US Virgin Islands Climate Change Ecosystem-Based Adaptation

Promoting Resilient Coastal and Marine Communities

GUIDANCE DOCUMENT

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NOAA CORAL REEF CONSERVATION PROGRAM

EXECUTIVE SUMMARY

As with the rest of the world and Caribbean in particular, the coastal and marine communities of the US Virgin Islands (USVI) are susceptible to the effects of climate change including increasing hazardous coastal conditions and loss of life-sustaining marine, coastal and island resources. Climate change is anticipated to add to the stresses of our coastal environment by altering temperature and precipitation patterns, increasing the likelihood of extreme precipitation events, and accelerating rates of sea level rise. Responding and adapting to such changes requires an understanding of the risks; weighing options for adapting to changing conditions; and instituting a suite of strategies to implement, measure, and fund response actions having the most benefits to the ecosystems and communities that depend on those services. With support from National Oceanic and Atmospheric Administration's (NOAA) Coral Reef Conservation Program, The Nature Conservancy's (TNC) Caribbean Program directed a project with the objective of developing decision-support tools and conservation strategies that will advance the implementation of **ecosystem-based adaptation (EBA)** to climate change within the USVI.

In June 2013, TNC convened a USVI Climate Change Ecosystem-based Adaptation workshop for community leaders, researchers, resources managers and climate change adaptation practitioners to:

1. Document the broad array of adaptation to climate change initiatives in the territory which are completed or underway and to identify projects necessary for near-term planning and preparation.
2. Demonstrate methods on the use of geographic information systems (GIS) to identify optimal areas for implementing ecosystem-based adaptation based on ecological and socioeconomic criteria.
3. To develop nature-based solutions to address changes to the coastal and marine environment in the US Virgin Islands.

At this workshop, the participants developed a vision for continuing the work of EBA planning for the territory. Together, the group decided the ongoing goal for EBA practitioners in the territory is to:

> ***"Strategically integrate data, policy, communications and ecosystems services initiatives to advance climate change adaptation in the US Virgin Islands."***

This initiative draws on stakeholder and expert knowledge of the territory, including understanding of existing development stresses, in order to identify critical socio-economic and ecosystem vulnerabilities to climate change and to identify feasible options for adaptation. Using input from workshop participants and applying mapping tools available at coastalresilience.org, we identified the ten coastal areas in the territory most vulnerable to climate change and least likely to respond. They are (with vulnerability scores in parentheses): Two Brothers (142), Demarara (124), Kings Quarter (120), Honduras (109), Nadir (81), East Street (78), Mount Pleasant and Retreat (72), Bovoni (70), and Enighed (63). We can then begin to examine some possible solutions aimed at:

- Improving **coastal protection,**
- Increasing **emergency services** to particular areas, and
- Building **community's resilience** to hazardous weather and future impacts.

These spatial decision tools now allow us to develop long-term strategies to create environments that allow for resiliency to changes over time. Things we can consider are:

- **Setting aside key pieces of land** to allow for coastal habitats to expand or migrate,
- Developing plans for **green infrastructure** to enhance engineered coastal barriers, and
- Directing **restoration efforts** of coral reefs and other critical habitats to build ecosystem services.

Components of this guidance document that outline the EBA approach strategies, derived from stakeholder input and decision support tools include:

- **INTRODUCTION TO ECOSYSTEM-BASED ADAPTATION:** What does EBA address? Making the case for EBA in the USVI. (pages 1-3)

- **COASTAL RESILIENCE:** TNC developed a decision-support tool for EBA planning called Coastal Resilience (coastalresilience.org) that includes species and habitat distribution maps, demographic and infrastructure data, socio-economic vulnerability maps, and sea level rise models using the Sea, Lake and Overland Surges from Hurricanes (SLOSH) model to incorporate effects of storm surge with various projection scenarios. The background, methods, and output of this GIS-based vulnerability assessment that supports adaptive management decisions for coral reef and coastal management. (pages 4-21)

- **OUTREACH AND EDUCATION:** An outreach and education guidance section that suggests various discussion points, materials and media useful for conveying the issue and EBA options to various audiences. (pages 22-23)

- **RECOMMENDATIONS FOR SITE-LEVEL EBA AND NEXT STEPS:** Recommendations to promote ecosystem services in the bigger picture of climate change adaptation for the territory and specific steps for site-level implementation to protect, enhance and restore ecosystem services of coastal areas in the USVI. (pages 24-28)

Additionally, the summary from the June 2013 workshop (Appendix A, pages 29-41) contains the following sections:

CURRENT KNOWLEDGE: A summary of the latest information and sources of recent studies, models and initiatives in the USVI. (pages 33-34)

SUPPORTING POLICY and REGIONAL INITIATIVES: A summary of pertinent policy and local initiatives enacted by government agencies and institutions that in one way or another supports the comprehensive approach to territorial adaptation planning. (pages 35-37)

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INTRODUCTION to ECOSYSTEM-BASED ADAPTATION

Caribbean nations are particularly vulnerable to the impacts from climate change due to their high coastal population, limited land space, geographic isolation, scarce freshwater supplies, and high dependence on tourism and fisheries. These islands now face significant threats from increasing severe storm events, flooding, coastal erosion, drought, saltwater intrusion of coastal aquifers, and bleaching of coral reefs. In response to these threats, the government of the US Virgin Islands seeks to implement ecosystem-based adaptation strategies throughout the territory (St Thomas, St John, St Croix and outlying islands/cays) to help build the resilience of coastal ecosystems and communities. This document explains the methods used by The Nature Conservancy to identify potential EBA sites using a geographic information system (GIS)-based vulnerability modeling exercise. These coastal and marine sites are areas subject to the effects of sea level rise and increasing storm surge and intensity. It is hoped that these model outputs will help guide the implementation of EBA strategies through the use of planning and decision making tools, including restoration actions. On-going coral nursery, watershed and site-level MPA management projects are already being used as focal points for communication and outreach strategies for raising awareness and garnering community involvement regarding EBA methods in the USVI. Ultimately, this project serves as a platform to educate and build momentum within the USVI to streamline EBA actions and strategies into territorial policy and implementation plans.

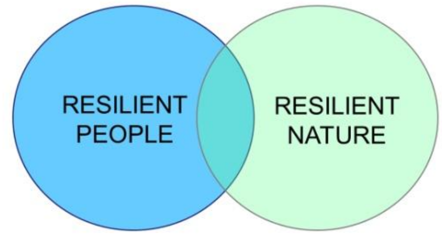
Why Ecosystem-based Adaptation?

There is a growing volume of evidence that suggests in some situations, the most successful and cost-effective actions to protect people from the impacts of climate change is to preserve, enhance and restore natural systems that provide critical protection from the elements, or that provide food, water or work opportunities. *Ecosystem-based adaptation,* or nature-based adaptation to climate change, is a holistic response based on the premise and experience that by protecting, maintaining, and restoring natural ecosystems, we can reduce the scale and scope of impacts to human communities and to the natural systems upon which they depend. Ecosystems are the first line of defense against impacts of climate change and EBA is the protection, sustainable management and restoration of ecosystems to help human communities respond to climate change and to adapt to adverse impacts. It is a critical part of a suite of climate adaptation responses, typically involving multiple sectors. A key aspect of this approach is to design and implement solutions to climate change impacts that integrate nature's infrastructure- mangroves, forests, wetlands, coral reefs and beaches – with human infrastructure and socio-economic needs. Examples of EBA include the protection of recharge zones or restoration of floodplains and wetlands to secure water resources; or restoration and protection of natural infrastructure such as barrier beaches, mangroves or coral reefs to lessen storm and wave impacts on human communities. In summary, EBA projects should meet three basic criteria:

1. **be implemented in a *climate change-vulnerable place* where *biologically significant ecosystems exist* and where *communities may experience socioeconomic impacts*;**
2. **address and *offer solutions to specific human vulnerabilities to climate change*; and**
3. ***engage key communities, decision-makers, and stakeholders.***

EBA includes a range of actions for the management, conservation, and restoration of ecosystems that help reduce the vulnerability and increase the resilience of communities in the face of climate change. EBA is a cost-effective and accessible means of adaptation that can help address multiple threats and local priorities and is often more accessible to the rural poor than technology or infrastructure solutions. To be successful, EBA solutions should be integrated with other adaptation options through multi-agency cooperation and delivered through adaptive management. EBA efforts should be aimed at strengthening the resilience of coastal communities and decreasing levels of vulnerability to and risk posed by climate change. Protecting and restoring “green” infrastructure is much less expensive to maintain than built structures such as dykes or sea walls which can degrade the environment. The Nature Conservancy has worked on many projects around the world that provide the best science and latest knowledge to planners, managers, governments and communities so that they can make informed decisions about managing current and future climate change impacts across a variety of ecosystems. Through our marine conservation work, we are implementing tangible solutions on the shore and in the water and supporting communities in their climate change adaptation efforts.

Limitations of EBA should be recognized including the variability and likely natural changes in the ecosystem; difficulty in differentiating between natural and human-induced changes, insufficient information on ecosystem function; disagreement on ecosystem sustainability indicators; and difficulty incorporating socio-economic considerations from multiple economic sectors into a single ecosystem management approach (IUCN, 2011).



The Role of Coastal Habitats in EBA

Coastal ecological habitats such as mangroves, coral reefs, seagrass beds, and beaches are most heavily impacted by coastal hazards and present the greatest potential to provide protection 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 buffering the shoreline from waves thus decreasing potential for land based erosion and flooding. Seagrass beds help to trap sand in coastal bays, working with reefs to attenuate waves. Beach dunes act as barriers to storms and help anchor coastal ecosystems. See Tables 1a-1d below for further description on ecosystem services, function, and their mediating vulnerability role that these habitats provide.

Table 1a: Coral reefs (based on Barbier et al., 2011)

Ecosystem service	Ecosystem process and Function	Role in mediating vulnerability
Coastal Protection	Wave dissipation and formation	Reduces *exposure* to wave force
	Sediment formation and retention	Supports other habitats (e.g. seagrass) which in turn reduce exposure
Maintenance of Fisheries	Provision of suitable reproductive habitat and nursery grounds	Leads to multiple sources of food and livelihood which reduce both sensitivity and adaptive capacity
	Provision of sheltered living space	Leads to multiple sources of food and livelihood which reduce sensitivity and increase adaptive capacity
Tourism, ed., maintenance & res.	Provision of unique and aesthetic reefscapes	Leads to multiple sources of livelihood and overall feeling of well-being (e.g. spiritual connectedness) increasing adaptive capacity
	Provision of suitable habitat for diverse fauna and flora	Leads to multiple sources of livelihood and overall feeling of well-being (e.g. spiritual connectedness) increasing adaptive capacity

Table 1b: Mangroves (based on Barbier et al., 2011)

Ecosystem service	Ecosystem process and Function	Role in mediating vulnerability
Coastal protection	Attenuation and/or dissipation of wave and wind energy	Reduce exposure to wind and wave force
Erosion Control	Sediment stabilization and soil retention in root structure	Reduce exposure by providing soil control (stabilization and retention)
Maintenance of Fisheries	Provision of suitable reproductive habitat and nursery grounds	Leads to multiple sources of food and livelihood which reduce sensitivity and increase adaptive capacity
	Provision of sheltered living space	Leads to multiple sources of food and livelihood which reduce sensitivity and increase adaptive capacity
Tourism, ed., maintenance & res.	Provision of unique and aesthetic reefscapes	Leads to multiple sources of livelihood and overall feeling of well-being (e.g. spiritual connectedness) increasing adaptive capacity
	Provision of suitable habitat for diverse fauna and flora	Leads to multiple sources of livelihood and overall feeling of well-being (e.g. spiritual connectedness) increasing adaptive capacity

Table 1c: Seagrass (based on Barbier et al., 2011)

Ecosystem service	Ecosystem process and Function	Role in mediating vulnerability
Coastal protection	Attenuation and/or dissipation of wave and wind energy	Reduce exposure to wind and wave force
Erosion Control	Sediment stabilization and soil retention in root structure	By providing soil control (stabilization and retention), mangroves reduce exposure
Maintenance of Fisheries	Provision of suitable reproductive habitat and nursery grounds	Leads to multiple sources of food and livelihood which reduce sensitivity and increase adaptive capacity
	Provision of sheltered living space	Leads to multiple sources of food and livelihood which reduce sensitivity and increase adaptive capacity
Tourism, ed., maintenance & res.	Provision of unique and aesthetic reefscapes	Leads to multiple sources of livelihood and overall feeling of well-being (e.g. spiritual connectedness) increasing adaptive capacity
	Provision of suitable habitat for diverse fauna and flora	Leads to multiple sources of livelihood and overall feeling of well-being (e.g. spiritual connectedness) increasing adaptive capacity

Table 1d: Beaches and Dunes (based on Barbier et al., 2011)

Ecosystem service	Ecosystem process and Function	Role in mediating vulnerability
Coastal protection	Attenuation and/or dissipation of waves and reduction in flooding and spray from sea	Reduce exposure to wave force
Erosion Control	Sediment stabilization and soil retention in root structure of beach vegetation	Beaches are the last buffer zone between the ocean and communities; a healthy beach reduces exposure
Tourism, ed., maintenance & res.	Provision of unique and aesthetic reefscapes	Leads to multiple sources of livelihood and overall feeling of well-being (e.g. spiritual connectedness) increasing adaptive capacity
	Provision of suitable habitat for diverse fauna and flora	Leads to multiple sources of livelihood and overall feeling of well-being (e.g. spiritual connectedness)

		increasing adaptive capacity

COASTAL RESILIENCE

Modeling Coastal Vulnerability for Implementing Ecosystem-based Adaptation to Climate Change in the USVI

Summary:

Map layers were produced as part of a project to estimate socioeconomic vulnerability to climate change for the 336 estates within the U.S. Virgin Islands. To assess the socioeconomic vulnerability of communities, TNC used the 2010 census information to construct indices for a) Social Sensitivity; b) Adaptive Capacity; and c) Exposure. Each index was comprised of several representative variables. The Social Sensitivity Index is a suite of variables and aggregate view that provides a sense of a communities' overall sensitivity to storm surge and climate change. The Adaptive Capacity Index represents human and civic resources that are critical component for coping with disasters including literacy, level of education, access to retraining programs, and other factors that determine how flexible individuals may be in adapting to new employment opportunities or shifts in living patterns brought about by climate variability or change. Finally, the Exposure Index measures how much of a community is impacted by each inundation scenario by calculating the amount and percentage of roads inundated in different scenarios (e.g. 1m and 2m SLR, storm surge). The total socioeconomic vulnerability was defined as a function of community sensitivity and exposure to a scenario, offset by its adaptive capacity. The digital elevation model used in the flood scenarios was derived from a 3x3m LIDAR dataset acquired by NOAA in 2007. Zero elevation represents Low Mean Sea Level (LMSL) based on updated Geoid12a. The calculation and visualization of the 1 and 2-meter SLR levels was done by selecting 1 and 2-meter elevation cells near the coast that are hydrologically connected– simulating inundation at a constant elevation (similar to rising water in a bathtub). These scenarios effectively highlight the most susceptible places to flooding impacts.

The updated coastal resilience web tool which incorporates more accurate digital elevation models, population statistics for socioeconomic vulnerability assessments, and updated storm-surge modeling along with draft visualization tools were presented via webinar to territory partners on August 7, 2013. Participants discussed the utility of the updated tools and provided input on the direction and use of the data. Feedback on the tool itself has led to the identification of several next steps. The tool was also used to identify site-level issues in protected areas and to strategize areas for restoration, coastal planning for climate adaptation, and education and outreach. A presentation covering the following methods can be viewed via the link:

https://nethope.webex.com/nethope/lsr.php?AT=pb&SP=MC&rID=67161107&rKey=8c38dc1f62bfab69

Steps to Identify EBA Sites in the USVI

Before an ideal EBA implementation site can be identified, future climate change impacts need to be modeled in order to understand how people and nature may be impacted. GIS plays an important role in estimating the extent of potential impacts, while the development of spatial models helps to provide insight into how people and nature may respond to these impacts. The following steps describe the process used to map socioeconomic impacts from climate change within the USVI and consequently identify optimal areas to implement EBA solutions.

Establishing a vulnerability framework

We used a vulnerability framework that was first implemented in the At the Water's Edge (AWE) project that was carried out in the Grenadine Bank (countries of Grenada and St Vincent and the Grenadines). This framework was based on an extensive literature review and permits the calculation of several indices that are used to assess socioeconomic vulnerability. The goal of this framework (and EBA projects in general) is to strengthen the ***resilience*** of coastal communities by decreasing their ***vulnerability*** to and risk posed by climate change such as sea level rise and storm surge.

> *Resilience* can be defined as the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt to stress and change" (IPCC, 2007).
>
> *Vulnerability* can be defined as the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes.

It is a function of the character, magnitude, and rate of climate change, and variation to which a system is exposed, the sensitivity, and the adaptive capacity of that system (IPCC 2007). As IPCC explains, assessing the impacts of climate change, the vulnerability of natural and human environments, and the potential for response through adaptation, allows for prioritization of actions and tradeoffs to be considered between adaptation and mitigation.

We used the following vulnerability framework where vulnerability can be defined as a function of *sensitivity* and *exposure* to an impact scenario, offset by its *adaptive capacity*.

$$V = f\,(E + S) - A$$

Where:

> **V** = V*ulnerability* of a system.
>
> **E** = *Exposure*, or the amount of a system impacted by *x* scenario. It is the degree to which a system experiences climate change and variation and is a result of the magnitude, frequency, duration, and/or spatial extent of a weather event or pattern.
>
> **S** = *Sensitivity*, defined by characteristics of a system that influence its likelihood to experience harm. These characteristics can exacerbate or diminish the effect of climate exposure.
>
> **A** = *Adaptive Capacity*, describing the ability of a system to anticipate, respond to, cope with, and recover from climate impacts (short and long-term). For communities, it can be influenced by economic status, human resources, and environmental capacity. For natural systems it is defined by both natural as well as human context (for example the ability of a mangrove to migrate is driven by characteristics specific of a particular species as well as the surrounding built environment).

The total *impact* is the cumulative experience of a system to climate exposure and is based on both sensitivity and total exposure of the system (**E** + **S**). In the next steps, we will explain how we calculated the level of exposure, sensitivity, and adaptive capacity for the USVI. We mapped two levels of sea-level rise (SLR) and used the 2010 census information to arrive at an impact estimation that is offset by the calculated adaptive capacity. We used the US Census estate polygons as our minimum mapping units for which we calculated these indices.

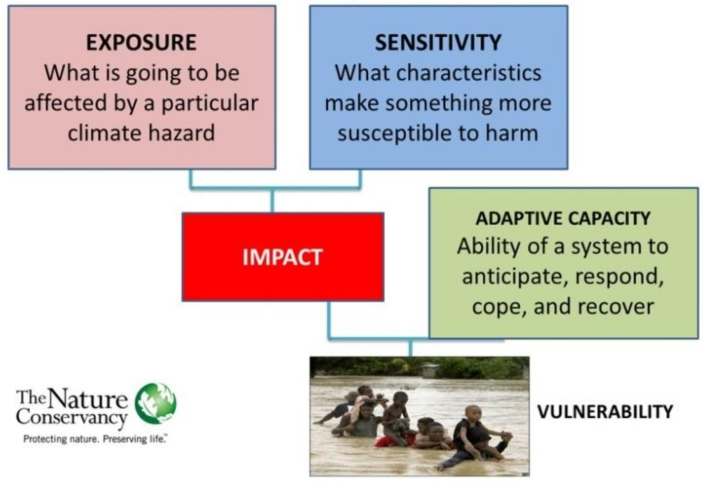


Figure 1. Vulnerability framework that uses exposure and sensitivity to estimate impact that is offset by the calculated adaptive capacity. (adapted from Marshall 2009)

1. Mapping Exposure

Selecting the flood scenarios

In order to assess potential social exposure to sea level rise and storm surge within the USVI, we modeled potential inundation impact zones based on 1 and 2-meter sea-level rise (SLR) as well as a Sea, Lake, and Overland Surge from Hurricanes (SLOSH) analyses, which modeled a 1989 Hurricane Hugo-type storm for the year 2100.

Flooded areas were mapped using the most accurate digital elevation model (DEM) available for the USVI. This information represents detailed surface topography (3x3m cell) acquired from LIDAR data that was collected by the Army Corps of Engineers, Jacksonville District in 2007. LIDAR is a mapping system that measures the height of objects using thousands of laser pulses emitted from an airplane. This model can be used to predict how water's movement is constrained or uninhibited within coastal areas and has a Root Mean Square Error (RMSE) of 16.0cm. Zero elevation represented Low Mean Sea Level (LMSL) based on updated Geoid12a.

Modeling 1 and 2-meter SLR

The level of the sea is expected to rise in future years because the oceans are warming and consequently expanding, and from the contribution of land-based ice due to increased melting. Following the best available SLR mapping science (Gesch 2009), it was determined that our elevation data supported whole meter interval mapping. Furthermore, these scenarios are consistent with several recent studies (Nicholls 2011) that anticipate 1 to 2 meters of SLR by the end of this century. The calculation and visualization of the 1 and 2-meter SLR levels were based on where cells of 1 and 2-meter elevation near the coast were selected, filled, and mapped – simulating inundation at a constant elevation (similar to rising water in a bathtub). We anticipate that these scenarios effectively highlighted the most susceptible places to SLR impacts throughout our study area, while still employing the best available spatial analysis and data standards. The new water boundaries that were created at both the 1 and 2-meter elevation marks were then overlaid onto socioeconomic features to estimate the extent of impact within the coastal zone for St. Croix, St. Thomas and St. John. We then calculated the level of exposure for each estate census polygon by intersecting the flood area with the road network. Higher levels of exposure means more roads inundated and consequently more infrastructure impacted by SLR at 1 and 2-meter height.

