An Inventory of Sea-Level Rise Adaptation Assessment Tools and Resources

Florida Coastal Management Program

Acknowledgements

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Completed June 2015.

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This document is excerpted from the "Sea-Level Rise Vulnerability Assessment Tools and Resources: A Guide for Florida's Local Governments." The larger 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.

Introduction

This document provides a comprehensive inventory of sea-level rise vulnerability visualization tools, modeling tools, decision support tools, and databases of resources. A visualization tool creates simulations and graphics of current and potential future conditions and processes. A modeling tool models current and potential future conditions of geophysical, biological, and/or socioeconomic processes. A decision support tool develops scenarios of future conditions resulting from the effects of potential sea-level rise and management decisions. A database of resources provides information on available vulnerability analysis tools, case studies, and other relevant information.

Each record in the inventory includes a one-page summary that contains snapshot information for local government stakeholders to use when considering which of these resources would be most useful for their community's needs. The sample profile found on pages 4 and 5 provides an overview of what information can be found in each of the summaries found in this document. Generally, each summary includes:

- The **Tool/Resource Name**;
- An overview that provides information about:
  - The *Tool/Resource Type* (visualization tool, modeling tool, decision support tool, or database of resources);
  - *Sectors* for which the tools is capable of processing data and creating output (natural resources, agriculture, built environment, transportation and/or energy);
  - *Relevant Adaptation Planning Process Phase(s)* to which the tool applies (Stakeholder Engagement, Scoping/ Inventory, Assessment/Analysis, Strategy/Scenario Development, and/or Implementation/Monitoring[1]);
  - *Geographic Scale* for which the tool/ resource can be applied;
  - *Cost* of the tool/resource;
  - *Data Inputs* required by the tool/resource;
  - *Website* where more details about the tool/ resource can be found; and,
  - *Developer/Sponsoring Agency* who was responsible for developing the tool/ resource.
- A brief general **Description** of the tool/ resource, including a discussion of the following criteria (where applicable):
  - Methodology;
  - Cost;
  - Transferability;
  - Precision;
  - Accuracy; and,
  - Capacity.
- **Examples of Use** documenting where the tool/ resource has been used or applied;
- A summary of best examples of **When and Where to Use** the tool/resource; and,
- **Images** of the tool/resource interface or the tools itself.

A summary table is provided on pages 6 and 7 to identify the relevant adaptation planning phases to which each tool/resource can be applied. Additionally, a detailed inventory matrix is included at the end of this document to allow readers to easily compare the tools to each other.

[1] Note: These are generalized phases of the planning process. To see how each phase relates to specific steps of the adaptation planning process refer to the "Where the Tools Fit within the Adaptation Planning Process" section in Chapter 2 of the *Sea-Level Rise Vulnerability Assessment Tools and Resources: A Guide for Florida's Local Governments.*

Name of Tool / Resource

Tool/Resource Type: *Visualization Tool / Modeling Tool / Decision Support Tool / Database of Resources*

Sector(s): *Sectors for which the tool is capable of processing data and creating output (Natural Resources, Agriculture, Built Environment, Transportation, and/or Energy)*

Relevant Adaptation Planning Process Phase(s): *Point at which tool may be involved in the adaptation planning process (Stakeholder Engagement, Scoping / Inventory, Assessment / Analysis, Strategy / Scenario Development, and/or Implementation / Monitoring)*

Geographic Scale: *Geographical extent of analysis to which the tool can be applied*

Cost: *Cost of purchasing the tool (may be a range)*

Data Input(s): *Data requirements to use/run the tool*

Website: *URL where additional information about the tool can be found*

Developer/Sponsoring Agency: *Organization responsible for developing the tool*

Images

This section of the profile shows images of the tool in action, such as screen shots of the user interface and outputs

Description

This section of the profile provides an overall description of the tool, how it can be used, and how it relates to the sea-level rise adaptation planning process

Examples of Use

This section of the profile identifies examples of the tool/resource being used in communities

Examples for a small, medium, and large size jurisdiction are provided wherever possible

When & Where to Use

This section of the profile summarizes when and where a community can best use the tool and highlights how it applies to sea-level rise vulnerability analysis as well as its relationship to the adaptation planning process (i.e., public engagement, build awareness, visualization, vulnerability assessment, etc.)

