INSIDE STORIES on climate compatible development

Climate & Development Knowledge Network

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Key messages

- Flooding in Jamaica has significantly damaged major infrastructure on coastal areas and floodplains.
- Flood hazard maps showing present and future flood risk for vulnerable communities at national and subnational levels are vital for disaster management and for planning climate compatible development in flood-prone areas.
- Local government staff including disaster coordinators at parish level and community representatives should be offered ongoing training in using geospatial data and understanding its importance in disaster management and climate studies. Improved data sharing and cooperation between academia and local and national governments will be vital.
- High-quality data on hazards and risks can inform good policies that save lives and reduce loss of livelihoods and damage to property.

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Climate change and flood risk: Challenges for Jamaican towns and communities

Climate variability in the Caribbean may cause tropical storms and hurricanes to become more intense in the future, although perhaps not more frequent. Intense storms carry extreme, flood-inducing rainfall, and cause storm surges that can inundate coastal lowlands, affecting tourism, agriculture and major infrastructure. Although maps showing potential flood areas exist for the major watersheds in Jamaica, they do not take climate change into account. To assess future flood risk properly, rainfall projections obtained from computer models of climate should be used to incorporate climate change into risk assessments. The challenge faced by disaster-management authorities, planning agencies and researchers is how best to use the results from the climate models to predict future flood risk for vulnerable communities. These ideas led to the CDKN-supported project "Climate Change and Inland Flooding in Jamaica: Risk and Adaptation Measures for Vulnerable Communities" (2013–14), which aimed to address the potential medium- and long-term impacts of climate variability and change on flood risk for selected study areas in Jamaica.

The key objectives of the project were to:

- provide a historical overview of the frequency and severity of flooding in Jamaica, and use climatic and non-climatic data to create an island-wide riverine flood hazard map
- assess and increase local knowledge, attitudes and practices of project communities regarding climate change through meetings and training
- create models for past and future flood events for the selected watersheds
- disseminate the results through community and stakeholder training workshops and radio interviews, and via open-access web portals for government and non-government stakeholders and private sector organizations to provide data for mainstreaming climate change in disaster-management strategies.

The project results will also assist Caribbean islands to achieve Sustainable Development Goals (SDGs) 13, 11 and 9 (see *Box 1*).

CDKN has a growing portfolio of work in states, provinces, cities and districts. It is committed to capturing the lessons learned, and to better understanding what makes low-carbon and climate-resilient development efforts work well at the subnational level. CDKN and ICLEI – Local Governments for Sustainability have set up a joint learning programme to distil and share these lessons with others. This *Inside Story* is one output of the learning programme. For more in the series, visit www.cdkn.org/cdkn_series/inside-story

The study areas

The project focused on two contrasting watersheds in Jamaica (*Figure 1*).

- Yallahs, in eastern Jamaica, which is a steep, mountainous river catchment, largely rural in the upper section and urbanised in the lower section.
- The South Negril–Orange River situated in western Jamaica, an important area for tourism with much of the 8 km shoreline of Negril Bay comprising tourism infrastructure.

Figures 2 and *3* show some of the effects of past flooding from hurricanes and tropical storms in Yallahs and Negril.

Project results

Flood hazard maps

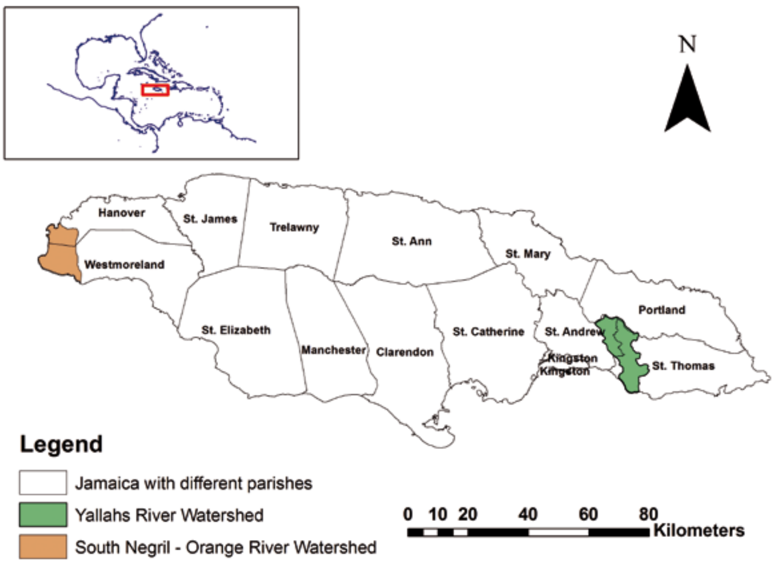
Future flood risk was assessed for the two sites using rainfall and temperature data at watershed level obtained from a Regional Climate Model (RCM) for Jamaica. The PRECIS RCM[5], developed by the Hadley Centre (UK), is being used to generate high-resolution climate change information for the countries of the Caribbean, including Jamaica. The RCM was run as a part of a collaborative multi-country initiative to provide future climate information at national and subnational scales for the Caribbean Small Island States.[6,7] Flood inundation maps were developed for the two watersheds for different scenarios including tropical storm Gustav (August 2008), present and future climatic conditions using regional climate model (RCM) derived rainfall data for mid-term and end of century (2070-2099) projections.