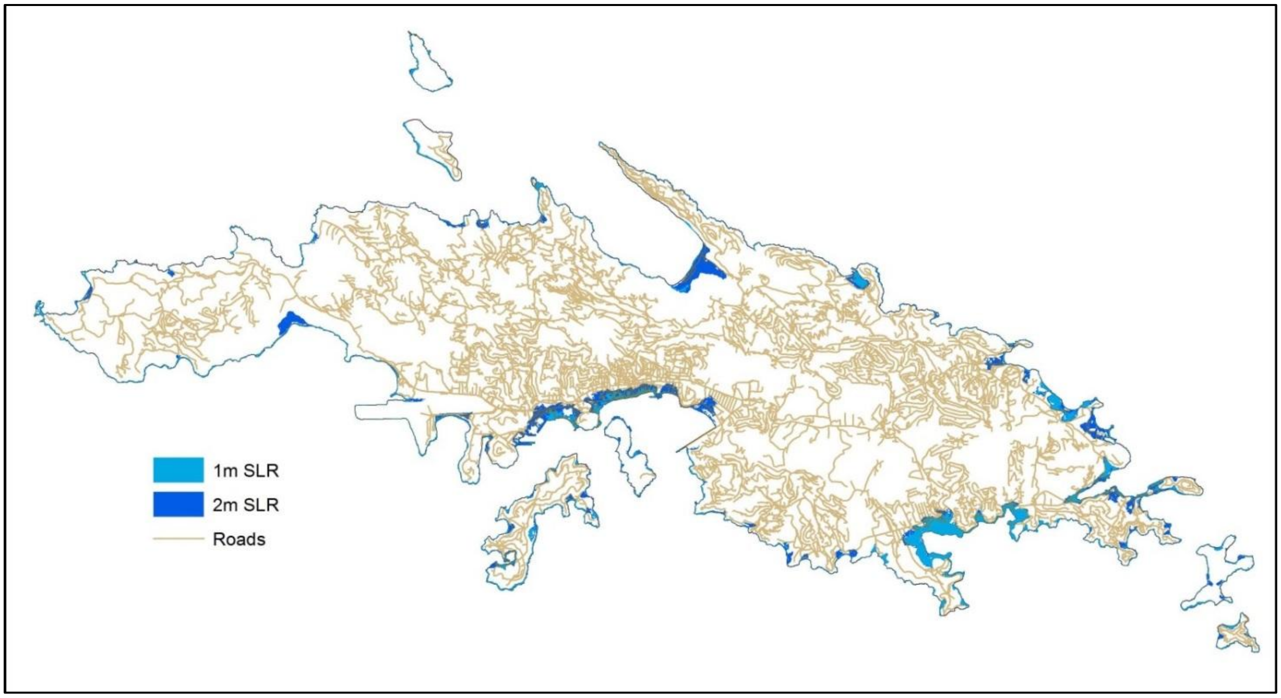


Figure 2. St Thomas: 1 and 2-meter sea level rise (SLR) model based on NOAA's 3m LIDAR Digital Elevation Model with vertical datum correction.

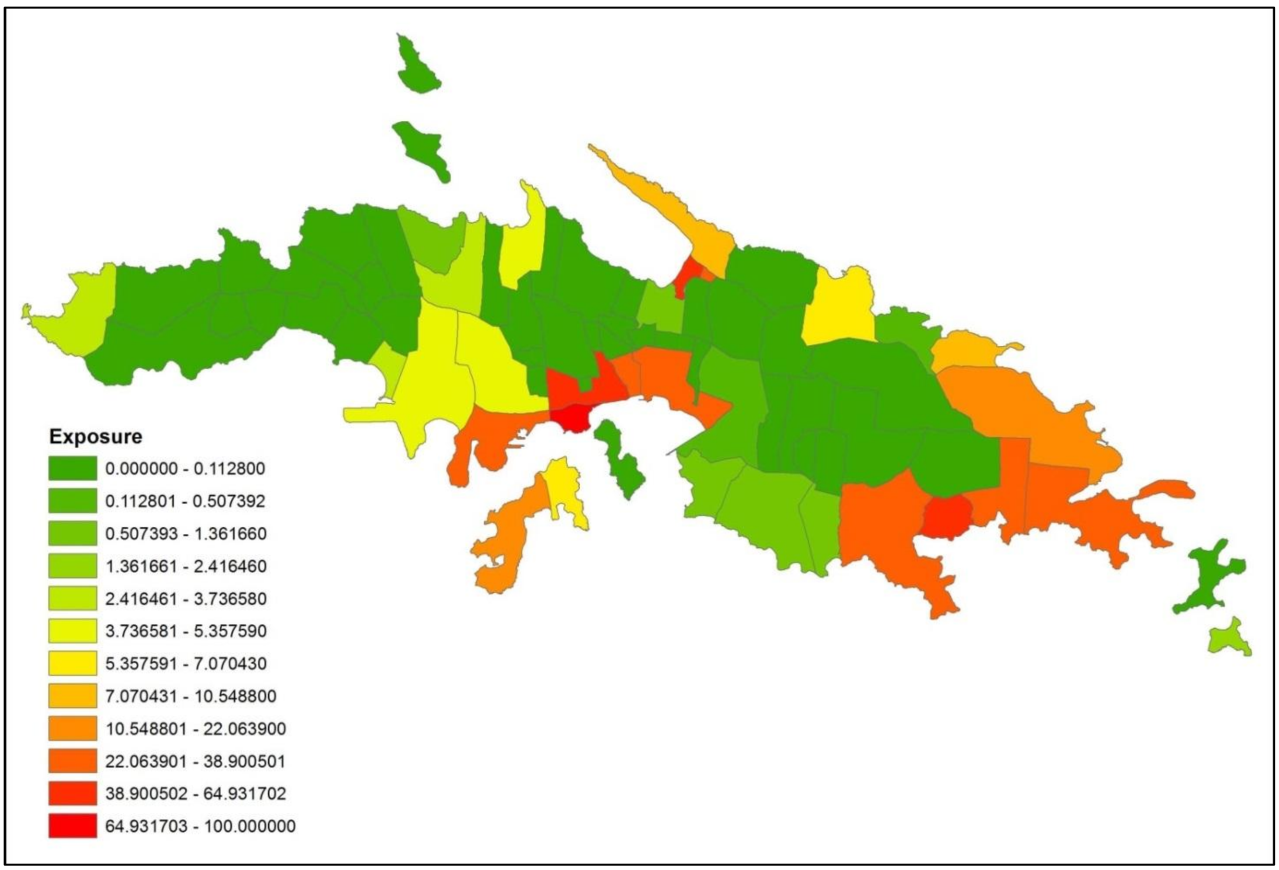


Figure 3. St Thomas: Total exposure model based on total number and length of roads inundated in the SLR model.

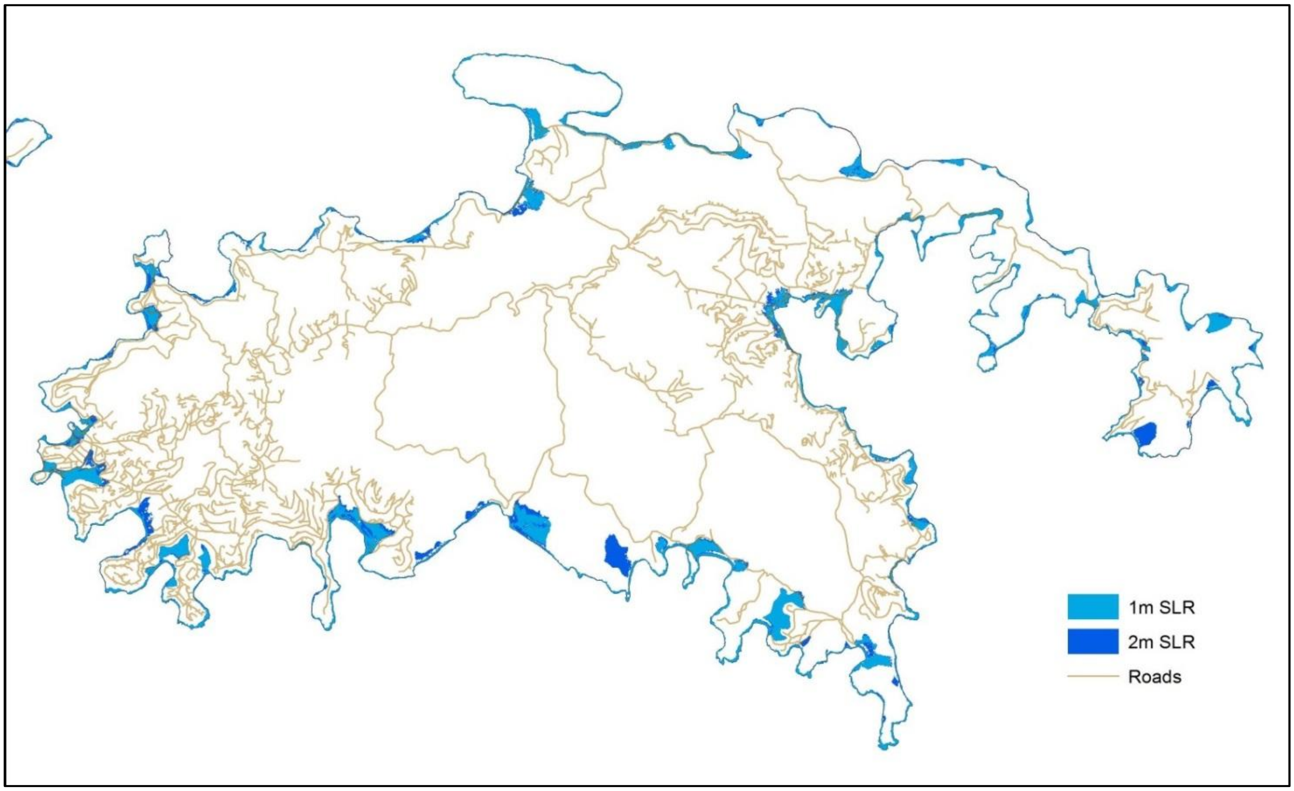


Figure 4. St John: 1 and 2-meter sea level rise (SLR) model based on NOAA's 3m LIDAR Digital Elevation Model with vertical datum correction.

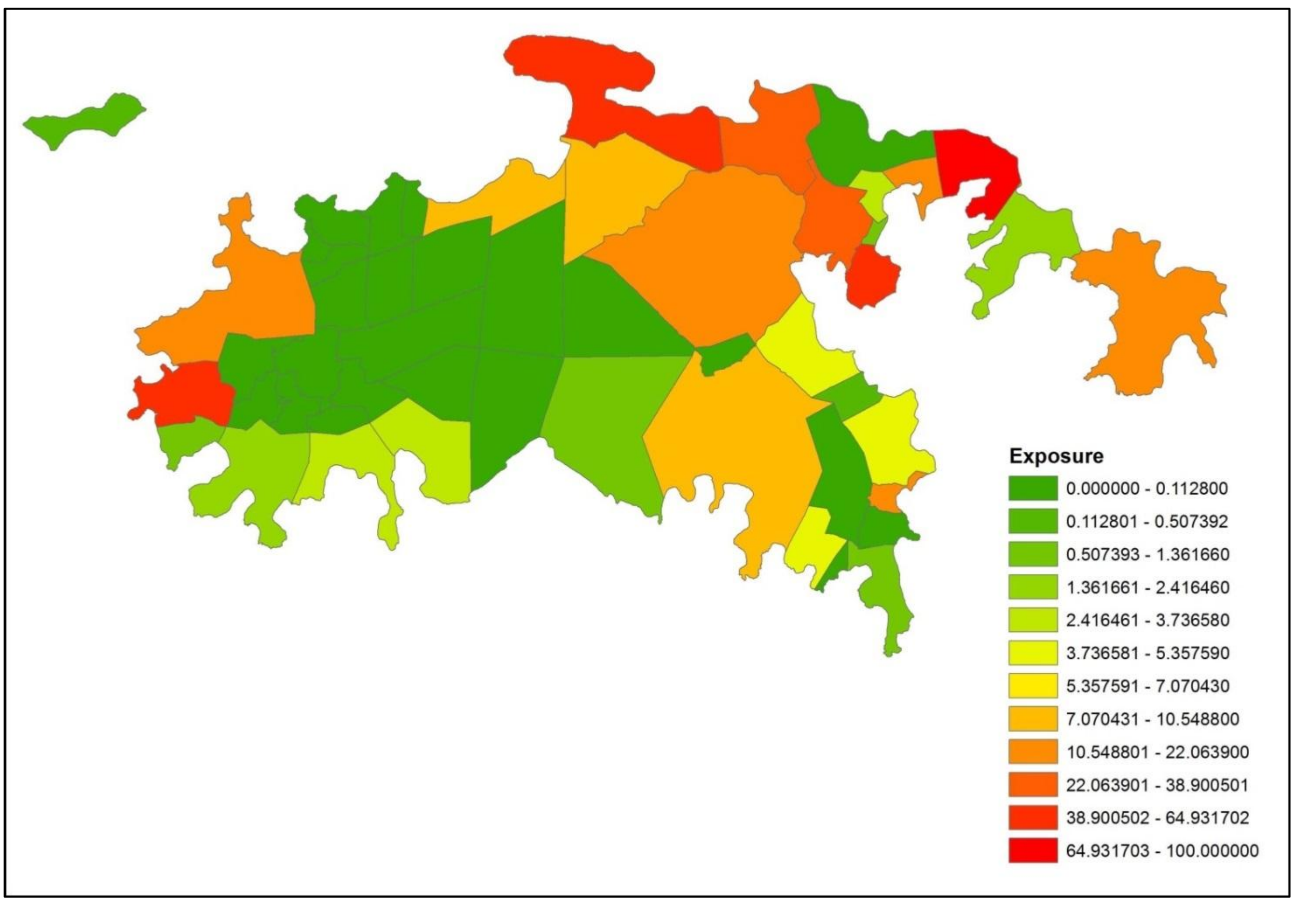


Figure 5. St John: Total exposure model based on total number and length of roads inundated in the SLR model.

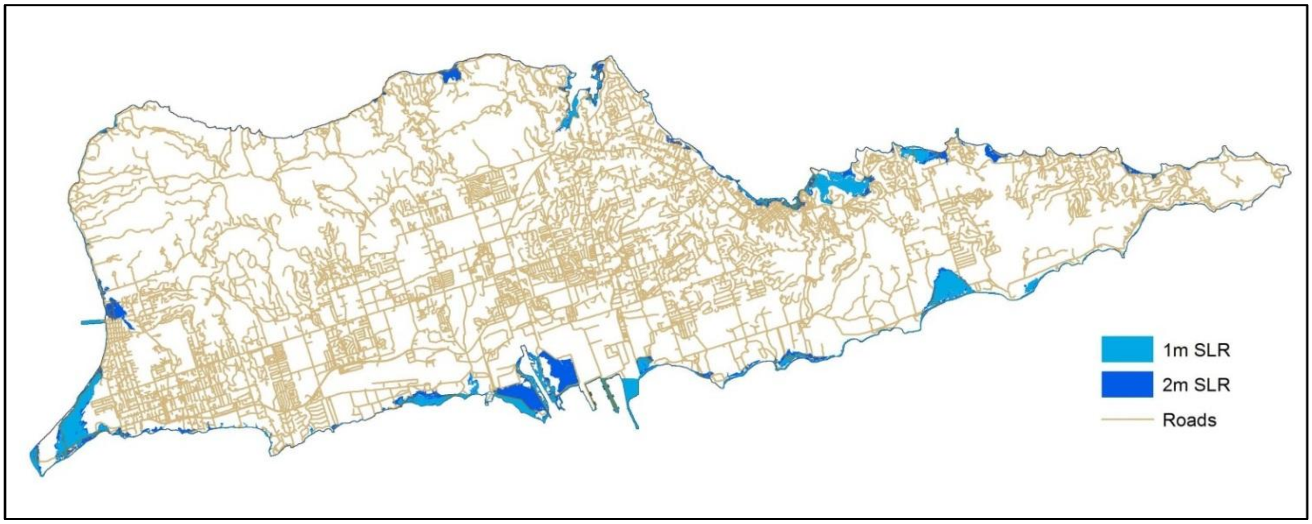


Figure 6. St Croix: 1 and 2-meter sea level rise (SLR) model based on NOAA's 3m LIDAR Digital Elevation Model with vertical datum correction.

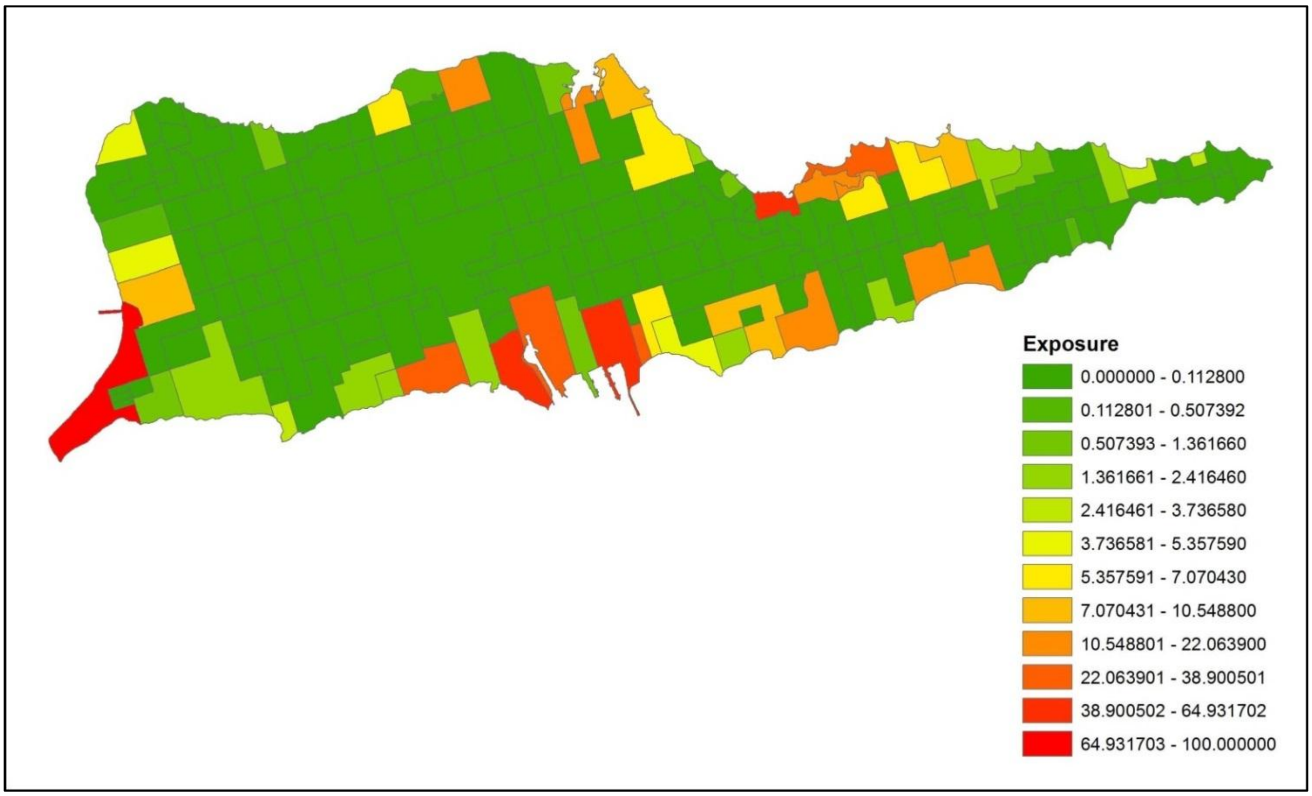


Figure 7. St Croix: Total exposure model based on total number and length of roads inundated in the SLR model.

Modeling the Storm Surge Scenarios

The elevated water level that accompanies hurricanes creates flooding and causes damage to coastal infrastructure is known as storm surge. Storm surge has both static and dynamic components. It is a complex function of each individual storm and the bathymetry and topography that it interacts with during its passage. For estimating storm surge in the USVI, TNC's Virgin Island and Caribbean Program staff worked with agency partners and climate change experts including but not limited to the Division of Fish & Wildlife, DPNR, and NOAA to select an appropriate storm surge model. Based on expert consensus, a Sea, Lake, and Overland Surge from Hurricanes (SLOSH) analysis was conducted, modeling a 1989 Hurricane Hugo-type storm for the year

2100. The SLOSH methodology was chosen as being the most applicable model given local conditions and data available. To map storm surge projections that included anticipated sea level rise by the year 2100, we followed methodologies from the Coastal Inundation Mapping Guidebook and the Coastal Resilience Long Island Project. We first mapped the projected inundation from the storm using SLOSH then modeled the storm layers on top of the SLR projections. The model used a NAD83 projection with a vertical reference output in local tidal datum at Mean Sea Level (MSL). The Hurricane Hugo type storm used represented a storm heading towards the northwest that struck the shore as a category 4 with winds sustained at 140 mph.

1. Mapping vulnerability

As local and regional conditions change in response to climate change, decision makers and communities need to be able to identify vulnerable communities and ways to improve their adaptive and coping capacity. In tropical small islands, inundation from storms and sea level rise has significant implications for communities' safety and way of life. Vulnerability indices are a way to assess community vulnerability and help decision makers allocate resources and implement actions that can reduce overall community vulnerability.

If coastal vulnerability models have previously been defined, it is important to review how these data were collected and compiled, considering each input data layer and visiting each of the indices and the methods used to calculate vulnerability. Here we show how socioeconomic vulnerability was calculated for the USVI, using the same vulnerability function listed above. To assess the socioeconomic vulnerability of communities, we constructed indices for *exposure* (based on inundation from 2 meter sea level rise), *social sensitivity*, and *adaptive capacity*. We constructed our indices using 2010 census data and did not attempt to model future growth projections. These indices can be defined as follows:

Exposure Index – Exposure is a measure of how much of a community is impacted by each inundation scenario. Amount and percentage of roads and buildings inundated provides an indication of how exposed communities will be to different scenarios.

Social Sensitivity Index - A suite of variables contribute to a communities' overall sensitivity. An aggregate view of some of these variables can give a sense of a communities overall sensitivity.

Adaptive Capacity Index - Human and civic resources are a critical component of the coping and adaptive capacity of communities. This category includes literacy, level of education, access to retraining programs, and other factors that determine how flexible individuals may be in adapting to new employment opportunities or shifts in living patterns brought about by climate variability or change.

Each index is comprised of several representative variables based on the definition provided above and listed below. Potential variables were identified based on a review of local, regional, and global literature and reports. In order to spatially understand the distribution of vulnerable communities, these indices and their supporting variables were mapped to the US census estate level. Values for each variable were scaled from 0-100 and summed to the summary unit. These summed scaled values were then re-scaled from 0-100. This final scaled value represents the index score for each estate polygon. The results are shown in the maps below for each index with low values in green and high values in red.

