



Sea-Level Rise Vulnerability Assessment Tools and Resources

A Guidance Resource for Florida's Local Governments



Acknowledgements

This resource was prepared by the following team of individuals:

Department of Economic Opportunity

Julie A. Dennis, Community Program Manager
Daniel Fitz-Patrick, Project Coordinator

ATKINS North America, Inc.

Margaret M. Walton, Project Manager
Sara Seremak, Project Coordinator

DEO Staff: Richard Fetchick, Planner; Cassidy Mutnansky, Planning Intern; Hannah King, Planning Intern

ATKINS Staff: Hilary Kendro, AICP, Planner; Michael Salisbury, PE, Engineer; Stephen Bourne, PE, Solutions Consultant; Janet Luce, Technical Coordinator; Jack Hampson, Project Director; Laura Coventry, Multi-Media Design Specialist

This resource was funded in part, through a grant agreement from the Florida Department of Environmental Protection, Florida Coastal Management Program, by a grant provided by the Office of Ocean and Coastal Resource Management under the Coastal Zone Management Act of 1972, as amended, National Oceanic and Atmospheric Administration Award No. NA12NOS4190093. The views, statements, findings, conclusions and recommendations expressed herein are those of the author(s) and do not necessarily reflect the views of the State of Florida, NOAA or any of their sub-agencies.

Completed June 2015.

This guidance resource provides an overview of the information found in the “Sea-Level Rise Vulnerability Assessment Tools and Resources: A Guide for Florida’s Local Governments.” The comprehensive guidebook provides guidance for approaching, developing, and completing sea-level rise risk and vulnerability analyses and scenarios and for incorporating the appropriate process and process outputs into local planning efforts.

Planning for Adaptation

Communities that are subject to sea-level rise may experience an increase in coastal hazard vulnerability. Impacts to communities may include:

- Increased flooding and drainage problems,
- Destruction of natural resource habitats,
- Higher storm surge,
- Increased evacuation areas and evacuation time frames,
- Increased shoreline erosion,
- Saltwater intrusion into surface and groundwater, and
- Loss of infrastructure and existing development.

Adaptation to sea-level rise represents concrete steps a community takes to become more resilient to the impacts of rising seas over a period of time. The purpose of this guidance resource is to summarize the information necessary for local governments in Florida to select the appropriate vulnerability analysis tools to support local sea-level rise adaptation planning efforts. This guidance resource identifies the types of tools available to facilitate multi-sector sea-level rise adaptation planning and reviews the utility and role of the tools in relevant components of the adaptation planning process. It also identifies the other local planning efforts into which the tools can be integrated.

Components of an Adaptation Planning Process

Sea-level rise adaptation planning seeks to reduce the negative impacts of potential sea-level rise by reducing exposure, promoting resilience, and accommodating adaptation of ecosystems, species, communities, and infrastructure to changing conditions. Whether a community is starting a new adaptation planning process for the first time or updating existing plans – it is important to understand how and when a vulnerability analysis fits into the overall adaptation planning process. Figure 1, below, illustrates the key steps of adaptation planning.

Figure 1: Adaptation Planning Process



Figure 2: Adaptation Plan Overview

Sea-Level Rise Adaptation Plans

Main and Supporting Components

1. **Context**
 - 1.1. Assemble a Steering Committee
 - 1.2. Identify Opportunities for Community Participation
 - 1.3. Describe the Planning Context
 - 1.4. Set Guiding Principles + Motivations
2. **Vulnerability Assessment**
 - 2.1. Conduct an Exposure Analysis
 - 2.2. Conduct an Impact Analysis
 - 2.3. Assess Adaptive Capacity
3. **Adaptation Strategies**
 - 3.1. Assign Focus Areas
 - 3.2. Identify Adaptation Strategies
 - 3.3. Prioritize Adaptation Needs
4. **Implementation Strategies**
 - 4.1. Survey Funding Options
 - 4.2. Integrate into Existing Plans
 - 4.3. Create a Schedule of Activities
 - 4.4. Monitor and Evaluate

As described in this section, a sea-level rise adaptation plan includes 4 major activities (components) and 14 steps (subcomponents) (see Figure 2). The subcomponents which support and can be supported by the sea-level rise vulnerability analysis tools are outlined below. However, it is important to note that the adaptation planning process does not have to be a linear process. For example, some communities may choose to consider how they might implement possible strategies first (i.e., identify funding streams that are available which may require or promote the development of a plan). This in turn may drive the focus of the adaptation planning process and have a significant influence on the tools/resources and approaches that are selected in order to conform to the predetermined strategy (e.g., funding might be available for transportation improvements – so, a community might use a FDOT or FHWA product for related assessments).

