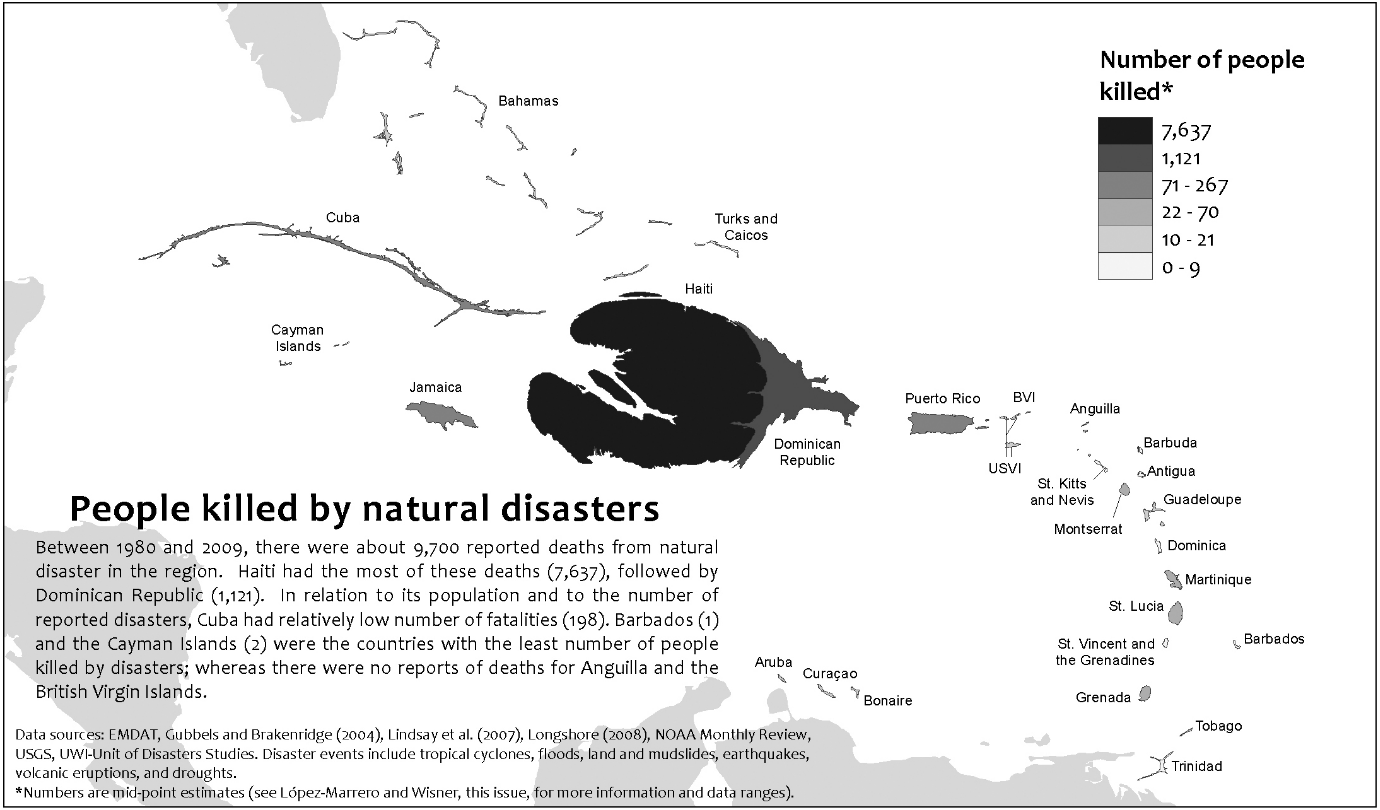
Map 7. Physiological density in the insular Caribbean in 2009.