Table 2. Socioeconomic vulnerability indices and their representative variables

INDEX	VARIABLE
Exposure	Total Road Length
	Road Density (Length/Divided by area)
	Total road length inundated at 2m SLR
	Percent of total roads inundated at 2m SLR
Social Sensitivity	Total population
	Population under 5
	Population over 65
	Population living in group quarters
	Population living in institutionalized facilities
	Total households
	Total families with 5 or more children
	Grandparents living with own grandchildren under 18 years
	Total with disabilities
	Total housing units
	No vehicle available
	Without telephone service available
	Without Internet service
Adaptive Capacity	School enrollment (>3yrs)
	Education attainment (any education)
	High school or above
	High school graduate or higher (percent)
	In labor force
	Unemployed
	Unemployed civilian labor force (percent)
	Standard deviation of work diversity
	No health insurance coverage
	Less than $25K salary
	Total below poverty level

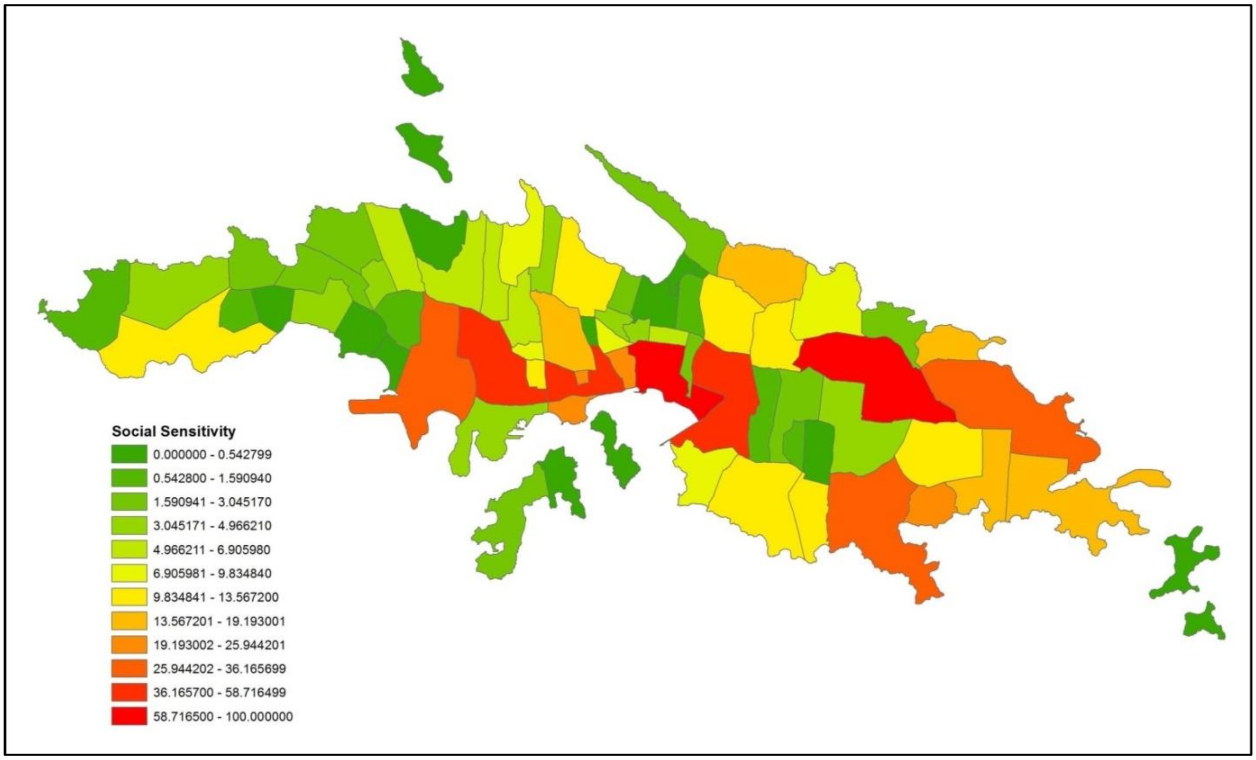


Figure 8. St Thomas: Modeled social sensitivity based on 13 parameters from census data. Green shades represent low social sensitivity and red shades indicate higher social sensitivity, or areas that would may be more susceptible to the impacts of climate exposure.

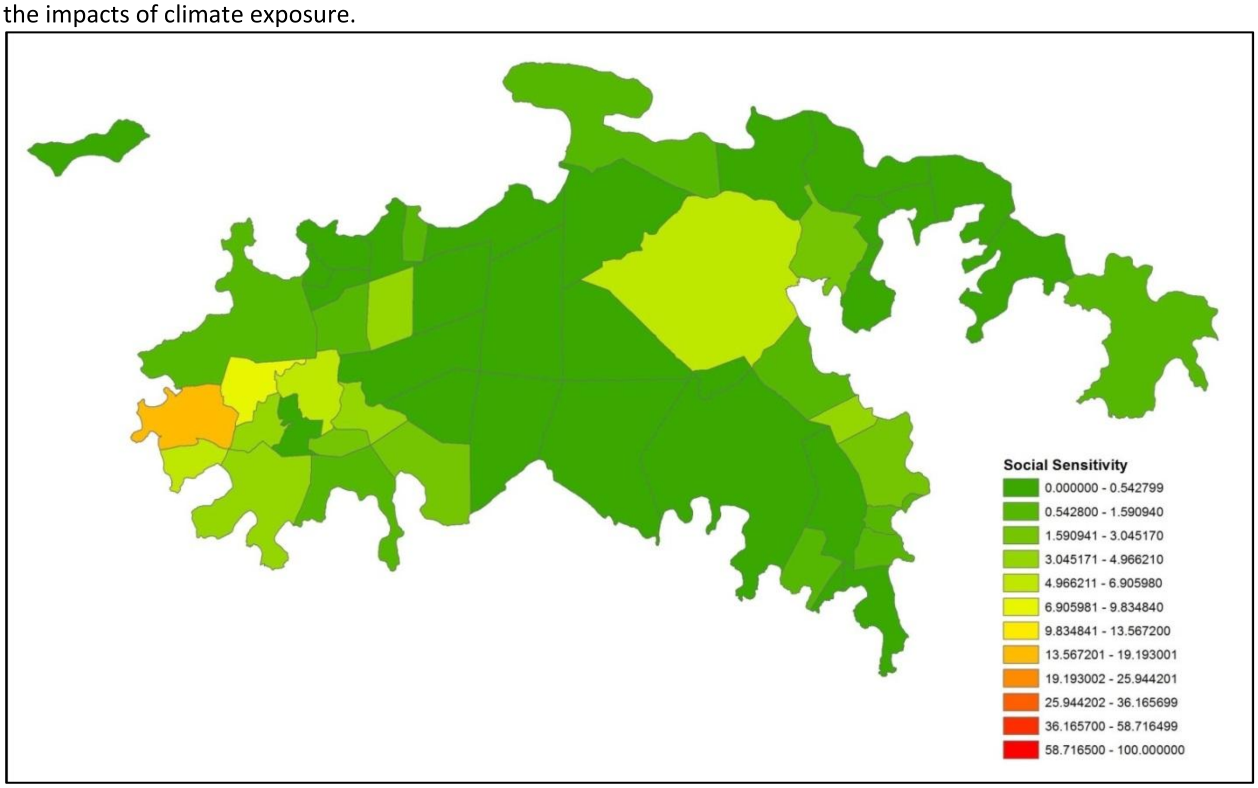


Figure 9. St John: Modeled social sensitivity based on 13 parameters from census data. Green shades represent low social sensitivity and red shades indicate higher social sensitivity, or areas that would may be more susceptible to the impacts of climate exposure.

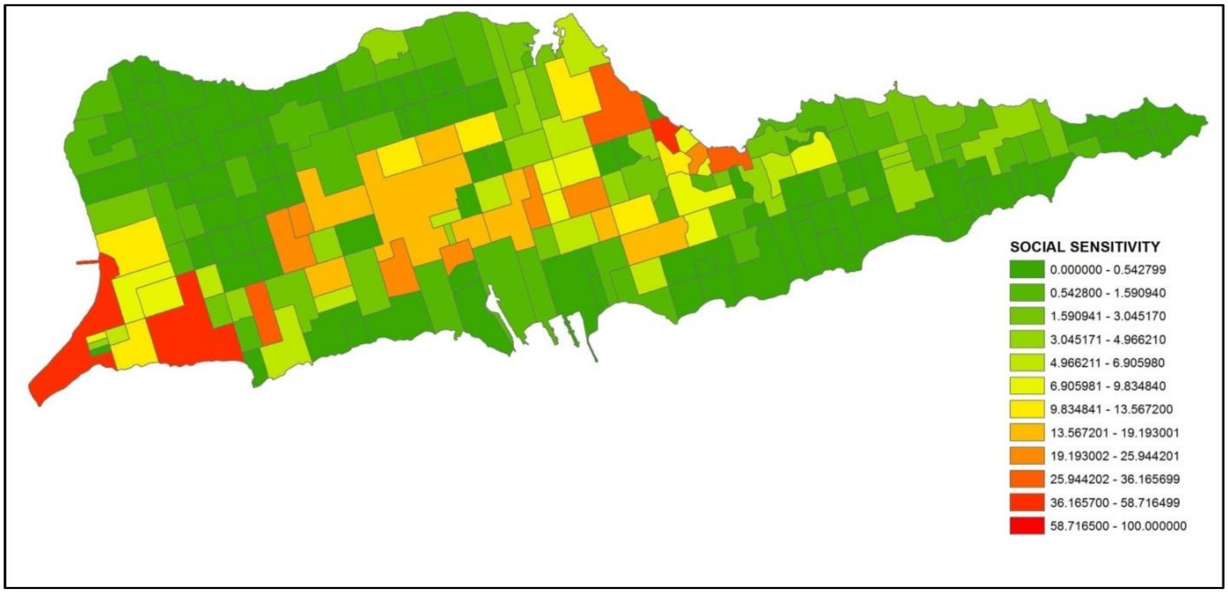


Figure 10. St Croix: Modeled social sensitivity based on 13 parameters from census data. Green shades represent low social sensitivity and red shades indicate higher social sensitivity, or areas that would may be more susceptible to the impacts of climate exposure.

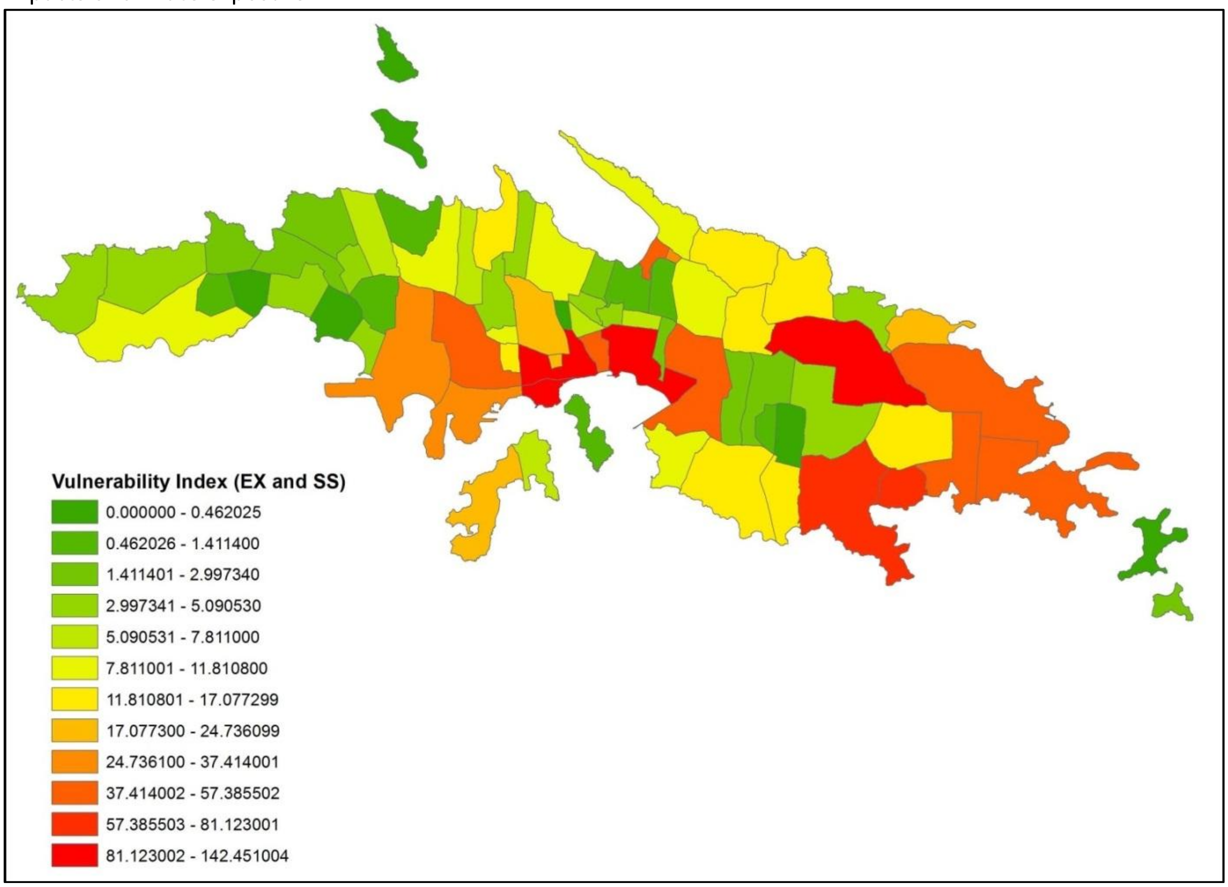


Figure 11. St Thomas: Combining the exposure and social sensitivity indices, we can estimate vulnerability. Green shades represent low social sensitivity and red shades indicate higher levels of vulnerability or areas that would may be more susceptible to the impacts of climate exposure.

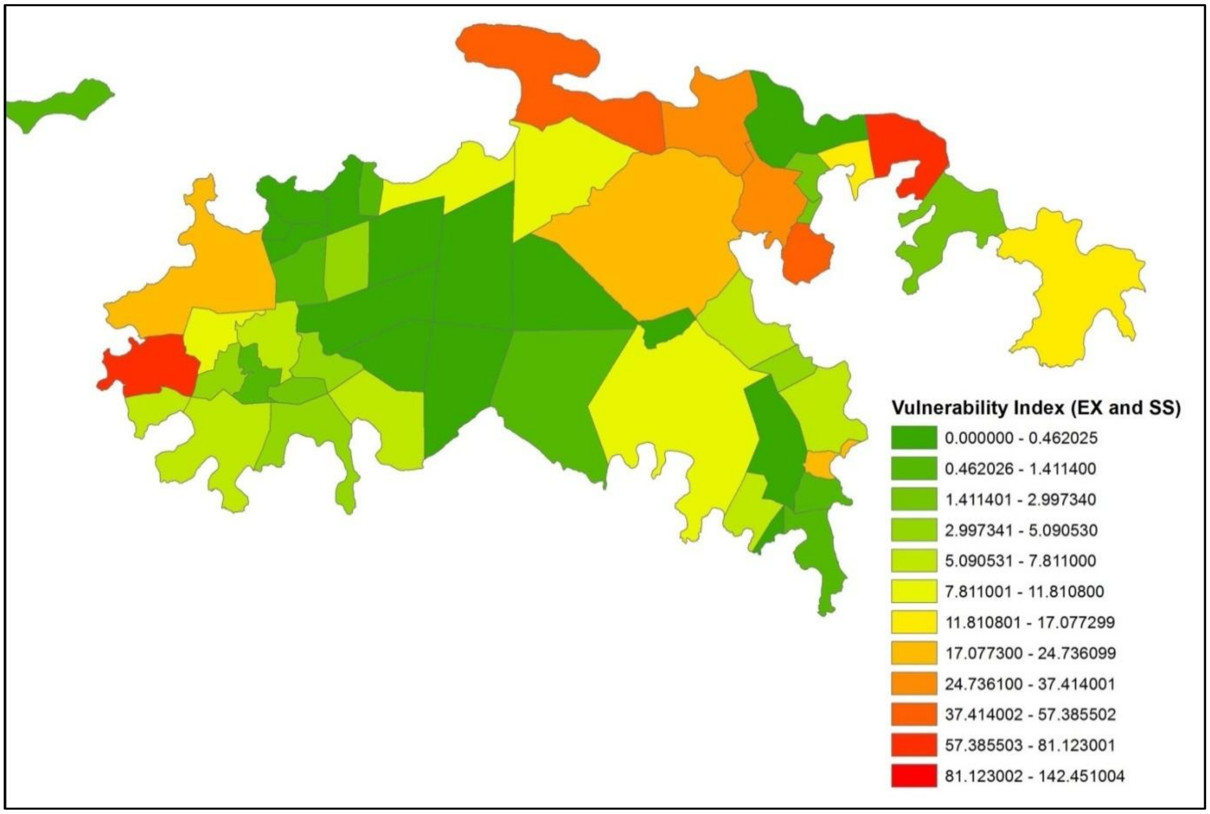


Figure 12. St John: Combining the exposure and social sensitivity indices, we can estimate vulnerability. Green shades represent low social sensitivity and red shades indicate higher levels of vulnerability or areas that would may be more susceptible to the impacts of climate exposure.

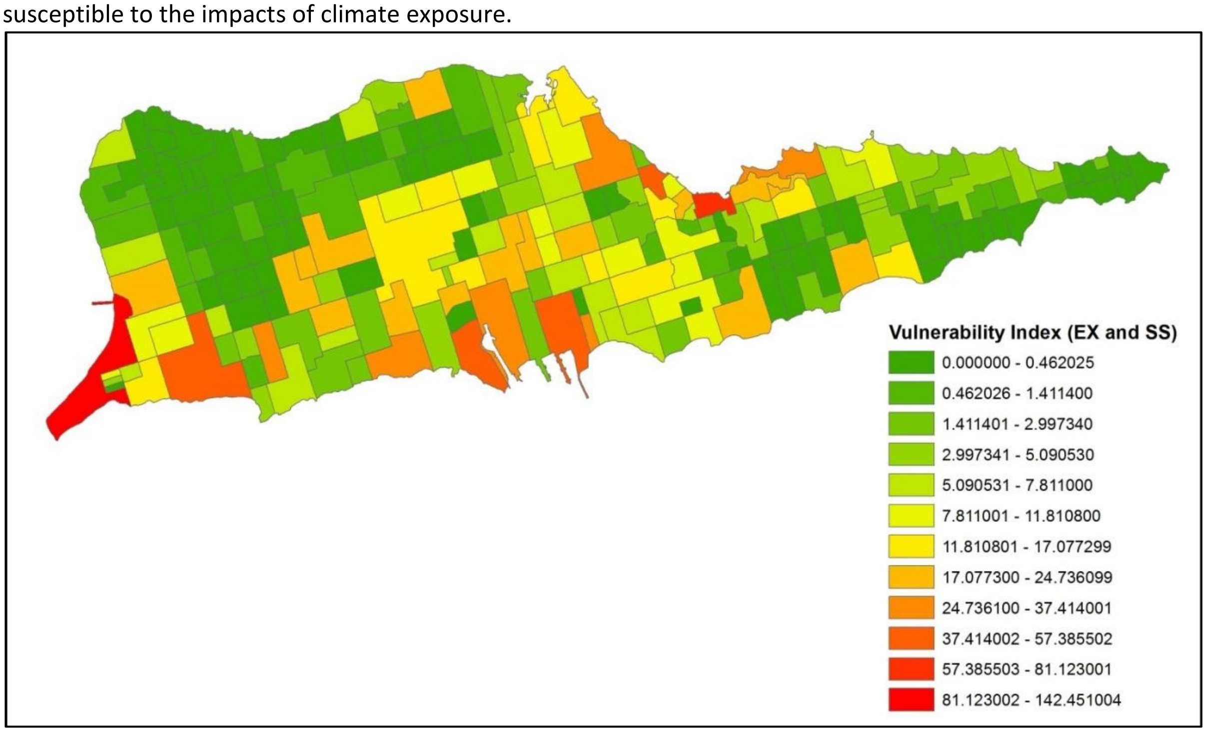


Figure 13. St Croix: Combining the exposure and social sensitivity indices, we can estimate vulnerability. Green shades represent low social sensitivity and red shades indicate higher levels of vulnerability or areas that would may be more susceptible to the impacts of climate exposure.

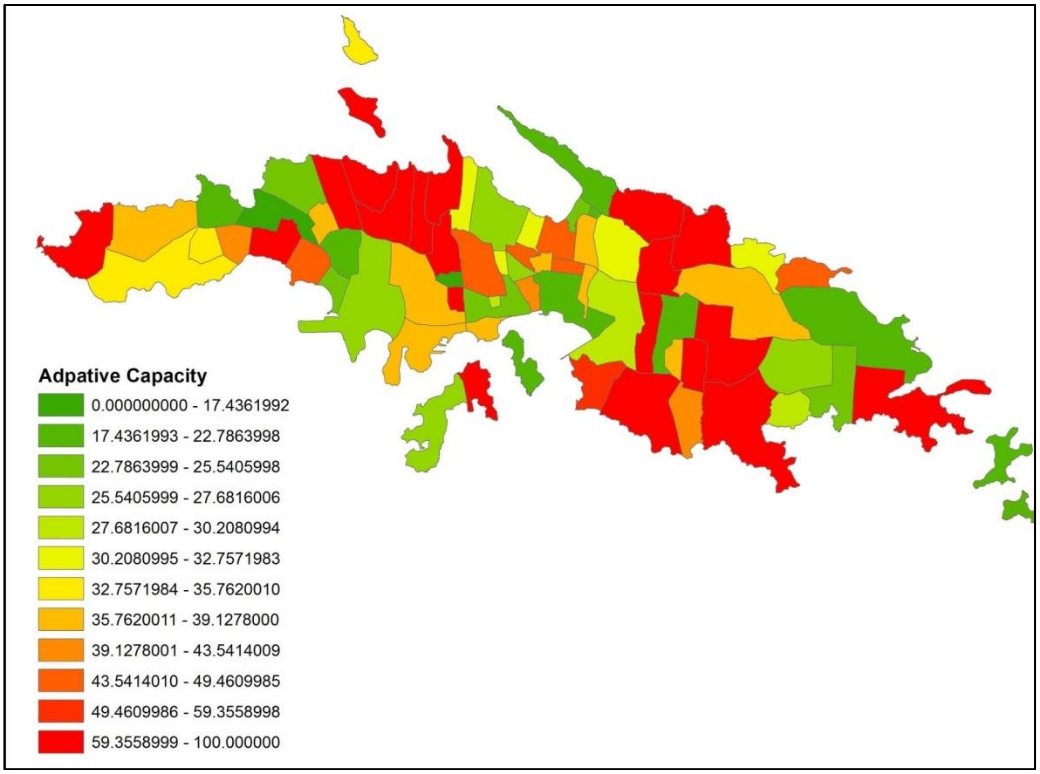


Figure 14. St Thomas: Modeled adaptive capacity based on 11 parameters from census data. Green shades represent higher levels of adaptive capacity and red shades indicate lower levels of adaptive capacity, or areas that may have more difficulty being able to anticipate, respond to, cope with, and recover from climate impacts (short and long-term).