Model results showed flood depth of up to 4 m along the river channel and approximately 2 m downstream for the urban areas for the Yallahs

Box 1. Sustainable development goals related to the project[1]

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE	**Goal 9:**	Build resilient infrastructure, promote sustainable industrialization and foster innovation
11 SUSTAINABLE CITIES AND COMMUNITIES	**Goal 11:**	Make cities inclusive, safe, resilient and sustainable
13 CLIMATE ACTION	**Goal 13:**	Take urgent action to combat climate change and its impacts

Figure 1. The location of the two study areas in Jamaica



Map showing the location of the two study areas. Data for the maps obtained from Water Resources Authority of Jamaica.

Figure 2. Flooding in the community near the mouth of the Yallahs River (Poor Man's Corner), August 2012[2,3]

Flooding in community upstream of Poor Man's Corner, Yallahs watershed in Roberts Field damaging the fording, people wading through the flood waters, October, 28, 2012. (Source: *http://jamaica-gleaner.com/gleaner/20121028/lead/lead7.html*)

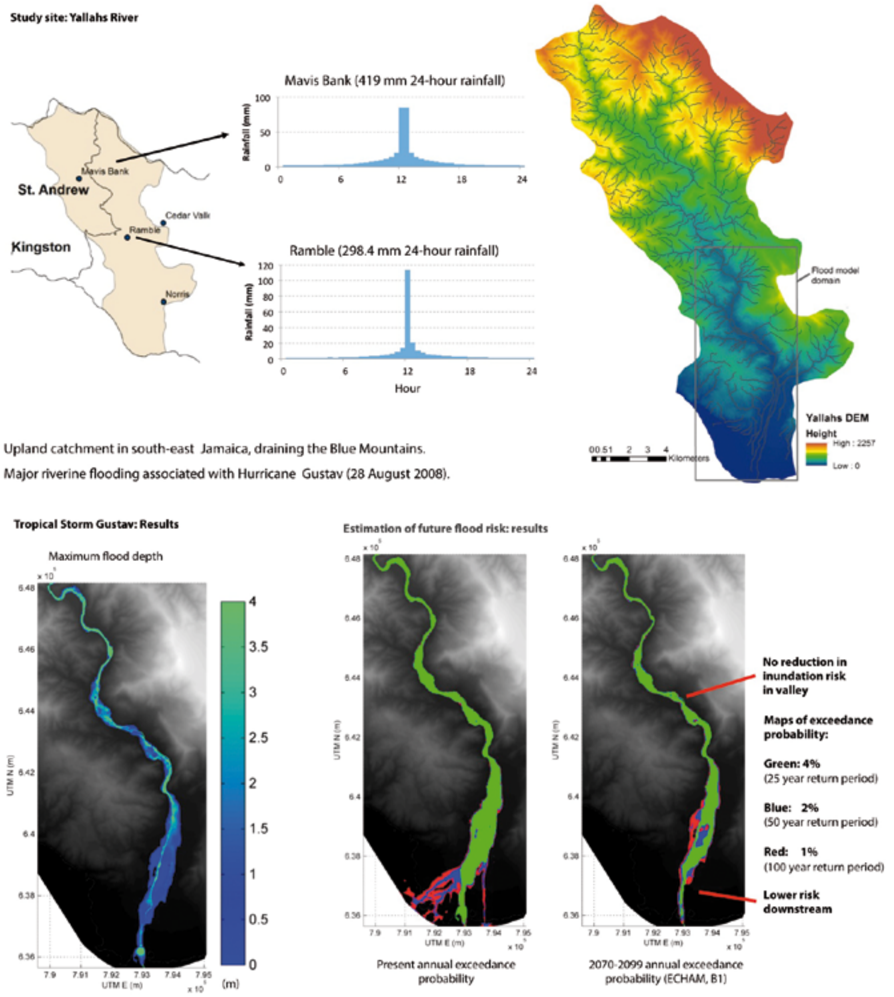
Flooding in Poor Man's Corner. mouth of the Yallahs river, where most of the urbanisation is, August 28, 2012 (Source : *http://www.jamaicaobserver.com/news/Some-flooding-in-Poor-Man-s-Corner_12364722*) watershed from tropical storm Gustav in August 2008 (*Figure 4)*. Rainfall data were used from the rain gauges at Mavis Bank and Ramble which recorded a maximum of 419 mm and 298 mm for Gustav (2008). Present and future flood risk maps (end of century projections) do not show any significant reduction in the extent of inundation for communities on the floodplain.