Sea-Level Rise Vulnerability Tools/Resources Inventory Summary Table[2]

Tool/Resource Name	Stakeholder Engagement	Scoping / Inventory	Assessment / Analysis	Strategy / Scenario Development	Implementation / Monitoring
Visualization Tools					
CanVis	■		■		
Climate Central's Surging Seas	■	■	■		
FDOT Sea Level Scenario Sketch Planning Tool	■	■	■		
The Nature Conservancy Coastal Resilience Mapping Portal	■	■	■		
NOAA Coastal Change Analysis Program (C-CAP) Land Cover Atlas and Coastal Comparison Tool	■	■			
NOAA Sea-Level Rise and Coastal Flooding Impacts Viewer	■	■	■		
NOAA Sea Level Trends		■	■		
Social Vulnerability Index (SoVI)		■	■		
USGS National Assessment of Coastal Vulnerability to Sea-Level Rise: Coastal Vulnerability Index (CVI)		■	■		
USGS Digital Shoreline Analysis System (DSAS)		■	■		
Modeling Tools					
ADvanced CIRCulation Model (ADCIRC)			■		
Hazus-MH			■		
Integrated Valuation of Environmental Services and Tradeoffs (InVEST)			■	■	
NatureServe Climate Change Vulnerability Index (CCVI)			■		
NOAA Wave Exposure Model (WEMo)			■		
Sea Levels Affecting Marshes Model (SLAMM)			■		
Simulator of Climate Change Risks and Adaptation Initiatives (SimCLIM)			■		
USACE Sea Level Change Curve Calculator		■	■		

[2] Note: This table identifies the relevant adaptation planning phases to which each tool/resource can be applied based on the most common applications of each tool/resource. Keep in mind that if a planning phase is not checked, it does not necessarily exclude the tool/resource from being utilized during that phase.

Sea-Level Rise Vulnerability Tools/Resources Inventory Summary Table Continue

Tool/Resource Name	Stakeholder Engagement	Scoping / Inventory	Assessment / Analysis	Strategy / Scenario Development	Implementation / Monitoring
Decision Support Tools					
Beach-*fx*		■		■	
Coastal Adaptation to Sea-Level Rise Tool (COAST)	■	■	■	■	
CommunityViz	■	■	■	■	
NatureServe Vista	■	■	■	■	
NOAA Inundation Analysis Tool		■	■		
U.S. DOT Vulnerability Assessment Scoring Tool (VAST)		■	■		
Databases of Resources					
Adaptation Database for Planning Tool (ADAPT)		■		■	
Climate Adaptation Knowledge Exchange (CAKE)		■		■	
Ecosystem-Based Management (EBM) Tools Network and Database		■			
FL DEP Map Direct Gateway		■			
Florida Natural Areas Inventory (FNAI)		■			
Georgetown Climate Center		■		■	
Geospatial Assessment Tool for Operations and Response (GATOR)		■			
U.S. Climate Resilience Toolkit	■	■		■	
weADAPT		■		■	

