Building Resilience to Climate Change

Ecosystem-based adaptation and lessons from the field

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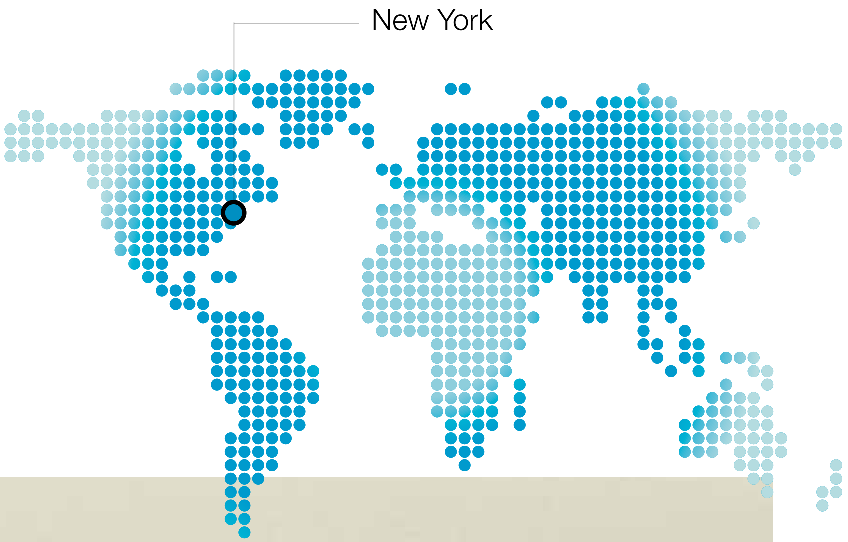
Chapter 6



Adapting to Climate Change

Building Interactive Decision Support to Meet Management Objectives for Coastal Conservation and Hazard Mitigation on Long Island, New York, USA

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The Long Island shores of New York, USA, have highly developed lands in the coastal zone. Much of this private property is only inches above sea level, putting millions of dollars in public and private funds at risk. This also puts coastal wetlands and other ecosystems at risk that provide habitat, natural buffers to storms and other services. Despite a growing awareness global climate change, local decision makers – the primary regulatory authorities on coastal development – still lack the tools to transparently examine different management objectives such as coastal hazards and conservation. Critical information shortfalls limit the options for coastal managers to address climate change-related risks. The costs to human and natural communities are increasing as development continues and natural buffers, such as coastal wetlands and dunes, are lost. Adaptation to coastal hazards has traditionally been undertaken – often unsuccessfully – using shoreline hardening and engineered defences. An alternative approach to built infrastructure, Ecosystem-based Adaptation (EbA), is sorely needed as part of an overall strategy for creating human community resilience in the face of climate change. To address this, the Coastal Resilience project was designed to provide a decision support platform and information to better inform local decision making and the implementation of EbA approaches.

EbA facilitates coastal resilience, the self-organizing ability of a coast to respond in a sustainable manner to morphological, biological and/or socioeconomic pressures. The goal of this project was to design, build and discuss alternative future scenarios that address sea level rise, storm surge, social and ecological vulnerability and conservation priorities. The Nature Conservancy led this effort, working with project partners including the Center for Climate Systems Research (CCSR) at Columbia University and the National Aeronautics and Space Administration's (NASA) Goddard Institute for Space Studies, Association of State Floodplain Managers (ASFPM), the Pace Land Use Law Center, the National Oceanic and Atmospheric Administration's Coastal Services Center (NOAA-CSC), the Department of Geography and Geology at the University of Southern Mississippi (USM) and the Marine Science Institute of the University of California Santa Barbara (UCSB). Through interactive decision support, a web mapping application called the Future Scenarios Mapper allowed local decision makers to examine current ecological, biological, socioeconomic, and management information, alongside coastal inundation scenarios developed from widely accepted climate and hazard models.

The first phase of the Coastal Resilience project, conducted over an 18-month period from January 2008 to July 2009, was guided by the following primary objectives: a) build a spatial database and interactive web mapping application http://www.futurescenarios.org/ that provides decision support for meeting both biodiversity conservation and coastal hazard mitigation objectives, b) construct a website http://www.coastalresilience.org/ that explains the approach, methods, and strategies for EbA to climate change; and c) identify reasonable and viable alternatives that reduce losses and vulnerability of coastal communities for people and ecosystems. At the same time, we conducted an analysis of selected local land use ordinances, regulations, and legal precedent that include specific mention of sea level rise or that incorporate appropriate policy responses that may be used to address the rising seas. Finally, we convened meetings of stakeholders throughout this phase to begin discussing how through interactive decision support important social and ecological characteristics can be compared with sea level rise and storm surge events and visualized within local and state planning processes.

The information presented by the Coastal Resilience Project's web mapping application are intended to advance land use, natural resource management, and emergency response planning when considered and applied according to the needs of local communities on Long Island. We are actively pursuing a five-part approach for designing and implementing EbA strategies on Long Island and in other geographies: 1) amending and passing key legislation; 2) promoting voluntary land acquisition; 3) relocating vulnerable infrastructure and development; 4) engaging in comprehensive, post-storm redevelopment planning; and 5) restoring and protecting natural resources.

