China and US Case Studies: Preparing for Climate Change

Louisiana: Addressing Sea-Level Rise

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China-US Case Studies Project: This report is part of a series of six case studies ((http://www.georgetownclimate.org/US-China-case-studies) that explore how subnational actors (municipalities, states, and special administrative regions) in the United States and China are building resilience to natural hazards, extreme weather, and climate change. These case studies examine efforts to adapt to impacts in three U.S. and three Chinese jurisdictions, including efforts to prepare for: (i) increasing coastal flooding due to more frequent and intense coastal storms and rising sea levels in coastal Louisiana and Shanghai; (ii) increasing water scarcity in Austin, TX, and Beijing; and (iii) increasing heat waves and urban heat islands in Washington, DC, and Hong Kong. These case studies are oriented toward building resilience to the weather and climate related impacts being experienced in each jurisdictions; these actions are not always explicitly linked to climate change, and we do not evaluate the effectiveness or appropriateness of the specific activities undertaken by each jurisdiction.

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Introduction

The Mississippi River Delta in coastal Louisiana faces significant risks of the combined effects of sea-level rise and land subsidence. The state's vulnerability was brought into sharp relief when Hurricane Katrina came ashore on August 29, 2005, causing substantial loss of life and damage to communities, infrastructure, and coastal lands in Louisiana and the Southeast region of the United States.

Scientists agree that damaging extreme weather events are likely to become more frequent and more intense with climate change.[1] As sea levels rise, impacts from these storms will become more devastating with higher storm surges that are driven further inland.[2] These impacts are exacerbated by land

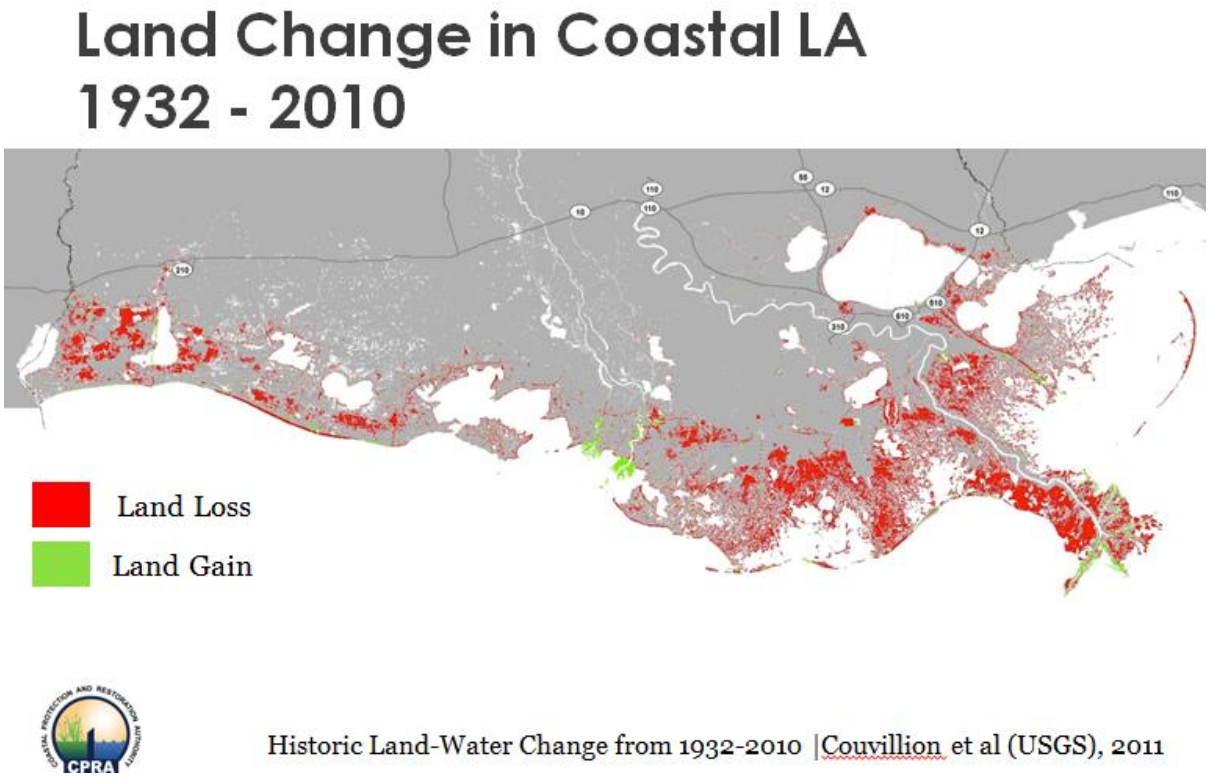
* Research Contributed by Emily Rose and her case study "Louisiana Climate Change Adaptation Initiatives," and by Llewelyn Engel and her case study "Efforts to Mitigate Greenhouse Gas Emissions In Louisiana," both submitted for Professor Vicki Arroyo's course Advanced Environmental Law: Climate Change Practicum at the Georgetown University Law Center.

[1] Lynne M. Carter et al., *Chapter 17: Southeast and the Caribbean*, *in* CLIMATE CHANGE IMPACTS IN THE UNITED STATES: THE THIRD NATIONAL CLIMATE ASSESSMENT 397 (J.M. Melillo et al. eds., U.S. Global Change Research Program 2014). [Ch 17: Southeast and the Caribbean, National Climate Assessment].

[2] *Louisiana's 2012 Coastal Master Plan,* THE STATE OF LOUISIANA, http://www.coastalmasterplan.louisiana.gov/whats-at-stake/coastal-crisis/ (Last visited March 20, 2015).

subsidence[3] which has caused coastal Louisiana to lose over 1,880 square miles of land (an area roughly the size of the state of Delaware) over the last 80 years.[4]

In this case study, we explore Louisiana's adaptation activities, examining how some state agencies and local governments have begun to prepare for impacts from more intense storms, sea-level rise, and land loss.



Map of historic land loss along the Louisiana coast.
Image credit Louisiana Coastal Protection and Restoration Authority, 2012 Coastal Master Plan.

