Addressing Coastal Vulnerabilities Through Comprehensive Planning

How RAND Supported the Development of Louisiana’s Comprehensive Master Plan

According to the U.S. Census Bureau, U.S. coastal counties have grown by more than 45 percent between 1970 and 2010, amounting to 50 million new coastal residents and billions of dollars in additional assets (homes and businesses) in these areas. Coastal residents are vulnerable to many potential risks, including damage to human life and property that result from storm flooding. And the increasing concentration of people, property, and other activities in coastal areas can itself contribute to the problem by removing or diminishing wetlands, barrier islands, and other features that serve as natural buffers to storm surges.

The Gulf Coast has borne a substantial portion of the damage from coastal storms in recent decades. For example, Hurricanes Katrina and Rita in 2005 and Gustav and Ike in 2008 collectively caused approximately $150 billion in damage to Louisiana, Mississippi, and other Gulf Coast states. But these coastal risks are also prevalent in other areas, as shown by the massive damage and disruption that “Superstorm” Sandy caused to the people, homes, businesses, and infrastructure of coastal communities along the Eastern Seaboard.

Coastal risks may increase as the climate warms. Sea levels are anywhere from 6 to 12 inches higher now than a century ago and continue to rise at a rate of more than an inch per decade. Current projections suggest that the rate of sea-level rise will continue to increase because of warming oceans and melting glaciers, leading to sea levels from 8 inches to as much as 4–6 feet higher than 1990 levels by 2100. Such increases, when combined with coastal tides and storm surge, will likely dramatically increase the risk of floods to coastal residents and property. And warming sea surface temperatures and changing climate patterns could also either intensify future tropical storms and hurricanes or make large and powerful hurricanes more common.

Reducing the vulnerability of coastal communities to these threats is challenging, given both the scale of the problem across broad geographic regions and uncertainty about the specific nature of the risk. Several restoration efforts in the United States have begun to take more-comprehensive planning approaches to addressing such challenges. Those in the Florida Everglades, Chesapeake Bay, and San Francisco Bay Delta regions are notable recent examples. But such efforts have not yet led to a broadly applicable methodology for identifying and reducing coastal vulnerabilities to climate change.

A Comprehensive Plan for Coastal Louisiana

Although the challenges that coastal Louisiana faces are not unique, the region is a prime example of the need to address coastal planning challenges in a comprehensive way. In Louisiana, storm-surge flood-risk challenges are exacerbated...
by the loss of land brought on by how the Mississippi River was managed during the past century. Coastal Louisiana is on an unstable path of ongoing land loss. Since the 1930s, 1,800 square miles of land have been lost to open water, and more will be lost in the next 50 years. Spurred on by the devastating effects of Hurricanes Katrina and Rita in 2005, the State of Louisiana, through its Coastal Protection and Restoration Authority (CPRA), decided to simultaneously and systematically address both coastal flood risk and ongoing coastal wetland loss by developing Louisiana’s Comprehensive Master Plan for a Sustainable Coast.1

This Master Plan defines a set of coastal risk-reduction projects (structural projects, including levees, and nontstructural projects that reduce flood damage to residential and commercial structures by, for example, elevating structures) and restoration projects (such as bank stabilization, sediment diversions, and barrier island restoration) to be implemented over the next 50 years to reduce hurricane flood risk to coastal communities and to restore the Louisiana coast.

**RAND Contributed to a Comprehensive Planning Approach in Louisiana**

Given the large number of potential projects, the range of stakeholders with competing interests and objectives, and the significant and deep uncertainties to be considered, CPRA asked RAND to support the development of the Master Plan by helping to develop a science-based, objective approach to identify a comprehensive strategy of investments in risk-reduction and restoration projects to address the coast’s problems.

Figure 1 provides a simplified flow chart showing the overall approach RAND helped to develop. The approach starts by applying a suite of seven interconnected predictive models to estimate the effects that hundreds of proposed projects could have over the next 50 years on expected annual damage (EAD), land building or land loss, and ecosystem services. The predictive models evaluated the effects of each project for two future scenarios that reflect different assumptions about future sea-level rise, the rates at which coastal land subsides (through sediment compaction and other processes), and other key uncertainties about the future: a moderate one that assumes low to moderate sea-level rise and subsidence rates, and a less optimistic one that assumes much higher values for each.

RAND developed one of these predictive models, the Coastal Louisiana Risk Assessment Model (CLARA), which is designed to estimate flood depths and damage that would occur from major storms (see box).

The estimated project effects serve as inputs into the Planning Tool, which RAND researchers developed to identify potential alternatives (groups of projects) that could make up the 50-year Master Plan. The Planning Tool uses an optimization model to identify alternatives that both minimize coast-wide risk to economic assets through risk-reduction projects and maximize coast-wide land building through restoration projects, subject to planning constraints related to available future funding, sediment availability, and Mississippi River flows.

RAND researchers used the Planning Tool to formulate hundreds of potential alternatives based on project effects and on the preferences of CPRA senior management and a 33-member stakeholder group consisting of representatives from business and industry; federal, state, and local governments; nongovernmental organizations; and coastal institutions.

A key part of the Planning Tool, as shown in Figure 1, is interactive visualizations that present estimates of how alternatives would or would not achieve CPRA’s goals. These visualizations allowed CPRA and stakeholders to review and understand the trade-offs among the alternatives during the deliberation process. For example, the Planning Tool enabled stakeholders and decisionmakers to change different input variables—such as the environmental scenario, preferences for ecosystem service outcomes, and specific funding constraints—to understand the effects of these changes on key outputs of interest, such as damage reduction or land building over time.

