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Modeling Climate Change Mitigation Strategies for Coastal Communities Using GIS

MODELING CLIMATE CHANGE MITIGATION STRATEGIES FOR COASTAL COMMUNITIES USING GIS

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This project uses parcel-level GIS analysis to evaluate the costs and benefits of alternative adaptation strategies for coastal-resiliency. The project provides coastal communities the costs and benefits of specific policy options that are available to mitigate the risk of flood damage. It measures how those costs and benefits will change with sea level rise, and it shows the importance of more detailed local studies to guide specific policy decisions.

As Hurricane Irene demonstrated recently along the Eastern seaboard, even a relatively mild storm can cause enormous damage to coastal communities. Strauss et al. (2012) estimate the number of people that could be affected by rising sea levels, finding for example, that 1.6 million coastal residents in Florida live on land less than one meter above the mean high water mark. When coastal properties become uninhabitable and roads impassable due to flooding, the entire community sees the loss of economic output.

Today, most coastal communities face few planning decisions that would convert undeveloped land to new development. Rather, the likely scenario is rebuilding after a disaster, most likely a hurricane. Landowners face a choice after storm damage: to rebuild a pre-storm structure, or pursue other options. Coastal communities need to be prepared with flexibility, options and desirable alternatives for the landowner. By having the building blocks in place in advance, a landowner can weigh the outcomes and determine if building elsewhere may be in his or her best interest. There are policy tools currently available to communities that can be used to guide development and mitigate the risk of flood damage over time. Communities with clear objectives to achieve coastal resiliency have tools at their disposal. Coastal resiliency implies reducing the risk of loss of life and property, and reducing the municipal costs of servicing coastal properties and infrastructure. In both cases, gradually transferring density from high risk areas provides a clear transition process for both the property owner and community.

Two Florida counties, Martin and Okaloosa, were chosen as pilots to evaluate alternative strategies to reduce risks from storm surge and sea level rise to private property and citizens. Martin County is a coastal county on the Atlantic Ocean with a population of 146,000, while Okaloosa County is on the Gulf with a population of 180,000. Mitigation alternatives evaluated included ownership based strategies such as easements or buyouts, incentive strategies such as transfers of development rights, and physical protection strategies such as armoring. Benefit to cost ratios were calculated for each parcel and compiled by alternative. The analysis addressed parcel-specific characteristics such as property value, land use type, topography, environmental impacts, and proximity to roads, water, and other amenities. GIS analysis was used to estimate the economic benefits and costs at the parcel-level, in order to determine the elements that make a

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strategy feasible and to determine the value of incentives necessary to successfully implement specific mitigation policies. Over 6,000 parcels in the Coastal High Hazard Area (CHHA) in both counties were analyzed. Results were summarized using histograms to show the distributions of results of each alternative.

Estimates show that under current conditions all strategies are viable (that is, benefits exceed costs) for some parcels, but each strategy does not apply to all parcels. In addition, the viability of a particular strategy varies widely across each county. Some ownership-based approaches, (conservation easements, and rolling easements) have very high average returns, but have relatively few applicable candidates. Conservation easements, for example, accrue high value for environmental benefits at relatively little cost to the community, generating average benefit to cost ratios over 50 to 1. This policy alternative, however, is only applicable to 14 percent of the parcels in Okaloosa County's Coastal High Hazard Area.

Incentive-based strategies (transfers or purchase of development rights) are a good option for most property types and parcels. Purchase of development rights is a feasible option for as many as 70 percent of the parcels in Martin County's CHHA, with an average return over 3 times larger than costs. In contrast, physical protection such as coastline armoring showed slightly positive benefit ratios on 35 percent of parcels, but no parcels showed high returns.

A policy's viability depends in part on property values, but a more important factor is how close the parcel is to valuable amenities such as the beach, conservation areas, and parks. The results show that policy makers have many options; most parcels in the High Hazard Area have multiple strategies that are viable under current conditions.

Costs and benefits were estimated for future conditions of sea level rise as well as under current conditions. Future conditions were modeled by migrating and mapping the CHHA landward based on a one meter increase in inundation. This level of inundation is consistent with published guidelines used by the Army Corps for infrastructure decisions in Florida. Under these conditions, the number of viable strategies declines precipitously as the locations of amenities migrate and many parcels are inundated. In Martin County, 14 percent of parcels have no viable policy alternative before Sea Level Rise, but that share rises to 84 percent after inundation. In Okaloosa County, the 3 percent of parcels with no viable strategy initially increases to 76 percent after inundation. Among the parcels that continue to have viable strategies, those parcels that currently have the highest number of viable strategies continue to have the highest number of strategies in the future, although the absolute number of options is smaller. Parcels that currently have few viable options tend to have even fewer options in the future.

One of the most important factors determining the number of viable options is the proximity of the property to amenities that are valuable to the community, such as beaches, or wetlands. Those properties that are not near such amenities now are not likely to be near them in the future. On the other hand, properties that are near such features may become even closer. A property that was not waterfront property before, but is under future conditions, receives social amenity values associated with waterfront property.