The South Negril–Orange River watershed is one of the main tourist hubs of the island. Almost all the major infrastructure – hotels, restaurants and craft markets – is located along the coastal section of the watershed, which is impacted by storm surges from tropical storms and hurricanes. In the study, flooding from tropical storm Gustav showed maximum flood depths ranging from 0.5–1 m from inland to coastal areas. This was a combined result of rainfall and storm surge from the event. Future climate projections showed little change in rainfall-induced flood risk, with a moderate decline in risk inland due to reduced rainfall levels. The main area of impact was along the coast, with a larger number of buildings at risk in the future due to rising sea level (*Figure 5*). Buildings along the coast continue to show high levels of risks to hazards under future climatic conditions as observed from the model.

Figure 3. Effect of tropical storm Nicole , 2010, on beach in Negril, picture shows whole beach gone.

Flooding in much of the beach was lost in the storm - there used to be at least 15 feet of sand between this wall and the water (*https://nept.wordpress.com/2010/10/27/damage-from-tropical-storm-nicole/*)

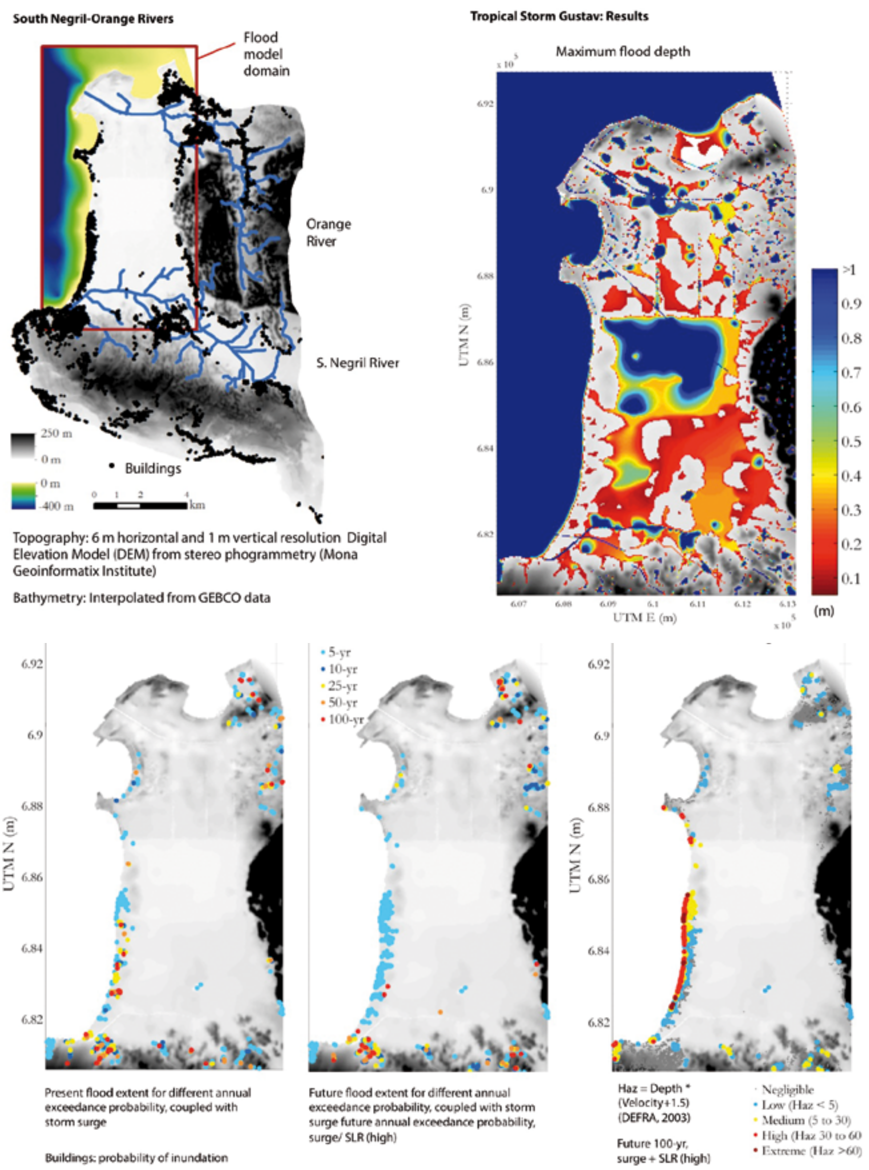
Figure 4. Yallahs River watershed flood risk assessment.