Background

Louisiana is one of the states that is most vulnerable to sea-level rise in the Southeast region,[5] due to its location in a subsiding deltaic landscape on the Gulf Coast, its high rate of land loss, and its economic

[3] Land subsidence occurs when sediment compacts and falls in on itself, due to tectonics, sediment loading, ground water, oil or mineral extraction, or surface water drainage Brendan Yuill, Dawn Lavoie, and Denise J. Reed, *Understanding Subsidence Processes in Coastal Louisiana,* JOURNAL OF COASTAL RESEARCH: SPECIAL ISSUE 54: 23 – 3, available at http://www.jcronline.org/doi/full/10.2112/SI54-012.1 .

[4] *Louisiana's 2012 Coastal Master Plan,* THE STATE OF LOUISIANA, http://www.coastalmasterplan.louisiana.gov/whats-at-stake/coastal-crisis/ (Last visited March 20, 2015).

[5] *Louisiana's 2012 Coastal Master Plan,* THE STATE OF LOUISIANA, Ch 17: Southeast and the Caribbean, National Climate Assessment, 401, available at http://www.coastalmasterplan.louisiana.gov/whats-at-stake/coastal-crisis/ .

reliance on coastal resources.[6] Louisiana is home to approximately 4.65 million residents.[7] With 43,204 square miles of land, the state has a population density of 104.9 people per square mile, placing it around the median of US states in this regard. As of 2012, 18.7 percent of residents lived below poverty level,[8] a higher proportion than the U.S. average of 15 percent.[9] Much of the economy in Louisiana, like most of the US Southeast, relies heavily on the energy sector, and a significant portion rests on tourism in New Orleans and the rest of the state's coastal area.[10]

The state, along with the Southeast generally, is vulnerable to sea-level rise, extreme heat, hurricanes and storm surges, flooding, extreme rainfall, and decreased freshwater availability. Louisiana has already felt the impact of climate change on its economy, infrastructure, and communities. According to the National Climate Assessment, over the past thirty years Louisiana has experienced 36 to 44 weather and climate-related events causing $1 billion or more in damages (the second highest for the Southeast region).[11]

In addition to storm damage, the state has suffered ongoing land loss, exacerbated by storm surge and sea-level rise.[12] Scientists estimate that without action, 1,750 more square miles of land will disappear by 2064.[13] About 40 percent of coastal wetlands in the continental US are located in Louisiana, and at a loss rate of 40 square miles of marsh per year in recent decades, Louisiana's diminishing coastline accounts for 80 percent of annual coastal land loss in the US.[14]

This catastrophic land loss crisis has effects across the coast from large urban areas to smaller towns and native tribal communities. Tribal populations in the state are especially vulnerable to land loss, as they rely on the land not only for housing but for hunting, sacred places, healing plants, habitats for critical wildlife, ability to sustain agriculture, and in many cases, connectivity to the mainland. Tribal communities in Southeast Louisiana such as Grand Bayou Village, Grand Caillou/Dulac, Isle de Jean Charles, and Pointe-au-Chien have experienced land loss impacts in full force, and in some cases have been forced to migrate when tribal lands are flooded.[15]

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[6] *Id.*

[7] *State and County Quick Facts: Louisiana*, UNITED STATES CENSUS BUREAU, http://quickfacts.census.gov/qfd/states/22000.html (Last visited March 20, 2015).

[8] *Id.*

[9] *Poverty: Highlights*, UNITED STATES CENSUS BUREAU, https://www.census.gov/hhes/www/poverty/about/overview/ (Last visited March 20, 2015).

[10] Ch 17: Southeast and the Caribbean, National Climate Assessment, 397.

[11] *Id.*

[12] *Id.*

[13] George Hobor, Allison Plyer, and Ben Horwitz, *The Coastal Index: The Problem and Possibility of Our Coast*, THE DATA CENTER, http://www.datacenterresearch.org/reports_analysis/the-coastal-index/ (Last visited March 16, 2015).

[14] *Louisiana Coastal Wetlands Planning, Protection and Restoration Act Program: About CWPPRA,* CWPPA, http://lacoast.gov/new/About/ (Last visited March 20, 2015). There are other factors contributing to the Louisiana land-loss crisis. Much of the state's coastal land is wetland, and the federal levee system and river management practices have deprived the coast of the freshwater and sediment needed to replenish wetlands. Land loss is also related to the energy industry. Erosion and salt water intrusion from dredging canals through marshes for oil and gas exploration and the building of pipelines as well as subsurface oil extraction has also contributed to land loss.

[15] Ch 17: Southeast and the Caribbean, National Climate Assessment, 398.

As a port city already lying mostly below sea level, New Orleans is particularly vulnerable; but the city also has a strong system of defenses given recent investments.[16] The U.S. Army Corps of Engineers is managing the Greater New Orleans Hurricane and Storm Damage Risk Reduction System (HSDRSS), an infrastructure system that provides New Orleans with defense against a 100-year storm. The project is still underway, but the Army Corps had strengthened the 133-mile Greater New Orleans perimeter system of gates, levees, flood walls, and pump stations, and improved approximately 70 miles of pumps, levees, floodwalls, and other barriers within the City's boundaries. Funding for the HSDRSS was authorized by Congress after Hurricane Katrina in 2005.[17]

The effects of climate change that are already being felt in Louisiana are only expected to increase. Climate change projections for the region include increased annual average temperatures, sea-level rise, and more intense storm events. This includes a projection for 30 to 40 more hot days (temperatures above 95 °F) annually,[18] and a projected decrease in cold days (temperatures below 32 °F).[19] The state is also anticipating between 0.8 to 1.5 feet of sea-level rise by 2061 according to the Coastal Protection and Restoration Authority's coastal master plan, *Louisiana's Comprehensive Master Plan for A Sustainable Coast* (discussed in more detail below). Sea-level rise is expected to exacerbate economic damage from flooding along the Gulf Coast. Coastal Louisiana, Alabama, Texas, and Mississippi already face an average of $14 billion each year from damage caused by hurricanes, land subsidence, and flooding.[20] This cost is expected to increase to $18-23 billion per year by 2030, depending on different hurricane and sea-level rise scenarios.[21]

Sea-level rise can have devastating consequences on infrastructure and the economy for the region. It contaminates freshwater supplies with saltwater and puts strain on communities' drinking water resources and water supplies for energy utilities. According to a study by Entergy Corporation quantifying climate risks to the Gulf Coast, the area could face a cumulative $350 billion in economic losses by 2030. As of 2010, the Gulf Coast experienced approximately $14 billion in annual losses.[22] To fund key infrastructure projects, including levees and wetlands for flood protection, Entergy estimates that $44 billion in public funding and $76 billion in private funding will be required over the next 15 years.[23]

Impacts to Louisiana will also have ripple effects throughout the national economy. The Gulf accounts for about a quarter of domestic oil and gas production and these industries are particularly strong drivers of the Louisiana economy.[24] The state's total oil production reached 65.2 million barrels onshore and

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[16] *Id.*

[17] *Hurricane & Storm Damage Risk Reduction System,* US ARMY CORPS OF ENGINEERS, http://www.mvn.usace.army.mil/Missions/HSDRRS.aspx (Last visited March 19, 2015).