1. Context. For the first part of an adaptation planning process, communities are encouraged to consider factors typical of all planning exercises, with a focus on how each factor relates to sea-level rise adaptation. This includes a survey of existing geographic, social, infrastructural, and environmental conditions. It also entails the creation of principles (e.g., goals, objectives, and policies) to guide the planning process, which are distinct from prioritized needs set during the Adaptation Strategies Analysis phase.

Context refers to the preparatory activities taken by the planning team and the community to increase their understanding of the planning issue at hand and to unite and fortify their efforts addressing the issue.

1.1 Assemble a Steering Committee. In order to write a sea-level rise adaptation plan that reflects the expertise and interests of the community's local stakeholders, a steering committee can be assembled. Steering committees have the ability to enhance all ensuing activities in the adaptation planning process.

1.2 Identify Opportunities for Community Participation. Within this sub-component, the planning team is encouraged to identify opportunities for community participation to discuss the resources created during the Vulnerability Assessment, Adaptation Strategies, and Implementation Strategies components.

1.3 Set Guiding Principles and Motivations. By deciding on guiding principles and motivations, the community can establish its compass for navigating through the following components. The principles and motivations are one of the plan’s most inter-active sub-components and may be recalled to assist decision-making activities in the second, third, and fourth components.

1.4 Describe the Planning Context. Describing the planning context offers an opportunity to analyze prior adaptation planning efforts that may have occurred within or near the community, information gaps related to adaptation planning, the available human capacity (such as coastal scientists and land-use planners), and the outside resources needed to conduct the locally desired planning effort. Essentially, this sub-component provides a chance to assess the scope of work and the resources applicable to the adaptation planning process.

2. Vulnerability Assessment. The Vulnerability Assessment represents the second component in the sea-level rise adaptation planning process and consists of measuring the impact of sea-level rise and identifying the people, infrastructure, and land uses that may be affected. Vulnerability is often used interchangeably with risk when measuring hazard impacts.

The **Vulnerability Assessment** draws from the Risk Assessment framework described in the Code of Federal Regulations (Title 44 CFR 201.6(c)(2)), which measures the hazard exposures a community is likely to experience and the sensitivities—e.g., populations and land uses—that may be exposed to the identified hazards.

2.1 Conduct an Exposure Analysis. An exposure analysis utilizes a sea-level rise projection to answer the question “where” based on two choices – when (what horizon) and how much (which scenario). The “where” will depend on which computer model is used (e.g., SLAMM, ADCIRC, etc.) to produce the sea-level rise projection. The analysis can depict which areas in the community are likely to be susceptible to the chosen sea-level rise scenario on a map.

2.2 Conduct an Impact (Sensitivity) Analysis. Conducting an impact (sensitivity) analysis helps the community to identify natural resources, structures, populations, and other entities located in areas that are at risk to the sea-level rise scenario projected during the Exposure Analysis.

2.3 Assess Adaptive Capacities. This sub-component encourages the community to measure the degree to which it is equipped to adapt to sea-level rise through the existence of policies, structures, finances, and human resources that can assist, or already are assisting, adaptation to potential changes.

3. Adaptation Strategies. Adaptation Strategies represent the third component in the adaptation planning process and are in effect a set of responses to the findings from the Vulnerability Assessment. Adaptation strategies are often classified according to their status as Protection, Accommodation, and Retreat (PAR) strategies. There are also a set of supporting activities that assist the development of the strategies themselves, which are described in this component. This component also identifies how adaptation strategies can be prioritized for each focus area and then applied through PAR and No Regrets interventions.

Adaptation Strategies refer to the toolkit of responses that communities can take to adapt to sea-level rise as well as the steps taken to decide which adaptation strategies are the best fit based on the needs of individual communities.

3.1 Assign Focus Areas. With the assistance of the steering committee and community stakeholders, the planning team may assign focus areas. This sub-component responds to the sensitive entities identified in the vulnerability assessment and assigns community preferences to areas that will receive the majority of adaptation strategy attention.