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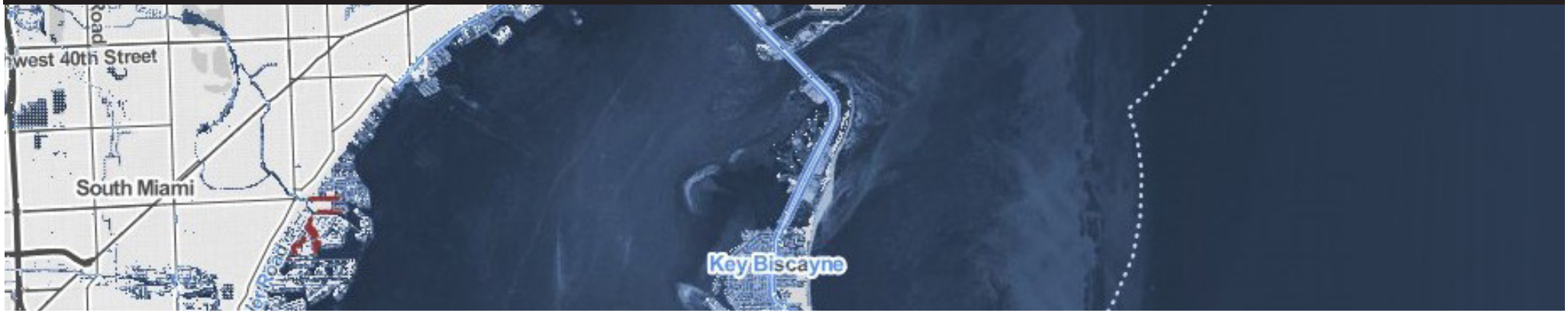
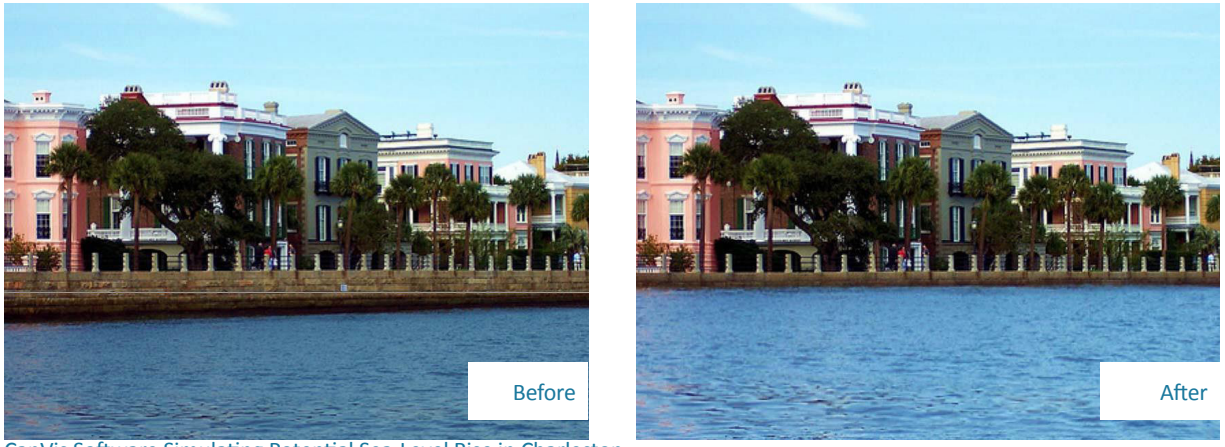
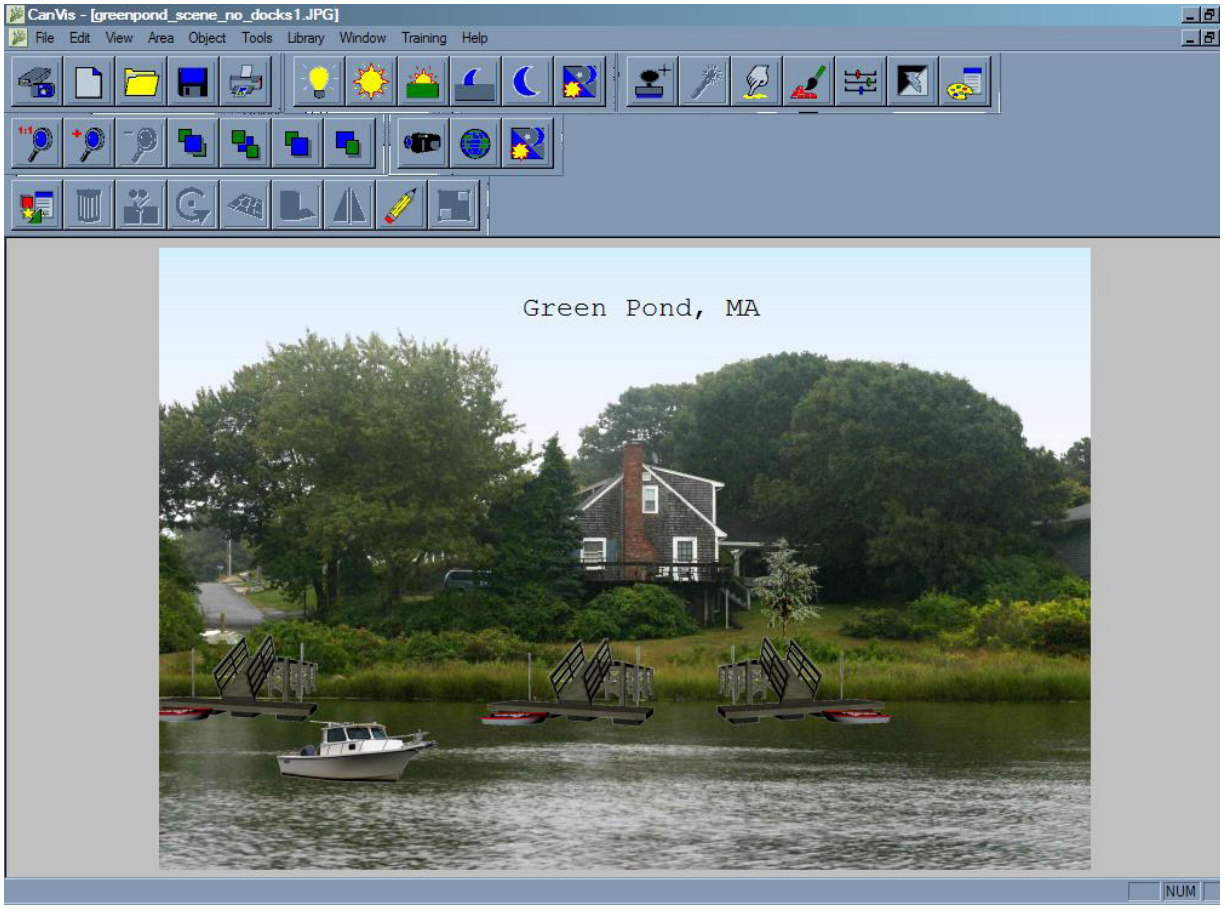
Visualization Tools



CanVis



CanVis Software Simulating Potential Sea-Level Rise in Charleston



Tool/Resource Type: **Visualization Tool (Software)**

Sector(s): **Natural Resources, Built Environment**

Relevant Adaptation Planning Process Phase(s): **Stakeholder Engagement, Assessment / Analysis**

Geographic Scale: **Determined by horizontal width and depth of view shown in digital photograph uploaded by user**

Cost: **Software Download = Free**

Data Input(s): **Digital photograph**

Website: **http://coast.noaa.gov/digitalcoast/tools/cnvis**

Developer/Sponsoring Agency: **National Oceanic and Atmospheric Administration**

Description

CanVis is an image editing software that allows users to create photo-realistic simulations for visualizing potential impacts from sea-level rise. Users create visual simulations by duplicating elements (e.g., houses, boat docks) already in a digital photograph and adding an image of rising waters. The software allows elements to be resized, color-adjusted, and have shadows added to create realistic looking simulations. The software also allows text boxes to be added to photographs. To utilize, assistance by personnel with photo editing software experience is recommended.