Keywords: Climate change, Coastal resilience, Community vulnerability, Conservation, Decision support, Ecosystem-based adaptation, Geographic information systems, Multiple objective planning, Sea level rise

Introduction

Background

Climate change is already driving significant changes to our coasts that will have long term consequences,[1] including rising sea levels and increased storm surge height, intensity and frequency. IPCC (2007) estimates suggest that climate change will lead to increases in sea level from 18 to 59 meters, excluding rapid ice melt; with more repaid ice melt, the increase could be significantly higher (NPCC, in press). Despite a growing awareness of sea level rise (SLR) and coastal storm risks, communities and local decision makers still have only limited access to the full suite of information needed to protect natural and human coastal communities. Critical information shortfalls limit the options for coastal managers to address climate change-related risks through adaptation. Here we present an integrated approach for organizing spatial information in an Internet-based mapping application designed to provide

[1] Climate change here refers to a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer (IPCC, 2007, 2008).

Figure 1. Study area along the southern shores of Long Island, New York, USA. The boundary of the study area is shown in yellow.

interactive decision support among stakeholders concerned about coastal climate issues on Long Island, New York, USA (Fig. 1).

Options do exist for addressing losses and protecting communities through the proactive management of coastal natural resources. In direct response to the need for more comprehensive information to address coastal climate change, an interdisciplinary team from non-government organizations (NGOs), state and federal agencies, and academic institutions formed the Coastal Resilience Long Island project. Project partners include the Center for Climate Systems Research (CCSR) at Columbia University and the National Aeronautics and Space Administration's (NASA) Goddard Institute for Space Studies, the National Oceanic and Atmospheric Administration's Coastal Services Center (NOAA-CSC), the Association of State Floodplain Managers (ASFPM), the Department of Geography and Geology of the University of Southern Mississippi (USM), the Marine Science Institute of the University of California Santa Barbara (UCSB), and Pace University's Land Use Law Center. Through interactive decision support, web mapping applications allow users to examine current ecological, biological, socioeconomic, and management information alongside coastal inundation scenarios developed from widely accepted climate and hazard models.

The gradual nature of sea level rise creates a risk that communities will ignore until it is too late for a thoughtful and well-planned response. Storms are harder to ignore but easy to forget in the calm periods between major events. This case study focuses on climate change impacts on Long Island, its effects on ecological and socioeconomic resources, and how The Nature Conservancy (TNC) and its partners are engaging local communities to develop Ecosystem-based Adaptation (EbA) strategies.

The Issue

Long Island's south shore supports a diverse array of marine and coastal organisms and habitats. The area is home to significant island and fringing salt marshes, with eelgrass beds just offshore. A number of beach-dependent birds come to south shore beaches to breed and feed during spring and summer months including the federal and state listed piping plover, least tern, and roseate tern. In addition, the south shore bays support populations of shellfish and finfish that are important recreational and commercial resources, in addition to being important to overall ecosystem dynamics and water quality.

Sea level rise will continue to change the shores of Long Island in fundamental ways. Globally, climate change contributes to sea level rise in two ways: melting ice caps, glaciers, and ice sheets increase the total amount of seawater; and higher temperatures cause the volume of that seawater to increase through thermal expansion. At a local level, relative sea level rise is affected by land subsidence stemming from ongoing adjustments to the melting ice sheets at the end of the last ice age; other accretion and subsidence forces; and local ocean mass effects. Topographic changes, such as those associated with shoreline development, shoreline protective structures (e.g. bulkheads and sea walls) and impervious surfaces, affect the extent to which relative sea level rise actually impacts particular areas.

Large storm events such as tropical storms (hurricanes) and extratropical storms (nor'easters and other winter storms) have driven the formation and continued development of Long Island's shoreline. During the past 75 years, hurricanes and nor'easters have caused rapid beach erosion, dune displacement, and coastal flooding on Long Island's south shore. The most significant was the Great Hurricane of 1938 (September 21), also known as "The Long Island Express." The storm produced winds that reached over 300 kilometres per hour, generated 5-metre-high breakers, overwashed approximately one half of the island, and created 12 new inlets (Donnelly, Bryant et al., 2001). The "Ash Wednesday" storm of March 6, 1962 was a major nor'easter that resulted in more than 50 washovers. With sea level rise, the baseline sea level on which storm surge operates will be higher, resulting in increased shoreward extent of flooding and severity of impact. For example, if the 1938 hurricane occurred in 2004, it would be imposed upon a sea level nearly 21.3 cm (9 inches) higher than in 1938, thereby having a much more devastating flood effect (Psuty et al., 2005). The interplay of these various factors, and the gaps in our current knowledge, make precise sea level predictions for any given geographic area challenging. While different models yield different estimates virtually all models agree that effects of sea level rise on the region are potentially dramatic.