3.2 Identify Adaptation Strategies by Focus Area. The four main types of strategies a community may use to adapt to sea-level rise are:

- Protection – Hard and soft structurally defensive measures to mitigate the impacts of rising seas (e.g., seawalls, bulkheads, rip-rap, and living shorelines).
- Accommodation – Physical design alterations allowing a structure or land use to remain in place (e.g., floodable development, floating structures, and bio-swales).
- Managed Retreat – Relocation of existing development/limitation of future development (e.g., rolling easements, transfer of development rights, and design for dis-assembly).
- No Regrets – Comprehensive and targeted strategies, such as incorporating sea-level rise scenarios into other plans and enhancing sea-level rise outreach.

3.3 Prioritize Adaptation Needs. This sub-component recommends that the planning team assess the relative merits and costs of each adaptation strategy within a given focus area in order to prioritize the preferred adaptation strategy. This may be accomplished through a benefit-cost alternatives analysis, stakeholder feedback, or even new output from a tool utilized during the Vulnerability Assessment.

4. Implementation Strategies. Once a set of adaptation strategies has been developed and analyzed, it is recommended that communities prepare for the supporting activities that can facilitate adaptation activities to be successfully undertaken. This includes locating, preparing for, and applying for potential

Implementation Strategies encourage communities to look into available funding for adaptation activities, describe which groups will complete which tasks, and create mechanisms to evaluate how the adaptation plan strategies are being accomplished.

funding opportunities; creating a schedule of adaptation actions for the future; and addressing monitoring and evaluation needs.

4.1 Survey Funding Options. A survey of funding options includes a systematic review of all known funding sources as well as inquiry into new funding opportunities that may facilitate a successful implementation strategy.

4.2 Integrate into Existing Plans. In order to integrate the components of the sea-level rise adaptation plan into other plans, the planning team is encouraged to: identify all relevant documents, assess documents for potential inclusion points, and (if applicable) initiate collaboration with the responsible party to ensure that the applicable sea-level rise objective can be included at the time of the next update.

4.3 Create a Schedule of Adaptation Activities and Actors. Creating a schedule will provide an impetus to the actions to be completed and assign the staff responsible for each action. This sub-component can serve to program different types of adaptation activities according to their prioritized need (see sub-component 3.2 above) and, in pairing with funding opportunities, generate a concise and easy-to-follow plan.

4.4 Monitor and Evaluate. Monitoring and Evaluation extends throughout the horizon of the plan's implementation, which could extend decades. The ability to communicate the guiding goals of the plan across generations of implementing actors is essential. This is done through a Monitoring and Evaluation plan that uses consistent language, such as "indicators" that can be tracked throughout the implementation horizon and rated as to successfulness by different implementing actors.

Relationship of the Vulnerability Assessment to other Components

Conducting a vulnerability assessment is a key analytical step in adaptation planning since it identifies assets, both ecological and community infrastructure assets, which may be impacted by sea-level rise. In addition to assessing assets' potential sources of vulnerability, a vulnerability assessment also considers the likelihood and consequences of potential sea-level rise impacts. This assessment will help pinpoint a community's vulnerable assets and the resulting community needs as well as help identify actions that can be implemented to address them.

Context

Defining the planning context sets the stage for the vulnerability assessment and, as such, is the most important part of the adaptation planning process. Engaging steering committee and community stakeholders allows a community to set guiding principles and motivations of the assessment and planning process early on as well as ensures that the process meets a community's needs. This will have a significant impact on the tools, resources, approaches, and planning horizons that are utilized to conduct a community vulnerability assessment, and it will also have a direct relationship to the feedback that is provided once the draft assessment has been completed.

Adaptation Strategies

Adaptation strategies are the responses that communities take to adapt to sea-level rise and are based on the needs of each individual community. Once a community's vulnerability and risk has been determined, adaptation strategies

can be selected in response to the specific needs of a community that were identified. A vulnerability assessment provides the scientific basis for adaptation strategies and it can be used to gain public buy-in since stakeholders often determine how the vulnerability assessment is carried out. Due to the predictive nature of vulnerability assessments, there is a degree of uncertainty in the results. Understanding and accounting for this uncertainty when considering management actions is an important aspect of adaptation planning.

Implementation Strategies

Implementation strategies are the steps a community takes to incorporate adaptation strategies into existing planning, budgeting, and staffing mechanisms. Even before the vulnerability analysis is conducted, communities may consider possible implementation strategies based on available capacities, existing implementation schedules, or available funding sources. Communities must be able to support and implement adaptation activities in order to successfully reduce the negative impacts of potential sea-level rise that were identified during a vulnerability assessment.