[18] Projection for 2041-2070 compared with historical climate from 1971-2000. Ch 17: Southeast and the Caribbean, National Climate Assessment, 399.

[19] *Id.* at 400.

[20] Ch 17: Southeast and the Caribbean, National Climate Assessment, 400.

[21] *Id.*

[22] *Building a Resilient Energy Gulf Coast: Executive Report,* ENTERGY CORPORATION, 1 (2010), available at http://www.entergy.com/content/our_community/environment/GulfCoastAdaptation/Building_a_Resilient_Gulf_Coast.pdf.

[23] *Id* at 10.

[24] Ben Geman, *Hurricane Could Shake Offshore Policy Debates,* E&E News: Greenwire (August 30, 2005), http://www.eenews.net/greenwire/stories/29001/search?keyword=katrina

6.76 million barrels offshore in 2013,[25] making it the third largest producer of petroleum in the United States.[26] The state is also the second largest producer of natural gas in the US.[27] According to the Minerals Management Service, when Katrina struck, 83 percent of Gulf Coast gas production and 92 percent of Gulf Coast oil production had to be immediately shut down.[28] Louisiana State Highway 1 (LA-1), which provides a critical land-based route for delivering oil and gas,[29] is also highly vulnerable to impacts. The highway is sinking and it will become increasingly vulnerable to damage from flooding and storm events as sea levels rise.[30] A Department of Homeland Security report estimated that a 90-day shutdown of this highway due to a severe flooding event would cost the US economy $7.8 billion.[31]

Shutdown of LA-1 would also have devastating effects on local economies. At the end of LA-1 is Port Fourchon, which is the terminal for shipping oil and gas supplies. As the hub of energy production in the Gulf, Lafourche and the other parishes surrounding the port could face up to $3.9 billion in GDP losses if the port were to close for 90 days.[32] There is an effort to elevate LA-1, as the highway is at risk of tidal inundation and frequent wash-out due to sea-level rise and coastal storms. The LA-1 Coalition is a local non-profit organization in Lafourche Parish that has raised private and government funds to elevate seven miles of the highway between Leeville and Port Fourchon. Further extensions of the raised highways are under design or construction pending further funding from tolls, bond sales, and a federal transportation loan. Once finished, the elevated highway will stretch about 22 miles north to Golden Meadow.[33]

With increases in flooding, some communities in Louisiana may become unsustainable and people may be forced to move from flood-prone areas.[34] Migration of affected communities will stress not only the individuals involved by also the capacity of surrounding jurisdictions.

State and Local Adaptation Activities

Hurricane Katrina brought much attention to the need to better prepare for extreme storm events. Much of Louisiana's efforts to adapt to climate-change impacts occurred in the aftermath of Hurricane Katrina. Although Louisiana has not developed a state-wide climate adaptation plan, state agencies and local entities have taken a variety of actions to address the impacts of land loss, sea-level rise, and land subsidence.

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[25] *Louisiana Total Crude Oil and Condensate Production,* LOUISIANA DEPT. OF NATURAL RESOURCES, http://dnr.louisiana.gov/assets/TAD/data/facts_and_figures/table04.htm (Last visited January 8, 2015).

[26] *Louisiana Industry,* LOUISIANA DIV. OF ADMINISTRATION, http://doa.louisiana.gov/about_industry.htm (Last visited January 8, 2015).

[27] *Id.*

[28] *Id.*

[29] Ch 17: Southeast and the Caribbean, National Climate Assessment, 401.

[30] *Id.*

[31] *Louisiana Highway 1/ Port Fourchon Study*, U.S. DEPARTMENT OF HOMELAND SECURITY, iii (July 15, 2011), available at http://www.nimsat.org/sites/nimsat/files/Final%20Report.pdf.

[32] *Id*. at iv.

[33] *Description,* LA 1 COALITION, http://www.la1coalition.org/the-highway-project/description (Last visited March 18, 2015).

[34] *Id.*

Louisiana's Coastal Master Plan

Much of the state's effort to adapt to sea-level rise and climate change has been driven by the Louisiana Coastal Protection and Restoration Authority (CPRA). CPRA was created after Hurricane Katrina to integrate and oversee coastal protection and restoration activities and to manage the deployment of some of the federal disaster relief funds directed to the state in the aftermaths of Hurricanes Katrina, Rita and Gustav.[35] The state consolidated authority over coastal protection and restoration projects in CPRA, allowing it to act as the single decision-making and oversight body. CPRA leads the state's flood risk reduction and coastal planning efforts, while coordinating with multiple other federal, state, and local governmental entities.[36] Centralizing authority in CPRA helped to streamline coordination with federal government agencies so that they can work with one agency and one budget rather than multiple different agencies, as in other states.[37] In addition, coordinating protection and restoration activities through a single state agency promotes more integrated planning and the strategic direction of scarce resources to projects that will have the most beneficial impacts for the coast as a whole.

In creating CPRA, the state legislature charged it with developing a Coastal Master Plan every five years; the plan is designed to provide a comprehensive strategy for protecting the coast and restoring coastal resources. The first Coastal Master Plan was released in 2007 and updated in 2012;[38] the 2017 version is currently in development. Projects delineated in the Coastal Master Plan are designed to address the root causes of coastal land loss and set the strategy for implementing large-scale efforts needed to protect communities, industry, and the natural landscape.