Top, elevation model for the watershed showing the locations of the rain gauges and the peak rainfall for tropical storm Gustav. Right, modelled flood depth from tropical storm Gustav, August 2008. Below, present and future flood risk: green, areas at risk from a 25-year flood event (4% annual exceedance probability); blue, 50-year event (2%); red, 100-year event (1%). (Topographic data available from Mona Geoinformatics Institute, rainfall from Meteorological Service of Jamaica, Soil and Landuse for model build up from Water Resources Authority of Jamaica). (*Conference Presentations : WCRP LAC PERU 2014 http://pampero.cima.fcen.uba.ar/cordex/final/MI/14_mwilson-vamos-cordex.pdf*)

The project also created an island-wide riverine flood hazard map (*Figure 6*). The map shows areas with a high likelihood of flooding, which are the floodplains of major river systems and sites for major towns and cities. This, when overlaid with the road network map, clearly shows that the major roadways pass through areas with high flood likelihood, highlighting the importance of building flood-resistant infrastructure for present and future climate conditions.

Figure 5. South Negril–Orange Rivers study site, comprising a large low-lying wetland area surrounded by sizable communities and tourist infrastructure.



In the centre, the modelled flood depth from tropical storm Gustav (August 2008) shows a maximum flood depth of 1 m. The two figures on the right show present and future flood risk.[9] for a 5, 10, 25, 50 and 100 year event. Future projections shown here are for end of century (2070-2099). (Topographic data available from Mona Geoinformatics Institute, rainfall from Meteorological Service of Jamaica, Soil and Landuse for model build up from Water Resources Authority of Jamaica). (*http://www.cima.fcen.uba.ar/WCRP/docs/prstt/4p_MatthewWilson.pdf*)

Engaging national and local stakeholders on the results

Community meetings were conducted in both Yallahs River (by Jamaica Conservation and Development Trust [JCDT]) and South Negril–Orange River watersheds at three-month intervals for the 18 months of the project with an average attendance of 30 members in each meeting. Almost 70% of participants reported that they were aware of the causes of flooding and recurrence of flooding in their communities, and demonstrated a broad knowledge of climate change and its impacts. Community workshops organised and delivered by representatives from the JCDT and project lead involved distribution of fliers on climate change and flooding in Jamaica, followed by presentation of results. In addition, information was broadcast via different radio channels both before and after major newscasts.

A three-day stakeholder workshop was conducted at the end of the project at the Department of Geography and Geology, UWI Mona Campus, Jamaica (May 2014), involving interactive exercises on climate information for Jamaica, dissemination of project results, and a day-long training session on the flood models and the use of the open-source data portal CARISKA.[12] The workshop was a useful platform for sharing knowledge and information from both sides. Stakeholders from the water and disaster-management sectors, as well as from the Meteorological Office of Jamaica, provided new insights on additional data sources (climate and geospatial) and ideas for refining the model with further data sets. Questions raised by participants at the workshop have been taken into consideration, and work is in progress on refining the resolution of the climate models from 50 km to 10 km. Post-project 25 km climate models have been developed for Jamaica and the results are being collated for incorporation in the flood risk models for the watersheds. CDKN funding has been received for a six-month outreach project from June–November 2016. This will involve training stakeholder and community disaster coordinators in use of the Open Data Kit (ODK) App[13] for data collection (flood data, damage data), followed by data analysis and uploading on CARISKA.

