Ecosystem based adaptation in St. Vincent and the Grenadines, West Indies: changing perception and supporting decisions

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Abstract

Small islands are adapting to inundation from storm surge and sea level rise by largely choosing strategies that include shoreline hardening which can handicap and exclude natural communities. Incorporating nature based solutions to mitigate inundation impacts on human communities is termed Ecosystem Based Adaptation. The Nature Conservancy is working to reduce vulnerabilities from inundation by changing perceptions about shoreline hardening that include nature based solutions. With help from the National Parks, Rivers and Beaches Authority of Saint Vincent and the Grenadines, we are demonstrating how this can be done with tropical island habitats. Raising awareness and supporting decisions to reduce vulnerability has been facilitated by the use of three geographic based decision support tools; open source GIS software training of government employees and community leaders, participatory 3D mapping and interactive web mapping. The result of this work has impacted perceptions by providing creative ways to visualize inundation scenarios.

Introduction

Coastal areas and small islands are already adapting to cope with impacts from storm surge and sea level rise (SLR) (Hale *et al.*, 2009). The adaptation strategies chosen often depend on the perception that decision makers and communities have about what will reduce their vulnerabilities. The decisions being made on pre-existing knowledge and perceptions greatly impact both the human and natural communities that exist along the coast. The traditional contemporary way to reduce vulnerability of human communities is to use grey infrastructure such as seawalls and shoreline hardening. Mounting evidence suggests that external costs can be offset if these efforts are complemented by nature based solutions that either enhance or restore ecosystems (Beck and Shepard, 2012). The concept of using nature to protect human communities from the effects of climate change has been termed "Ecosystem Based Adaptation" or EBA. Currently, the Nature Conservancy, along with a host of partners, is involved in an innovative EBA project titled At the Water's Edge (AWE) to apply this concept in the context of the small tropical islands in the eastern Caribbean.

A key component of the project is a GIS-based methodology to understand and map socioeconomic and ecological vulnerability. The products derived from this methodology directly feed into mapping and visualization tools for the purpose of awareness raising or helping to change existing perceptions and support decisions that are being made about how best to allocate resources for reducing coastal vulnerability. Three main approaches have been taken thus far; hands on trainings of government workers and community leaders using free and open source desktop GIS software, participatory 3-dimensional mapping (P3DM) and interactive web mapping. The application of these decision support tools for Saint Vincent and the Grenadines (SVG) is discussed.

Method

A national assessment was performed through a spatial analysis that identified human communities most vulnerable to inundation from SLR and storm surge. Modeling SLR and storm surge scenarios was performed on the highest resolution digital elevation model available. For SVG, the final product was a mosaic of a 1 m light detection and ranging product for the main island of Saint Vincent and an elevation product derived from stereo pair aerial imagery for the Grenadines.

The method of computing the storm surge scenarios involved calculations at various scales to obtain both overall representation of the characteristics of the storms being modeled and how they specifically impact the Grenadine Bank. The computer program MIKE 21 was used to simulate storm shape, size, movement and wind speed while integrating ocean depth and land elevation to estimate potential storm surge inundation levels. Five scenarios were generated each representing various simulations such as a 100-year storm event and Hurricane Lenny as a Category 4. The “bathtub” model was used to generate the SLR scenarios. The final scenarios represented the extent of all dry land below one and two meters at current sea level.

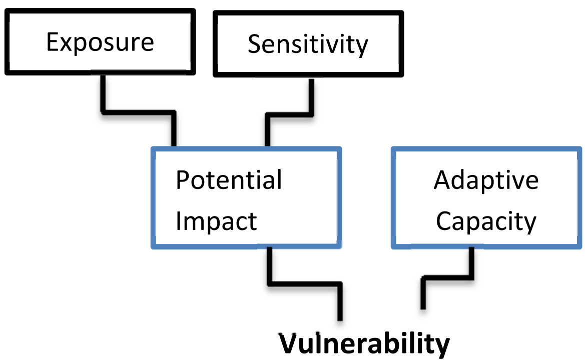

Figure 1. Framework depicting the measurable and mapped components of vulnerability

These models were then used to calculate vulnerability. We defined vulnerability as the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change. We determined vulnerability to be a function of the relationship between the degree to which a community is exposed, the sensitivity of a community, and the adaptive capacity of that community as seen in Figure 1 (IPCC 2007).