The program includes a scale tool that is calibrated to an actual ruler and allows users to base relative measurements off a known object height. This allows users to depict inundation that is equal to a given water height, such as one foot, to simulate that amount of sea-level rise. The images of future conditions will only be accurate if the known object height that is used to scale the water level is precise. Careful measuring with the scale tool will also be required to generate a more accurate output image. Rather than providing actual data which can be used for sea-level rise adaptation, CanVis provides a visualization of possible future sea level conditions.

Limited expertise and effort are required to create a realistic image using CanVis, making it accessible to communities of all sizes. The basic features of this program can be learned in under 30 minutes by users with little or no photo-editing experience.

Examples of Use

Green Bay, WI (Pop. = 105,000)—created photorealistic visualizations of potential flooding impacts on shore-abutting residences along Lake Michigan. Visualizations were shared with residents of possible flooding scenarios caused by strong storms in order to raise awareness and increase further adaptation planning support.

Charleston, SC (Pop. = 128,000)—created a visualization of future sea-level rise by simulating 1.5 meters of sea-level rise relative to prized community landmarks which are characterized by historical, aesthetic, and economic importance in the tourism- driven region. By visualizing potential impacts to community landmarks, the City hoped to raise awareness of potential sea-level rise impacts and build community support for adaptation planning activities.

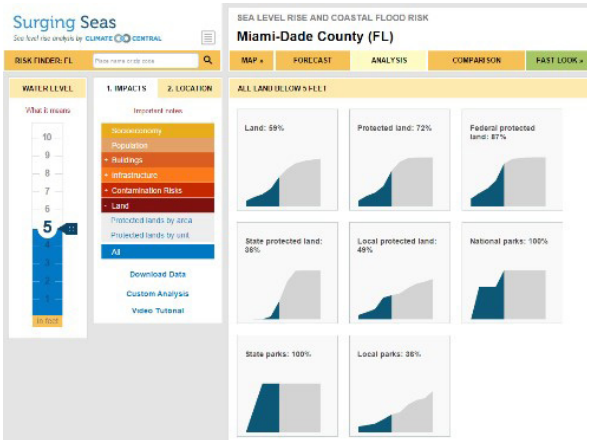
Seattle, WA (Pop. = 652,000)—created a visualization of future sea-level rise by making a before and after image of the Seattle Boardwalk. Mean projections indicate that Seattle will experience 7 inches of sea-level rise by 2050 and 24 inches by 2100. By visualizing potential impacts to community landmarks, the City hope to raise awareness of potential sea-level rise impacts and build community support for adaptation planning activities.