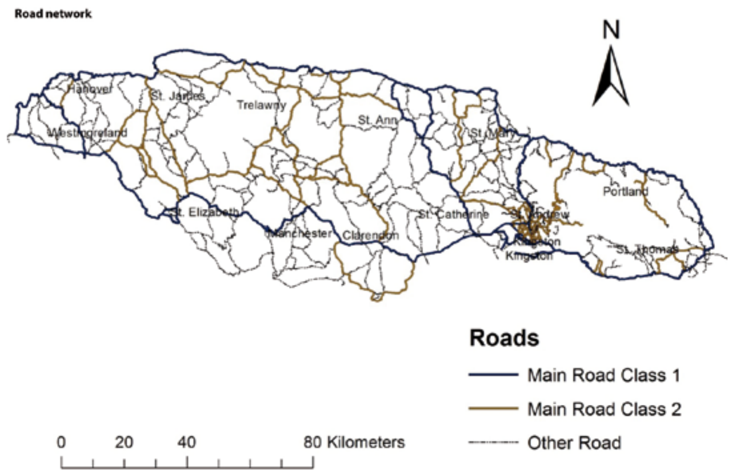
Challenges and enabling factors for implementation

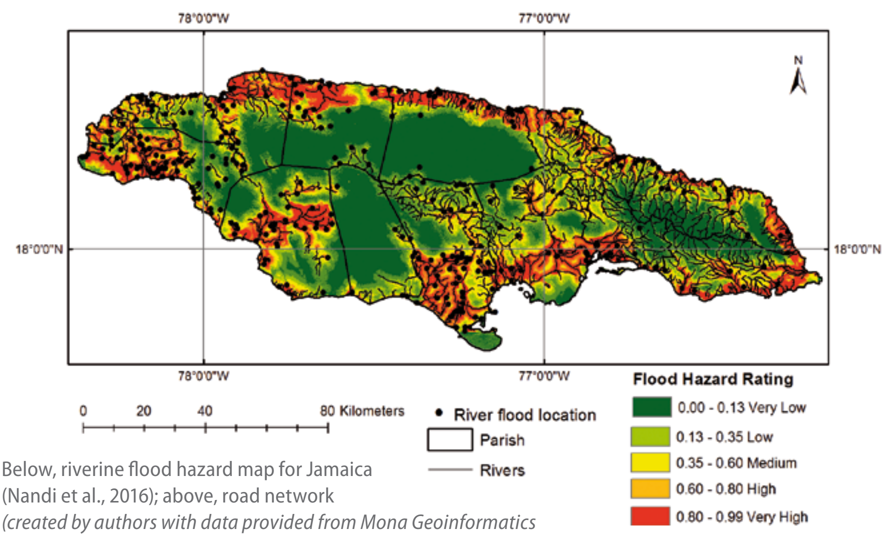
Scaling-down knowledge

While the study was able to obtain daily projections of rainfall for a grid with a horizontal resolution of 50 km, there are some concerns. First, the rainfall value across a 50 × 50 km box covers the entire watershed and does not provide climate data at the sub-watershed level or for the community where actual flooding occurs. Second, rain storms may vary significantly within a region and throughout a day. This may mean that future flood risk is underestimated. Current hydro-meteorological data at sub-watershed and community levels are lacking because there are not enough rain and flood gauges. Also, data (flood levels, rainfall) are lost from gauges damaged during intense storms. Incomplete data from specific events prevent detailed and accurate estimation of flood levels for the communities affected.