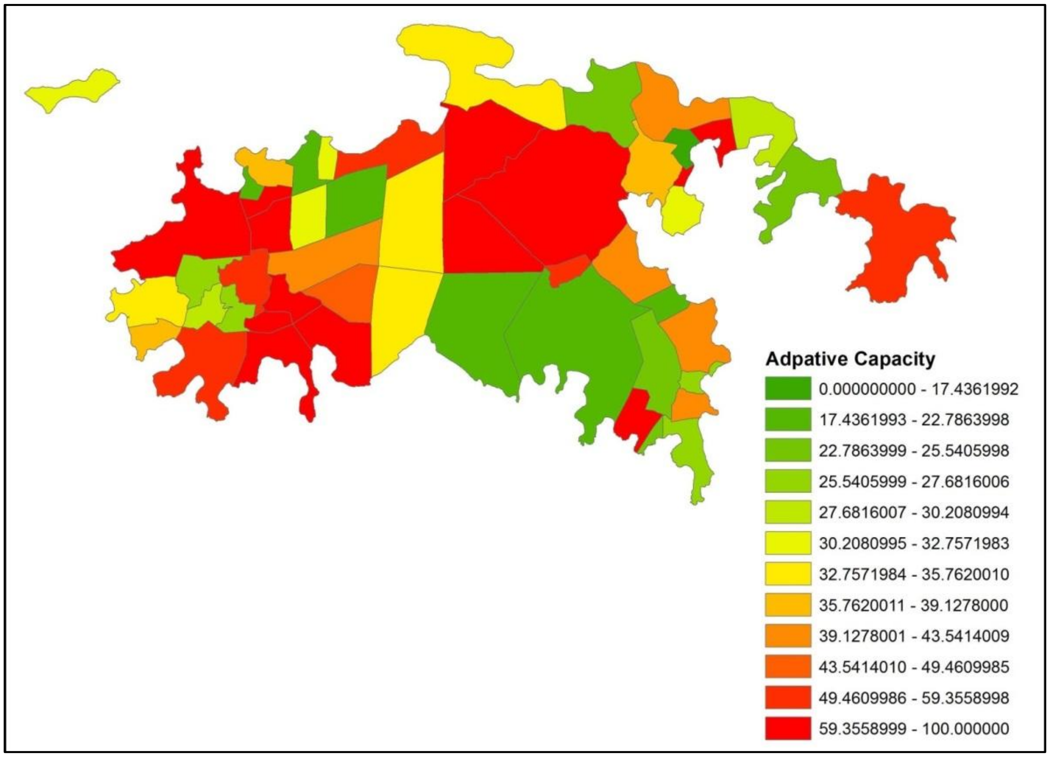


Figure 15. St John: Modeled adaptive capacity based on 11 parameters from census data. Green shades represent higher levels of adaptive capacity and red shades indicate lower levels of adaptive capacity, or areas that may have more difficulty being able to anticipate, respond to, cope with, and recover from climate impacts (short and long-term).

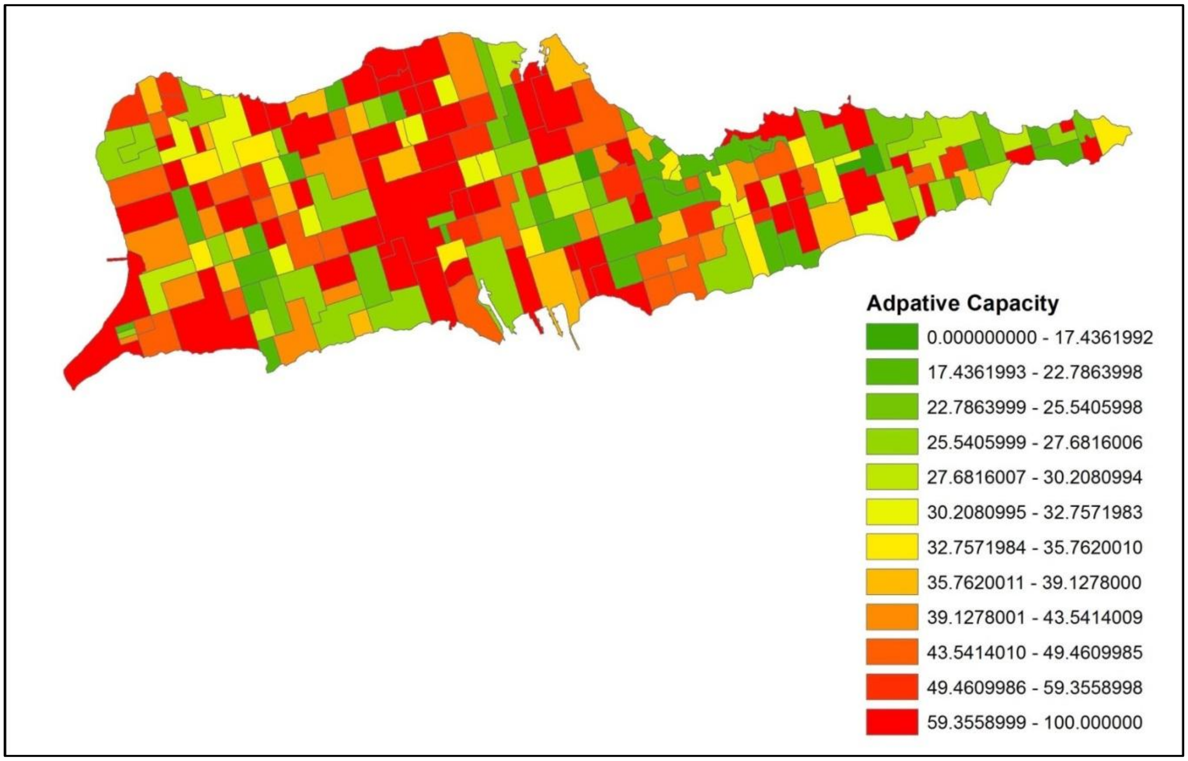


Figure 16. St Croix: Modeled adaptive capacity based on 11 parameters from census data. Green shades represent higher levels of adaptive capacity and red shades indicate lower levels of adaptive capacity, or areas that may have more difficulty being able to anticipate, respond to, cope with, and recover from climate impacts (short and long-term).

Mapping Mangrove Migration Zones

Rising sea levels will force coastal habitats to adapt – in many cases, this means migrating to higher areas with suitable areas to survive. In the case of mangroves, it is important for governments to protect adjacent space that is amenable to mangrove growing conditions. We attempted to identify mangrove migration areas for the USVI following work conducted for the AWE project (TNC, 2012) to identify where mangroves could potentially move in response to sea-level rise (SLR). In order to properly answer this question, two key datasets are needed to accurately model mangrove response to sea-level rise: accretion and erosion. Since neither of these datasets were available in our study area, we were therefore unable to model how mangroves might specifically be impacted by SLR (i.e. how mangroves would be structured in space in the future based on SLR impacts). Given this limitation, we were only able to identify where mangroves could potentially move based on topography/slope and existing land use and land cover. A simple rule-based model was used to identify areas where mangroves could potentially move based on impediments to landward migration, and contiguity to existing mangroves. Mangrove migration impediments used in this analysis were buildings, roads, slopes greater than or equal to 10%, and elevations greater than or equal to 5 feet. In application, the mangrove migration analysis selected all landward areas that were contiguous to existing mangroves until it reached an abovementioned impediment. The results of the mangrove migration analysis are presented below, showing current mangrove extent in green and highlighting the potential migration zones in red.

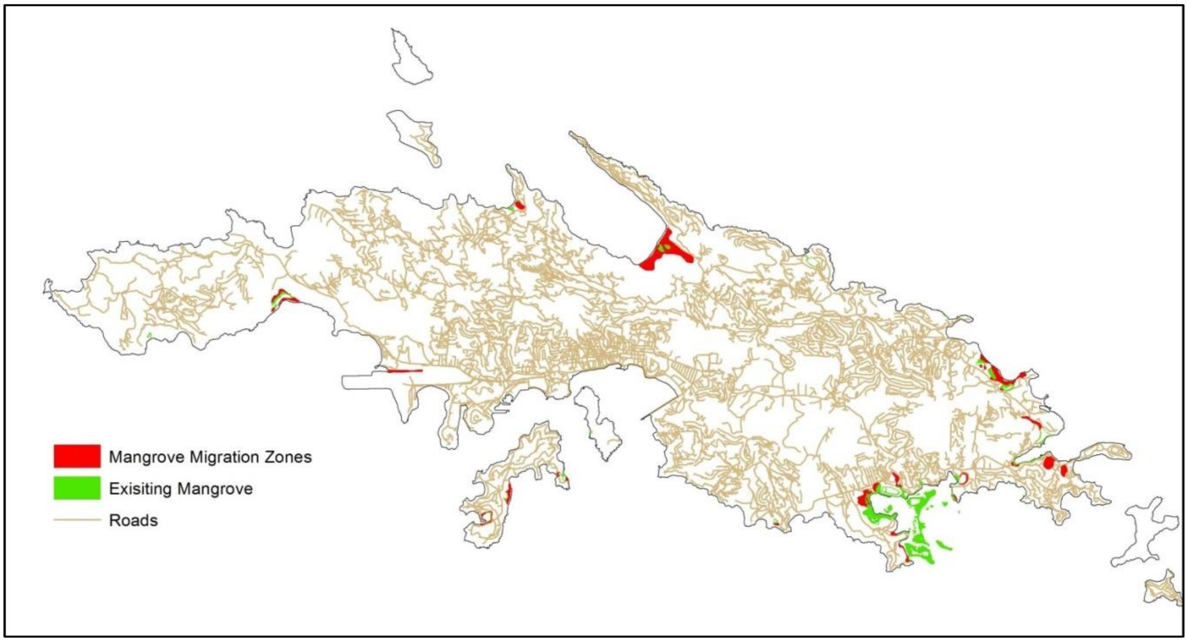


Figure 17. St Thomas: Areas in green show the distribution of existing mangrove forests. Areas in red indicate where mangroves may migrate in response to climate change based on mangrove habitat needs.

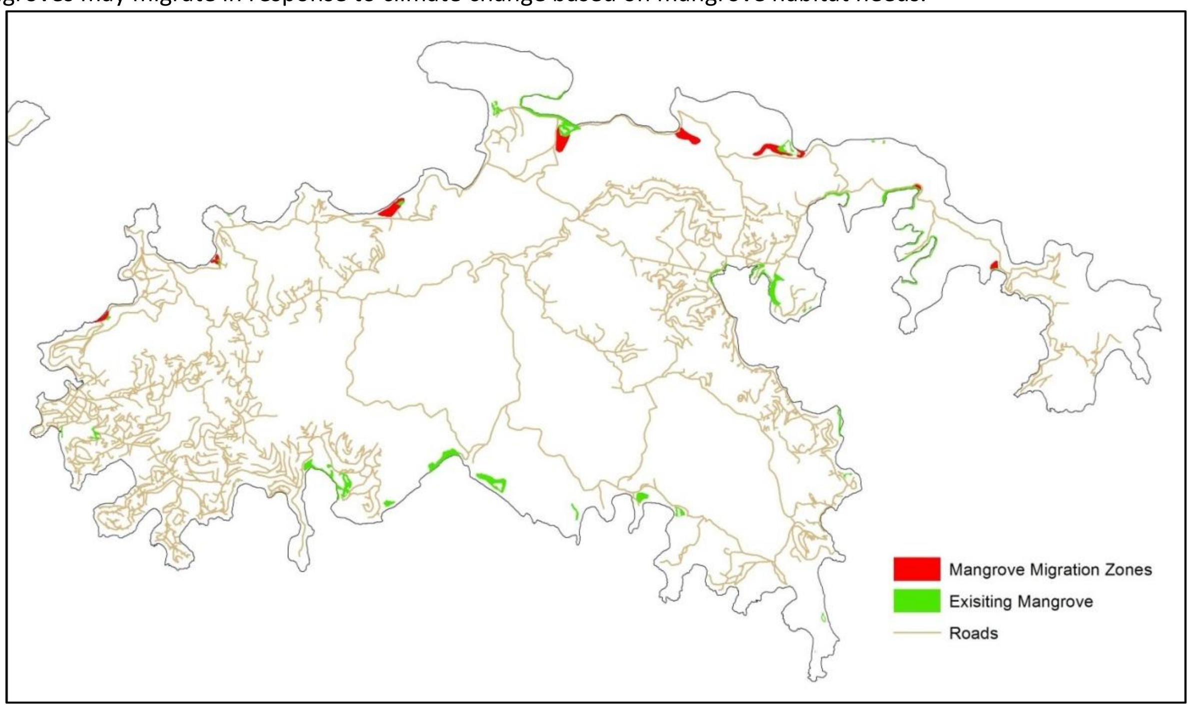


Figure 18. St John: Areas in green show the distribution of existing mangrove forests. Areas in red indicate where mangroves may migrate in response to climate change based on mangrove habitat needs.

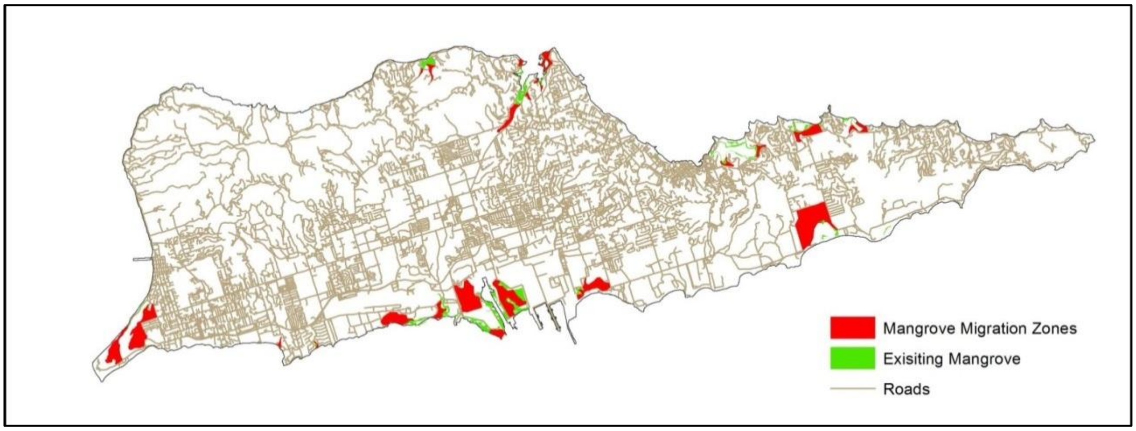


Figure 19. St Croix: Areas in green show the distribution of existing mangrove forests. Areas in red indicate where mangroves may migrate in response to climate change based on mangrove habitat needs.

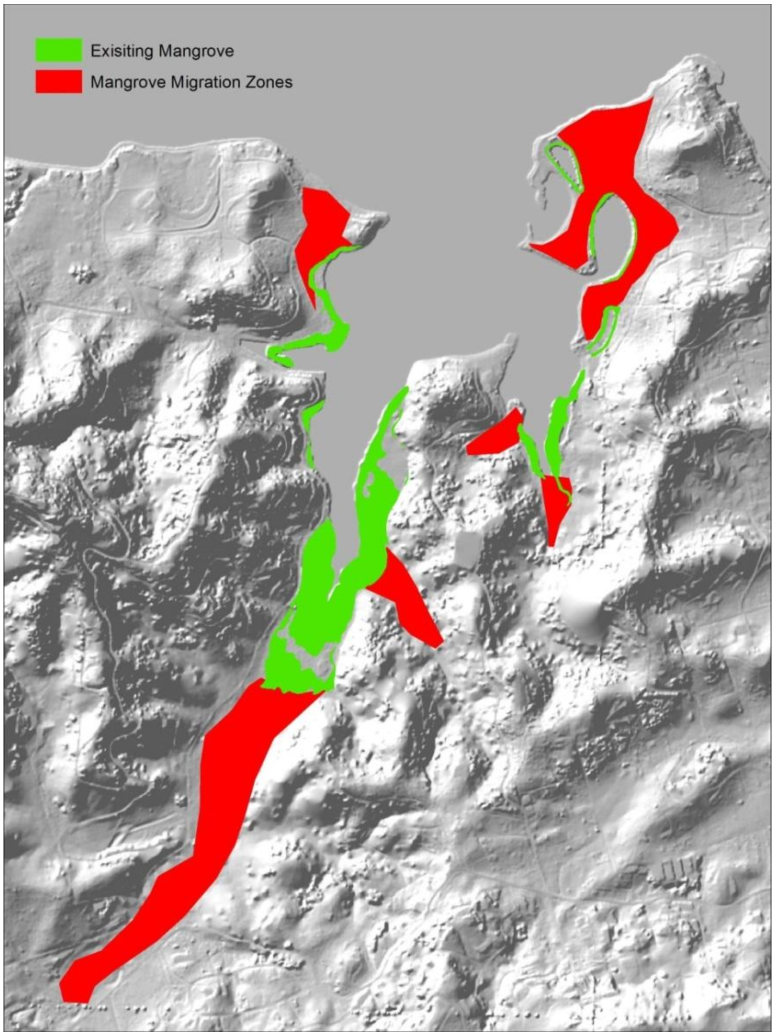


Figure 20. Mangrove migration model for the area around Salt River showing the extent of existing mangroves and where mangroves are likely to migrate to in response to sea-level rise.

Identifying EBA Sites

When choosing optimal areas to implement EBA, consider areas that have high impact (exposure and sensitivity) and low adaptive capacity. The figure below illustrates how impact and vulnerability can be used to locate these areas in a spatial context. The *x* axis shows the resulting score of *adaptive capacity* from low to high values. When exposure and sensitivity are combined into one *impact* indicator, the results are shown on the *y* axis with range of values low to high. By combining these two indicators (many ways to do this in a GIS if you have a range of values), we can spatially dissect the data into four classes based on an unacceptable/acceptable threshold (e.g. using the mean as the threshold):

1) Optimal areas to implement EBA, where high impact and low adaptive capacity (these are the areas of concern where adaptive capacity needs to be strengthened)
2) High impact and high adaptive capacity (there areas are able to bounce back – resilience has been achieved)
3) Low impact and low adaptive capacity (these areas are of less concern, but we still may want to work on building adaptive capacity)
4) Low impact and high adaptive capacity (these areas will be less fine since they have low impact, but are already high in adaptive capacity)

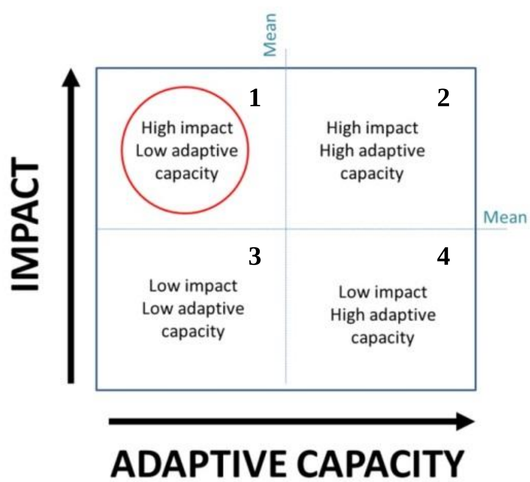


Figure 21. Areas that are good candidates for EBA work are those that are highly impacted and have a low adaptive capacity level. These are areas that may have a hard time recovering from storm events and may benefit from EBA projects to raise the level of adaptive capacity.

The map below shows estates that were selected based on the modeled high impact scores with low adaptive capacity within the USVI. As was previously described, several variables were carefully chosen and used to calculate the *exposure*, *sensitivity*, and *adaptive capacity* indices for all estates within the USVI. These were mapped, scaled, and assigned a category of high, medium, or low based on the statistical distribution of the range of values that were calculated. Estates that rank high in *exposure* represent a high percentage of potential inundation areas from sea-level rise or other flooding events. Estates that ranked high in *sensitivity* represent areas that are more likely to experience harm based on characteristics that exacerbate the effect of climate exposure. Estates that are both high in *exposure* and *sensitivity* constitute high impact areas and require high levels of adaptive capacity to anticipate, respond to, cope with, and recover from climate impacts. As illustrated in the figure above, good candidate sites for EBA are high *impact* areas with low *adaptive capacity*. These sites include for the following islands in order of modeled priority in parentheses: St Thomas: Nazareth (1), Bovoni (4), Mandahl (5), Frydendal (8), and Queens

Quarter (9); St John: Carolina (2); and St Croix: Two Brothers (3), Boetzberg (6), La Grande Princess (7), and La Grange (10). The next step would be to look at these areas in terms of their ecological restoration potential – being able to restore mangroves, coral reefs, and other habitats that provide coastal protection. Sometimes a combination of grey and green infrastructure should be considered as well as bioengineering techniques to lower the *exposure* potential while working with the coastal communities to decrease *sensitivity* and improve *adaptive capacity*.

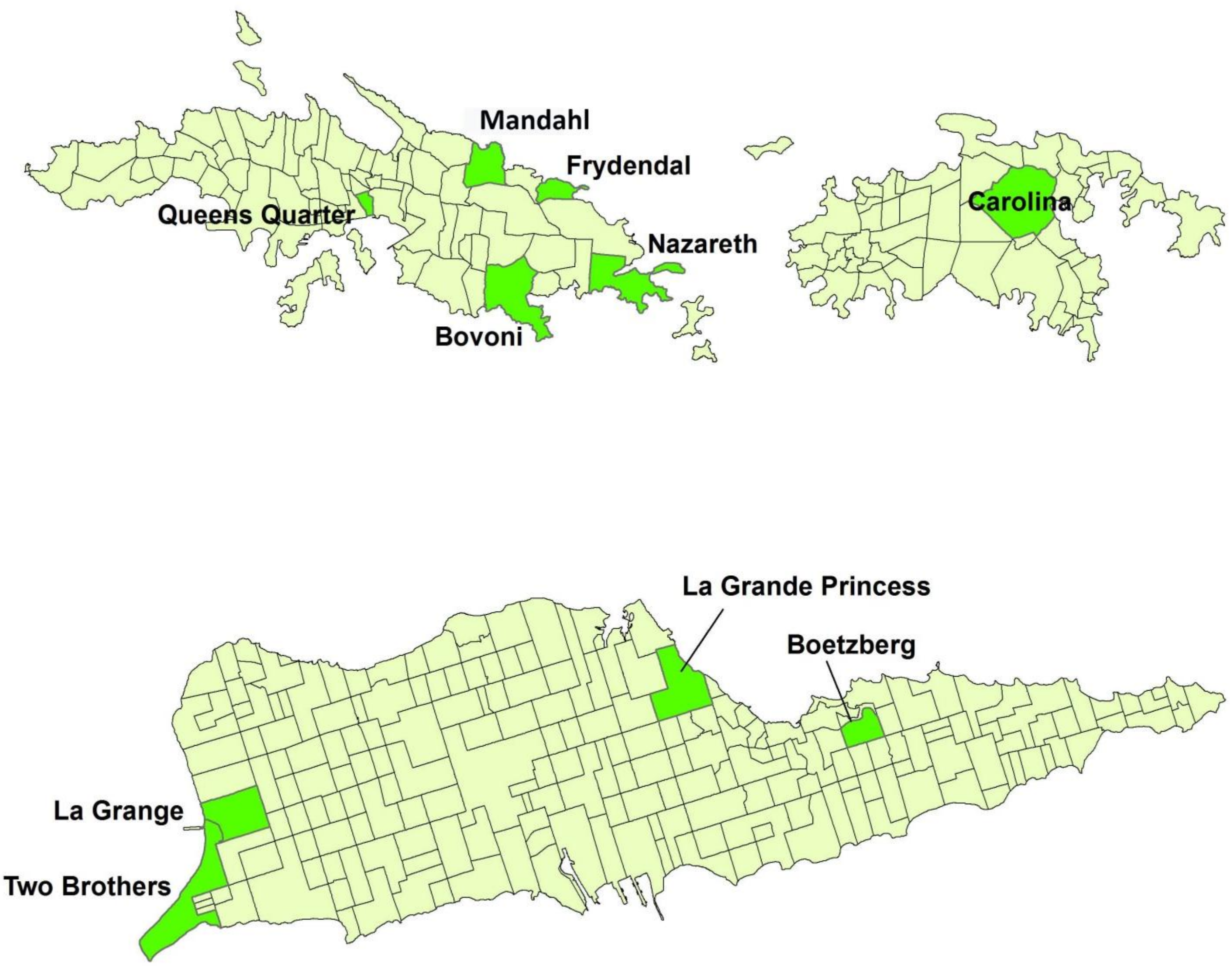


Figure 22. The top ten candidate estates for EBA action in the USVI based on modeled vulnerability and adaptive capacity. The green areas represent high impact and low adaptive capacity.

