Technical Insights

At the Water's Edge: Nature-based Coastal Resilience in Grenada and St. Vincent and the Grenadines

By Steven R. Schill, Sr. Scientist, The Nature Conservancy, sschill_at_tnc.org

Today's society faces unprecedented challenges. Dwindling natural resources, declining economies, a rapidly changing climate and other threats require that all of us begin working together to reach common solutions. With increasing demand on our limited resources, innovative solutions are needed to ensure that nature can continue to provide the food, clean water, energy and other services our growing population depends upon for survival. The mission of The Nature Conservancy (TNC) is to conserve the lands and waters on which all life depends. Founded in 1951, TNC has grown to be the world's largest environmental NGO and accomplishes its mission through a network of partners who implement innovative science. With a team of over 600 scientists, TNC works closely with local partners from individuals and governments to nonprofits and corporations from around the world to ensure the preservation of the local plants, animals, and ecosystems. To date, TNC has protected more than 119 million acres of land, 5,000 miles of rivers, and operates more than 100 marine conservation projects globally with a vision to leave a sustainable world for future generations.

Project Background

As climate change continues to impact areas around the world, there is no place that is more evident than in small island nations. This is particularly true in the Eastern Caribbean, where climate change is already placing intense pressure on human livelihoods and coastal and marine resources. These small islands contribute very little to global climate change in terms of greenhouse gas emissions, yet they are the most vulnerable to the impacts from climate change due to their high coastal population densities, limited land space, geographic isolation, scarce freshwater supplies and significant dependence on tourism and fisheries. In addition, these islands face significant threats from increases in severe storm events, flooding, coastal erosion, drought, saltwater intrusion of coastal aquifers, and bleaching of coral reefs.

With limited resources, islands require innovative adaptation strategies, and in particular how they can enhance their resilience to climate change by protecting, restoring and effectively managing their marine and coastal ecosystems and strengthening local capacity for adaptation. Coastal ecosystems such as mangroves, coral reefs, and coastal wetlands provide valuable services that people rely on. They act as a natural infrastructure, forming physical barriers against extreme weather that absorb storm impacts and regulate flooding, provide food, clean water, and erosion control. These natural buffers can be effective if managed properly, and are much less expensive to maintain than built structures such as dykes or sea walls which can degrade the environment. Sustainably managing, conserving and restoring ecosystems so that they continue to provide the services that allow people to adapt to climate change is known as Ecosystem-based Adaptation (EbA). This approach builds on traditional knowledge, generates a range of social, economic and cultural benefits and helps to conserve biodiversity.

Project Goals and Objectives

In the Eastern Caribbean, TNC has been working with the government and people of Grenada and St. Vincent and the Grenadines for more than a decade, helping strengthen national parks and protected area systems and develop sustainable finance and human capacity for effective environmental management. During this time, TNC's Global Marine Team has been working on coastal resilience projects and has developed a tool framework and decision support system upon which governments can draw upon to identify suitable places to implement EbA solutions (see costalresilience.org). Identifying risk and vulnerabilities is an important part of developing priorities for adaptation. The goal of the At Water's Edge (AWE) project was to demonstrate that governments and communities of Grenada and St. Vincent and the Grenadines can enhance their resilience to climate change by protecting, restoring and effectively managing their marine and coastal ecosystems and strengthening local capacity for adaptation. The project relied heavily on remote sensing and GIS technologies to document the socioeconomic and ecological vulnerability to sea level rise and storm surge impacts, laying the groundwork for adopting EbA solutions throughout. The spatial products developed throughout the course of the project are being used in Decision Support Tools to help government and communities visualize and interact with information in order to make important long-term planning decisions in regards to minimizing the impacts of climate change from both a socioeconomic and ecological perspective.