Climate models with finer resolution (10 × 10 km or less; sub-daily) are needed to derive future rainfall data

Figure 6. Top, road network;[10] Bottom, riverine flood hazard map for Jamaica.[11]



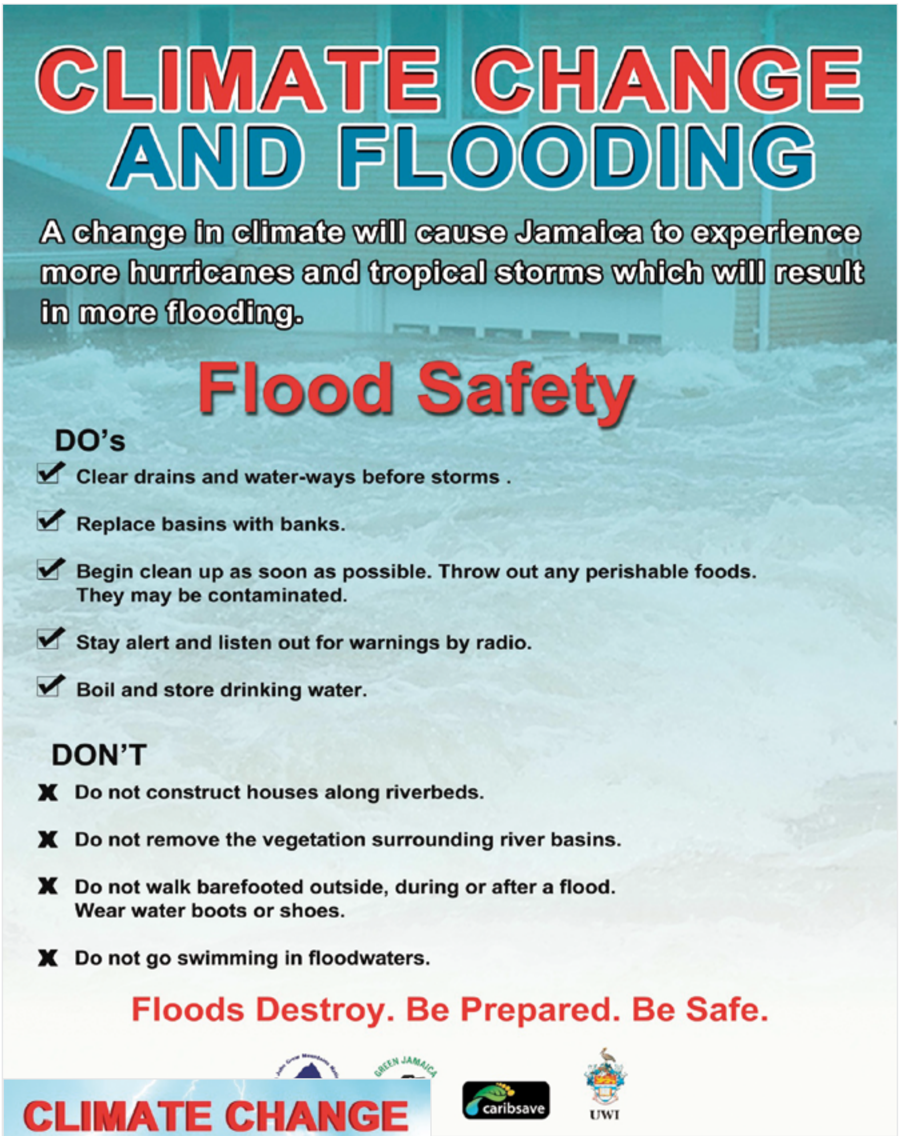


Below, riverine flood hazard map for Jamaica (Nandi et al., 2016); above, road network
(created by authors with data provided from Mona Geoinformatics Institute, Water Resources Authority of Jamaica).

Figure 7. Workshop with project team showing project results

Community meetings and workshop showing project results by project partner.

Figure 8. Samples of fliers designed and distributed by project partner JCDT to communities during training and workshops.



at community or sub-watershed level. Climate models for Jamaica have evolved from the 50 km resolution model used in this project to a finer 25 km resolution. Work is ongoing to increase the resolution to 10 km. A denser network of gauges to cover vulnerable areas would also help to make more accurate predictions.

High-quality topographical data

The accuracy of flood risk predictions will improve if more accurate topographical data for the terrain can be obtained. Even small changes in elevation, of less than 1 m, can be critical for modelling precisely which areas will be inundated and determining which communities, homes, roads and buildings may be affected. The best data for this type of assessment can be obtained using laser technology. It is strongly recommended that this technology be used on all Caribbean islands with high flood risk.