References for Coastal Resilience

Barbier, B.B., S.D Hacker, C. Kennedy, E.W. Koch, A.C. Stier, B.R Silliman. 2011. The value of estuarine and coastal ecosystem services. Ecological Monographs. 81(2):169-193.

Cutter, S. L., C. T. Emrich, J. J. Webb, and D. Morath. 2009. "Social Vulnerability to Climate Variability Hazards: A Review of the Literature", Final Report to Oxfam America.

Ferdaña, Z., S. Newkirk, A.W. Whelchel, B. Gilmer, M.W. Beck. Building Interactive Decision Support to Meet Management Objectives for Coastal Conservation and Hazard Mitigation on Long Island, New York, USA, in Andrade Pérez, A., Herrera Fernandez, B. and Cazzolla Gatti, R. (eds.). 2010. Building Resilience to Climate Change: Ecosystem-based adaptation and lessons from the field. Gland, Switzerland: IUCN. 72-87. http://data.iucn.org/dbtw-wpd/edocs/2010-050.pdf.

Granger, K. 2003. Quantifying Storm Tide Risk in Cairns. Natural Hazards 30 (2):165-185.

IPCC. 2007. "Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change", M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 976pp.

IUCN. 2011. Using Ecosystem Based Approaches for Biodiversity Conservation and Climate Adaptation in the Insular Caribbean, Working Paper on EBA.

Millenium Ecosystem Assessment. 2005. Ecosystems and human well-being: current state and trends. Coastal systems. Island Press, Washington, D.C. USA.

Moss, R. H., E. L. Malone, and A.L. Brenkert. 2002. "Vulnerability to climate change: A quantitative approach." Joint Global Change Research Institute, http://www.globalchange.umd.edu/data/publications/Vulnerability_to_Climate_Change.PDF

O'Brien K., R Leichenko, U. Kelkar, H. Venema, G Aandahl, K. Tompkins, A. Javed; S. Bhadwal, S Barg, L. Nygaard, J. West, 2004. Mapping vulnerability to multiple stressors: climate change and globalization in India, Global Environmental Change 1: 303–313.

Shepard, C., V. N. Agostini, B. Gilmer, T. Allen, J. Stone, W. Brooks, M. W. Beck. 2011. Assessing future risk: quantifying the effects of sea level rise on storm surge risk for the southern shores of Long Island, New York. Natural Hazards. DOI: 10.1007/s11069-011-0046-8.

Wongbusarakum, S. and C. Loper. 2011. "Indicators to assess community-level social vulnerability to climate change: An addendum to SocMon and SEM-Pasifika regional socioeconomic monitoring guideline".

OUTREACH AND EDUCATION

The outreach recommendations and strategies for communicating issues of climate change and adaptation options was developed based on the feedback received at the June 2013 EBA workshop (Appendix A) and the more recent presentation to the territorial partners in August 2013 (https://nethope.webex.com/nethope/lsr.php?AT=pb&SP=MC&rID=67161107&rKey=8c38dc1f62bfab69). The following contains strategies for outreach, examples of visualization products and various discussion points, materials and media useful for conveying the issue and EBA options to various audiences.

Goal of a Climate Change and EBA Communications Strategy

The primary goal of an EBA communications strategy is to convey the threat of climate change as it relates to coastal processes and communities and to empower people to make decisions that will allow for ecosystem-based adaptation to those threats. Recommendations for communicating issues of climate change and adaptation include using the web-based scenario maps from coastalresilience.org as a visualization and planning aid, along with CanVis, a photo modification program used to "see" potential impacts from coastal development or sea level rise (see examples in Appendix E). Using these tools and the information contained in this guidance document, planners, policy-makers and stakeholders are better equipped to have the discussion about community choices, building resilience and taking action to increase adaptive capacity.

Table 3. EBA Communication Strategy; Target Audience, Objectives and Key Message

Target Audience	Objective and Key Message	Suggested Means for Outreach
Legislators and Policy-makers	Make sure government officially recognizes the problem and pass legislation to ensure funds are being channeled properly.	Providing a copy of the EBA Guidance Document Summary (Appendix F) when meeting with government officials.
Planners	Users can explore different socioeconomic and ecological data layers and evaluate risks based on selected storm events or sea-level rise scenarios in coasalresilience.org.	Demonstration of coastal resilience, working together to update data layers, explore future use of coastalresilience.org, etc.
Resource Agencies	Understand the most likely scenarios that changing physical, biological, and chemical processes will have on wildlife and habitat management	Fact sheets, demonstration of coastalresilience.org, presentation of sections of site-level management plans that pertains to EBA
Coastal Communities and Public at Large	Understand the threat to coastal areas and impact to coastal activities related to commerce, development, recreation and resources management. Know what choices we have to adapt and the role coastal communities can play in implementation of EBA.	Increasing monitoring efforts and get the public involved, regular media spots to discuss the problem and solutions, talk shows, newspaper articles, etc. Listserve with news and notices of opportunities to stay involved. Host public activities and outreach (e.g. community walks, parades, videos) at community events like Ag Fair, Eco Fair, carnival, etc.
Educators	Knowing the impacts of climate change to island communities, what people can do to prepare and adapt, ways that children can be active in decisions about their future, etc.	Climate Stewards Education Project (CSEP)-Marcia Taylor of UVI (see presentation at http://virrp.reefconnect.org)

Needs

General information to impart to all target audiences, whether in a presentation, media talking points, or in creating materials for distribution should include:

- A review of storm surge, wave attenuation, role of coastal habitats in providing shoreline protection and ecosystem services.
- A review of the impacts of rising sea levels to coral reefs, beaches, mangroves and coastal infrastructure. Discuss issues relating to changing precipitation patterns affecting stormwater runoff, increases in hazardous conditions and events, and water quality.
- Some possible ways to adapt, emphasizing natural solutions.

Implementation

A concerted implementation of a communications and outreach campaign will require separate, dedicated funding and resources from local management agencies. The involvement of partners will continue to benefit the USVI's overall outreach campaign with the integration of workshop recommendations into existing and nascent geospatial programs with UVI, CLCC, CROP and others. Incorporation into already enacted management plans for marine protected areas, namely STEER and STXEEMP, is a matter of making sure the message of climate change and topics relating to EBA is considered in all forthcoming activities. Both the St. Thomas East End Reserves (STEER) and the St. Croix East End Marine Park (STXEEMP) have existing management plans and watershed management plans. The management plans will be updated on a 5 year basis. Incorporation of EBA implementation activities into revisions of the management plans will be critical. Additionally as actions from the management plans and watershed management plans are implemented, impacts of climate change and EBA strategies should be considered by DPNR, UVI, SEA, TNC and partners. Wide distribution of this EBA report as well as the outreach document (Appendix E) will help ensure that EBA is considered during site level implementation in both STEER and STXEEMP.

RECOMMENDATIONS & NEXT STEPS

Recommendations have emerged from this work that include both ways to promote ecosystem services in the bigger picture of climate change adaptation for the territory and specific steps for site-level implementation to protect, enhance and restore ecosystem services of coastal areas in the USVI. As partners continue to incorporate EBA into their policies and activities, the following broad recommended next steps should be considered with a focus on the coastal areas most vulnerable to climate change and least likely to respond.

1. **Secure funding** (see Appendix D for a list of potential sources of funding).
2. Bring into consideration the coastal impacts and expected weather variation into **best management practices** for stormwater control, development planning and watershed protection.
3. Incorporate these spatial planning tools into **comprehensive planning and emergency response**.
4. Getting **communities more involved**: heightening awareness and fostering the dialogue on solutions (see Outreach and Education, starting page 28, above).
5. Incorporate **climate change and EBA outreach** into site-level management projects such as in the STEER, STXEEMP and National Park Service's MPAs on St. Croix and St. John through the Virgins Islands Marine Protected Area Network (VIMPAN).
6. Incorporate **coral reef** data into the coastal resilience mapping tools, including information on threats, resilience of reefs, mapping management actions, and visualization of future scenarios affecting reefs, in terms of sea level, sea surface temperature, acidification, changing patterns of currents, fish migration and other biological processes.
7. Develop risk maps for **beaches**, similar to the mangrove maps showing potential migration, to prioritize restoration activities for ecosystem-based shoreline protection. Sea turtle nesting habitat data, socio-economic considerations, and historic and cultural criteria should be incorporated into the risk factors when working with communities to develop adaptation strategies for beaches.
8. Have a suite of options for **restoration and protection of coastal ecosystems**, starting with demonstration sites. This entails developing projects (with proposals securing funding) to implement specific shoreline restoration and adaptation projects at select sites. Criteria set forth for the EBA projects being discussed include how vulnerable the areas are to storm surge and rising ocean levels and the impact that would have on populations. Using CoastalResilience.org, particularly the mangrove migration maps, will better inform restoration activities in specific coastal areas. EBA strategies might include restoring the mangrove forests or reefs adjacent to more vulnerable coastal areas.

Site Level EBA

Priority areas where possible EBA adaption strategies could be implemented are:

Coral Bay on St John

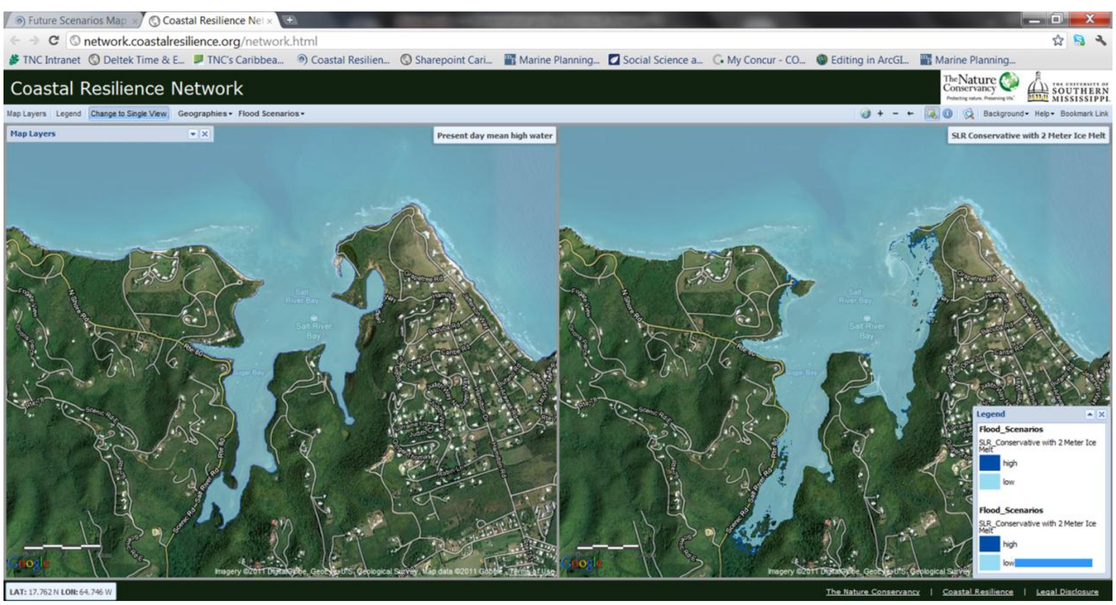
Coastal flooding due to gradual sea level rise as well as significant storm events in this area could severely impact coastal drainage, roadways and businesses. In long-range planning, residents should consider how infrastructure projects (both land and sea), stormwater management, and shoreline protection can incorporate EBA solutions. Using the coastal resilience web tools, viewing some of the extreme flooding scenarios that have incorporated storm surge from a seaward direction, coupled with some CanVis outputs that illustrate what the rise in sea level would look like, community leaders can have the discussion with residents, planners and regulators on ways to be better prepared for climate change in this bay. Some EBA strategies to consider include:

1. In the context of current watershed planning and implementation projects, take into account the additional problems that rising sea levels will have on drainage, recharge areas, and stormwater filtration. Consider additional culvert or other design factors for areas most prone to sea level flooding.
2. Plant mangroves at key areas with the greatest erosion potential to reduce the impact that gradual sea level rise and increasing wave energy will have on the shoreline.
3. Consider a suite of green and grey shoreline protection to protect priority businesses and infrastructure on the shore.
4. Restore reefs at the mouth of the bay to reduce overall attenuation of waves entering Coral Bay.

Salt River Bay on St. Croix

Salt River Bay has great potential to naturally adapt to a gradual sea level rise, however, specific coastal protection strategies could enhance the adaptive capacity of the shoreline, marine structures, and stakeholders in this bay. Some EBA strategies to consider include:

1. Examine the potential landward migration of mangroves. Protect parcels with the greatest adaptation potential (either through existing conservation activities by resource agencies or in the new purchase of land) and ensure that hard structures do not impede migration.
2. Remove derelict vessels in the bay so natural adaptation processes, including potential seaward migration of mangroves can occur.
3. Consider engineered coastal restoration projects using green infrastructure to design and build mangrove buffers for the marina.
4. Plan for flooding contingencies on the critical archaeological areas (removal of artifacts, engineering hard structure coastal protection for particular areas, etc.).
5. Restore the Acropora reefs that have historically been at the mouth of the bay to help reduce wave energy entering the bay.



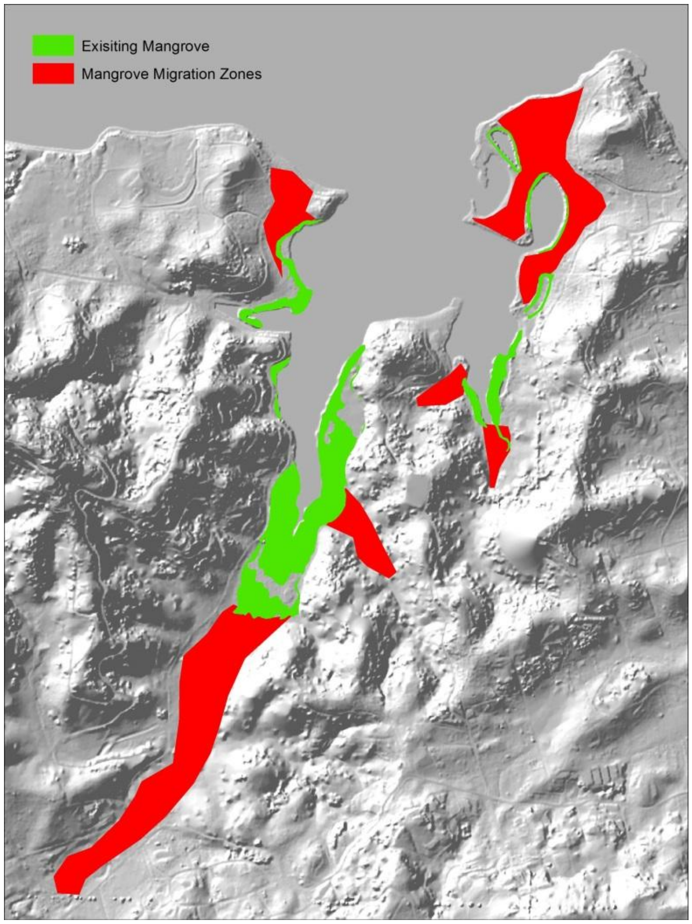


Figure 23. Mangrove migration model for the area around Salt River showing the extent of existing mangroves and where mangroves are likely to migrate to in response to sea-level rise.

The Primary Island Harbors

Due to the critical importance of maintaining the navigable waters of the USVI's harbors for commerce, emergency response, and recreation, and the high density of businesses and historical structures that are at risk due coastal flooding and erosion, planners and communities will need to consider a suite of options for funding, planning and implementing EBA strategies in the priority areas of Charlotte Amalie, Christiansted Harbor, Cruz Bay, the Frederiksted Pier, the former HOVENSA port, and Red Hook. Coastal restoration and shoreline protection in these areas will require a better understanding of the potential impacts of sea level rise to infrastructure and the secondary effects of increased coastal pollution from inundation of contaminated harbor facilities.

Smaller bays that serve as boat and fishing harbors, recreational areas, and extreme weather shelters (such as Coral Bay, Benner Bay, etc.) will likely respond better to EBA, whereas the primary harbors will require much more extensive engineering solutions and landward infrastructure projects to be able to adapt to the coastal hazards brought on by sea level rise. However, planning with EBA in mind can be useful for such things as restoration of historical mangrove areas in Charlotte Amalie, engineering reefs to buffer waves, and enhancing the natural stormwater control mechanisms provided by ghuts and recharge basins adjacent to these harbors. A comprehensive approach is likely to be expensive. This is where the use of INVEST and other advanced economic modeling will be helpful to understanding the economic losses and tradeoffs.

Mangrove Lagoon and Benner Bay in STEER

The St. Thomas East End Reserves is already a focus for conservation by TNC, DPNR, schools, businesses, federal agencies and citizen action groups active in the area. Managers and partners in STEER can easily add a layer of consideration for climate change and EBA to activities already being implemented for watershed protection, recreational use, education and outreach and other strategies outlined in STEER's Management Plan. Using the coastal resilience planning tools, a preliminary list of EBA strategies for STEER include:

1. Examining the potential landward migration of mangroves. Protect parcels with the greatest adaptation potential (either through existing conservation activities by resource agencies or in new purchase of land) and ensure hard structure does not impede migration.
2. Planting mangroves on the fringes of cays and islands to encourage seaward expansion of mangroves, and in areas that will protect the Compass Point Salt Pond, the mouths of Nadir and Turpentine Run ghuts and the shoreline at the racetrack.
3. Restoring coral reefs in STEER to improve overall reef function and wave attenuation.
4. Ensure SLR scenarios are taken into consideration during the closing of Bovoni dump, so that slope, potential flooding, increased precipitation and stormwater erosion and buffer zones of mangroves are maximized.
5. Remove derelict vessels so that natural adaptation processes, including potential seaward expansion of mangroves and shallow seagrass beds, can occur.

Outplanting of *A. cervicornis* in STEER. (K. Lewis)

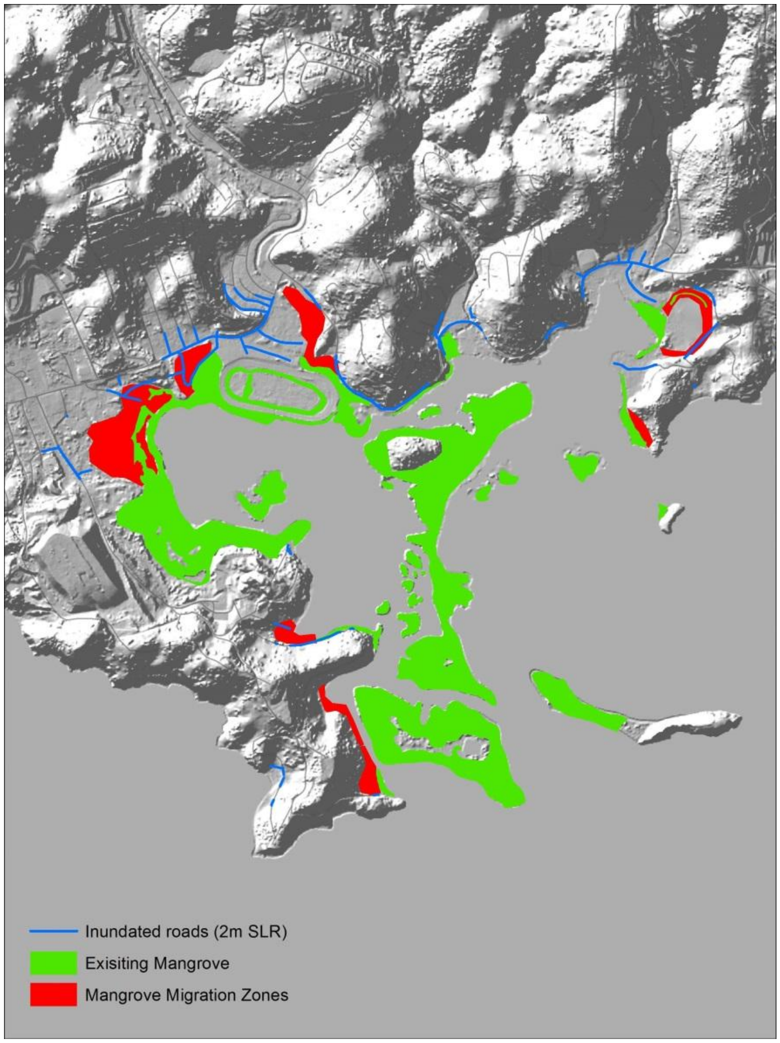


Figure 23. Mangrove migration model showing the extent of existing mangroves and where mangroves are likely to migrate to in response to sea-level rise in STEER.

Appendix A: Climate Change EBA June 2013 Workshop Summary

USVI Climate Change Ecosystem-based Adaptation Workshop: *Allowing for Resilient Communities*

June 4-5 2013, 9.00am- 5.00pm

Emerald Beach Resort

Lindbergh Bay, St. Thomas, USVI

Collaborators: VIDPNR, TNC, SEA, EAST and VI-Conservation Alliance, CLCC, Foundations for Development, UVI, NOAA's Coral Reef Conservation Program, USGS, CaRA/CariCOOS, Puerto Rico Climate Change Council, VITEMA, Coral Bay Community Council, Virgin Island's Energy Office, BVI Ministry of Natural Resources and Labor

Participants are listed in tables at the end.

Purpose:

1) To document the broad array of adaptation to climate change initiatives in the Territory which are completed or underway and to identify projects necessary for near-term planning and preparation.
2) Demonstrate methods on the use of GIS to identify optimal areas for implementing ecosystem-based adaptation based on ecological and socioeconomic criteria.
3) To develop nature-based solutions to address changes to the coastal and marine environment in the US Virgin Islands.