Methodology

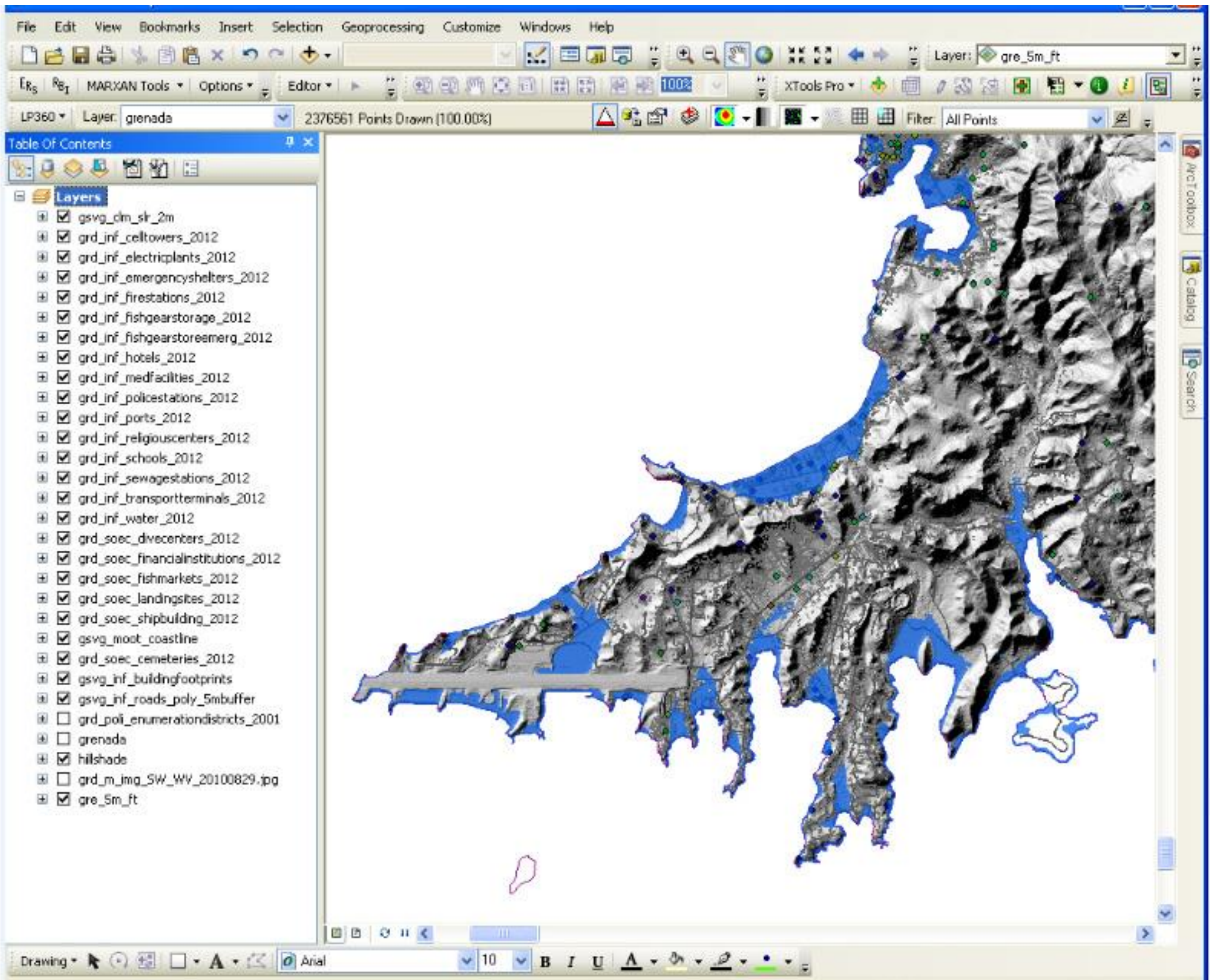
High resolution elevation and bathymetric models were used to identify potential areas of flooding from both sea level rise and storm surge. These flood scenarios were intersected with socioeconomic and ecological features that were digitized from high resolution satellite imagery. In order to spatially capture the sensitivity of coastal communities, three aspects of community structure were mapped: a) livelihood (fishing and tourism); c) critical infrastructure and facilities (transportation, utilities and emergency response); and c) social systems (people and access). Socioeconomic features such as buildings, roads, market centers, critical infrastructure, and demographic information were used to identify trends in social sensitivity to the impacts of climate change and the potential for communities to anticipate, respond to, cope with, and recover from climate impacts. For communities, this can be influenced by economic status, human resources, and environmental capacity.