The importance of data quality and its implications for final model output was stressed at the stakeholder workshop, which received inputs from the water, environment and disaster-management sectors. Policy-makers realised the importance of data collection, storage and dissemination. Participants recommended further discussion on compiling available data (rainfall, flood levels, topography), cross-checking the quality, creating an inventory of missing data, and sourcing funding for data collection. This is crucial – policies based on poor data may be insufficient and unreliable. This poses a challenge at times as it involves time and human resources which may be lacking in some organisations. Often projects are time-bound, and lack of post-project sustainability due to funding issues can present a challenge for continuing with data collection and improving data quality.

A need for increased capacity at national and subnational levels

A survey carried out by the Institute for Sustainable Development on eight Caribbean territories showed that important data for disaster risk management are often not available in digital form or at the scale required to support planning decisions, and sometimes exist in file formats that are not useful.[14] In many countries there are few working rain or wind gauges except at airports, so collecting data is a problem. This was also common for the present project, where rainfall data for the watersheds exist only from 1992 to 2013 because pre-1992 data were lost due to fire at the Meteorological Service of Jamaica.

While the availability of data is a limiting factor in estimating flood risk in many Small Island Developing States of the Caribbean, the capacity of local authorities to use such data is also limiting. For example, few parish councils in Jamaica can attract and keep persons trained in the use of geospatial data and computing. Although the project was able to train some personnel at the appropriate level of governance, this kind of intervention needs to be continuous, as staff move on and their replacements need to be trained.

One way to address this problem is to increase the number of persons trained in geographic information systems (GIS) coupled with continuous monitoring of river and rain gauges and collecting hazard data. It is important for local and national governments to share climate and spatial data between agencies and with academia to increase the amount of information available on hazards and improve the accuracy of disaster risk estimation.

Implications for decision-makers and practitioners elsewhere

High-quality data on hazards and risks can inform good policies that save lives and reduce loss of livelihoods and damage to property. Risk reduction can be improved by continually monitoring hydro-meteorological data and installing flood gauges and flood warning systems in vulnerable watersheds. Projects should be designed with a long-term sustainability plan involving government and private stakeholders and academia, while trying to meet the SDGs as well as national and local plans and policies.

Climate models for the Caribbean have been developed over the past 10 years and continue to provide climate information at the watershed level that can be used across all sectors. These research outputs have been used by decision-makers to frame policies and plans for the island. Results from climate models (as used in the project described here) were used to create the Climate Change Policy Framework for Jamaica[15] and the State of the *Jamaican climate 2012* report.[16]

The 2015 Climate Change Policy Framework for Jamaica[17] was developed to support the goals of the Vision 2030 National Development Plan,[18] to mainstream climate change considerations into different sectoral plans, and to strengthen key sectors to develop and implement their adaptation plans. This and other policy tools, such as Jamaica's first and second National Communications on Climate Change to the UNFCC in 2000 and 2011, respectively,[19,20] should rely on scientific information emerging from research projects involving development of high-resolution climate models and their sectoral impacts (water, agriculture, health and tourism) at watershed and sub-watershed levels. Currently a number of policies have been developed in Jamaica and the Caribbean, including the draft National Water Sector Policy and Implementation Plan[21] and the *Regional comprehensive disaster management strategy and programming framework (2014–2024)*,[22] which are tied to including climate information for the relevant sectors. A number of community disaster plans have been developed for vulnerable communities by the Office of Disaster Preparedness of Jamaica;[23] one example is the plan for the community of Llandewey, Yallahs watershed.[24] Community disaster plans address the different hydro-meteorological hazards affecting communities and the impact of climate change on such hazards. The plans also provide communities with an outline of shelters, evacuation plans, possible adaptation measures and an overall plan for reducing risk. The work done in this project can further assist these plans where information on flood risk at subnational level is available under future climate scenarios.

Caribbean Islands will continue to experience climate change and will need to adapt to the increased risk from severe weather caused by these changes in the climate. The methodology used in this project can be extended to other Caribbean islands with similar topographies and histories of flood risk. Even in situations where data are lacking (and this is the case for much of the Caribbean and many developing countries), the method can help communities and governments plan for increased flooding in the future and reduce their disaster risk. Hopefully, this will mean fewer lives and properties will be at risk. As time progresses and more data are collected, the plans and actions can be made more precise. A key benefit of this method is that in places where few data exist, it allows for some action to be taken that reduces disaster risk, rather than waiting for data that may never be generated.

Acknowledgements

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Endnotes

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