Sea-Level Rise Vulnerability Analysis Tools

Types of Tools

There are four main types of tools available to assist local governments conducting a sea-level rise vulnerability analysis to support local sea-level rise adaptation planning efforts. These four types of tools include: visualization tools, modeling tools, decision support tools, and databases of resources.

Visualization Tools can be used to create simulations and graphics of current and potential future conditions. These tools often perform analyses but generally require less user input and customization than other analytical tools. Often, they do not have the ability to run customized analyses with local data. These tools are generally easy to use and do not require specific software or hardware. Visualization tools are often used to support the Opportunities for Community Participation, Guiding Principles and Motivations, Planning Context, and Exposure Analysis components of adaptation planning.

Modeling Tools are computer software programs or GIS add-ins that can calculate future coastal flood scenarios and visualize current and potential future conditions of geophysical, biological, and/or socioeconomic processes in a map-based, tabular, or graphic format. These tools are generally the most technically challenging to use and often require GIS software and appropriate hardware, technical expertise, and training. Modeling tools also generally require local data on the process being investigated. These tools are often used to support the Planning Context, Exposure Analysis, Impact Analysis, and Adaptive Capacity components of adaptation planning.

Decision Support Tools help develop scenarios of future conditions resulting from potential sea-level rise and management decisions. These tools can integrate outputs from various tools, such as models, to help develop “what if” scenarios and investigate a wide variety of management outcomes. Decision support tools generally require at least a moderate degree of technical capacity such as GIS expertise. These tools are often used to support the Opportunities for Community Participation, Guiding Principles and Motivations, Impact Analysis, Adaptive Capacity, Focus Areas, and Adaptive Needs components of adaptation planning.

Databases of Resources provide information on available sea-level rise vulnerability analysis tools, case studies, and other information relevant to adaptation planning. These databases often provide information on the available visualization, modeling, and decision support tools identified in the *Sea-Level Rise Vulnerability Assessment Tools and Resources* guidebook as well as information that can be used to support adaptation decision making. These databases are often used to support the Planning Context component of adaptation planning.

Selecting the Right Tool

Selecting the right tool can be a challenging task. It is best to take a systematic approach to selecting a tool in order to make the decision process easier and more straightforward. The general process that can be used to select a tool is as follows:

1. Characterize Planning Questions
2. Identify Tool Functions Needed
3. Research Available Tools
4. Assess Data and Topical Expertise Needed
5. Assess Available Capacity

Alternative Tool Selection Methods

In addition to following the systematic approach outlined above, communities can also use one of the following alternative methods when selecting the best tool to conduct a sea-level rise vulnerability assessment:

1. Interactive Approach
2. Homework Approach
3. Leader/Contractor Approach
4. Combination Approach

Other Considerations

When selecting a tool, the level of detail in the data output is dependent on location-specific data used within the tool's database and/or the precision of required input data. The more detail-specific the input data is, the more reliable the output data produced by the selected tool will be. If a community is looking for generalized sea-level rise information to use for strictly visual purposes or

in larger scale planning initiatives, then a tool with a broader, less exact data methodology would be appropriate for use, such as CanVis or the USACE Sea Level Change Curve Calculator. If a community is looking for site-specific sea-level rise information for a certain location to determine more precise calculations or to support smaller scale planning processes, then a tool with a more detailed, defined data methodology would be appropriate, such as SLAMM or Hazus-MH. The more specific the sea-level rise data on which planning decisions are based is, the more reliable and defensible land use decisions will be.

With the recently signed Senate Bill 1094 "Perils of Flood Hazard," Section 163.3178 (2)(f)1, F.S., requires communities to "include development and redevelopment principles, strategies, and engineering solutions that reduce the flood risk in coastal areas which results from high-tide events, storm surge, flash floods, stormwater runoff, and related impacts of sea-level rise." There is also a legal mandate that basic decisions about building locations, development intensity, and by what means development occurs should be based on the character of the land (e.g., sea-level rise vulnerability) and that the projected availability of infrastructure and services be the principals by which land use planning decisions impact mitigation and adaptation. Local governments have the ability to determine the most appropriate use of land which can be based on vulnerability and/or susceptibility. "Planning decisions are legislative, subject to the most deferential standards of judicial review", *Martin County v. Yusem*, 690 So.2d 1288, 1295 (Fla. 1997). Local and regional agencies should use appropriate judgment to guide development and avoid extending or rebuilding roads, water and sewer lines, and other infrastructure into projected vulnerable areas. Planning tools and processes for cities and counties are required to "[l]imit public expenditures that subsidize development in coastal high-hazard areas." §163.3177 (6)(g)6, Fla. Stat., 2014.