In addition to socioeconomic features, coastal ecological features such as mangroves, beaches, wetlands, coral reefs, and seagrass were mapped in order to identify where these ecosystems are potentially vulnerable to the impacts of climate change and how improved management can increase the ecosystem service potential in areas where vulnerable communities live. When healthy, coastal habitats can provide the greatest potential to provide protection to communities from flooding and wave action. Mangroves act as a buffer from storms and flooding, absorbing impacts from waves, and help guard against coastal erosion, in addition to providing critical fish habitat. Coral reefs also provide valuable ecosystem services by reducing wave action thus decreasing potential for land based erosion and flooding. Seagrass beds help to trap sand in coastal bays and beach dunes act as barriers to storms, helping to anchor coastal ecosystems.

Use of LP360

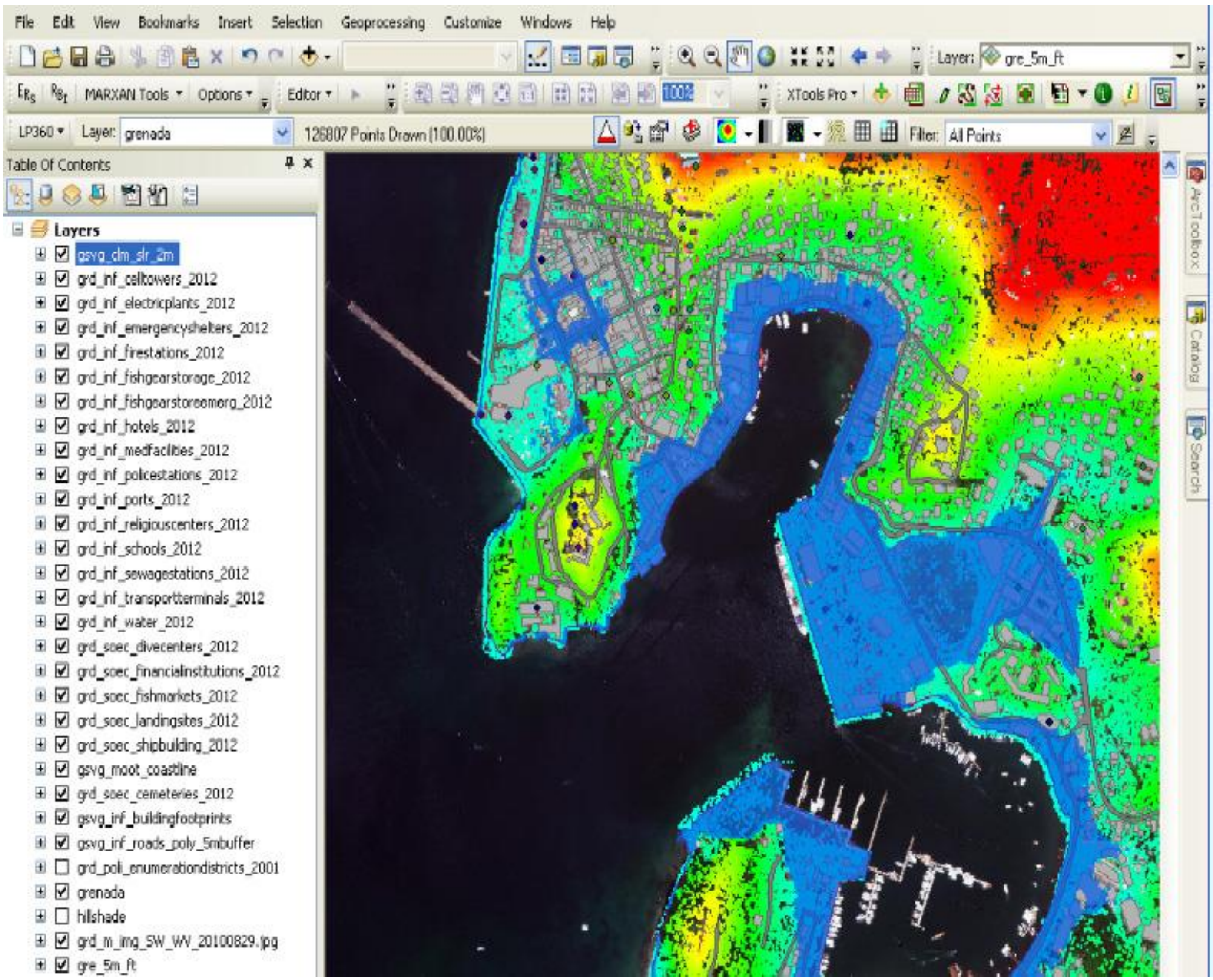
Prior to running the storm surge and sea level rise models, many pre-processing steps had to be conducted on the high resolution elevation datasets. For example, a 1-meter LIDAR dataset that was previously acquired for the island of Grenada was delivered in ASCII x,y,z format. TNC used LP360 for ArcGIS to import the files directly into LAS format as a data layer for visualization and evaluation of data quality. The team was surprised at how easy and fast LP360 handled the large LAS files. The ability to conduct all the analysis within an ArcGIS environment using the industry standard LAS file format made the process extremely efficient as the team was able to analyze the point cloud and determine problem areas that needed additional filtering. The Point Cloud Task framework was used for generating point cloud statistics and previewing basic classification filters, and height from surface filters. Ultimately, the final LIDAR surface resulted in a first of its kind – the highest resolution and most accurate elevation and bathymetric model available for both countries.