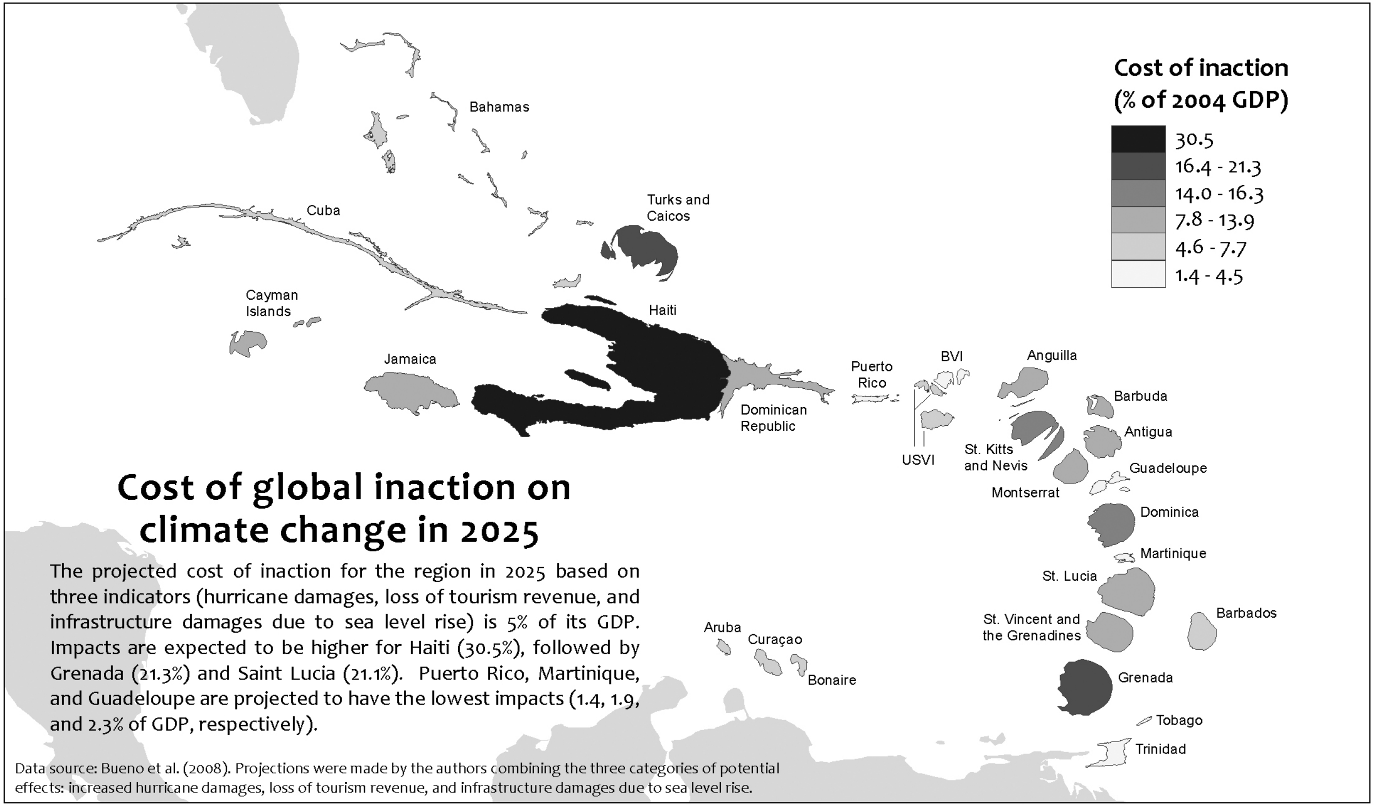
Map 8. Occurrence of natural disasters in the insular Caribbean between 1980 and 2010.



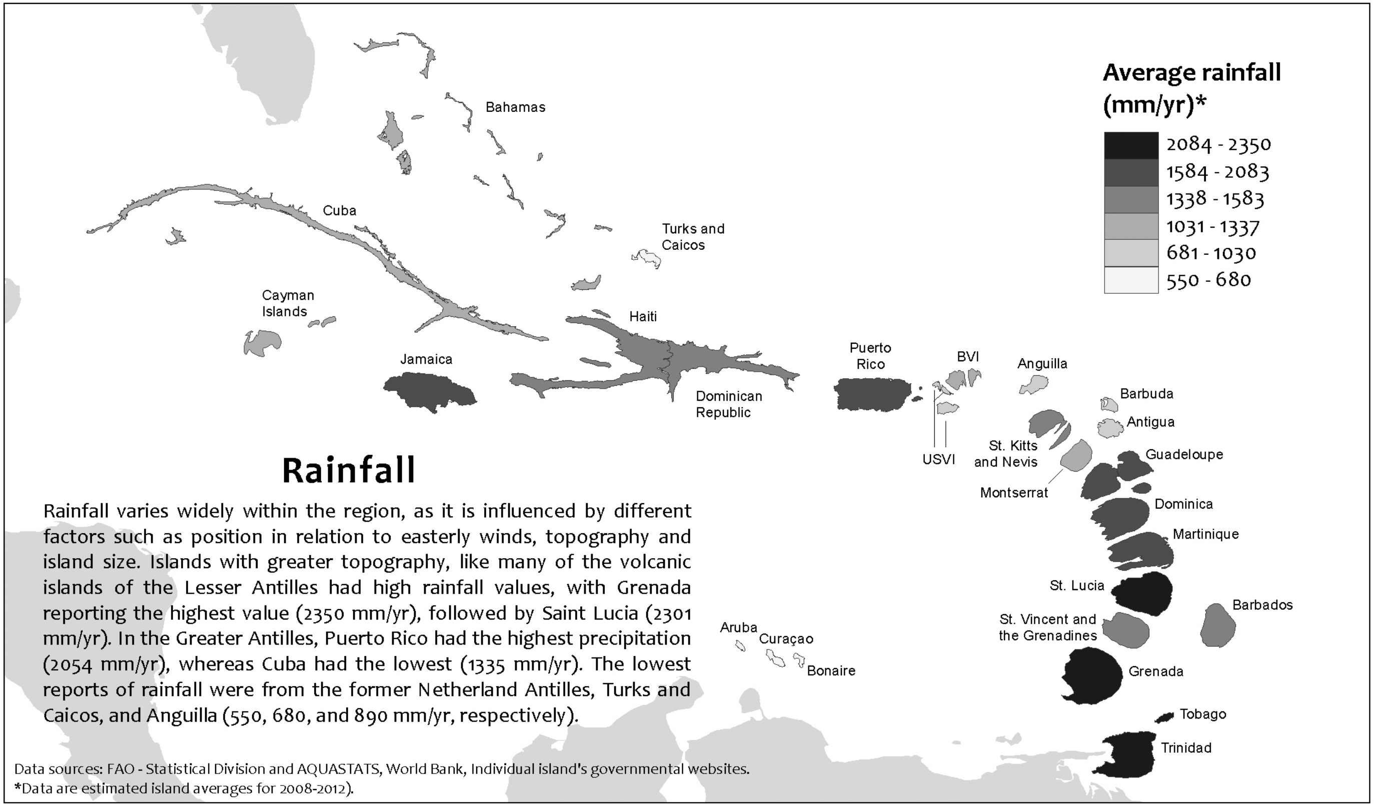
Map 9. People killed by natural disasters in the insular Caribbean between 1980 and 2010.