The Planning Tool was used to identify a final alternative that struck an acceptable balance of investments across different types of projects, coastal regions, near-term and long-term risk reduction and land-building benefits, and projected future ecosystem services. This group of projects was then reevaluated together using the predictive models to better understand synergies or trade-offs among the selected projects.

**RAND’s Approach Helped Louisiana Identify a Plan That Will Succeed in Different Future Scenarios**

Deep uncertainty is a key characteristic of the decisions Louisiana planners faced when developing the Master Plan. In particular, how would the chosen Master Plan perform in terms of risk reduction in either of the two different scenarios (with different assumptions about sea-level rise and other uncertainties) 50 years in the future?

Flood-damage results developed with CLARA show that storm-surge flood damage represents a major threat to coastal Louisiana and that, if no action is taken, this damage can be expected to grow significantly in the future (Figure 2). The increase in flood damage, however, varies substantially by scenario. For instance, in 2061, EAD is projected to increase to between $7 billion and $21 billion in the future without action, depending on the scenario (purple bars). But, with
the Master Plan in place, this damage level is reduced to between $3 billion and $5 billion for the two scenarios (beige bars). This corresponds to a reduction of approximately 60 to almost 80 percent compared with flood-damage levels in the future without action.

**RAND Helped Louisiana Evaluate Trade-Offs Between Different Restoration Approaches**

One of the key benefits of Louisiana’s Master Plan approach is the use of objective, scientific information, such as the results generated from the predictive models (e.g., CLARA), within a quantitative framework that enables the development and comparison of different strategies and supports deliberations among them. Interactive visualizations are useful to ensure that decisionmakers understand the key trade-offs among strategies.

For example, because land building is an important goal, the Planning Tool identified a series of sediment diversion, marsh creation, and other restoration projects that are likely to lead to the most land building over the 50-year planning horizon. This alternative includes several large
sediment-diversion projects. But policymakers face other decision criteria beyond maximizing land building. One key criterion is preserving habitat for different species of aquatic life in the Gulf, and large sediment diversions can affect that habitat. This is because such projects, which are very effective at building land in the long term, also decrease the salinity of shallow wetlands where many aquatic species spend a portion of their lives.

This trade-off is reflected in Figure 3, which shows changes in land in square miles from 2012 to 2061, along with the likely effects on habitats of saltwater aquatic species. The “without action” alternative results in the significant loss of about 700 square miles and shows a slight increase in the saltwater species habitat. The “maximize land building” alternative, conversely, leads to stabilization of coast-wide land area over time but would lead to a significant decline in the saltwater species habitat. The Planning Tool also created another alternative: “maximize land without diversions.” Although this alternative leads to only a slight decline in the saltwater species habitat, it would not achieve the state’s objective of stabilizing the coast-wide land area. This trade-off analysis led the state to consider additional alternatives (not shown here) in which sediment diversions were used, but sparingly, to strike the right balance between land building and support for all aquatic habitats.

The visualization tool does not tell policymakers which alternative to choose. Rather, it allows them to visualize what the trade-offs are in choosing one alternative over another. In deciding on the Master Plan, policymakers actually needed to understand the implications of trying to balance multiple decision criteria (not just saltwater species habitat) relative to the ultimate goal of the sustainability of the landscape.

**RAND’s Approach Helped Louisiana and Can Benefit Other Regions**

This work provides a successful example of how integrated, objective, analytic-based planning can address pressing coastal challenges. By using RAND’s analytic approach, CPRA was able to develop a $50 billion 50-year Master Plan. The planning processes helped CPRA and stakeholders grapple with tough trade-offs between “hard” (infrastructure) and “soft” (restoration and nonstructural mitigation) approaches to coastal resilience and sustainability. Concurrently, it helped CPRA consider how different future scenarios would affect the success of different approaches.

The resulting Master Plan is the first comprehensive solution for Louisiana’s coast to receive broad support from the Louisiana public and the many agencies—federal, state, and local—engaged in protecting the Gulf Coast. It passed the Louisiana legislature unanimously in May 2012 and is currently being implemented. And, with the analytic infrastructure in place, this approach will also help as CPRA takes steps to secure long-term funding, refine its near-term implementation strategy, and adapt the Master Plan over time as assumptions change.

There are several key principles that emerge from this work that will be beneficial for other coastal planning efforts:

- Identify integrated risk-reduction strategies designed to reduce future damage and postdisaster recovery costs.
- Use quantitative models based on the best available scientific information to evaluate risks under many scenarios reflecting uncertainty about the future.
- Identify key vulnerabilities, evaluate both soft and hard infrastructure-based strategies to reduce these vulnerabilities, and seek strategies that are robust to future uncertainty.
• Provide real-time information to decisionmakers and stakeholders at key decision points by using interactive visualizations to display uncertainties, outcomes, and trade-offs.

Coastal Louisiana is only one of many areas of the nation dealing with such challenges. The Mid-Atlantic states, for one, are currently facing similar challenges in planning for a more resilient coastline after Superstorm Sandy. The application of this approach and these principles can help that region assimilate different goals or points of view and disparate and potentially conflicting technical analyses into a framework to identify a robust strategy for recovery and future risk reduction. Other coastal areas could also benefit from the application of this approach, including the State of California as it seeks to address its vulnerability to sea-level rise and other threats to its Sacramento–San Joaquin River Delta.

Notes


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