Desired Outcomes:

- An informed community in the USVI about what EbA is, different types of strategies and case studies from around the region, as well as specific strategies that may be effective in the USVI
- A draft outline, timeline and assigned responsibilities to produce an adaptation guiding document
- To identify and capture case studies from the region to be included in the guiding document
- To jump-start specific sites to implement EbA using existing data sources to, in a hands-on manner, brainstorm what EbA could look like in the USVI
- To generate a list of known climate change impact and spatial data gaps and devise a plan for filling those gaps to bring the data to one place
- To share knowledge across key stakeholders at different stages in progress with a communications plan outlining strategic public outreach
- To further EbA work and collaborations in USVI

Appendix A: Climate Change EBA June 2013 Workshop Summary

DAY 1- Overview of Climate Change Information and Initiatives in the Territory: *Current initiatives and direction, discussion about territorial approach* **Day 1 Goals and Objectives:** • To share climate change work in the region, specifically for the USVI: studies, impact analysis, restoration, planning and funding and highlight data and project limitations • To provide an overview of ecosystem-based adaptation (EbA) concepts and on-going regional initiatives • To promote EbA from agency level to NGOs and help establish EbA as a priority for management • To share knowledge and ideas across key stakeholders	
9.00-9.30am	**Welcome, Workshop Objectives, Introductions, and Review of Agenda** *Jeanne Brown, The Nature Conservancy*
9.30-9.40am	**Overview of Territorial Initiatives: VI Department of Planning and Natural Resources** *Jean-Pierre Oriol, Director Coastal Zone Management*
9.40-9.45am	**Q/A**
	Modeling future impacts & how will people and nature be affected?
9.45-10.00am	**Climate change models in-progress or available for the Territory: precipitation, temperature, sea level rise and vegetative modeling** *Kasey Jacobs, Caribbean Landscape Conservation Cooperative*
10.00-10:15am	**Local effects in the marine environment: warming rates, acidification, oceanographic patterns** *Roy Watlington, CaRA/CariCOOS*
10.15-10:30am	**Caribbean coral change with increasing thermal stress events** *Tyler Smith, Center for Marine and Environmental Studies, University of the Virgin Islands*
10.30-10.45am	**BREAK**
	How will people and nature be impacted? cont…
10.45-11.00am	**Climate Change Implications for the USVI: Adaptation Planning in Key Sectors** *Lloyd Gardner, Foundation for Development Planning, Inc.*
11.00-11:15am	**How will people and nature respond?**

Appendix A: Climate Change EBA June 2013 Workshop Summary

11:15-11:30am 11:30-12:00pm	**Participatory Reflections in Climate Change Adaptation Scenarios: A Social-Ecological Systems Perspective** *Kostas Alexandridis, University of the Virgin Islands* **How can we make nature and people more resilient?** **Building resilience in reefs through threat abatement and restoration** *Kemit-Amon Lewis, The Nature Conservancy* **Q&A and Group Discussion** (other efforts from participants)
12:00- 1:00pm	**LUNCH (provided)**
1.00-1.45pm	**Ecosystem-based Adaptation (EbA) – What is it and why should we be doing it?** *Dr. Steve Schill, The Nature Conservancy*
1.45-2.00pm	**Tools, Communications, Funding** *Jeanne Brown, The Nature Conservancy*
2.00-3.30am	**Puerto Rico's Climate Change Council design, organization, purpose** *Kasey Jacobs, Caribbean Landscape Conservation Cooperative*
3.30-3.45pm	**Break**
3.45-4.00pm **4.00-4:15pm** **4.15-4.45pm**	**Climate Stewards Education Project: involving USVI's youth** *Marcia Taylor, University of the Virgin Islands* **Update to the Territorial Hazards Mitigation Plan: VITEMA's incorporation of climate risks in mitigation planning** *Mr. William Linzey, Assistant Director Virgin Islands Territorial Emergency Management Agency* **Question & Answer Panel session:** Open discussion on the territorial approach and outline for structure for adaptation planning across sectors **Identifying common priorities for advancing EbA** (communications, research, planning and funding)
4.45-5.00pm	**Wrap-up, take home messages**- Jeanne Brown
5.00pm	**Adjourn**

Appendix A: Climate Change EBA June 2013 Workshop Summary

<u>DAY 2</u> <u>Ecosystem-based Adaptation Strategies Clinic</u>: *Delve into vulnerability assessments, risk factors, adaptive capacity and strategies* **Day 2 Goals and Objectives:** • To examine the Coastal Resilience web-based tools for planning • Advance vulnerability assessments and refine tools to make adaptive management decisions for coral reef and coastal management, and to promote ecosystem services in the bigger picture of climate change adaptation. • Identify gaps in information and develop step-by-step plan to fill those data gaps through multi-partner collaboration • Explore initial strategies that explore nature-based adaptation potential for specific coastal areas to reduce disaster risk and promote ecosystem services	
9.00-9.30am	**Welcome, Workshop Objectives, Recap of Day 1, review of agenda** *Jeanne Brown, The Nature Conservancy*
9.30-10.00am	**CoastalResilience.org as a planning aid** Demonstration of coastal adaptation decision making using coastalresilience.org Case studies, other geographies *Shawn Margles, The Nature Conservancy*
10.00-11.00am	**In-depth review of the methods used in the AWE project** Discuss EbA case studies that could serve as applicable strategies for USVI Step-by-Step demonstration of EbA strategy planning using Coastal Resilience and other spatial data 1) Map socio economy vulnerability- where are vulnerable communities, ecosystems, can respond to CC, what is ability to adapts 2) Exposure, sensitivity and adaptive capacity. What information has come out of the vulnerability assessments or is otherwise available that lends itself to EbA efforts in USVI? Relevant data: satellite imagery, vertical datum, census data, socioeconomic data, critical infrastructure, etc. OBJECTIVES- Identify areas where investment in nature help to: 1. Increase adaptive capacity, reduce sensitivity. 2. Overlay of high risk communities and habitats that are resilient= best places to apply EbA
11:00-11:15am	**BREAK**
11:15-11:45am	**USVI's Geospatial Information Council: status of cadastral parcel information and 2010 census data for spatial demographics** *Stevie Henry University of the Virgin Islands*
11.45-12.00pm	**Group discussion of spatial data sources and gaps, studies needed**

	Build consensus on the outputs of CoastalResilience, identify data needs, plan for how to fill the gaps. *Steve Schill with Jeanne Brown & Aurora Justiniano, The Nature Conservancy* Selection of site-level strategies and development of adaptation and restoration plans for the afternoon session
12:00- 1:00pm	**LUNCH (provided)**
1.00-1.45pm	In depth examination of selected sites #1 (Coral Bay?) begin to outline strategies plan for restoration, zoning, resources management, etc.
1.45-2.30pm	In depth examination of selected sites #2 (working waterfront?) begin to outline strategies plan for restoration, zoning, resources management, etc.
2.30-3.15am	In depth examination of selected sites #3 (Salt River Bay or potential coastal development site?) begin to outline strategies plan for restoration, zoning, resources management, etc.
3.15-3.30pm	**Break**
3.30-4.10pm **4.10-4.25pm**	**Question & Answer Panel session** **Final presentation,** next steps and products to be developed from workshop. Set timeline, responsibilities, etc.
4.25-4.35pm	**Wrap-up, take home messages**- Jeanne Brown
	Adjourn

http://stthomassource.com/content/news/local-news/2013/06/06/nature-conservancy-seeks-environmental-solution-climate-change

CURRENT KNOWLEDGE

The following are summaries from presentations given at the USVI Climate Change Ecosystem-based Adaptation Workshop on Day 1. Presentations and supporting material from this workshop can be seen at http://virrp.reefconnect.org/.

Climate change models in-progress or available for the territory: precipitation, temperature, sea level rise and vegetative modeling
Kasey Jacobs, Caribbean Landscape Conservation Cooperative (CLCC)

Kasey Jacobs, who has extensive experience working with the Puerto Rico Climate Change Council, presented on what new models, studies and resources are available or soon available. For more information, please see Kasey's presentation at: http://virrp.reefconnect.org/

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- Baseline environmental databases available or being developed include: climate, vegetation, urban growth & hydrology.
- Future scenarios of land-coverage based on climate change.
- Predicting vulnerability of sea turtle nesting
- CLCC has products on: downscaled climate data and modeling (not available yet)
- They carried out a dynamical analysis – 32 temperature and rainfall models could predict temperature and precipitation in the Caribbean.
- Some results:
    - PR is expected to warm faster than global average.
    - Frequency of moderate extreme precipitation is predicted to decrease.
    - Extreme rainfall events are expected to be more common
    - Temperature- Increasing – warming trends.
    - Precipitation- decreasing – drying trend in the Caribbean.
- Can request certain models or information from the Climate Science Center

Local effects in the marine environment: warming rates, acidification, oceanographic patterns
Roy Watlington, CaRA/CariCOOS

Roy Watlington discussed what some of the most recent oceanographic and climate data and measurements tell about the environment:

- Some indicators of climate change: atmospheric temperature, atmospheric CO_2, lowering seawater pH (ocean acidification).
- Meteorological stations: measuring wind speed & detection, temperature, humidity, barometric pressure.
- Buoys: measures currents, temperature, barometric pressure, etc. so that we can integrate data into available models.
- Contributions: concentrate in ocean acidification, atmospheric temp trends, ocean water temp trends, status of the meridional overturning and changes in climate indices (NAO, ENSOI, etc.), sea-level rise, meso-scale ocean circulation
- Seawater acidification: carbonate saturation state (affects rate of coral reef calcification)- Caribbean is slightly better than western Atlantic.
- CaTS observed gradual warming.

Caribbean coral change with increasing thermal stress events
Tyler Smith, Center for Marine and Environmental Studies, University of the Virgin Islands

Tyler Smith addressed the two severe bleaching events which have damaged coral in recent years and presented some recent evidence on the incidence of cigautoxins in the environment and incidence of ciguatera poisoning in the USVI over the last 30 years.

- Effects of thermal stress on corals: UVI monitors benthic coverage, coral communities, fish, coral health, and physical patterns.

- It is often the mortality that following bleaching due to subsequent disease that changes the state of our coral reefs
- Bleaching & white band disease causes decrease on coral coverage but there is variability in the response of coral reef communities to thermal stress – dependent on species.
- There are 3 grouping of species in terms on the way they respond to thermal stress: type 1 susceptible to bleaching but recover after time, type 2 susceptible to disease after bleaching and type 3, resistant to bleaching.

Appendix A: Climate Change EBA June 2013 Workshop Summary

- The mesophotic reefs are possible refugia for corals, still a lot of questions to answer
- With millions in economic loss in the territories due to Ciguatera poisoning, there appears to be no increase overall in cases the last 30 years.
- With loss of coral cover (in part due to warming oceans from climate change), would expect more habitat available for the dinoflagellate that caries the toxin

Other emerging information pertinent to the USVI will be coming from studies led by Kostas Alexandidis of the University of the Virgin Islands who presented on "**Participatory Reflections in Climate Change Adaptation Scenarios: A Social-Ecological Systems Perspective".** Main points from his presentation are:

- What does adaptation mean?
- We need to understand who has to adapt and why
- High level of risk exposure, dominated by the nature of our biophysical systems (islands) so adaptation in the only option.

Further needs for better-informed public and decision makers including resources managers include a better understanding of:

- Changes in oceanographic patterns such as that which brought significant amounts of sargassum algae to the Lesser Antilles and central Caribbean in 2012
- Formation of South Atlantic cyclones, potentially influencing currents and events introduction of exotic species
- Incidence of Oronoco River plumes affecting the territorial waters
- Changes to migratory patterns of fish and bird species

SUPPORTING POLICY and REGIONAL INITATIVES:

Pertinent policy and local initiatives enacted by government agencies and institutions that in one way or another supports the comprehensive approach to territorial adaptation planning include Governor John P. de Jongh Jr's declaration in August 2013 to advance climate change adaptation for the territory (Appendix B and C), and his economic plan with the formation of a coalition to address the issues of climate change. UVI is engaging in science/ technical/ planning in the next five years with VIEPSCoR and support from NSF, which will help inform the socio-economic plan. The Virgin Islands Territorial Emergency Management Agency's updates to the territorial hazards mitigation plan, DPNR's coastal zone management and planning policy, and other summaries from the June 2013 workshop follows.

Overview of Territorial Initiatives: VI Department of Planning and Natural Resources
Jean-Pierre Oriol, Director Coastal Zone Management

- For the most part, VI DPNR /CZM has been the face of climate change for the department since about 2011
- Coastal resources are the driver of our way of life, and the health of our coastal systems tied to our economy
- DPNR is involved in various watersheds planning at local and regional scales, and the recent watershed management plans for St Thomas East End Reserves, Coral Bay, and the St. Croix East End Marine Park have components that take into consideration climate change.
- Part of DPNR/CZM mandate is to promote and enhance ecosystem services of the territories and ensure sustainable balance between ecosystem and economic development.
- Initiatives such as the CROP plan for the future of coastal and marine resources between PR and USVI.

- Various initiatives are looking at ecosystem adaptation (such CLCC).
- It is important to forge partnerships.

Climate Stewards Education Project: involving USVI's youth

Marcia Taylor, University of the Virgin Islands

- Climate change education for educators

Update to the Territorial Hazards Mitigation Plan: VITEMA's incorporation of climate risks in mitigation planning

Mr. William Linzey, Assistant Director Virgin Islands Territorial Emergency Management Agency gave an update on the Territorial Hazards Mitigation Plan. He pointed out that though ocean levels were rising, vertical land movements were actually causing some land masses to rise higher above sea level. Mr. Linzey said he would like to see models specifically making predictions about the Virgin Islands include information about continental shelf movement. Most in attendance agreed that information would be valuable.

- VITEMA considering new hazards to incorporate into the updated hazard mitigation plan due in 2014
- They will be hiring a consultant/facilitator to help update the plan
- Are considering ways to incorporate climate change to the hazard mitigation plan

USVI's Geospatial Information Council: status of cadastral parcel information and 2010 census data for spatial demographics

Stevie Henry University of the Virgin Islands

- USACE – 2007 orthophoto & LIDAR
- NOAA National Geodetic Service
- FEMA – digital flood insurance rate maps – developed off local high water mark
- Street Addressing Initiative

Climate Change Implications for the USVI: Adaptation Planning in Key Sectors

Lloyd Gardner, Foundation for Development Planning, Inc.

- Temperature increase 2-3 C -migration of tropical fish further north as temperature gets warmer – What does this mean for communities like for example fishers?
- Sea level rise (1-3m)- impacts on coastal infrastructure, contamination of groundwater, tourism.
- Variability of precipitation 20-30% decrease, more intense rainfall events.
- Increased storm intensity – ecological changes, pests, damage to property, tourism, insurance.
- Concerns: food security, health, livelihood/economic activities, damage to property and infrastructure, disruption of ecosystems.
- Focal points: climate change and adaptation, security, economic tools and models for decisions, protected areas policy and planning, natural areas management and planning.

Building resilience in reefs through threat abatement and restoration

Kemit-Amon Lewis, The Nature Conservancy

- Decline of Caribbean Reefs by threats such as overfishing, vessel groundings, non-point sources of pollution, invasive species.
- Nurseries in USVI
- Data Collection: light and temperature, fragment survivorship, annual growth rate
- Importance of genetic diversity

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Participants also mulled the following broad points to advancing policies:

- Is a climate change adaptation policy necessary for agencies to incorporate ecosystem-based adaptation into their mandates? Is it possible (or necessary) to go forward with EbA with or without such policies?
- We need a collaborative approach- share responsibilities and go for funding together, wisely, and efficiently
- We need to expand the dialogue to a bottom-up approach
- We can move on several fronts at the same time with agencies and institutions working together.

Other related initiatives in the region:

British Virgin Islands Climate Change Policy
Angela Burnett Penn, Environmental Officer with the BVI Ministry of Natural Resources & Labor, Conservation & Fisheries Department, British Virgin Islands
http://www.bvidef.org/main/content/view/90/149/
Angela presented the BVI Green Paper and discussed the process surrounding the development and ratification of the Virgin Islands Climate Change Policy. It is a source of pride for BVI Government and hopefully can kick start subsequent discussions among USVI stakeholders as to whether or not some or all of the BVI's process related to the policy would be a good fit for the USVI and if not, what alternatives are better suited to their particular situation. It demonstrated that establishment of a policy can be accomplished, and the ways to "use" the policy to greatest advantage. Specifically by providing links to it in other publications, policies, legislation, workshop materials or community action plans so that more people know about it, quoting from it during working group meetings and workshops and using it as a means to strengthen funding requests to government or when speaking to prospective partners.

Puerto Rico Climate Change Council (PRCCC)
The Puerto Rico Climate Change Council (PRCCC) is a partnership lead by the Coastal Zone Management Program (CZMP) of over 150 scientists, planners, practitioners, and communication experts. The PRCCC works to accurately assess vulnerability to life and property and identifying and assessing feasible adaptation strategies for government, the private sector, non-profit organizations, civil society, and all communities within Puerto Rico.
http://www.pr-ccc.org

NOTES DAY 2:

What people learned from Day 1:

- JP Oriol - Climate science in USVI – precipitation data is not gathered but is necessary for USVI – JP wonders why? Vital to have them in the models – USVI relies on PR data.
- Avram Primack - Surprise to learn that Dr. Watlington has 6 stations in USVI – incorporate precipitation data – main problem is maintenance.
- Kostas Alexandridis - Validation of tools on scientific level? Has to provide valid science behind it. What has been done to validate tool on scientific level?

CoastalResilience.org as a planning aid Demonstration of coastal adaptation decision making using coastalresilience.org Case studies, other geographies
Shawn Margles, The Nature Conservancy

- Not a decision maker, is intended to help people understand information, it is to support and facilitate communication and move projects forward.

Appendix A: Climate Change EBA June 2013 Workshop Summary

- JP - How often the tool is updated – the analysis and data?
- Shawn – it is important to determine the priorities and determine what analysis is needed. The system is available to be updated as often as geographies want to have it updated depending on their priorities.
- Jeanne- Will this be used? How will it be used? Where are we going with this?
- Avram – express data as probabilities and not actualities. These are models based on 1 hurricane instead of various hurricanes. Also concern about demographic data.
- Shawn – Depends on funding, resources and personnel available to improve the model and probabilities. Data changes all the time, so it is important to update data such as demographic data.

Statement made by participants as a short-range vision for the territory to:

> ***"Strategically integrate data, policy, communications and ecosystems services initiatives to advance climate change adaptation in the Territory."***

General Notes:

- Ecosystem services are the driving factors for our economic status- consider the valuation of our coral reefs
- Consider the role UVI extension services can play in outreach, information gathering, planning for community involvement and participatory decision-making
- If TNC wants to continue leading this effort, we need to evaluate the governor's economic plan and assess if it support the effort. This is a reasonable starting point.
- UVI engaging in science/technical/planning in the next 5 years with VIEPSCoR, grant from NSF, etc- which will help inform the socio-economic plan
- Ecosystem Based Adaptation is one initiative but we need a holistic approach that might incorporate other initiatives and demonstrate and define what does this mean.
- Focus on the communities. Climate change is a big area of investment for the USVI. Focus on social vulnerability and what people need. Understand what adaptation means for the communities and try to work together with the scientific communities and with what we have available.
- Integrate communities by reaching out to representative groups. Mechanism most practical and feasible was to deal with the level of the individuals as well as private companies and government.
- People handling the communication also have to be updated to be able to understand and handle the new tools, data management.
- *Integration* (not "comprehensive")– is the word that needs to be used - Integration of planning activities. Communication between all the people that are involved needs to happen.
- There is a lot that we can learn from other smaller nations that don't have the same resources as USVI but are able to develop planning programs with the little resources they have. Also learn from BVI (in terms of outreach and communication) and PR (in terms of policy). Get things done, workshops are great but we need to see results.
- Important to define the roles of agencies and NGOs to frame where we are going.
- Keep in sight our end goal- on-the-ground adaptation through restoration, protection, enhancing ecosystem services.

Other main points:

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- We should focus on tangible and feasible EBA strategies/solutions that involve multiple sectors
- We need to consider ecological, social, and economical issues together, looking at how to increase functionality of ecosystem services while strengthening resilience
- We may want to survey the communities on their perception of ecosystems, asking why they need to be protected, what services they provide, and how they value them? This would provide insight into what ecosystems we should focus on and education/outreach efforts that are needed.
- Can we determine and map out areas where we are seeing repetitive losses across the USVI? Can we measure/assess the time frequency, stress, and magnitude of each event?
- The issue of mismatches between the land & water plan vs. the zoning plan was also raised and should be explored
- There were multiple comments that the current audience of stakeholders does not fully represent all needs/voices (only 50%). Consequently we should conduct an inventory and reach out to targeted stakeholders who are not currently represented.
- Excitement regarding EBA work appears to be low. How do we get communities excited about participating and making their voices heard? This seems to be a big problem in the USVI.
- We need to first identify the primary objectives/goals of the EBA strategies/solutions that USVI would like to implement. Upon consensus, we can then consider the array of EBA frameworks that have been developed and choose/modify one that most appropriately fits the objectives/goals.
- Many countries have benefited from identifying and selecting working groups focused on EBA issues. This might be something USVI wants to consider – such as groups that look into issues regarding: a) understanding and visualizing vulnerability; b) empowering communities; c) developing solutions; measures of effectiveness; and d) communication and outreach. Another option might be a) Geophysical; b) Ecology; c) Society/Economy
- The group needs to consider how to manage the different knowledge levels of the various stakeholders. We really need to identify a local champion to really lead the EBA effort
- There were many references to getting the insurance companies involved since they have a vested interested in understanding risk

Suggested next steps stemming from the June workshop:

1) FILL DATA GAPS: Review and fill data gaps identified in the workshop, particularly the census and elevation data
2) VULNERABILITY ASSESSMENT: Complete a territory-wide GIS-based vulnerability analysis at the estate level using the 2010 census data. To do this, we will need to identify the variables that will be used to compute sensitivity and adaptive capacity categories (high, med, low) using framework similar to AWE methods.
3) UPDATED EXPOSURE: Correct current territory-wide exposure levels using the updated VDATAM elevation. Work with NOAA to do this
4) MANGROVE MIGRATION: Finally (and if we have time), develop a territory-wide mangrove migration index that will identify areas that the government should protect to allow mangroves to migrate.

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Name	Position	Agency	Email	Phone
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Katina Coulianos	Private Practice	Member, Magens bay Authority	coulsell@viaccess.net	340-776-8686
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Lloyd Gardner	President	Foundation for Development Planning	lsg_tr@hotmail.com	340-714-0936
Leslie Henderson	Research Analyst	University of the Virgin Islands	leslie.henderson@live.uvi.edu	340-626-0402

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Roy Watlington	Board Member CaRA/CariCOOS	CariCOOS	rawatlington@gmail.com	340-643-8183
Vanessa Wright	Oceanographic Tech	University of the Virgin Islands	vwright@live.uvi.edu	340-693-1378
Joining by Teleconference and Webex			-	

Appendix A: Climate Change EBA June 2013 Workshop Summary

Name	Position	Agency	Email	Phone
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Shawn Margles (presenter, Day 2)	Coastal & Marine Planner	The Nature Conservancy	smargles@tnc.org	(703) 841-4835
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Facilitators				
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221-2013 August 9, 2013

DE JONGH JOINS FELLOW GOVERNORS IN URGING ACTION ON CLIMATE CHANGE

Governor John P. de Jongh, Jr. joined several of his fellow governors in applauding President Obama's efforts to combat climate change and pledging cooperation to meet the urgent challenge of a warming planet.