To support the development of the Coastal Master Plan, CPRA developed advanced predictive models and analytic tools to identify effective risk reduction and restoration projects. These models project the coastal landscape, flood depths, and expected annual damages for current day and over the next 50 years in order to determine how possible projects could lessen future flood damages and land loss. In particular, the Coastal Louisiana Risk Assessment (CLARA) model (developed by RAND)[39] estimates the flood depths from various sized storms, the value of assets at risk, and the annual economic damages resulting from estimated flood events, both if no action is taken and if new protection and restoration projects are implemented. CPRA used the outputs of the CLARA model with the results of other models, CPRA's decision-making criteria, and input from stakeholders to prioritize various project options for the

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[35] *About CPRA: History*, COASTAL PROTECTION AND RESTORATION AUTH., http://coastal.la.gov/about/history/ (Last visited January 5, 2015).

[36] In a special state legislative session to address recovery in the wake of Hurricanes Katrina and Rita, CPRA was established under Act 8 of the First Extraordinary Session of 2005 when the Legislature restructured the existing Louisiana Wetland Conservation and Restoration Authority. In 2009, the Louisiana Legislature formed a new state body, the Office of Coastal Protection and Restoration (OCPR), as the implementation and enforcement branch of CPRA. To better coordinate and clarify roles and authorities, the legislature changed the legal nomenclature of the two bodies in 2012, renaming the CPRA as the CPRA Board and the OCPR as the CPRA Authority, retaining its implementation powers. To further consolidate restoration and protection powers, the 2012 legislation transferred additional responsibilities from various other state bodies to the CPRA Board and Authority.

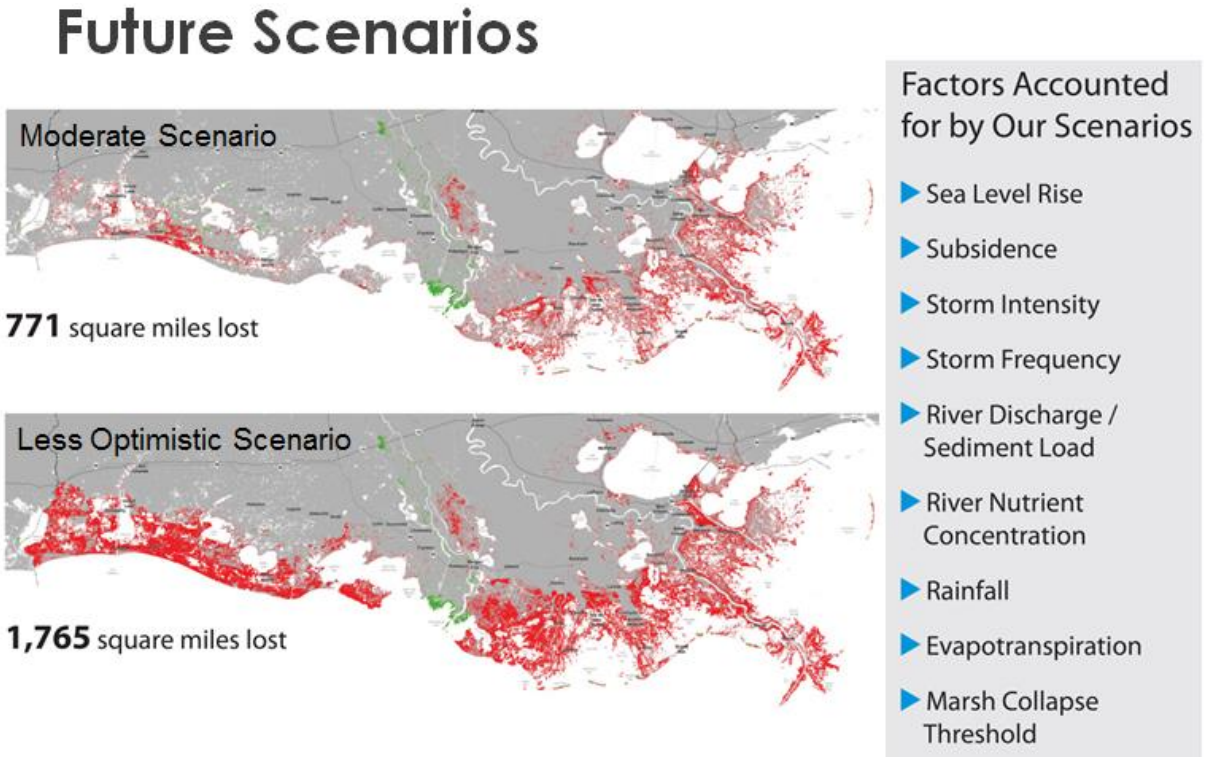
[37] *About CPRA: Structure*, COASTAL PROTECTION AND RESTORATION AUTH., http://coastal.la.gov/about/structure/ (Last visited January 8, 2015).

[38] *Master Plan Overview: Progress*, COASTAL PROTECTION AND RESTORATION AUTH., http://coastal.la.gov/a-common-vision/master-plan/progres/ (Last visited January 5, 2015).

[39] *Strengthening Coastal Planning*, RAND GULF STATES POLICY INSTITUTE, x (2014), available at http://www.rand.org/content/dam/rand/pubs/research_reports/RR400/RR437/RAND_RR437.sum.pdf.

Louisiana coastal region.[40] Based on their ability to build or maintain land or reduce flood risk, the 2012 Coastal Master Plan identifies 109 top-performing priority protection and restoration projects.

The 2012 Coastal Master Plan considers the long-term impacts of climate change on the dynamic Louisiana coast. The Coastal Master Plan states that "climate change was central to the analysis, given coastal Louisiana's vulnerability to increased flooding and the sensitivity of its habitats."[41] CPRA worked with national and international experts to develop two different scenarios (moderate and less optimistic) reflecting different sets of coastal climate conditions affected by factors like sea-level rise, frequency of storms, and river sediment load among other things. The "moderate" scenario assumes 0.27 meters (0.8 feet) of sea-level rise over 50 years, the same storm frequency as current conditions (one Category 3 or greater storm every 19 years), and 19 millimeters of land subsidence annually. The "less optimistic" scenario assumes more dramatic changes including 0.45 meters (1.47 feet) of sea-level rise over 50 years, a slightly higher storm frequency prediction (one Category 3 or higher storm every 18 years), and 25 millimeters of land subsidence annually.[42] Under these scenarios, the state projects that if no action is taken it would lose an additional 770 sq. miles of land under the moderate scenario and 1,750 sq. miles under the less optimistic scenario by 2061.