Other Local Planning Efforts

Sea-level rise vulnerability analysis tools can also be incorporated into other local planning efforts. These local planning efforts include the following:

1. Local Comprehensive Plan
2. Local Mitigation Strategy
3. Special Area Management Plan
4. Economic Development Plan
5. Post-Disaster Redevelopment Plan
6. Capital Improvements Plan
7. Stormwater Management Plan
8. Historic Preservation Plan

Other Adaptation Planning Resources

At the national, regional, and state level, there are a number of resources that may be useful to communities who are interested in learning more about the potential for sea-level rise and available adaptation options. The following is a list of resource recommendations:

[Climate Change and Sea-Level Rise in Florida](#)—The Florida Oceans and Coastal Council published a 2010 update concerning the potential effects of climate change on Florida’s coastal resources. This short primer provides a scientifically-based discussion of both historically observed and future projected sea-level rise, with an emphasis on sea-level rise effects across different coastal categories.

[How Countries, States, and Florida Address Sea-Level Rise: A compendium of climate adaptation research](#)—This Florida Department of Economic Opportunity Community Resiliency Initiative publication identifies national, state, and local adaptation projects.

[Incorporating Sea Level Change Scenarios at the Local Level](#)—This NOAA publication outlines eight steps to help communities calculate sea level change scenarios and communicate impacts. It is a “low-tech” companion document for a NOAA technical publication that assesses technical considerations for use of geospatial data in sea level change mapping and assessment.

[Planning Time Frames for Coastal Hazards and Sea-Level Rise](#)—This report provides guidance for the Florida Department of Economic Opportunity’s Community Resilience Initiative to assist coastal communities who wish to integrate adaptation planning for future sea-level rise into their comprehensive, hazard mitigation, and post-disaster redevelopment planning.

[Sea Level Changes in the Southeastern United States](#)—This 2011 publication by Dr. Gary Mitchum of the University of South Florida’s College of Marine Science presents a scientific overview of past, present, and future sea-level rise. Written with the non-scientist in mind, Dr. Mitchum’s paper is highly accessible, informative, and relevant to Florida’s coastal communities.

[Sea-Level Rise Adaptation Options for Local Governments](#)—This presentation, prepared by Dr. Robert Deyle of Florida State University’s Department of Urban and Regional Planning, delivers an overview of sea-level rise challenges facing local governments and available adaptation resources.

[Tools for Coastal Climate Adaptation Planning: A guide for selecting tools to assist with ecosystem-based climate planning](#)—This guide provides the information necessary for coastal natural resource managers and community planners to select appropriate tools for their projects. The guide focuses on spatially-explicit solutions for climate-related planning.

[Planning for Sea-Level Rise Legal Issues Facing Florida](#)—This document includes three presentations by the state’s leading experts on the legal ramifications of sea-level rise in Florida that identify potential challenges and appropriate local government responses.

Florida also has a number of sea-level rise adaptation planning processes completed and under development at the state, local, and regional levels. Notable projects include:

[The City of Punta Gorda Adaptation Plan](#)—The City of Punta Gorda completed a publicly-led adaptation planning process at the city-level to assess sea-level rise in its downtown area.

[Lee County Climate Change Resiliency Strategy](#)—Lee County followed up a 2010 Climate Change Vulnerability Assessment with the Climate Change Resiliency Strategy. This strategy includes approaches to mitigate and adapt to the effects of climate change while also positioning the county to take advantage of potential economic development opportunities associated with climate change.

[Municipal Adaptation to Sea-Level Rise: City of Satellite Beach, Florida](#)—In the fall of 2009, the City of Satellite Beach, Florida embarked on a project to assess municipal vulnerability to rising sea level and initiate the planning process to properly mitigate impacts.

[The Southeast Florida Regional Climate Change Compact](#)—The Southeast Florida Regional Climate Change Compact represents a joint commitment of Broward, Miami-Dade, Palm Beach, and Monroe Counties to partner in mitigating the causes and adapting to the consequences of climate change. The compact is the lead alliance that supports planning for “adaptation action areas,” and is working to secure funding to further this effort.