De Jongh signed a letter along with 13 other governors expressing approval of a recently announced Climate Action Plan and the president's leadership in the face of obstinance from Congress in addressing the threat of climate change. The governors share a commitment to reducing carbon pollution and better preparing the nation for the adverse consequences of a warming planet while promoting job creation and economic competitiveness in the global clean-energy market.

"While Congress has failed to take meaningful legislative action on this issue, we support the common sense policies that you have proposed and pledge the support and active partnership of our states and territories as you develop and implement this plan," the letter to President Obama reads.

De Jongh said the territory's development of wind and solar energy facilities across the islands, an increased focus on conservation and a recent agreement to convert to natural gas fuel in the territory's power plants puts the Virgin Islands on track to doing its part for the greater good—reducing its use of fossil fuels by 60 percent by 2025.

"Our states have stepped up to the challenge of reducing carbon pollution and addressing climate change, and are leading the way," the letter explains, going on to list the goals and achievements in lowering emissions across the Northeast, Mid-Atlantic, and in California and Colorado.

"Those policies to cut carbon pollution through increased efficiency and clean energy are also reducing energy costs, creating jobs and growing our state economies," the letter reads.

The governors told President Obama they appreciate his call for all Americans to join the fight against climate change, and they welcome establishing new partnerships with federal agencies to develop and implement climate policies. They encourage efforts throughout government and in the private sector to advocate for action at the federal, state, local, and community levels.

"To best take advantage of this global economic opportunity, and effectively respond to the threats of climate change, federal and state governments must work together as partners."

# # #

APPENDIX C: Governors' Declaration to President Obama

July 31, 2013

The Honorable Barack Obama
President of the United States
1600 Pennsylvania Ave NW
Washington, DC 20500

Dear Mr. President,

We applaud your recently announced Climate Action Plan and the federal leadership it brings in response to the growing threats posed by climate change. We share your commitment to reduce the carbon pollution that is driving climate change, to better prepare our nation for increasing climate impacts, and to promote job creation and economic competitiveness in the growing global market for clean and more efficient energy technologies. While Congress has failed to take meaningful legislative action on this issue, we support the commonsense policies that you have proposed and pledge the support and active partnership of our states and territories as you develop and implement this plan.

While too many still refuse to acknowledge the overwhelming scientific consensus of human-caused climate change, the devastating impacts of climate change in our states are all too real. Catastrophic storms, extreme droughts, uncontrollable wildfires, increasingly acidic coastal waters and other climate impacts have brought enormous economic and environmental costs, and are challenging the way we respond to disasters and rebuild our communities to withstand future disasters.

Our states have stepped up to the challenge of reducing carbon pollution and addressing climate change, and are leading the way. In the Northeast and Mid-Atlantic, the nine-state Regional Greenhouse Gas Initiative (RGGI) has helped reduce emissions from power plants by more than 30 percent since 2008. California is successfully implementing a law to reduce carbon pollution across the economy and is placing specific caps on sources responsible for 85 percent of those emissions. Colorado through legislation will see a 30 percent reduction in emissions by 2020 within the state's largest utility, and many other states have passed legislation and are implementing policies to reduce their emissions. And state governments around the country are also preparing for flooding, sea-level rise, drought and other impacts associated with climate change, and incorporating such considerations into their capital investments.

States policies to cut carbon pollution through increased efficiency and clean energy are also reducing energy costs, creating jobs and growing our state economies. According to the Brookings Institution, jobs in clean energy industries grew at twice the rate of job growth in the rest of the U.S. economy over the last decade, thanks in large part to successful state and federal policies. Increased use of energy efficiency and clean energy is not only important for our global climate, it also represents an economic opportunity for our states and an economic imperative for the competitiveness of our nation.

To best take advantage of this global economic opportunity, and effectively respond to the threats of climate change, federal and state governments must work together as partners. Indeed, to prevent the worst effects of climate change and to prepare our communities for the impacts we are already seeing, we will need action at the federal, state, local, and community levels. We therefore appreciate your call for all Americans to join the fight to beat climate change.

We welcome your directive to federal agencies to work with states in developing their climate policies, and we applaud your creation of a Task Force on Climate Preparedness that will include members of state, local and tribal governments. We request that you work with the states, and build upon our progress, to develop and implement the elements of your Climate Action Plan. States are working with industry and environmental stakeholders across the country in designing climate emission reduction and community resiliency programs that span government, private industry, and personal action, and we stand ready to collaborate with our federal partners on climate techniques that work.

While Congress has failed to enact the necessary legislation on this important issue, we support your decision to combat climate change using successful, existing federal authorities including reducing carbon pollution from power plants through the Clean Air Act, reducing energy waste through strengthened efficiency standards, and deploying more renewable energy on public lands and buildings. These policies will make a meaningful reduction in climate-changing pollution, and will give our states and territories better tools with which to plan for and respond to the impacts of climate change. They will also serve to slash energy costs for consumers and businesses, and promote growth in America's innovative clean energy industries.

APPENDIX C: Governors' Declaration to President Obama

We thank you for your leadership and we look forward to working with your Administration on essential efforts to address climate change.

Sincerely,

Governor Peter Shumlin
State of Vermont

Governor John Hickenlooper
State of Colorado

Governor Jay Inslee
State of Washington

Governor Jerry Brown
State of California

Governor Daniel P. Malloy
State of Connecticut

Governor Jack Markell
State of Delaware

Governor Neil Abercrombie
State of Hawaii

Governor Pat Quinn
State of Illinois

Governor Deval Patrick
Commonwealth of Massachusetts

Governor Martin O'Malley
State of Maryland

Governor Mark Dayton
State of Minnesota

Governor John Kitzhaber
State of Oregon

Governor Lincoln Chafee
State of Rhode Island

Governor John deJongh
U.S. Virgin Islands

APPENDIX D: Funding Sources for EBA as of January 2014

Funding Opportunities: Climate Funding Opportunities (January 2014) – A group at NOAA collates the most recent climate funding opportunities bi-annually. This document provides a snapshot of currently available, climate-related funding opportunities (as of January 15, 2014). The next version is scheduled to be released in July 2014. The document is posted on The Nature Conservancy's Collaboratory for Adaptation to Climate Change website. Follow the link below, and click the black "download PDF" box on the right side of the page https://adapt.nd.edu/resources/1322 for a comprehensive list of funding opportunities. A selection of pertinent EBA funding opportunities follows.

The Wildlife Conservation Society's Climate Adaptation Fund
In 2014, the Wildlife Conservation Society (WCS) will provide 1-2 year grants ranging from $50K to $250K for on-the-ground projects that focus on implementing conservation actions for climate adaptation at a landscape scale. The grants required a 1:1 match with a maximum of 50% of match funding from in-kind sources. WCS anticipates releasing its 2014 Request for Proposals to the Climate Adaptation Fund by mid-February. Interested applicants should check the program's website for updates on future grant opportunities. The link below offers information on previous grant awards.
Eligibility: U.S.-based (all 50 states and 6 territories) non-profit organizations with approved IRS 501(c)(3) status. Public agencies, tribal governments, and universities may partner with eligible non-profits to submit proposals. http://www.wcsnorthamerica.org/ClimateAdaptationFund

Gulf of Mexico Foundation – Community-based Restoration Partnership
This foundation offers a grants competition through its Community-based Restoration Partnership. This partnership, established in 2001 between the Gulf of Mexico Foundation, NOAA, and the EPA, has led to 76 restoration projects in the Gulf of Mexico and Caribbean Basin. In 2011, the foundation awarded approximately $500K to projects in the Gulf States and U.S. Caribbean Territories. Projects typically fell in the range of $50K - $100K. All participants were required to provide a 1:1 cash or in-kind match of the grant amount. Matching funds cannot be federal dollars. The Foundation also awarded approximately $250K in 2012. Interested applicants should check this website for future grant opportunities.
http://www.gulfmex.org/conservation-restoration/gulf-conservation-restoration-and-preservation/

Department of Commerce: National Oceanic and Atmospheric Administration (NOAA)
FY 2012-2013 Broad Agency Announcement (BAA)
Funding Opportunity Number: NOAA-NFA-NFAPO-2014-2003949
The purpose of this notice is to request applications for projects associated with NOAA's strategic plan and mission goals. The funded research, projects, or sponsorships must address one or more of the four mission goals in NOAA's strategic plan (Climate adaptation and mitigation and responding to climate and its impacts; Weather-Ready nation – society is prepared for and responds to weather-related events; marine fisheries, habitats, and biodiversity sustained within healthy and productive ecosystems; and resilient coastal communities and economies – environmentally and economically sustainable). Funding appropriation is dependent on FY 2014 and FY 2015 appropriations. The anticipated start date will be three to six months after receipt by NOAA, with applications generally submitted for a one-year award period.
Eligibility: Institutions of higher learning, non-profit organizations, commercial organizations, international or foreign organizations or governments, individuals, state, local and tribal governments. (Universities with a NOAA joint or Cooperative Institute (CI) should submit an application through the CI).
Application deadline is **11:59pm Eastern Daylight Time on September 30, 2015**
Information is found by searching for the above Funding Opportunity Number on . www.grants.gov

APPENDIX D: Funding Sources for EBA as of January 2014

U.S. Environmental Protection Agency
Green Infrastructure Technical Assistance Program
The EPA's office of Wastewater Management is currently seeking letters of interest from communities that are interested in implementing green infrastructure to protect water quality and increase community sustainability. This Technical Assistance program helps communities to: 1) overcome the barriers to green infrastructure, and 2) develop approaches to implement green infrastructure for the sake of attaining environmental, social, and economic goals. This opportunity is not a grant, but rather, EPA would provide technical assistance through an EPA contract, in the form of work conducted by contactors (paid by EPA). EPA estimates the value of this assistance to be around $400K (each community to receive approximately $60K in contractor support), and the program anticipates providing assistance to 5 – 7 communities. Project periods will last 9 months.
Eligibility: any combination of local government departments, offices, or agencies, as well as non-profit organizations may submit a letter of interest. Applicants must have a local government representative.
Deadline for submitting letters of interest is **5pm Eastern Time on January 24, 2014**
http://water.epa.gov/infrastructure/greeninfrastructure/gi_support.cfm#2014TechnicalAssistance

Climate Solutions University (CSU)
CSU aids local rural communities, connected through a peer learning network, by offering training, expertise, and support in climate adaptation planning. Through this training, expertise, and support, CSU strengthens local leadership, public engagement, and ecosystem protection efforts in rural communities. In the past, CSU has offered two distance-learning programs; the Climate Adaptation Plan Development Program and the Climate Adaptation Plan Implementation Program. The development program results in a local climate adaptation plan (focusing on forest and water resource resilience). The implementation plan supports participants in moving the plan into action. Each program typically has 8 positions available. Each participating community received ~$100K in training, mentoring, and access to tools/resources; however, communities must commit $5K of cost-share in the form of staff time and related resources.
Eligibility: Region non-profit organizations (501 (c)(3) status); local, county, or municipal governments; state or federal organizations (encouraged to participate with local agencies). Individuals may not apply
There is no strict application deadline as applications are accepted on a continual basis.
http://www.mfpp.org/csu/

National Science Foundation
Science, Engineering, and Education for Sustainability (NSF-wide investment area)
The National Science Foundation's Science, Engineering, and Education for Sustainability (SEES) program addresses the challenge of building a sustainable future through promoting research and education. SEES is expected to extend into FY15 with continuing research efforts to include global community sustainability; sustainable energy; modeling; vulnerability, resilience, and sensitivity to regional change; and public engagement. Since SEES is a NSF-wide investment area rather than an individual program, applicants are encouraged to check for updates to the collection of new and existing activities. Programs of interest include the Climate Change Education Partnership Program (CCEP), the Ocean Acidification (OA) program, the Coastal SEES program, and the Water Sustainability and Climate (WSC) program.
Eligibility: Unrestricted
http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=504707
The Doris Duke Charitable Foundation
The foundation's Environmental Program strives to meet four main strategies through grant awards. These strategies include: 1) enabling strategic wildlife habitat conservation in an era of climate change; 2) reducing impacts on the landscape from increased energy development and energy demand; 3) encouraging land stewardship and sustainability in the Tri-state area; and 4) helping to build a clean-energy economy. The

foundation typically provides funding support through a series of invited proposals. Unsolicited proposals are not considered by the foundation, information about future opportunities can be requested through a letter of inquiry, which is described on the webpage below.
Funding is limited to the U.S. Also, the foundation does not support green building projects (construction capital) or projects focusing on marine environments, toxics remediation, litigation, filmmaking, individual research, or scholarships.
http://www.ddcf.org/Programs/Environment/Grant-making-Process/

The Rockefeller Family Fund
This foundation's Environment Program is currently focusing on the challenges of Climate Change. The program focuses on public education of the risks of global warming and implementation of sound solutions, conservation of natural resources, protection of health as affected by the environment, meaning implementation of environmental laws, and public participation in national environmental policy debates. Grant applicants must submit a letter of inquiry online through the Fund's online application portal. If accepted, the applicant will be invited to submit a full proposal for evaluation. Grants are usually in the range of $25,000 – $30,000 and are normally made to the same organization for no more than two consecutive years. The Fund does not ordinarily consider projects pertaining to a single community, unless the project advances a national issue, or can serve as a national model.
Eligibility: United States tax-exempt organizations engaged in activities of national significance
Program information: http://www.rffund.org/grants/environment

The Kresge Foundation
This foundation's Environment program invests in projects within the U.S., as well as selects initiatives in Canada. The Environment program supports communities that are striving to become more resilient, meaning they will be better positioned to prosper amid the range of circumstances they could encounter as consequences of climate change. Currently, the Kresge foundation is refining the funding priorities for the Environment program; therefore, the portal is currently closed for unsolicited funding requests. As this foundation has been supportive of climate change adaptation work in the past, interested applicants should check back with the foundation's website frequently to stay abreast of new developments relating to the program refinement.
Eligibility: U.S. based 501(c)(3) organizations (and Canadian equivalents), government entities
http://www.kresge.org/programs/environment/adaptation-climate-change

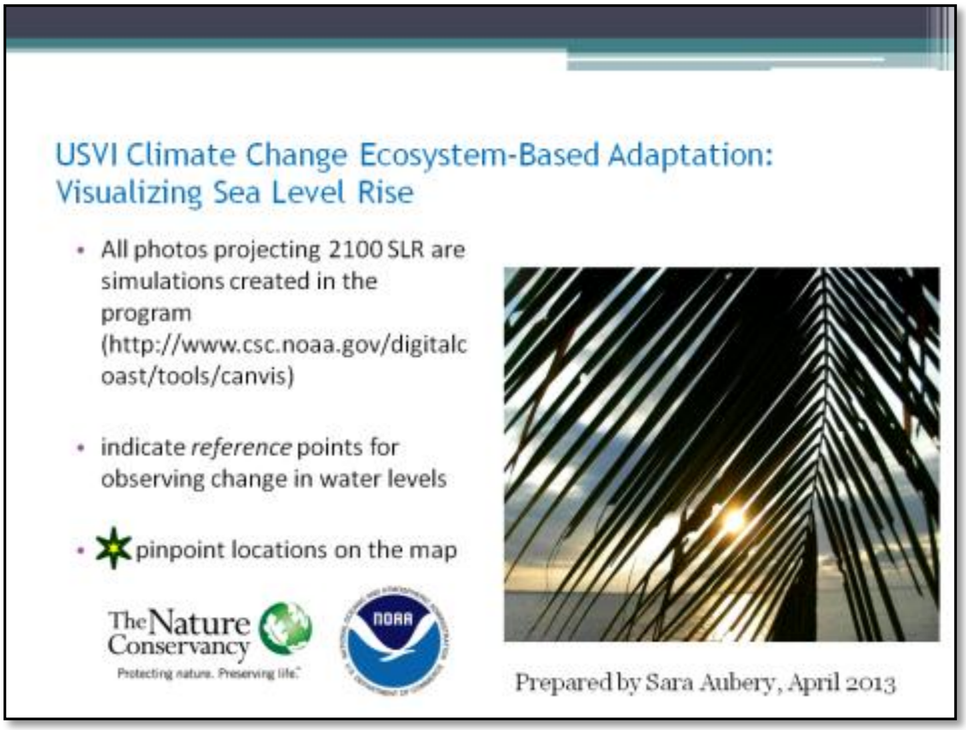
National Science Foundation
Coastal Science, Engineering, and Education for Sustainability (Coastal SEES)
Program Solicitation: NSF 14-502
NSF's Coastal SEES program focuses on the sustainability of coastal systems, which include barrier islands, mudflats, beaches, estuaries, cities, towns, recreational areas, maritime facilities, continental seas and shelves, and the overlying atmosphere. The Coastal SEES program, in short, seeks to 1) advance understanding of fundamental, interconnected processes in coastal systems, 2) improve capabilities for predicting future coastal system states and impacts, and 3) identify pathways for research to be translated to policy and management domains, enhancing coastal resiliency. The program seeks proposals from interdisciplinary research teams to conduct integrated coastal systems research (which may include theoretical, field, laboratory, or modeling activities). Proposal budgets should be in the range of $800K - $2 million (maximum) total, over a period of 3-5 years. NSF anticipates a funding amount of $13 million, thus awarding up to 10 proposals depending on availability of funds.
Eligibility: U.S. academic institutions (with NSF supported research areas), non-profit (non-academic) organizations (such as independent museums, observatories, research laboratories, or professional societies).

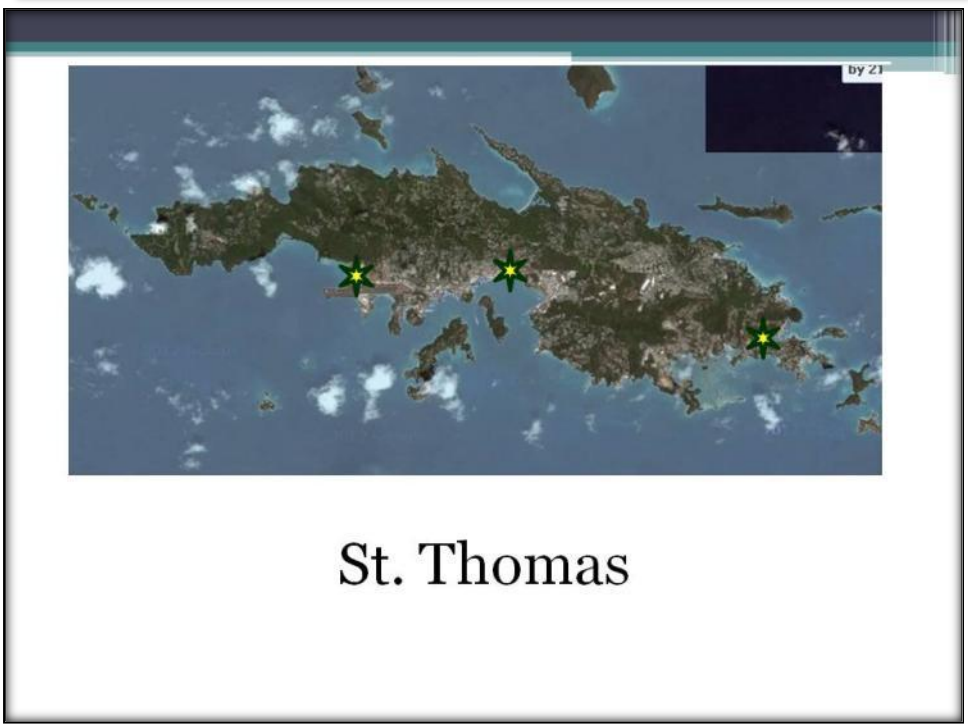
APPENDIX D: Funding Sources for EBA as of January 2014

Application deadline is **5pm proposer's local time on January 21, 2014**
http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=504816&org=NSF&sel_org=NSF&from=fund

Royal Bank of Canada (RBC)
Blue Water Project
The Royal Bank of Canada, through its Blue Water Project, is providing support for local/community based organizations in Canada, the U.S, and the Caribbean to protect and preserve water. Through this grant program, RBC anticipates projects to support measureable outcomes such as: reduced damage from flooding, reduced rate of stormwater runoff, increased water absorption through natural infiltration, improved water quality of beaches, etc. Projects could include stormwater harvesting, infiltration related projects, bioretention projects, as well as public education efforts on stormwater management practices and water conservation. Grant awards through the Community Action Grants range between $1K and $10K
Eligibility: a Canada Revenue Agency registered charity in Canada, a 501(c)(3) organization in the US, or an equivalent organization in a country outside the U.S. and Canada. Project work should focus on towns, cities, and urbanized areas with populations greater than 10,000 people.
Application deadline is **February 3, 2014**
http://www.rbc.com/community-sustainability/apply-for-funding/guidelines-and-eligibility/blue-water-project.html

APPENDIX E: Use of CanVis to Portray Sea Level Rise Scenarios





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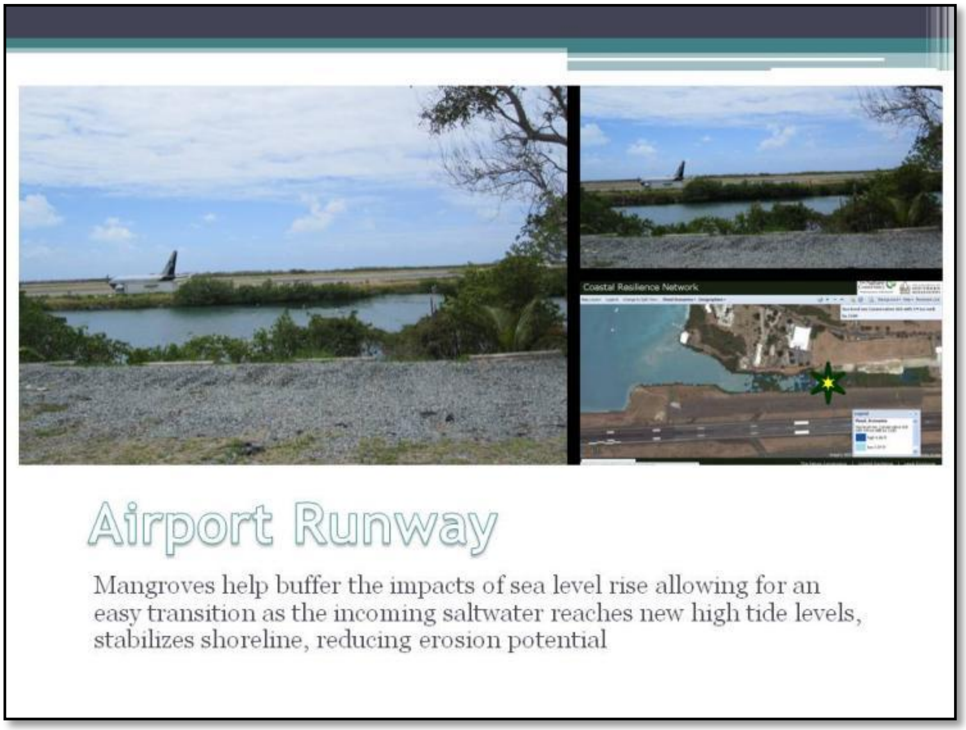