Future Scenarios for the Louisiana coast
Image credit: Louisiana Coastal Protection and Restoration Authority, 2012 Coastal Master Plan

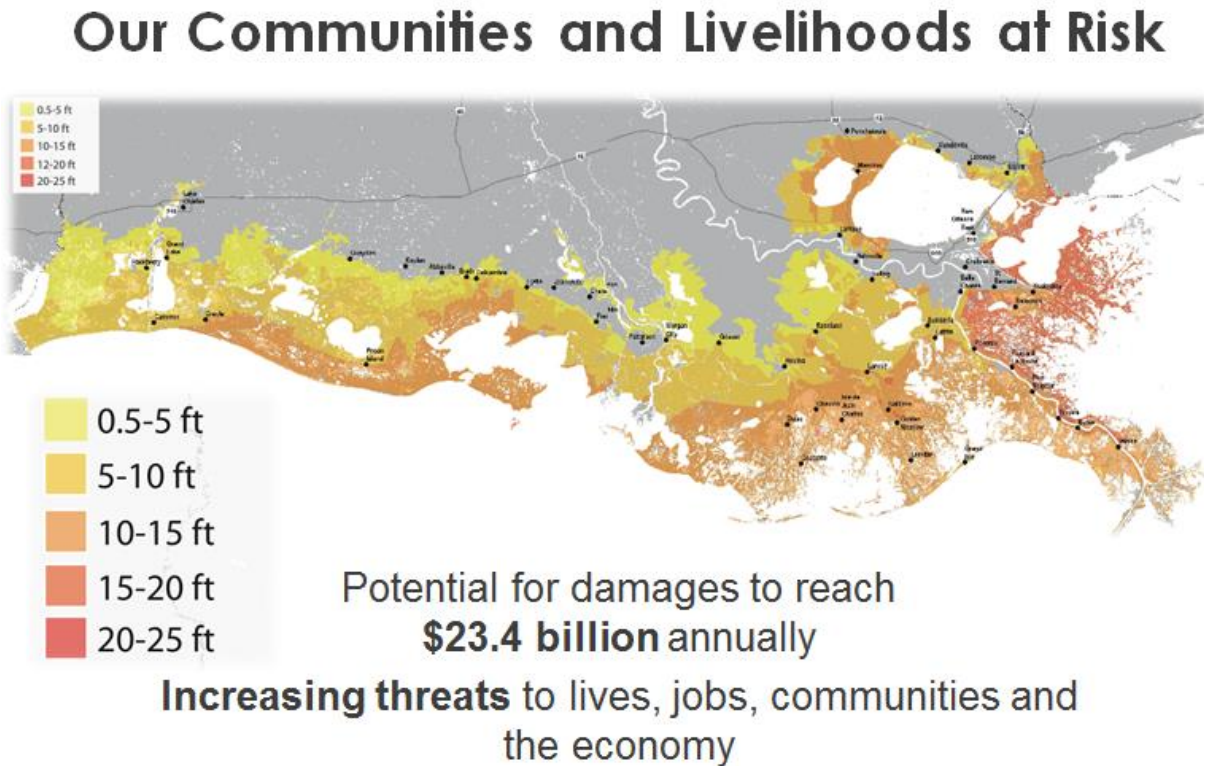
[40] *Id.*

[41] *Integrated Ecosystem Restoration and Hurricane Protection: Louisiana's Comprehensive Master Plan for a Sustainable Coast*. COASTAL PROTECTION AND RESTORATION AUTH., 82 (2012), available at http://coastal.la.gov/a-common-vision/2012-coastal-master-plan/.

[42] *Id.* at 83.

Under a moderate scenario, coastal communities could experience 9 feet of additional flooding during a 50-year storm event with total flood depths of up to 15 feet; 4 feet of additional flooding during a 100-year storm event with total flood depths up to 17 feet; and a 500-year flood event could result in total flood depths of up to 26 feet.[43] The additional flooding could increase annual flood damages from $2.4 billion today to $7.7 billion by 2061 under the moderate scenario, and up to $23.4 billion under the less optimistic scenario.[44]

To assess the benefits of coastal protection and restoration projects, the 2012 Coastal Master Plan compares the conditions of Louisiana's landscape in 50 years without action (under the two scenarios) to the conditions with the coastal protection and restoration projects identified through its planning process. A key finding of the Coastal Master Plan is that "bold coastal protection and restoration measures" are needed to address Louisiana's land-loss crisis, and that the risk of acting, even with uncertainty, is lower than the risk of taking no action at all.[45]



Our Communities and Livelihoods at Risk.
Image credit: Louisiana Coastal Protection and Restoration Authority, 2012 Coastal Master Plan

[43] *Id.* at 87.

[44] *Id.*

[45] *Id.* at 21.

The 2012 Coastal Master Plan recommends a variety of approaches to building or maintaining land and reducing flood risk. It recommends the implementation of restoration projects including sediment diversions, bank stabilization, marsh creation, oyster barrier reefs, and ridge restoration, among others, to restore and enhance the flood risk reduction benefits of natural coastal landscapes. The Coastal Master Plan also recommends construction of "structural flood protection" such as pumps, floodgates, levees and sea walls. Finally, it includes recommendations that local governments (parishes and municipalities) implement "nonstructural" measures as part of the "multiple lines of defense" strategy to reduce flood risk to coastal communities. Nonstructural measures include using land-use policies that require structures to be elevated or flood-proofed, or sited out of flood zones. Communities can also buy out structures that have repetitively flooded, limit new development and redevelopment in flood-prone areas, and preserve and enhance natural flood buffers.[46]

Louisiana's 2012 Comprehensive Master Plan for a Sustainable Coast.
Image credit: Louisiana Coastal Protection and Restoration Authority, 2012 Coastal Master Plan

To inform the development of the Coastal Master Plan, CPRA met with groups of scientists and engineers to review plan elements and make recommendations, and experts who provided technical assistance on modeling analysis. CPRA also engaged the public extensively when developing the list of projects included in the Coastal Master Plan. A group of 33 stakeholders including representatives from local businesses, industry, municipal governments, coastal institutions, and non-profits advised CPRA on the

[46] *Id.* at 71-72.