As of the 2000 US census there were 1.4 million people living in Suffolk County (United States Census Bureau, 2007), which includes part of Long Island's south shore, and a significant percentage of the south shore is heavily developed. Current development places considerable pressure on natural habitats through nutrient loading, toxic run-off, and habitat conversion and degradation. Long Island's coastal communities have a long history of trying to maintain their shoreline using a variety of structural mechanisms, including jetties, groins, and beachfill and construction of bulkheads. This extensive shoreline armouring increases the pressure on natural resources by modifying the sediment budget that supports them. Sea level rise will create a "squeeze" between the sea and these structures, reducing and eventually eliminating space for landward regression of natural features. Accelerating sea level rise will almost certainly increase the demand for shoreline engineering, as people seek to protect their property from erosion and catastrophic loss. As public and private investment in shoreline property continues the cost of coastal hazards increases. Further, human communities are at risk as we lose natural buffers, including salt marshes and dunes that protect the coastlines from storms.

Long Island is certainly not unique in its level of development, and potentially increased frequency and intensity of storm events, and vulnerability to sea level rise. As with much of the US East Coast, sandy beaches and low coastal profiles combine to make these areas attractive for settlement, but also at high risk from rising sea levels and higher storm surges.

The Nature Conservancy and its partners are working with local decision makers – who are the primary regulatory authorities on coastal development – to examine how different management objectives such as coastal hazard mitigation and conservation are related to one another and to visualize alternative scenarios for jointly managing them. Specifically, this project was designed to help stakeholders visualize the impacts of sea level rise and understand how they can make informed decisions about marine and coastal conservation, land protection, and coastal development and to enable local and state decision makers to use the information in their planning, zoning, acquisition, and permitting decisions.

Methodology

Objectives

The first phase of the Coastal Resilience project, conducted over an 18-month period from January 2008 to July 2009, was guided by the following primary objectives:

- Build a spatial database and interactive web mapping application http://www.futurescenarios.org/ that provides decision support for meeting both biodiversity conservation and coastal hazard mitigation objectives;
- Construct a website (http://www.coastalresilience.org) that explains the approach, methods, and strategies for Ecosystem-based Adaptation (EbA) to climate change; and
- Identify reasonable and viable alternatives that reduce losses and vulnerability of coastal communities for people and ecosystems.

Approach

At the same time the partnership team conducted an analysis of selected local land use ordinances, regulations, and legal precedents that include specific mention of SLR or that incorporate appropriate policy responses that may be used to address SLR. Finally, meetings of stakeholders were convened throughout this phase to begin discussing how, through interactive decision support important social and ecological characteristics can be compared with sea level rise and storm surge events and visualized within local and state planning processes.

Bringing together local and state managers and planners on Long Island in three community engagement workshops, stakeholders were asked to vet the information and discuss how online spatial information could facilitate better decision making. Participants explored the project's interactive decision support application, the Future Scenarios Mapper, to help visualize flooding given a range of sea level rise and storm surge scenarios. These current and future flood scenarios were mapped alongside socioeconomic and ecological features. The team frequently tested the utility of the application by discussing with stakeholders and decision makers the concept behind the project and eliciting feedback on the design, rollout, training, and ongoing maintenance of the site. Stakeholders were invited back to subsequent workshops when inundation projections and other data became available to discuss the extent of the projected impact, and what it was hoped would be done with the information.

Vegetation plays an important function in stabilizing sand dunes, as here at the Fire Island National Seashore, Long Island, New York.

The collection and analysis of Geographic Information System (GIS) data was a core component of this project, allowing visualization, exploration, and analysis of multi-layered issues influencing coastal resilience.

Conceptual Framework

The Coastal Resilience decision support platform used the following conceptual framework to allow users to plan and adapt to future changes:

> Assess risks of coastal hazards (storms and SLR) to human and natural communities;
> Visualize potential impacts;
> Provide information that allows decision makers to plan and adapt to minimize losses to human and natural communities; and
> Implement potential Ecosystem-based Adaptation (EbA) strategies in local planning processes.

Data Collection, Analysis and Interpretation

Coastal Flooding and Inundation

The elevation data used for mapping came from a LiDAR-based (Light Detection and Ranging remote sensing) digital elevation model provided by Suffolk County Information Services. These high resolution elevation data were used to map sea level rise and storm surge. Providing scenarios for future SLR on the south shore of Long Island under different Global Circulation Model (GCM) simulations and emission scenarios was done by Columbia University Center for Climate Systems Research which is affiliated with the National Aeronautics and Space Administration's (NASA) Goddard Institute for Space Studies. These projections were developed from the best available scientific information about greenhouse gas emissions (IPCC, 2008) and GCMs run by CCSR. The generation of scenarios including global variables (thermal expansion of the oceans due to global temperature increases and changes in the ice mass (including Greenland, Antarctica, and glaciers), and local variables such as land subsidence and local differences in mean ocean density. Project staff generated model probability distributions of SLR in decadal periods from the 2020s to the 2080s. Projections for the 2020s, 2050s, and 2080s were included as options in the mapping tool, labelled as "conservative," "medium," and "high" sea level rise projections that correspond respectively with IPCC scenarios A1b, A2, and A2 plus ice sheet melting (Fig. 2). The methods used to generate these SLR scenarios are described in NPCC (2010, Appendix A).