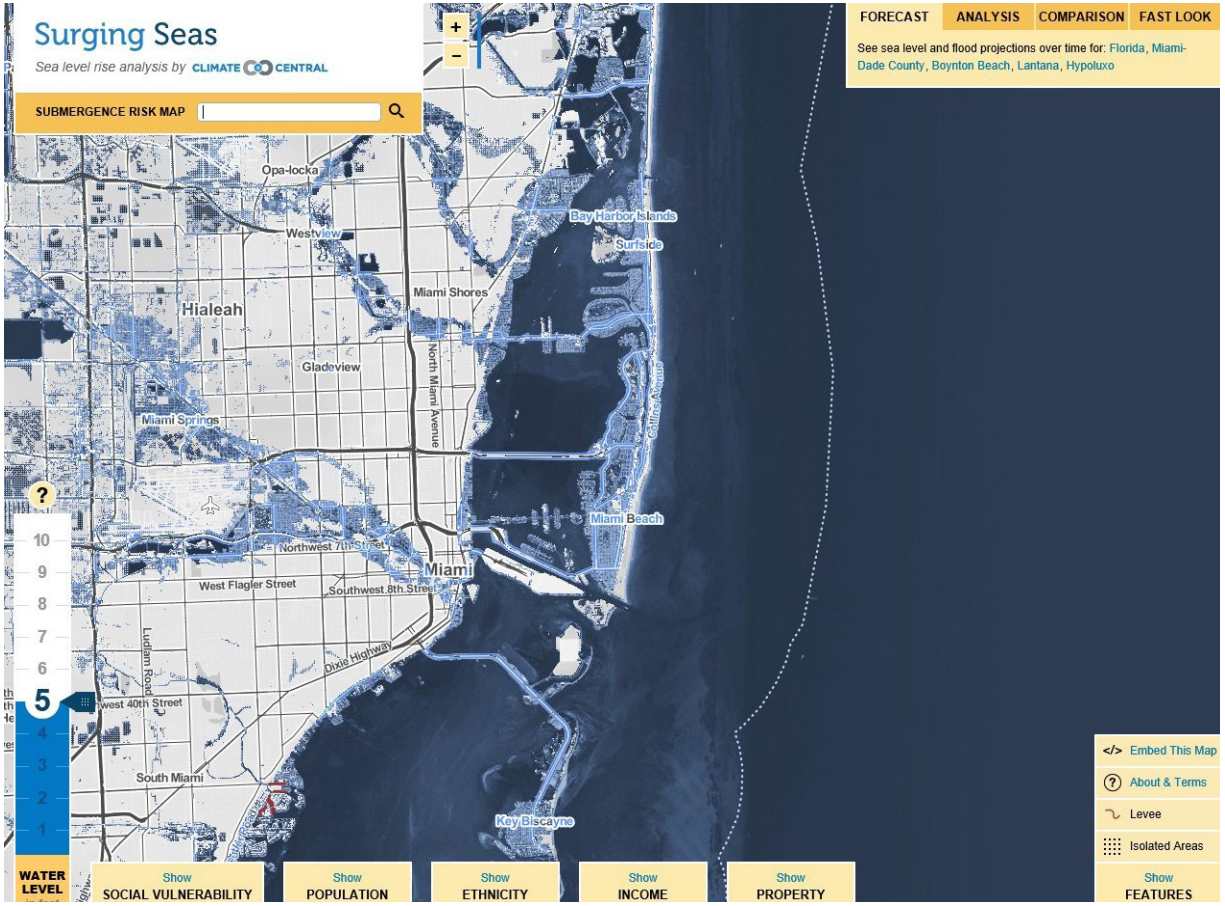
When & Where to Use

CanVis can be used to create visualizations of possible future conditions to help build awareness and facilitate public engagement during adaptation planning.

It may be applied to site-specific areas where digital photography near the waterfront exists.

Climate Central's Surging Seas





Tool/Resource Type: **Visualization Tool (Online Mapper, Data Download)**

Sector(s): **Natural Resources, Built Environment, Transportation**

Relevant Adaptation Planning Process Phase(s): **Stakeholder Engagement, Scoping / Inventory, Assessment / Analysis**

Geographic Scale: **Local, Regional, Statewide**

Cost: **Online Map Viewer = Free; Data Download = Free**

Data Input(s): **None**

Website: **http://sealevel.climatecentral.org/**

Developer/Sponsoring Agency: **Climate Central**

Description

Climate Central's Surging Seas analysis suite includes an interactive Risk Finder and Submergence Risk Map. The Risk Finder shows populations, infrastructure, and assets exposed to coastal flooding aggravated by different sea levels, as determined by the user (i.e., 1 to 10 feet of rise). The Submergence Risk Map is a tool that depicts sea-level rise scenarios. To utilize, assistance by personnel with Geographic Information Systems (GIS) experience is recommended.

The Risk Finder is a searchable data toolkit that allows users to explore vulnerability from zip code at the city, county, and state levels. It also provides the ability to compare risk across areas as well as the ability to analyze the likelihood of coastal flooding and sea level inundation occurring in the future by decade.

The Submergence Risk Map is a sea-level rise vulnerability assessment tool. This map is a web-based visualization tool that allows users to depict scenarios of sea-level rise for 1-foot height intervals from 1 to 10 feet above local high tide using an interactive slider. As the slider is moved, the map automatically updates to show what land would be covered or inundated by water and associated impact statistics (e.g., 21% of the population would be impacted). The tool also accounts for social vulnerability by identifying vulnerable communities and populations.

This tool is most useful for conducting a regional level exposure analysis; its use for informing site-specific decisions may be limited. Additionally, the tool does not incorporate physical modeling of storm surge or waves on top of sea-level rise, coastal erosion, or other coastal processes. Despite these limitations, Surging Seas is a good communications tool to help illustrate risk to others.

The data underlying the tool is available for download and the online tool can be used to generate interactive maps, tables, and figures, as well as risk timelines and other tools for assessing vulnerability to sea-level rise.

Examples of Use

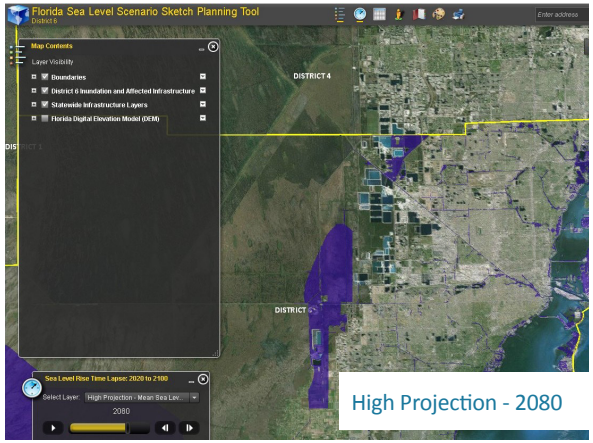
Benicia, CA (Pop. = 28,000)—is in the process of developing a vulnerability assessment and adaptation plan. The City's plan will contain strategies that address the risks identified during the vulnerability assessment. The vulnerability assessment utilized the Surging Seas tool to conduct financial assessments of impacts of future sea-level rise.