Master Plan process and all major elements. CPRA also created three focus groups to incorporate the perspectives of leaders from the oil and gas, fisheries, and ports.[47]

Through the projects identified in the Coastal Master Plan, CPRA has developed a vision for reducing flood risks and land loss. CPRA considers many components of climate change including sea-level rise, storm intensity, storm frequency, rainfall, as well as flooding which is a known impact of climate change.[48]

Since 2007, CPRA has secured about $18 billion for protection and restoration projects, which it has used to restore or enhance 26,241 acres of land, and move 150 structural projects into design or construction phases in 20 parishes, including the building or improvement of 256 miles of levees.[49] The 2012 Coastal Master Plan also contains recommendations for non-structural projects in 42 communities across the coast. which will undergo further analysis and planning before implementation.[50] Between 2011 and 2061, CPRA expects to receive $20 billion to $50 billion from combined state and federal funding sources.[51] However, while this funding is anticipated, it is not guaranteed. Funding included in these projections comes from sources such as the Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA), Louisiana's Coastal Protection and Restoration Fund, Gulf of Mexico Energy Security Act (GOMESA), Energy and Water Act (USACE funding), Deepwater Horizon Natural Resources Damage Assessment, Deepwater Horizon Clean Water Act Penalties, and other sources.[52] In July 2015, Louisiana was awarded $6.8 billion in a tentative settlement of the BP Deepwater Horizon oil spill, $5 billion of which is allocated to restoring coastal resources.[53] Since it was enacted in 1990, Louisiana has used CWPPRA funding to support over 151 coastal projects benefiting over 110,000 acres.[54]

State Support for Local Adaptation Activity

State agencies have also worked with local parishes to help them prepare for the impacts of sea-level rise. CPRA is working with parishes to further refine and create a framework for implementation of the non-structural measures recommended in the 2017 Coastal Master Plan. In 2008, the Louisiana Department of Natural Resources Office of Coastal Management (LA-DNR) released the *Louisiana Coastal Hazard*

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[47] *Current Master Plan: Working Together*, COASTAL PROTECTION AND RESTORATION AUTH., http://coastal.la.gov/a-common-vision/2012-coastal-master-plan/working-together-2012/ (Last visited April 9, 2015).

[48] Ch 17: Southeast and the Caribbean, National Climate Assessment, 397.

[49] Fiscal Year 2016 Annual Plan: Integrated Ecosystem Restoration and Hurricane Protection in Coastal Louisiana. COASTAL PROTECTION AND RESTORATION AUTH., (2015), available at http://coastal.la.gov/wp-content/uploads/2015/01/Full-AP.pdf.

[50] *Integrated Ecosystem Restoration and Hurricane Protection: Louisiana's Comprehensive Master Plan for a Sustainable Coast*. COASTAL PROTECTION AND RESTORATION AUTH., 25 (2012), available at: http://coastal.la.gov/a-common-vision/2012-coastal-master-plan/.

[51] *Id.* at 63.

[52] *Id.* at 93.

[53] Mark Schleifstein, *BP to Pay $18.7 Billion to Federal Government, 5 States to Settle Oil Spill Claims*, The Times-Picayune (Jul. 2, 2015), available at: http://www.nola.com/environment/index.ssf/2015/07/bp_to_pay_billion_to_settle_de.html.

[54] *Louisiana Coastal Wetlands Planning, Protection and Restoration Act Program: About CWPPRA,* CWPPA, http://lacoast.gov/new/About/ (Last visited March 20, 2015).

Mitigation Guidebook,[55] which provides tools to local parish officials, floodplain managers, and planners to help them protect their coasts from sea-level rise, natural disasters, and land loss. The *Guidebook* offers parishes guidance on how to consider these threats in planning, regulating land-use, and implementing best practices for construction.[56] In 2013, LA-DNR also released a white paper identifying gaps in local hazard mitigation preparation, and suggesting ways to leverage the state's coastal management program to improve local efforts to adapt to sea-level rise and stronger storms.[57] The white paper acknowledges that parish plans often do not currently address sea-level rise, climate change impacts, or land subsidence specifically. Instead, parish plans primarily focus on flooding hazards as determined using historical flood data. LA-DNR suggests that parishes will face a range of future threats including increased flooding from sea-level rise, land loss, erosion, subsidence, and extreme storms. It recommends that parishes consider these threat multipliers when developing local plans, policies and ordinances.[58] According to the LA-DNR white paper, while some efforts to decrease the speed of coastal erosion are underway, sea-level rise will make this process more challenging. The LA-DNR white paper directly relates sea-level rise to climate change, citing the 2007 International Panel on Climate Change (IPCC) report, which indicates that sea levels are likely to rise in the 21st Century, and are very likely to rise at a higher rate than seen during the last century due to warming caused by greenhouse gases in the atmosphere.[59]

As a way to help residents and policy makers at a local level understand the changes their coastal communities face, CPRA released the Flood Risk and Resilience Viewer (Flood Viewer). The Flood Viewer uses data produced for the 2012 Coastal Master Plan, and includes projections for the next five decades. It maps flood risk, expected land changes, projects included in the Coastal Master Plan, and impacts on community facilities, infrastructure, and transportation. It also offers resources to help homeowners and business owners reduce their flood risk.[60] The Viewer provides a unique, easily-accessible mechanism to foster increased access to information as well as an opportunity for better collaboration and coordination with local government planning efforts.

Local Adaptation Activity

Lafourche Parish and Terrebonne Parishes

Individual parishes have also taken steps to adapt to the impacts of climate change. Lafourche and Terrebonne Parishes have both developed plans that take into account the need to respond to the climate change threats faced by these communities. The *Lafourche Comprehensive Resiliency Plan* draft was released in 2014, and lays out a strategic framework for incorporating considerations of future land loss and wetland protection into policies, programs, and tools to help the Parish design its path for future development. The Plan discusses sea-level rise as contributing to land loss, and uses IPCC and NOAA

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[55] James Wilkens et al., *Louisiana Coastal Hazard Mitigation Guidebook,* LOUISIANA DEPARTMENT OF NATURAL RESOURCES, (2008), available at http://dnr.louisiana.gov/assets/docs/coastal/interagencyaff/LaCoastalHazMitGuidebook.pdf.

[56] *Id.*

[57] *Regulatory Best Practices to Make Louisiana Coastal Communities More Resistant to Natural Hazards,* LOUISIANA SEA GRANT PROGRAM, (2013), available at http://data.dnr.louisiana.gov/ABP-GIS/ABPstatusreport/White_Paper_final.pdf.

[58] *Id.* at 2.