Historic tide data and the most current storm surge tidal hydrodynamic data were used to develop flood recurrence intervals over time for high frequency floods such as frequencies of 2, 5, and 10 years; and less frequent storms with recurrence intervals of 40 years and more for the study area. These were also mapped onto the LiDAR elevation data. These were also mapped onto the LiDAR elevation data. Local tide data at the Battery and at Montauk gauge stations on Long Island were used to estimate recurrence periods of high water and surges. For storm surge events the team worked both with CCSR and with NOAA-CSC, utilizing National Hurricane Center's Sea, Lake and Overland Surges from Hurricanes model (SLOSH), which estimates storm surge heights and winds resulting from historical, hypothetical, or predicted hurricanes by taking into account pressure, size, forward speed, track, and winds. From the model's outputs Maximum Envelopes of Water (MEOWs) result from the SLOSH model to portray what could happen when a specific storm makes landfall. MEOW Category 2 and 3 Hurricanes, corresponding to storm surges with estimated 40 and 70 year return periods, respectively, were chosen for the Future Scenario Mapper. Including both high-recurrence interval (i.e. "basement flooding" or semi-annual flooding) and storm-induced flooding (i.e. nor'easters or hurricanes) in the Mapper gave stakeholders an array of realistic flood events both in the near term and future by combining them with SLR projections.

Figure 2. Comparing present-day mean high water (left) at Mastic Beach, Long Island, New York, USA, to an A2 sea level rise scenario as provided by the Intergovernmental Panel on Climate Change (IPCC).

Socioeconomic Vulnerability and Risk

Long Island's shores have some of the most highly developed lands in the coastal zone. Much of this private property is only inches above sea level, and even a moderate sea level rise will result in a significant increase in the likelihood of flooding. More significant rise – or the occurrence of a catastrophic storm – could be very costly in economic terms and potentially put many people in harm's way. We compiled and processed socioeconomic information in order to better evaluate the consequences of SLR and storm surge hazards on human populations and infrastructure. A characterization of at-risk communities provided managers with information to explore opportunities to minimize risk.

The project team used population data from the US Census Bureau (2000) to depict these distributions and to create various census block level indices based on demographic attributes such as age, income, and access to critical facilities such as hospitals. In addition, census block-level demographic data were combined with economic data to forecast the potential economic damage of future SLR and floods based on the present-day economic landscape. Supplemental datasets and analyses were included to further strengthen the baseline data upon which coastal managers might assess risk. These datasets included hardened shoreline structures, land use/ land cover information, and critical facilities locations (i.e. hospitals, fire stations).

Ecological Vulnerability

Among the most productive ecosystems on Earth, coastal wetlands and marshes perform many functions that are highly valued by society, often referred to as ecosystem services (Costanza et al., 1997, 2006 and 2008; Hale et al., 2009). Wetlands protect water quality by filtering land-derived nutrients and contaminants, support coastal food webs, provide valuable wildlife habitat, and protect upland and shoreline areas from flooding and erosion associated with storms. The barrier islands that fringe Long Island's south shore provide protection from storms and storm surge for the human communities along the mainland coast, but they also serve as unique habitats for many species. Fire Island (a barrier island complex) provides critical habitat for several rare and endangered species, and serves as a migratory corridor for birds, sea turtles, and marine mammals. Many species depend on the dynamic nature of barrier island beaches, including beach-nesting species such as the federally- and state-protected piping plover.

The project team selected species, habitat types, and ecological communities – including those discussed above – that are either representative of south shore ecosystems, highly sensitive to human disturbance, considered to be of ecological concern, or are afforded some level of regulatory protection. For this study we collected and analyzed data on the piping plover, barrier island habitats, and particularly coastal wetlands and marshes for their protective and ecosystem services.

Healthy, properly functioning wetlands contribute to shoreline protection and erosion control by mitigating the effects of flooding, particularly during large storm events. Erosion, transport, and deposition of sediment allows for natural evolution of beach and dune features, which naturally protect our coastal communities. In many coastal areas artificial structures have disrupted natural sediment movement, thus reducing the protective capacity of these features. This leaves coastal wetlands and dune ecosystems vulnerable to increased wave attenuation and other physical effects. An Ecosystem-based Adaptation (EbA) strategy, however, would call for the restoration of the natural sediment transport process to allow the shoreline and barrier landforms to respond naturally to sea level rise, restoring its protective capacity and reducing long term erosion rates caused by artificial disruptions in the system.

Results

The Coastal Resilience project was designed to highlight opportunities for promoting Ecosystem-based Adaptation (EbA) on Long Island's shores. The Future Scenarios Mapper illustrates sea level rise and storm surge inundation while it highlights areas of human vulnerability and identifying opportunities for natural protection. At the same time, the web mapping application helped identify strategies for maintaining the health of natural coastal systems so that they might continue to protect human communities into the future.

We conducted a series of socioeconomic and ecological analyses using multiple social, economic and natural resource datasets and developed indices that characterized overall human community vulnerability, estimated potential economic loss from coastal hazards, and provided an illustration of coastal wetlands' potential protective capacity and viability.

Socioeconomic Analyses

The socioeconomic analyses summarized the most likely consequences of SLR and storm surge hazards for human populations, ranking vulnerability on a relative scale for the south shore of Long Island. The project team chose demographic attributes that best represented the socioeconomic vulnerability of Suffolk County, and these attributes were combined to create indices that identified human communities at greatest risk from coastal hazards.