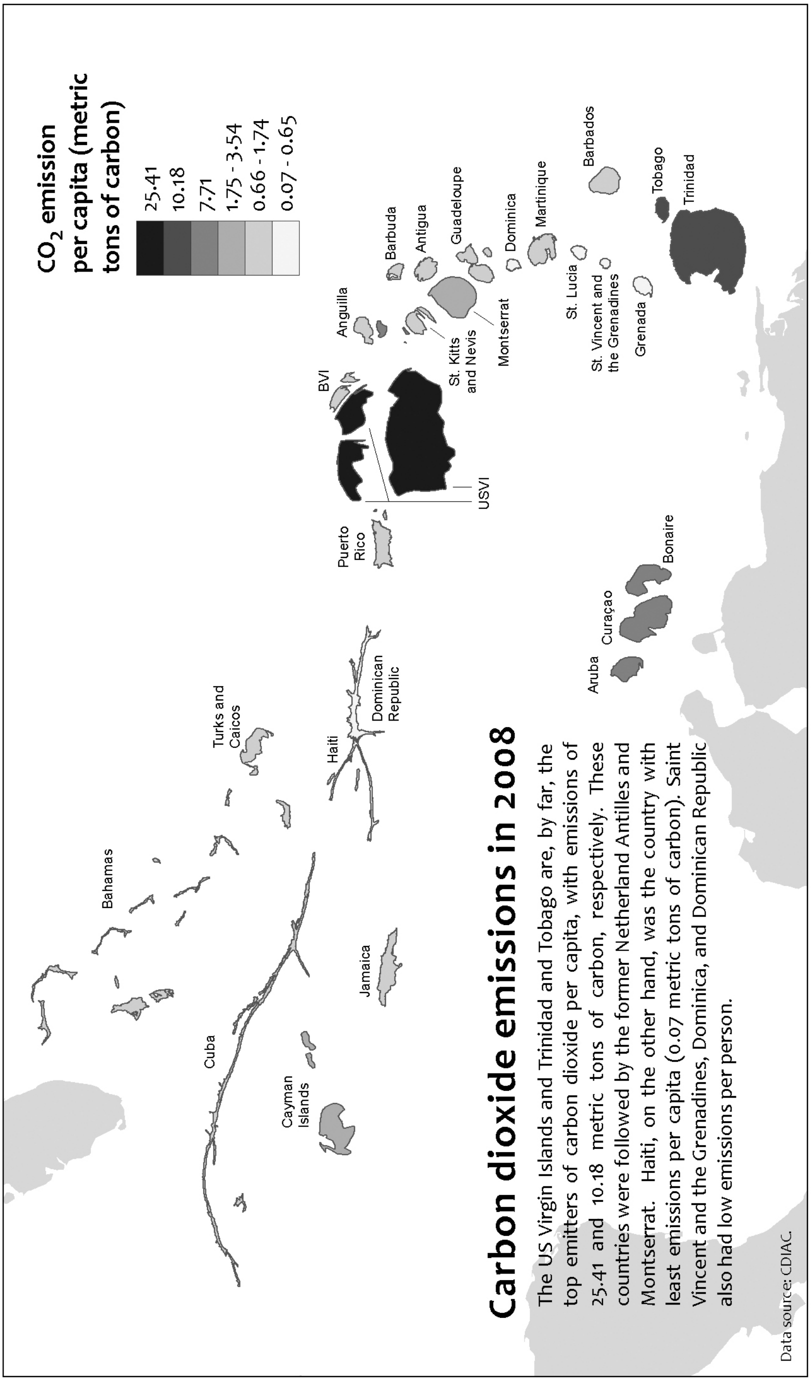
Map 10. Projected costs of global inaction on climate change in the insular Caribbean in 2025.