[59] *Id.* at 2-3.

[60] *Flood Risk and Resilience Viewer*, COASTAL PROTECTION AND RESTORATION AUTHORITY, http://cims.coastal.louisiana.gov/floodrisk/ (Last visited March 25, 2015).

predictions of future sea-level rise to make a case for the need to protect the community from coastal threats.[61] The Plan will serve as a guide for policymakers and residents of La Fourche Parish when determining how to invest in roads, public facilities, and infrastructure.[62]

Terrebonne Parish's Comprehensive Master Plan was updated in 2012 and has a chapter on environmental hazards which identifies options for mitigating air quality, water quality, pollution, and natural hazards within existing local regulatory frameworks.[63] The Plan identifies flooding, storm surge, subsidence, sea-level rise, coastal erosion, and hurricanes as natural disasters impacting the parish, and suggests guiding principles and goals for addressing them.[64]

City of New Orleans

The City of New Orleans is also active in preparing for sea-level rise and the threats posed by climate change. The city emphasized the need to adapt to climate change in its Master Plan, the *Plan for the 21st Century*, adopted in 2010 by the City Council and the City Planning Commission.[65] The Master Plan is the comprehensive planning framework for directing the future development of the city. The city's Master Plan takes into account future land loss, sea-level rise, other impacts of global warming, and the need to prepare for future impacts. It recommends a comprehensive resiliency strategy and recognizes Orleans Parish's special vulnerability to climate change. The Plan uses sea-level rise projections[66] of between 7 to 15 inches by the end of the century citing to the city's 2009 *New Orleans Carbon Footprint* report.[67]

One of the stated goals of the Master Plan is to achieve "[c]itywide preparation for future climate change and reduced contribution to global warming."[68] To this end, the Plan recommends specific actions to promote adaptation to the impacts of climate change. Some of these recommendations include:

- supporting coastal restoration projects;
- raising the minimum flood risk standard to account for 500-year flood levels;
- including considerations of climate-change impacts and sea-level rise when adopting new community standards for resilience (according to the Master Plan, the City will work with the Army Corps of Engineers and CPRA to develop these resilience standards);[69]

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[61] *The Lafourche Parish Comprehensive Resiliency Plan*, LA FOURCHE PARISH, 57, 77 (2014), http://www.planlafourche.com/wp/wp-content/uploads/2014/01/Lafourche-Comp-Plan_Jan23-small.pdf (Last visited March 18, 2015).

[62] *Id.* at 6-7.

[63] *Comprehensive Master* Plan, TERREBONNE PARISH, Chapter 7 (2012), http://www.tpcg.org/files/vision2030/final/Chapter%207%20-%20Environmental%20Hazard%20Mitigation.pdf (Last visited March 18, 2015).

[64] *Vision 3030: Terrebonne Parish, Louisiana Comprehensive Plan,* GEORGETOWN CLIMATE CENTER,

http://www.georgetownclimate.org/resources/vision-3030-terrebonne-parish-louisiana-comprehensive-plan (Last visited March 18, 2015).

[65] *Plan for the 21st Century*, THE CITY OF NEW ORLEANS, VOL. 1, Exec. Summary, 10 (2010), available at http://www.nola.gov/city-planning/master-plan/.

[66] *Id.*

[67] *Plan for the 21st Century*, THE CITY OF NEW ORLEANS, VOL. 2, CH. 13, 3 (2010), available at http://www.nola.gov/city-planning/master-plan/.

[68] Id at 1.

[69] *Plan for the 21st Century*, THE CITY OF NEW ORLEANS, VOL. 1, Exec. Summary, 103 (2010), available at http://www.nola.gov/city-planning/master-plan/.

- considering voluntary relocation for the most vulnerable areas; and
- developing a new ordinance on wetlands protection.[70]

New Orleans has also made efforts to adapt to increasingly frequent and severe storms in the aftermath of Hurricane Katrina.[71] Using FEMA Hazard Mitigation Grant Program funding,[72] the City is elevating some existing structures and demolishing flood-damaged ones.[73] New public facilities are now designed to withstand the "500-year" storm event (a storm with a 0.2 percent chance of occurring in any given year based upon historical flood data).[74] In the greater New Orleans area, officials have implemented sustainable water management strategies to decrease flood hazards and minimize soil subsidence.[75] The Georgetown Climate Center has worked with city officials to document the challenges New Orleans faced in using federal disaster relief funds to rebuild a more sustainable and resilient city in the aftermath of Katrina.[76]

Because of the risks posed by climate change, the city is also actively pursuing strategies to reduce its greenhouse gas emissions. The city published a Carbon Footprint Report in 2009[77] and developed a Climate Action Plan for reducing energy consumption and greenhouse gas emissions. The Carbon Footprint Report included an inventory of community and municipal emissions by type and sector, a comparison of 1997 and 2008 emissions levels, and projections for future emissions levels under the "business as usual" scenario.[78] The report lists recommendations, and was used as the basis for the city's Climate Action Plan.[79]

Using the Climate Action Plan as a blueprint, New Orleans launched a number of initiatives to reduce carbon emissions and increase sustainability throughout New Orleans. *GreeNOLA: A Strategy for a Sustainable New Orleans*, is the city's plan for rebuilding sustainably, and it examined viable population

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[70] *Plan for the 21st Century*, THE CITY OF NEW ORLEANS, VOL. 3, CH. 12, 5 (2010), available at http://www.nola.gov/city-planning/master-plan/.

[71] *New Orleans, Louisiana: Identifying and Becoming More Resilient to Impacts of Climate Change,* NATURAL RESOURCES DEFENSE COUNCIL, (July 2011), available at http://www.nrdc.org/water/files/ClimateWaterFS_NewOrleansLA.pdf.

[72] The Hazard Mitigation Grant Program is a federal disaster recovery program that provides funding to states and local governments to support implementation of hazard mitigation solutions after major disasters. *Hazard Mitigation Grant Program,* FEMA, https://www.fema.gov/hazard-mitigation-grant-program (Last visited January 5, 2015).

[73] *New Orleans, Louisiana: Identifying and Becoming More Resilient to Impacts of Climate Change,* NATURAL RESOURCES DEFENSE COUNCIL, (July 2011), available at http://www.nrdc.org/water/files/ClimateWaterFS_NewOrleansLA.pdf.