Under this vulnerability definition, we mapped its various components for both human communities, representing socioeconomic status and we mapped it for the mangrove system, representing ecological status. Ideally, ecological vulnerability would be represented by the ecosystem complex observed in this area which is composed of coral reef, seagrass, beach and mangroves and surrounding littoral forests (Moberg and Rönnbäck, 2003). However, mangrove was chosen to represent ecological vulnerability in the first phase of the project because of the available science regarding mangrove vulnerability and they were easily mapped (McIvor *et al.*, 2012; Moore, 2012). The components of vulnerability were calculated as indices represented by the census district for socioeconomic vulnerability and by mangrove patch for the ecological vulnerability.

We defined exposure as the degree to which a community experiences climate change as defined by the amount of the community that was inundated by a given scenario (Marshall *et al.*, 2009). We used the amount and percentage of mangrove, roads, buildings, and important livelihoods structures inundated by the modeled inundation scenarios to provide a value for how exposed human or natural communities might be.

Sensitivity captures characteristics of a community that influence its likelihood to experience harm under a given scenario. These characteristics can exacerbate or diminish the impact from exposure. For the socioeconomic aspect of this work, we applied this definition to identify and map two characteristics that contribute to total human community sensitivity. The first is access to critical infrastructure facilities, all represented as vector shapes in GIS. Second, the demographic profile of a community such as its age band structure, population density and access to radio and internet for example. For the ecological aspect of this work, we characterized the size, shape, openness to the coast and habitat type to name a few to represent mangrove sensitivity.

Adaptive capacity describes the ability of a system to anticipate, respond to, cope with, and recover from climate impacts. In this analysis, we mapped adaptive capacity using census data representing the highest level of education attained and available workforce for example. For the ecological aspect, adaptive capacity of mangrove was represented by their ability to migrate which incorporated surrounding slope, elevation and adjacent land use to name a few.

Although the information was used to assess national vulnerability for SVG, its biggest use has been to communicate and visualize the concept of EBA to the intended audience. However, the characteristics across this intended audience varied greatly. Depending on the audience member, the perspective to how this information was viewed varied by scale (i.e. local, national and regional or global). Moreover, the way audience members accessed this information also varied. For some, GIS experience was not necessary, thus accessing this information through GIS software and spatial datasets did not make sense. However, some audience members need access to the actual GIS information. For some audience members internet connectivity is good, for others it is poor. To best fit the various needs and characteristics of the intended audience, three approaches were taken; interactive web mapping, hands on training of government workers and community leaders using free and open source desktop GIS software and participatory 3-dimensional mapping (P3DM).

For audience members who are not trained in GIS, but have good internet, we set up an interactive web map through the Coastal Resilience website (coastalresilience.org). The Coastal Resilience website details the broader framework of coastal resilience, where EBA is nested (The Nature Conservancy, 2013). This allows audience members who visit this site to understand the broader context from which this work rests. It also gives an overview of the project's goals and objectives as well as provides the visual component of the data used and produced. Many of the spatial data layers are accessible, allowing viewers to turn them on and off. This format has been ideal for international development agencies, funders and outside regional interests to view what has been done.

For audience members who are trained in GIS, need access to the actual spatial data, do not have good internet connection and cannot afford proprietary GIS software we held a training using free and open source GIS desktop software. Through this effort, participants were able to download QGIS onto their personal desktops and begin to take a closer look at the spatial dataset, including metadata, naming convention, attribute tables and spatial extent and limitations (Quantum GIS Development Team, 2013). This provided an ideal opportunity for government technocrats to figure out how best this information can be applied to their work whether it is physical planning or disaster management.

For audience members who are not trained in GIS and do not have good internet connection, we helped fund a P3DM process (Rambaldi 2010). This process was completed in Union Island at a very local scale. Although some government workers attended, the process was mainly community led and built. Through this process, the ideas about what the community was concerned with and what they wanted to focus on were realized.

The measure of actual change of perception at the community level will be worked into a Red Cross survey. The intent is to measure the community's perception of vulnerability before and after the installation of an EBA solution. We have anecdotal evidence that the approaches taken thus far are impacting perceptions.

Conclusion

Decisions can be made to reduce vulnerability of human communities that incorporate natural solutions, an alternative to traditional and contemporary grey infrastructure. In order to facilitate the decision making process, the AWE project is working to change existing perceptions on how to reduce vulnerability by demonstrating the feasibility of nature based solutions and applying a host of mapping and visualization decision support tools. In SVG, the project has provided a set of tools for public education. In addition, the information collected and generated for the project has anecdotally raised awareness among decision makers about how they can individually and collectively adapt and strengthen coastal communities' climate change resilience.

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