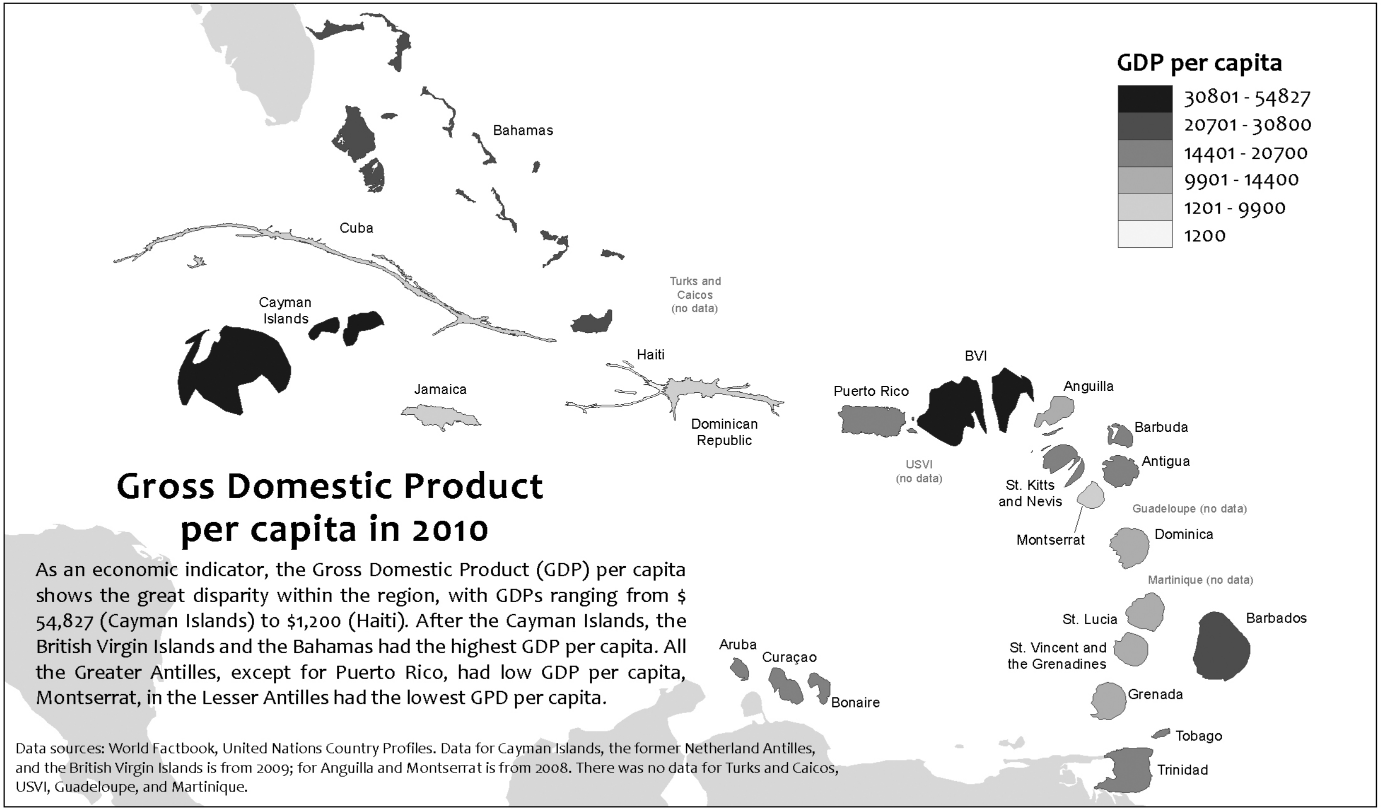
Map 11. Estimated annual rainfall averages in the insular Caribbean between 2008 and 2012.



Map 12. Carbon dioxide emission in the insular Caribbean in 2008.



Map 13. Gross domestic product in the insular Caribbean in 2010.



Map 14. Human Development Index in the insular Caribbean in 2010.