[74] *Id.*

[75] *Id.*

[76] J. Thomas & J. DeWeese, Georgetown Climate Center, *Reimaging New Orleans Post-Katrina: A Case Study in Using Disaster Recovery Funds to Build More Resiliently* (*Aug. 2015).*

[77] *City of New Orleans: Carbon Footprint Report*, ONE NEW ORLEANS, 4 (2009), available at https://www.globalgreen.org/docs/publication-102-1.pdf. The report describes the City's activities as a member of the Cities for Climate Protection (CCP) Campaign, established by the International Council for Local Environmental Initiatives (ICLEI).

[78] *Id* at 3.

[79] *Id* at 6.

resettlement patterns based on flood risk. *GreeNOLA* called on city officials to incorporate hazard mitigation into city plans and rebuild with stricter building codes and energy efficiency standards.[80] The city's Master Plan reinforces many of the recommendations in *GreeNOLA*, and is designed to support full implementation of it, including providing recommendations for securing funding for its initiatives.[81]

New Orleans was selected as one of Rockefeller Foundation's 100 Resilient Cities, granting it support as it prepares to face the challenges of extreme storm events and aging infrastructure. As part one of the 100 Resilient Cities, New Orleans received support to appoint a Chief Resilience Officer, a central point of contact in the city who oversees and coordinates resilience activities. The Chief Resilience Officer will also have support to develop a resilience plan for the city.[82]

Other support for local adaptation efforts

Other non-profit and academic entities have been instrumental in helping Louisiana communities prepare for climate change impacts. The Center for Planning Excellence (CPEX), a planning non-profit in Louisiana working with support from CPRA, released the *Best Practice Manual for Development in Coastal Louisiana*, a manual that highlights best practices that policy- makers in coastal communities can use to adapt to future threats.[83] The manual is accompanied by the *Louisiana Coastal Land Use Toolkit*, which provides tools for local governments to implement regulatory measures to address sea-level rise and other impacts of climate change. The *Toolkit* offers model development codes, including sample zoning and subdivision ordinances, which can be adopted in total or in part by communities to meet the needs of individual jurisdictions.[84] The Georgetown Climate Center worked with CPRA to help state agencies better understand the pathways for encouraging local governments to implement the non-structural approaches (e.g., floodplain buyouts, elevating structures, downzoning flood-prone areas) identified in the 2012 Coastal Master Plan.

The Louisiana Resilience Assistance Program (LRAP) offers a platform to connect residents, coastal planners, and scientists to resilience planning resources that support Louisiana communities. LRAP supported 30 communities in 2013, focusing on those affected by Hurricanes Gustav and Ike, and has created a clearinghouse of resilience planning best practices from communities in Louisiana and elsewhere. LRAP also provides training through workshops and webinars, and is funded by the Louisiana Office of Community Development Disaster Recovery Unit, through grants from the U.S. Department of Housing and Urban Development grants.[85]

Lessons Learned

After the devastation wrought by the 2005 and 2006 hurricanes, Louisiana moved toward recovery with efforts to rebuild after the disaster in ways that will reduce the state's vulnerability to future disasters. Louisiana has taken steps to prepare for imminent flooding and land subsidence, while also ensuring its

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[80] *Id* at 29.

[81] *Plan for the 21st Century*, THE CITY OF NEW ORLEANS, VOL. 3, CH. 13, 1 (2010), available at http://www.nola.gov/city-planning/master-plan/.

[82] *About Us,* 100 RESILIENT CITIES, http://www.100resilientcities.org/pages/about-us#/-_/ (Last visited April 9, 2015).

[83] *Best Practices Manual for Development in Coastal Louisiana*, CENTER FOR PLANNING EXCELLENCE, available at http://www.cpex.org/best-practices-manual-coastal .

[84] *Louisiana Coastal Land Use Toolkit*, CENTER FOR PLANNING EXCELLENCE, available at http://www.cpex.org/louisiana-land-use-toolkit .

[85] *About Us,* LOUISIANA RESILIENCY ASSISTANCE PROGRAM, available at http://resiliency.lsu.edu/about-us/#what.

long-term resilience to the threats of future disasters. The efforts of CPRA to help locals prepare, to the extent of their authority and in spite of political constraints, provides key lessons for other jurisdictions interested in preparing their communities for future impacts while attempting to minimize the political challenges of grappling with climate change head on.

First, state leadership may be needed to implement system-scale responses to climate change. In the aftermath of Katrina, Louisiana consolidated authority for state coastal protection and restoration projects in CPRA. CPRA provides a single entity for decision-making and oversight of coastal protection projects. By doing so, the state can more easily implement an integrated watershed-scale vision for reducing flood risks. This type of approach is vital to implementing large-scale protection and restoration projects that provide multiple lines of defenses. CPRA, as a single state entity, can also support and encourage local implementation of non-structural responses that will need to be implemented through local land-use powers.

Second, states can set priorities to help communities plan and be better prepared for the long-term impacts posed by climate change. Louisiana has demonstrated that coordinating substantial state resources and federal funding programs can aggressively kick-start efforts to adapt to the impacts of sea-level rise and land loss. For example, CPRA's Coastal Master Plan and Flood Risk and Resilience Viewer enable the public to better understand the future land loss, flood risk, and economic damages that the state may face over the next 50 years. In addition, these tools help to quantify and visualize the benefits of restoration and coastal protection projects for reducing land loss and flooding.

Finally, at the implementation stage, predictive models and planning tools like the ones developed to support CPRA's Coastal Master Plan can be used, along with stakeholder input, to prioritize investments.[86] Technical models can be very useful at demonstrating the difference in outcomes between the "business as usual" approach and different proposed protection and restoration projects. Ultimately, building support for a plan requires extensive outreach and engagement in order to win legislative approval. CPRA employed several useful methods of engaging the public and private sector during the development of the Coastal Master Plan, including dialogues between coastal stakeholders, focus groups, and multiple community meetings. In addition to developing models and technical tools for assessing future risk, CPRA found this outreach to citizens and stakeholders to be an indispensable component for building public support for the agency's efforts to prepare for future sea-level rise and extreme events.

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[86] *Strengthening Coastal Planning*, RAND GULF STATES POLICY INSTITUTE, (2014), available at http://www.rand.org/content/dam/rand/pubs/research_reports/RR400/RR437/RAND_RR437.sum.pdf.