Florida, New Jersey, New York, and Washington, D.C. (Pop. = 19.9 million; 8.9 million; 19.7 million; 646,000; respectively)—reports were released to summarize the major themes and findings taken from the results accessible via the Surging Seas Risk Finder. These reports have been used to build regional awareness about vulnerability due to projected sea-level rise and coastal flood risk. The research in the reports served to highlight the high concentration and wide range of populations, property, infrastructure, buildings, and potential contamination sources in low-lying coastal areas.

When & Where to Use

Climate Central's Surging Seas is designed to provide local regions and policy makers with the tailored information they need to understand and respond to the risks of sea-level rise and coastal flooding. However, users should note that the map provides aggregated site-specific projection, meaning that while the resolution of demographics and sea-level rise projection is detailed at the parcel level, that data can only be viewed as part of the larger map mosaic. The tool allows users to visualize sea-level rise scenarios plus the historic 1 percent annual coastal flood and identify vulnerable populations, infrastructure, and assets.

FDOT Sea Level Scenario Sketch Planning Tool



Tool/Resource Type: **Visualization Tool (Online Mapper, Data Download)**

Sector(s): **Transportation**

Relevant Adaptation Planning Process Phase(s): **Stakeholder Engagement, Scoping / Inventory, Assessment / Analysis**

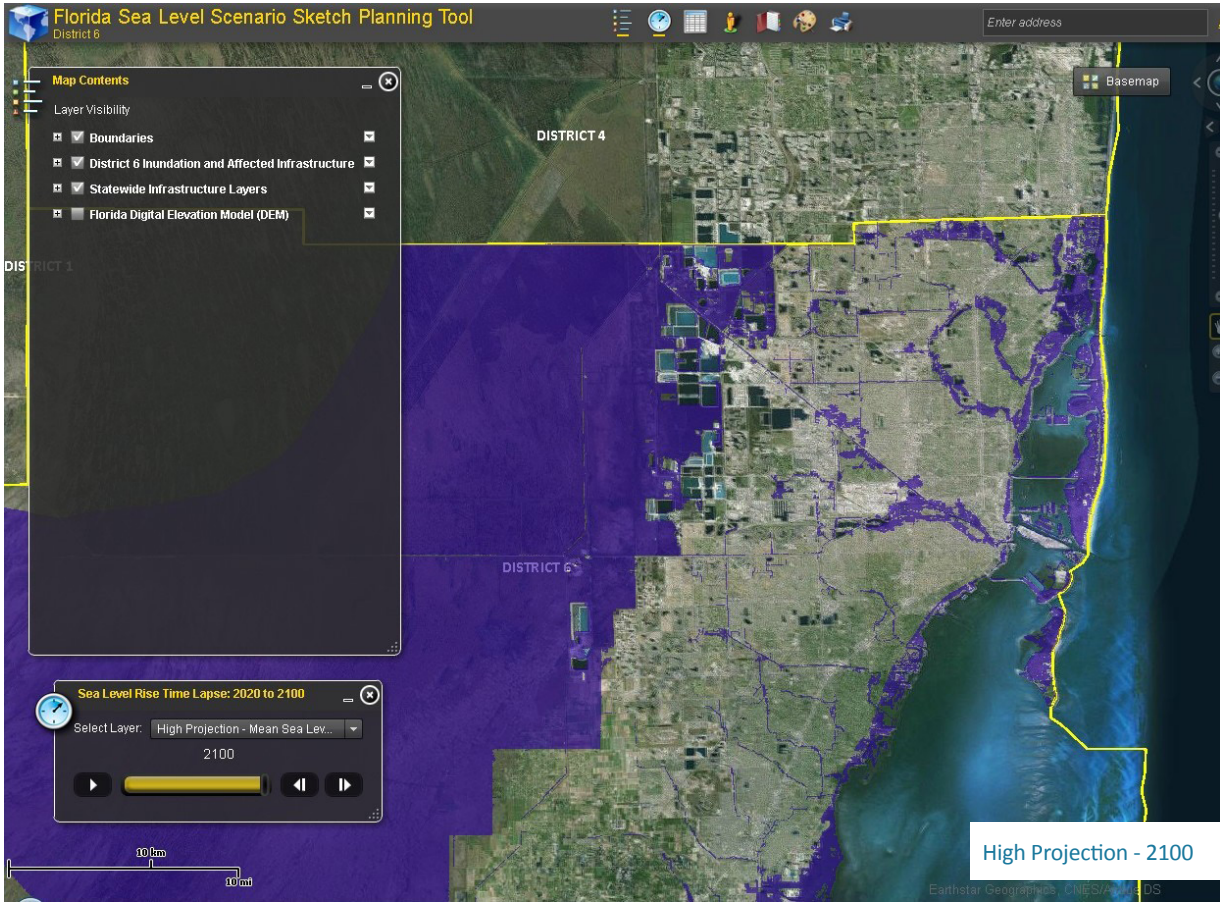
Geographic Scale: **Local, Regional, Statewide**