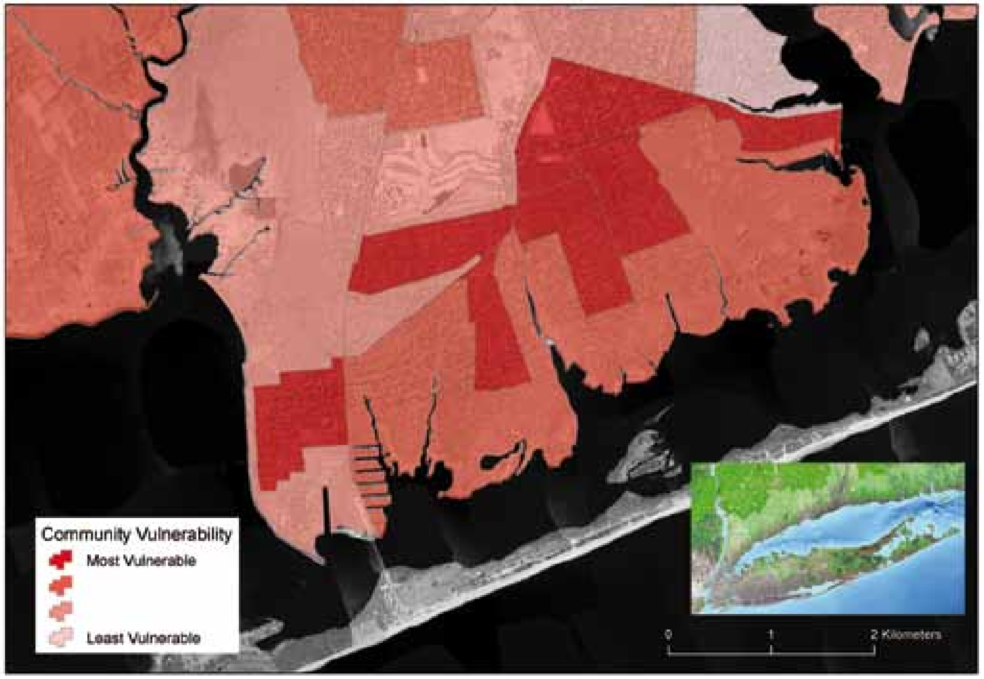
The analyses presented here were based on published risk and vulnerability assessment methodologies, including the Community Vulnerability Assessment Tool (CVAT), the AGSO Cities Project (Granger, 2003), and the Social Vulnerability Index for the United States (Cutter et al., 2003). These methods recommended several variables that characterize social vulnerability, including but not limited to population and population density, housing unit density, median income, households below poverty, those requiring public assistance, those that rent, live on Long Island seasonally, live in mobile homes, and do not have an automobile. These and additional variables were mapped at the census block group scale – the smallest geographical unit for which the census provides detailed demographic data.

A critical infrastructure and facilities index ranked census block groups based on the amount of infrastructure and facilities located within each. Extensive infrastructure related to public safety, communications, utilities, and community facilities increased a block group's vulnerability as communities within and adjacent to it are likely to be highly dependent on the services it provides. Infrastructure and service facilities were counted for each block group, and block groups were then ranked from "most" to "least" vulnerable for inclusion in the index.

An overall community vulnerability index combined the social vulnerability and critical facilities and infrastructure indices to represent the combined vulnerability to flooding of the people, property, and resources in a community. The index was mapped by census block groups in four categories, from "most" to "least" vulnerable (Fig. 3).

Along with these vulnerability indices, sea level rise, storms, and scenarios that combined their effects on economic exposure were

Figure 3. Overall community vulnerability index illustrating the Mastic Beach area, Long Island, New York, USA.



selected to examine economic losses from flooding of infrastructure, including housing, transportation, and commercial structures that are damaged or lost. Economic loss represents the full replacement value of commercial and residential structures. Loss calculations were the result of geographic analysis and display using the Hazards US Multi-Hazards (HAZUS-MH) tool developed by the Federal Emergency Management Agency (FEMA). HAZUS-MH uses GIS software to estimate potential economic losses from earthquakes, hurricanes, and floods.

All of the indices and economic loss calculations can be visualized in the Future Scenarios Mapper by either US census block groups or summarized across towns and villages along the south shore of Long Island.