The calculation and visualization of the 1 and 2-meter SLR levels were based on the newly created elevation model, where cells of 1 and 2-meter elevation near the coast were selected, filled, and mapped – simulating inundation at a constant elevation. In addition to SLR scenarios, TNC contracted with Smith Warren International (Kingston, Jamaica) to estimate storm surge inundation levels from a variety of simulated hurricanes. The computer program, MIKE 21 was used to simulate each storm's shape, size, movement, and wind speed, integrating ocean depth and land elevation to estimate potential storm surge inundation levels.



Results

The high resolution elevation models produced using LP360 software directly contributed to the accurate delineation of flood impact areas within the two countries. The new water boundaries that were created at both the 1 and 2-meter elevation marks estimated the total impact area within the coastal zone and resulted in the highest resolution and most accurate SLR models for both countries. Results for the storm surge models showed maximum wave heights for both sides of the islands and predicted the extent of flooding with maximum storm surge values above Mean Sea Level. Another important result of this project helped to answer the question of where mangroves could potentially move in response to SLR and which mangroves areas are most/least vulnerable to sea-level rise. These estimates were based on the calculation of a migration index using habitat requirements and biophysical constraints as well as a vulnerability index that was calculated through a simple weighted summation of the 8 individual, classified variables. Final socioeconomic indices that were computed using census and infrastructure data included a community infrastructure and facilities sensitivity, social sensitivity, and adaptive and coping capacity summarized at the enumeration district level.



Workshops conducted in-country taught community and government leaders how to use the information products to identify high priority areas to implement EbA actions, were investments in managing and restoring coastal ecosystem would help communities decrease their sensitivity and increase adaptive capacity to climate change. Areas identified as highly exposed (based on flooding potential) and highly sensitive with low adaptive capacity, highlighted were communities were most susceptible places to SLR and storm surge impacts. Such tools and data serve as valuable long-term planning resources for government and community leaders seeking to safeguard important coastal habitats that will provide critical ecosystem services for future generations.