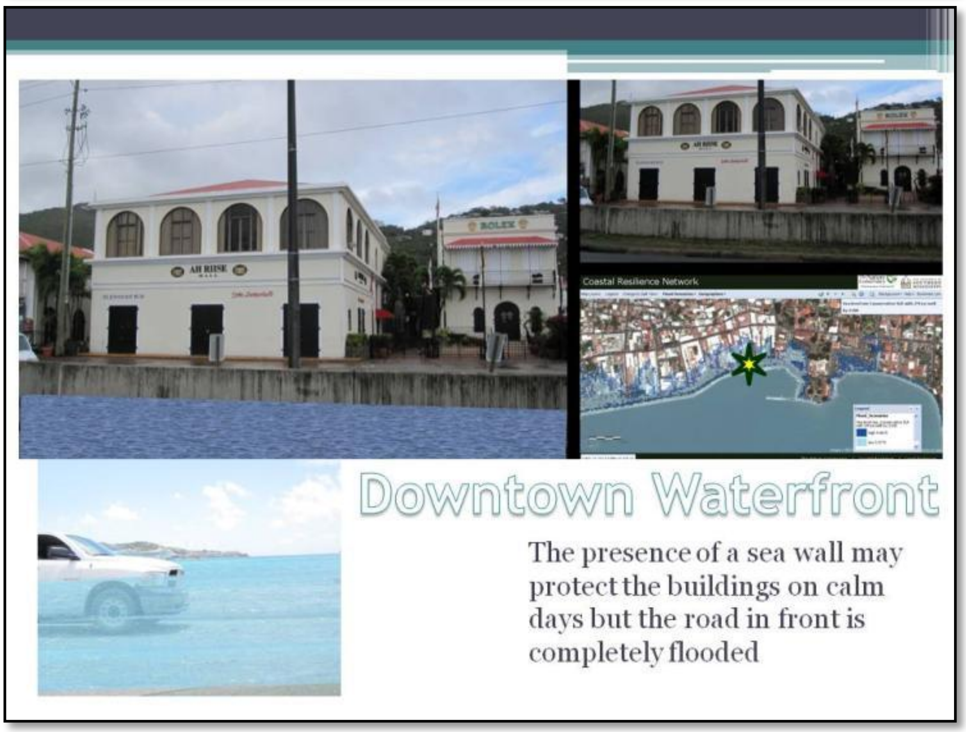

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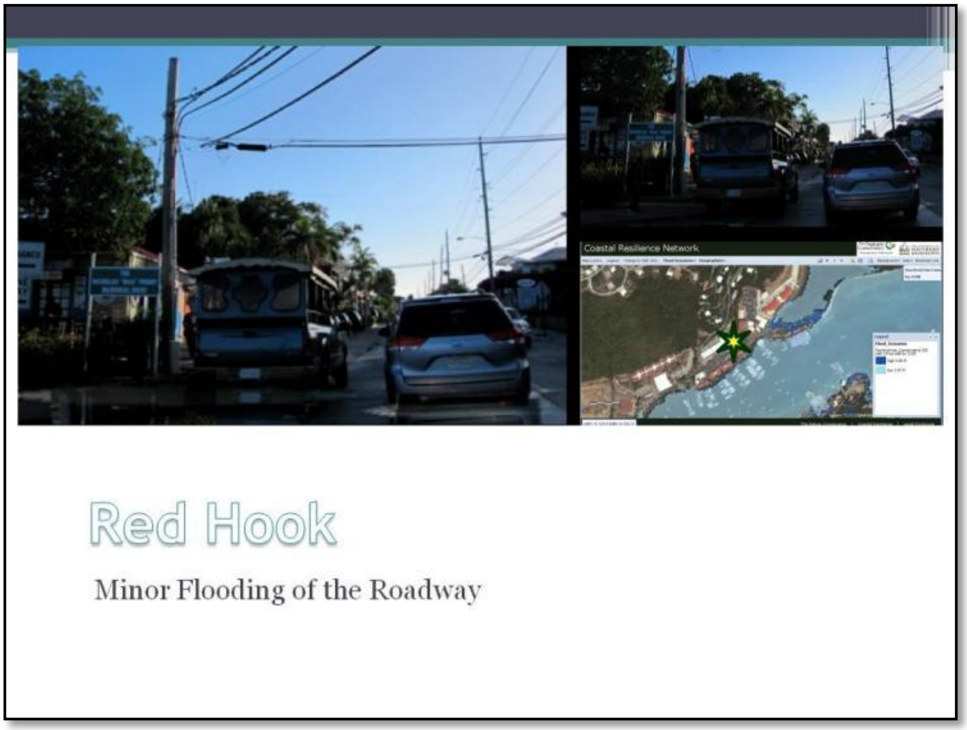

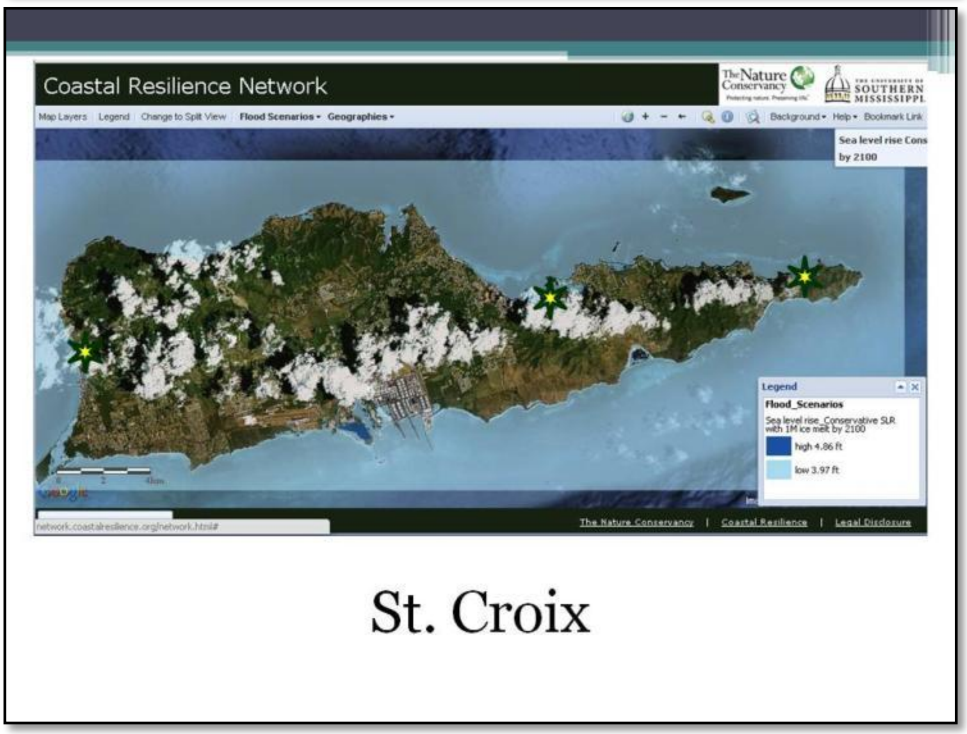

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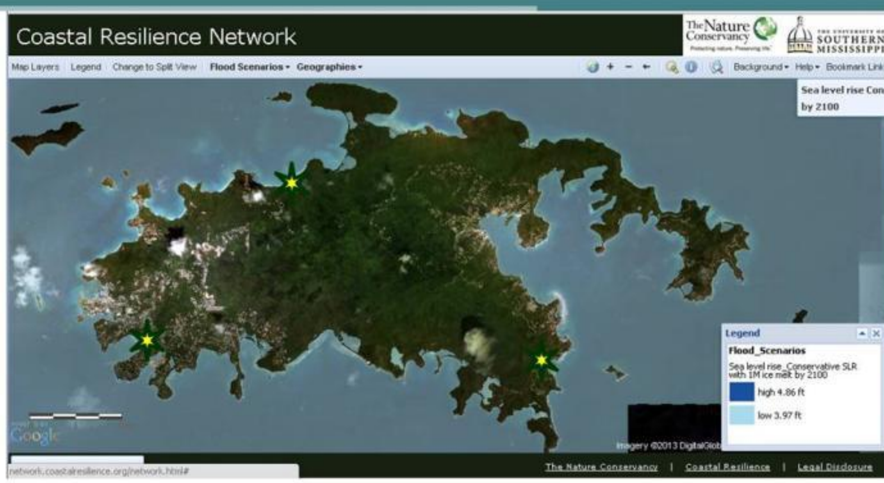
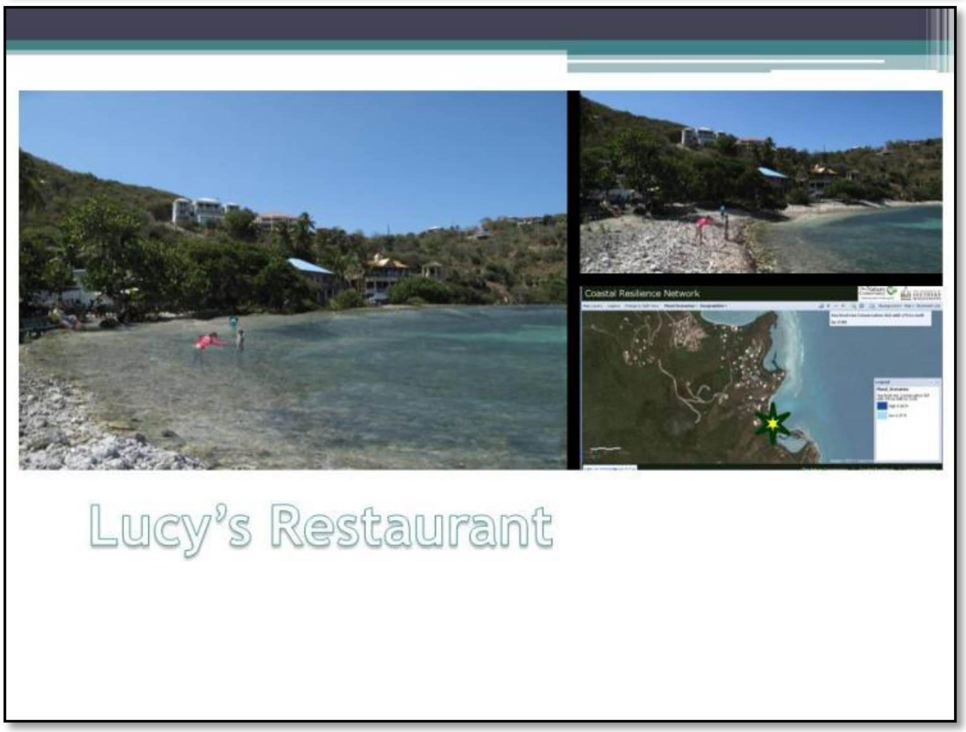
Cramer's Park

EEMP



St. John

APPENDIX E: Use of CanVis to Portray Sea Level Rise Scenarios



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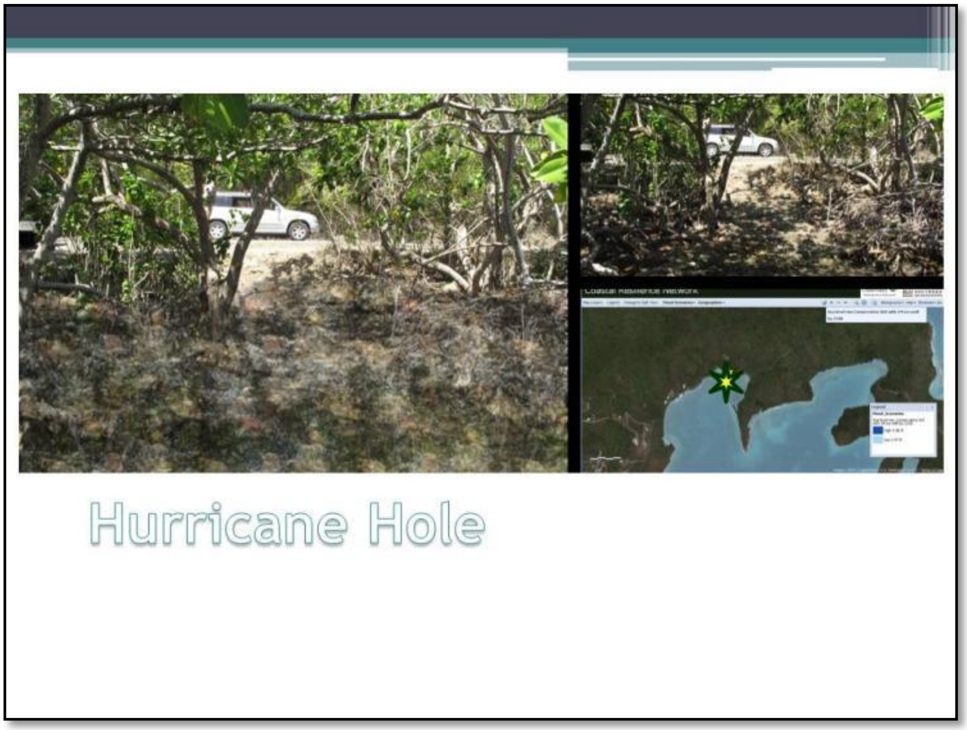
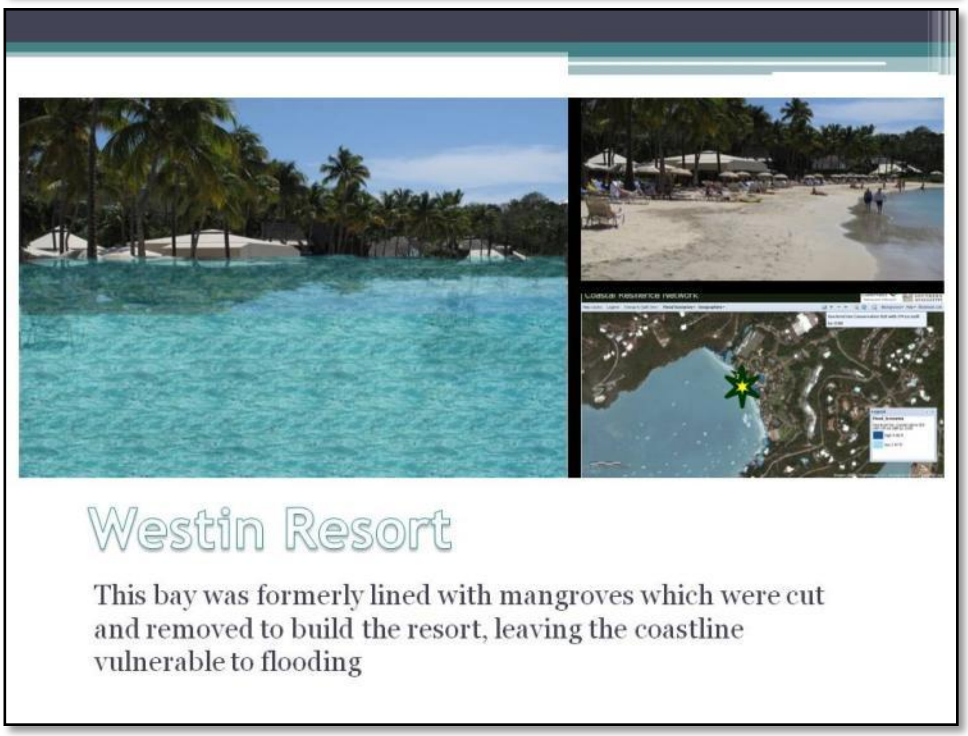




APPENDIX F: Summary of this Guidance Document

US Virgin Islands Climate Change Ecosystem-based Adaptation

Promoting Resilient Coastal and Marine Communities

Aurora Justiniano

Steve Schill

Jeanne Brown

January, 2014

NOAA CORAL REEF CONSERVATION PROGRAM

The Nature Conservancy

Protecting nature. Preserving life.

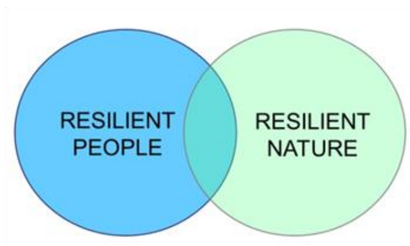
APPENDIX F: Summary of this Guidance Document

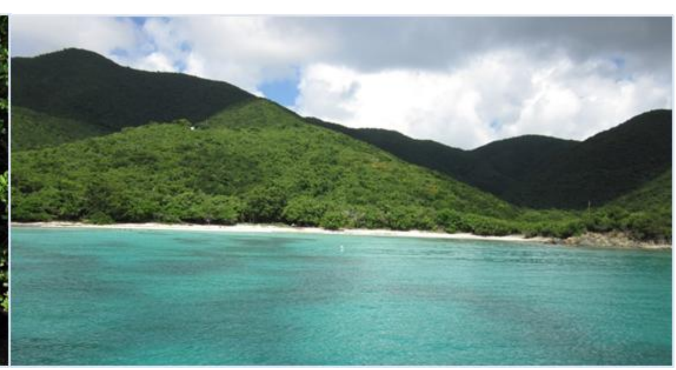
US Virgin Islands Climate Change Ecosystem-Based Adaptation

Introduction

Caribbean nations are particularly vulnerable to the impacts from climate change due to their high coastal population, limited land space, geographic isolation, scarce freshwater supplies, and high dependence on tourism and fisheries. These islands now face significant threats from increasing severe storm events, flooding, coastal erosion, drought, saltwater intrusion of coastal aquifers, and bleaching of coral reefs. In response to these threats, the government of the US Virgin Islands (USVI) seeks to implement ecosystem-based adaptation strategies throughout the territory to help build the resilience of coastal ecosystems and communities. This document summarizes the work carried out by The Nature Conservancy (TNC) to identify potential Ecosystem-Based Adaptation (EBA) sites using a geographic information system (GIS)-based vulnerability modeling exercise.

These coastal and marine sites are areas subject to the effects of sea level rise and increasing storm surge and intensity. It is hoped that TNC's work will help guide the implementation of EBA strategies through the use of planning and decision making tools, including restoration actions. On-going coral nursery, watershed and site-level MPA management projects are already being used as focal points for communication and outreach strategies for raising awareness and garnering community involvement regarding EBA methods in the USVI. Ultimately, this project serves as a platform to educate and build momentum within the USVI to streamline EBA actions and strategies into territorial policy and implementation plans.





APPENDIX F: Summary of this Guidance Document

US Virgin Islands Climate Change Ecosystem-Based Adaptation

Ecosystem-Based Adaptation

There is a growing volume of evidence that suggests in some situations, the most successful and cost-effective actions to protect people from the impacts of climate change is to preserve, enhance and restore natural systems that provide critical protection from the elements, or that provide food, water or work opportunities. Ecosystem-based adaptation, or nature-based adaptation to climate change, is a holistic response based on the premise and experience that by protecting, maintaining, and restoring natural ecosystems, we can reduce the scale and scope of impacts to human communities and to the natural systems upon which they depend. Ecosystems are the first line of defense against impacts of climate change and EBA is the protection, sustainable management and restoration of ecosystems to help human communities respond to climate change and to adapt to adverse impacts. It is a critical part of a suite of climate adaptation responses, typically involving multiple sectors. A key aspect of this approach is to design and implement solutions to climate change impacts that integrate nature's infrastructure- mangroves, forests, wetlands, coral reefs and beaches – with human infrastructure and socio-economic needs. Examples of EBA include the protection of recharge zones or restoration of floodplains and wetlands to secure water resources; or restoration and protection of natural infrastructure such as barrier beaches, mangroves or coral reefs to lessen storm and wave impacts on human communities.

Ecosystem-Based Adaptation projects should meet three basic criteria:

1. *Be implemented in a climate change-vulnerable place where biologically significant ecosystems exist and where communities may experience socioeconomic impacts;*
2. *Address and offer solutions to specific human vulnerabilities to climate change; and*
3. *Engage key communities, decision-makers, and stakeholders.*

APPENDIX F: Summary of this Guidance Document

US Virgin Islands Climate Change Ecosystem-Based Adaptation

Benefits of Ecosystem-Based Adaptation

- Includes a range of actions for the management, conservation, and restoration of ecosystems that help reduce the vulnerability and increase the resilience of communities in the face of climate change.
- Is a cost-effective and accessible means of adaptation that can help address multiple threats and local priorities
- Is often more accessible to the rural poor than technology or infrastructure solutions.
- EBA efforts are aimed at strengthening the resilience of coastal communities and decreasing levels of vulnerability to and risk posed by climate change.
- Protecting and restoring "green" infrastructure is much less expensive to maintain than built structures such as dykes or sea walls which can degrade the environment.

Limitations of Ecosystem-Based Adaptation

- Variability and likely natural changes in the ecosystem
- Difficulty in differentiating between natural and human-induced changes
- Insufficient information on ecosystem function
- Disagreement on ecosystem sustainability indicators
- Difficulty incorporating socio-economic considerations from multiple economic sectors into a single ecosystem management approach.

APPENDIX F: Summary of this Guidance Document

US Virgin Islands Climate Change Ecosystem-Based Adaptation

Ecosystem-Based Adaptation in the USVI

As with the rest of the world and Caribbean in particular, the coastal and marine communities of the US Virgin Islands (USVI) are susceptible to the effects of climate change including increasing hazardous coastal conditions and loss of life-sustaining marine, coastal and island resources. Climate change is anticipated to add to the stresses to our coastal environment by altering temperature and precipitation patterns, increasing the likelihood of extreme precipitation events, and accelerating rates of sea level rise. Responding and adapting to such changes requires an understanding of the risks, weighing options for adapting to changing conditions, and instituting a suite of strategies to implement, measure, and fund response actions having the most benefits to the ecosystems and communities that depend on those ecosystems. With support from NOAA's Coral Reef Conservation Program, TNC's Caribbean Program directed a project with the objective of developing decision-support tools and conservation strategies that will advance the implementation of EBA to climate change within the USVI.

This initiative draws on stakeholder and expert knowledge of the territory, including understanding of existing development stresses, in order to identify critical socio-economic and ecosystem vulnerabilities to climate change and to identify feasible options for adaptation. Using input from workshop participants and applying mapping tools available at coastalresilience.org, we identified the ten coastal areas vulnerable to climate change and least likely to respond: Two Brothers, Demarara, Kings Quarter, Honduras, Nadir, East Street, Mount Pleasant and Retreat, Bovoni, and Enighed .

We can then begin to examine some possible solutions:

- Improving coastal protection
- Increasing emergency services

"Strategically integrate data, policy, communications and ecosystems services initiatives to advance climate change adaptation in the US Virgin Islands."

APPENDIX F: Summary of this Guidance Document

The production of this document is made possible with support from NOAA's Coral Reef Conservation Program's cooperative agreement with The Nature Conservancy, #NA09NOS4190173, "Addressing Global Threats at Local Scales in Coral Reef Communities". The Nature Conservancy provided matching funds.