Cost: **Online Map Viewer = Free; Data Download = Free; Sea-Level Rise Inundation Surface Calculator Download = Free**

Data Input(s): **None**

Website: **http://sls.geoplan.ufl.edu/**

Developer/Sponsoring Agency: **Florida Department of Transportation**



Description

The Sea Level Scenario Sketch Planning Tool allows for visualization of areas that can potentially be inundated by sea-level rise, identification of transportation facilities potentially at risk from sea-level rise inundation, report creation to summarize and prioritize affected infrastructure, and the ability to create custom inundation surfaces. The Sketch Planning Tool consists of three tools: a map viewer, GIS data layers, and a sea-level rise inundation surface calculator, which can be used independently or together to conduct a preliminary assessment of vulnerable transportation infrastructure and assist transportation planners in assessing and prioritizing transportation facility investments. For communities who wish to use the data in their own software, assistance by someone with modeling experience in GIS is recommended.

The tool enables users to view map images online that depict sea level inundation scenarios for three sea-level rise projection ranges, three time horizons, and up to four tidal datums. Users can overlay these scenarios with an array of transportation infrastructure layers and a variety of base maps. Users can also run an animated time-lapse that illustrates how inundation boundaries may change over time. The selection procedure and small scale analysis may in some cases overestimate the affected infrastructure. However, applied at the appropriate scale, those errors, while potentially significant, do not diminish the utility of the toolkit as a useful statewide and regional indicator of potentially vulnerable infrastructure.

Examples of Use

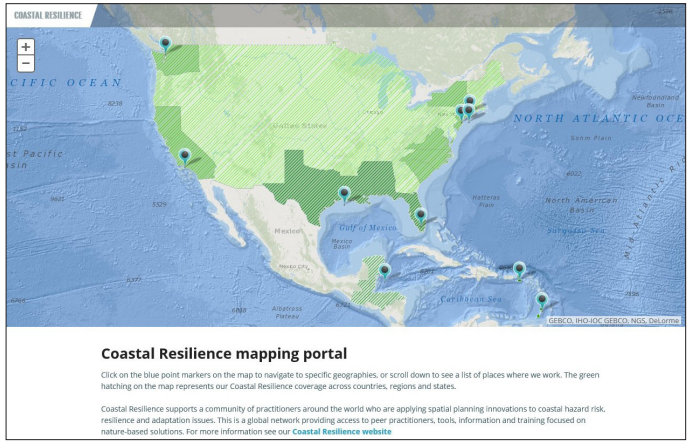
Hillsborough County, FL (Pop. = 1.3 million)—the Hillsborough County MPO 2040 Long Range Transportation Plan Needs Assessment used the Sketch Planning Tool's "high" 2040 scenario (current mean sea level plus 14 inches) to illustrate sea-level rise and help estimate disruption to the entire county and its transportation needs.

Monroe County, FL (Pop. = 76,000)—the county's Climate and Sustainability Program adaptation planning efforts included conducting a preliminary assessment using the FDOT Sea Level Sketch Scenario Planning Tool. The tool was used to identify the transportation facilities in the county that are potentially vulnerable to sea-level rise using the tool's inundation and affected infrastructure layers. Low/High projections for the years 2040 and 2060 were used model scenarios based on those adopted by the Southeast Regional Climate Compact sea-level rise projections. The results from the assessment were used to determine, for county maintained roads, where "low" and "high" daily inundations of would occur in 2040 and 2060.