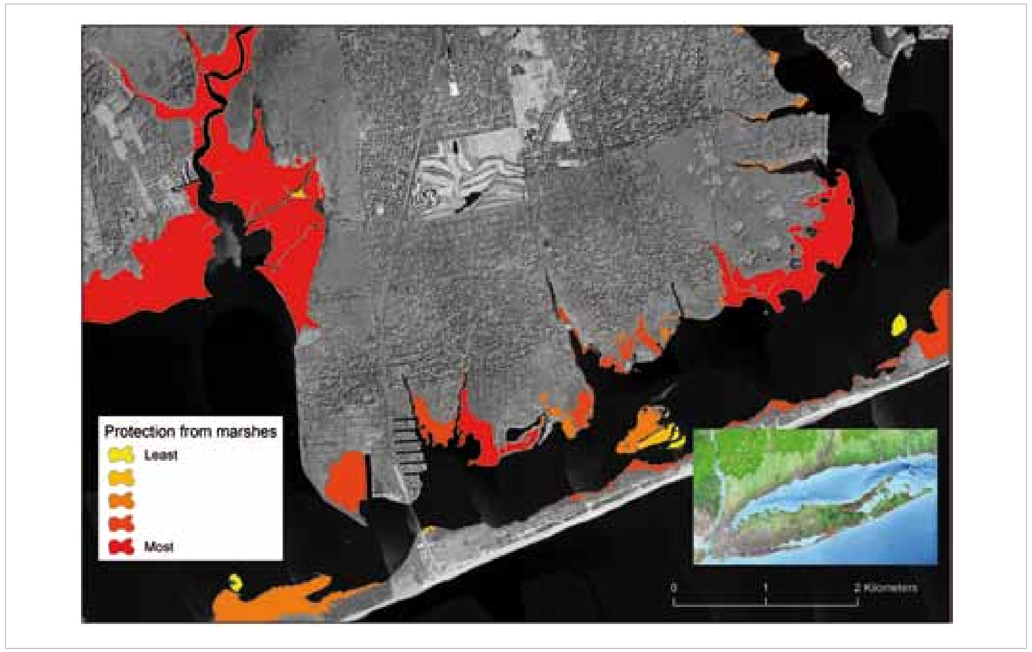
Ecological Analyses

The team conducted a suite of ecological analyses to help estimate the ecological impacts of sea level rise (SLR) and coastal storms on natural resources, with a focus on coastal wetlands. Specifically, relationships between marshes and adjacent lands that either limit or offer space for the potential landward migration of marshes as sea levels rise were examined. In addition, the project team explored the relative potential storm buffering capacities of marshes and their potential to protect coastal communities based on size and proximity to human communities.

Intertidal habitats, including wetlands, require adjacent non-developed space to migrate over time in order to keep pace with rising sea levels; therefore the relationship between marsh distribution and impediments such as roads, land slope, and shoreline hardening was analyzed. A potential marsh viability indicator was calculated by combining the percentage of marsh adjacent to migration impediments, marsh size, and marsh elevation; these results were displayed as a "lower" to "higher" potential viability index.

One of the areas where there are real opportunities for identifying win-win solutions for human and natural communities is in building approaches that combine hazard mitigation and

Figure 4. Potential population protection index for marshes illustrated in the Mastic Beach area, Long Island, New York, USA.



biodiversity conservation in coastal zones to preserve infrastructure while protecting human communities. Coastal wetland ecosystems have the ability to provide protection to these coastal communities. A population protection potential index was calculated as a function of marsh size and proximity to human communities (Fig. 4). Adjacent population was determined by distributing population data from the US Census across Suffolk County parcel data, a process called dasymetric mapping. Housing density values per parcel were used to calculate population density on a sub-census block scale. This index provided a general estimation of a marsh's potential to act as a buffer from flooding and other storm impacts; results were arranged from "less" to "more" protection potential.

Next Steps

The purpose of the Coastal Resilience project is to provide communities – specifically planners and natural resource managers – with easy access to information to assist in coastal planning and management decisions regarding resources at risk from sea level rise and hazards. Coastal Resilience was not designed to promote a specific outcome or agenda; it was hoped that with better information, planners and managers would make decisions that better protected both communities and natural resources. In order to achieve the objective of promoting planning and management of economic, social, and natural resources in the face of climate change, it is essential that planners and managers are aware of the availability of this information and are trained to use it. Consequently, the team designed a three-phase outreach program: the first phase was an expansive overview of the project and objectives described above, the second phase will involve smaller working groups designed for focused, preliminary planning, and the third phase will provide in-depth training tailored for existing, local planning processes.

Following the completion of this first phase of project outreach, we conducted a usability analysis to gauge how workshop participants understood the Future Scenarios Mapper and knew how to use it, and what specific changes would make it more intuitive and applicable to their decision making. The usability test involved working with six workshop participants for an hour each, asking them to complete a series of tasks, and observing what they did. Time to complete each task was measured, and patterns of problems

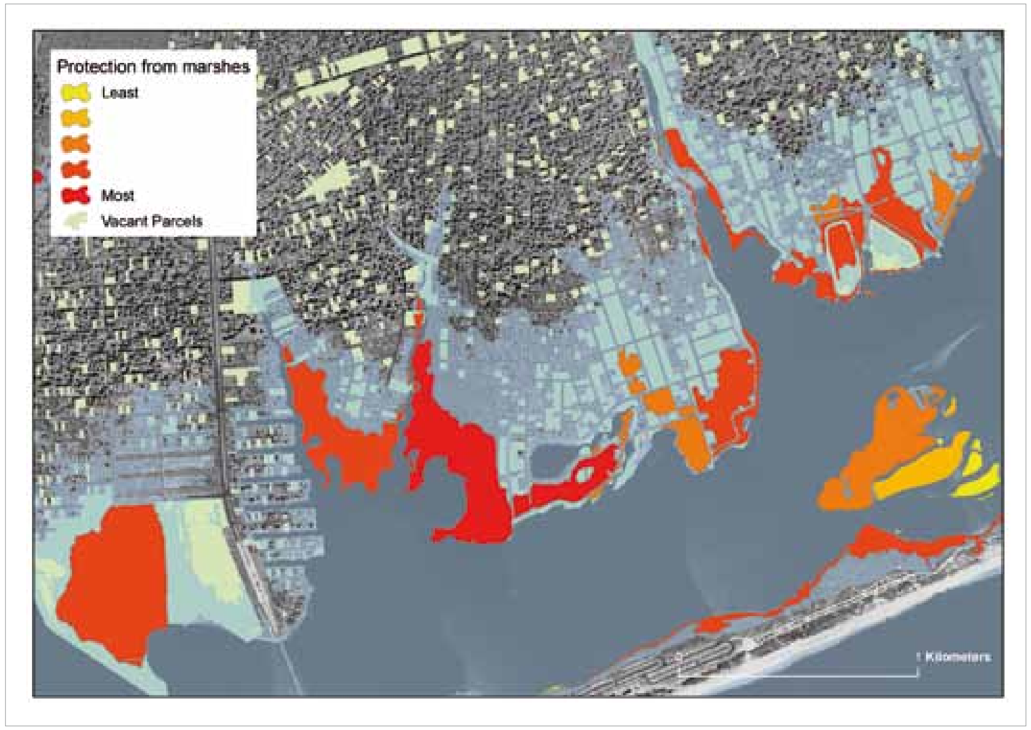
with the training or the interface were identified. The usability analysis served to identify a number of specific technical changes that could improve the use efficiency of the mapping application. In addition, it helped to identify the issues and concerns that the user community had with the overall approach, and impediments to broader use. The overwhelming sentiment among testers was that the application was approachable and friendly. Testers saw value in the mapping application, but many commented that non-planning/science staff would struggle to understand what to do with the information presented therein. Several worried that it might be used by concerned residents to justify shoreline hardening/revetments, or that companies offering such services could exploit the interactive decision support application as a way to foster business.

In the next stages of the project, the team will focus on providing additional functionality for the Future Scenarios Mapper for identifying ecosystem-based shoreline management strategies, to suggest how communities can move away from structural approaches that could adversely impact natural resources. For example, Fig. 5 is an example of how communities can use the Future Scenarios Mapper to identify Ecosystem-based Adaptation strategies to anticipate to future changes. This graphic shows how the Future Scenarios Mapper can be used to identify vacant parcels for conservation, into which marshes could potentially migrate under future SLR scenarios. Further, we will use the results of the usability analysis to make technical changes to the web interface and the mapping application to facilitate the use of Coastal Resilience in on-the-ground planning.

Community Working Groups

We invited several potential users at the local and state level in New York to a working retreat to discuss their own work on sea level rise and how the information in the Future Scenarios Mapper and Coastal Resilience project could inform these planning efforts. Local participants informed us that for many local decision makers, sea level rise was, at most, an ancillary issue. Many local elected officials do not believe that sea level rise poses a

Figure 5. Using the Future Scenarios Mapper tool to identify vacant parcels (light orange) for the conservation of salt marshes (red and dark orange) in the Mastic Beach area, Long Island, New York, USA.



threat; much less think that it should be a major consideration in planning. The state agency participants have somewhat more flexibility to promote planning for sea level rise, but since most land use planning is accomplished by local governments, state agencies generally need a local partner to engage in sea level rise or coastal hazards projects.

Next, the team conducted an internal exercise to evaluate how local decision makers would respond to recommendations for integrating sea level rise projections into existing planning efforts. In this workshop, participants anticipated the responses of local officials in a role-playing exercise, attempting to identify major planning goals, resources of interest, likely impacts of several SLR and storm scenarios on these resources, and likely response.

Local governments have multiple objectives in shoreline management and planning. First, local governments wish to protect human health, life and property. Second, the towns are interested in protecting natural resources, both for their own sake, and for their value in protecting human health, life, and property. Although some argue that these values are in conflict, in the case of sea level rise planning, in many places this is an inaccurate characterization. Adaptation strategies that aim to enhance the resilience of ecosystems to enable the continued provision of goods and services can be particularly important for vulnerable communities that are often directly dependent upon natural resources. A growing body of evidence suggests that EbA can be a cost-effective strat¬egy across sectors (Campbell et al., 2009). In addition, EbA strategies often address multiple coastal management objectives. An ecosystem-based approach of protecting and restoring “green infrastructure” like healthy coastal wetlands could be a more cost-effective, lower-maintenance means of protecting large coastal areas (Moberg and Ronnback, 2003). In any case, it is generally agreed that natural resources are among the interests that local officials are charged with protecting.

An important principle illustrated by this planning exercise is that doing nothing (sometimes called the no-action alternative) needs to be explicitly considered when weighing alternative strategies for jointly managing community and ecological resources. The no-action alternative is the most likely alternative in places where income levels are too low for sustained private investment in shoreline protection and people are not well connected to political processes that might ensure a government financed project. This alternative would result in no protection for coastal natural resources, and the gradual abandonment of nearshore property, with tax-default parcels reverting to local governments. These governments would then be left with the expensive task of remediating the waste disposal systems on waterfront lots and restoring them. Failure to do so would likely result in a water quality catastrophe when a major storm hits the area. Because this is an undesirable outcome, local officials might be convinced to act.

The next step is to bring together teams of planners and natural resource managers from a subset of town governments to undergo this hypothetical planning exercise for areas within their jurisdictions. The purpose of this workshop will be to ground truth the outcomes of our internal exercise, and to generate interest in the more in-depth planning process described below.

Engagement in Local Planning

The final stage is the development of adaptation plans specific to local communities’ needs and priorities. Such plans may be stand-alone sea level rise/coastal hazard adaptation plans, but they are more likely to be components of pre-existing planning processes, like comprehensive plans, wetlands management plans, or other resource management plans. In furtherance of this goal, the team will develop a hands-on process whereby local officials, community leaders, and other key stakeholders integrate hazard and sea level rise risk information into their specific local planning and decision-making activities. Participants will target specific priority hazards and SLR issues and identify locally feasible and sustainable mechanisms for addressing those issues (infrastructure, land use, transportation, community development, and natural resource planning and policy frameworks).

As noted above, the local leaders we have worked with are not always inclined to affirmatively tackle SLR as a stand-alone issue. Accordingly, we are seeking towns that were undergoing pre-existing planning processes, and trying to integrate SLR issues and potential EbA strategies into those processes.

Conclusions and Recommendations

Coastal towns and villages on Long Island are well aware of the threats climate change poses to their communities. They are willing to explore different climate change strategies including Ecosystem-based Adaptation. Although an increasing number of states and local governments are beginning to consider the effects of climate change, only a small number have specifically addressed SLR and its impacts. A leading example of this is found in New York City (NPCC, in press).

The information presented by the Coastal Resilience Project’s web mapping application is intended to advance land use, natural resource management, and emergency response planning when considered and applied according to the needs of local communities on Long Island. This information is critical, but actual adaptation to SLR on the ground will require substantial changes in our present shoreline management paradigm. We are actively pursuing a five-part approach for designing and implementing EbA strategies on Long Island and in other geographies:

1. Amending and passing key legislation: Most shoreline management regulations and laws at the federal, state, and local level

Coastal settlements, such as the Long Island Barrier Islands, are particularly vulnerable to sea level rise.

predate the current understanding of the implications of coastal climate change. Amendments that address the realities of SLR at the federal level with respect to the Coastal Zone Management Act, the National Flood Insurance Program, and the various FEMA Hazard Mitigation Programs would increase the ability to both plan for and fund EbA at the regional, state, and local levels. Numerous local and state statutes and ordinances regulating development and natural resource management should be revised to reflect the changing boundaries of the shoreline and adjacent wetlands.

2. Promoting voluntary land acquisition: The passage and/or amendment of progressive adaptation legislation at the federal and state level should provide financial incentives to local governments to enable the voluntary acquisition of coastal property as a means to protect human life and permit natural, sustaining processes to occur in the coastal zone.

3. Relocating vulnerable infrastructure and development: In some cases where risk to human communities is extremely high and/or nature can adapt to rising sea levels by migrating landward, moving vulnerable infrastructure may be necessary.

4. Engaging in comprehensive, post-storm redevelopment planning: Adoption of post-storm redevelopment programs at the local level should be considered as an opportunity to remedy previous land-use decisions that did not address current and longer-term risks and costs attributable to climatic change. The recognition of and need for post-storm redevelopment adaptation strategies should be reinforced and enabled through the federal programs mentioned above.

5. Restoring and protecting natural resources: Central to the advancement of coastal adaptation approaches is the need to invest in restoration and protection of natural resources. Healthy, properly functioning natural shorelines and tidal marshes provide buffers that mitigate storm damage and dampen the impact of tidal surges. A continued and sustained investment in natural resources will provide a return of important ecosystem services and increased nature-based solutions for shoreline protection and erosion control.

In many cases, a successful approach will require the integration of multiple strategies to achieve the desired goals.

The Coastal Resilience project represents a platform for providing information to local communities, but it is also relevant at state and national scales. Building the case for coastal resilience will require local, state, and national integration and coordination, with the premise that what occurs locally can both inform and be informed by state and national policy. By focusing first on local decision makers, we address the needs of stakeholders within their communities while providing a robust framework for identifying place-based ecological, social, and economic relationships and appropriate coastal adaptation solutions. Careful deliberation with regard to the combination of feasible adaptation approaches and the appropriate scales for implementation require greater emphasis at multiple governance scales.

Human and natural communities will need to adapt in order to survive. Mutually beneficial solutions for human and natural communities lie in examining relationships between coastal hazard mitiga¬tion and biodiversity conservation to preserve infrastruc¬ture and livelihoods while protecting nature. Reducing coastal losses to people and nature, and clearly recognizing that decision makers will address people's needs first, the team proposes here that common ground can be reached with ecosystem-based solutions. The well-being of coastal communities is so closely linked to the natural environment that many of the strategies that will protect natural resources in the face of global warming will also enhance the resilience of human communities. At this stage in Ecosystem-based Adaptation, efforts are required

to integrate climate science and inundation scenarios with local decision making. This work is just beginning; the present project is one of the first to attempt this integrated approach.

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