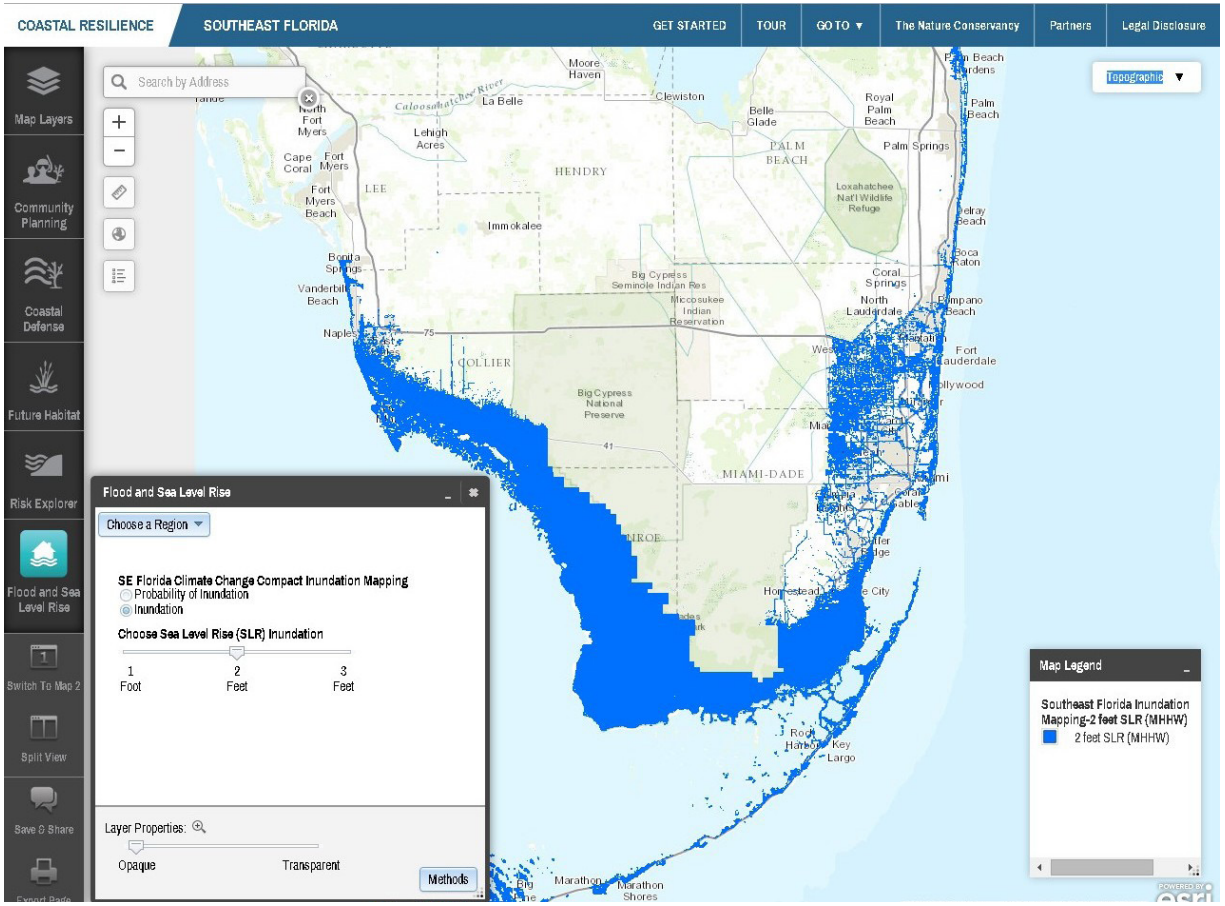
When & Where to Use

This tool displays statewide and regional vulnerability assessments of transportation facilities. More advanced users can download the base maps, infrastructure layers, and inundation layers as well as the underlying statewide digital elevation model (DEM) to create their own inundation scenarios and conduct their own local vulnerability assessments.

The Nature Conservancy Coastal Resilience Mapping Portal



- Tool/Resource Type: **Visualization Tool (Online Mapper)**
- Sector(s): **Natural Resources, Agriculture, Built Environment, Transportation**
- Relevant Adaptation Planning Process Phase(s): **Stakeholder Engagement, Scoping / Inventory, Assessment / Analysis**
- Geographic Scale: **Local, Regional, Statewide**
- Cost: **Online Map Viewer = Free**
- Data Input(s): **None**
- Website: **http://maps.coastalresilience.org/network/**
- Developer/Sponsoring Agency: **The Nature Conservancy**



Description

The Nature Conservancy Coastal Resilience Mapping Portal gives users access to interactive tools to visualize future flood risks from sea-level rise and storm surge. The tool compiles social and natural resource data, inundation scenarios, and spatial analysis results in an interactive web mapping tool. To utilize, assistance by personnel with GIS experience is recommended.

The Mapping Portal is part of a suite of tools, Costal Resilience 2.0, released by the Nature Conservancy to enable decision makers to assess risk to coastal hazards in terms of land use, environmental characteristics, and social vulnerability. The mapping portal can help users identify areas and populations at risk from coastal hazards and gain a better understanding of ecological, social, and economic impacts. This information is particularly helpful for officials in coastal planning, zoning, and land acquisition who must take rising sea levels and increased storm intensity and frequency into consideration.

The Mapping Portal includes a "Global" interactive map that provides comparative statistics regarding coastal resilience, as well as detailed interactive maps at select locations. Detailed maps are currently available for Southeast Florida and the Florida Keys. The Portal supports open-ended "what-if" exploration of the magnitude and extent of sea-level rise. Users can adjust the hypothetical amount of sea-level rise and view model-based projections for 2020, 2050, and 2080. Users can also weigh a series of environmental and socio-economic variables to explore how sea-level rise might degrade habitats. Users can view side by side comparisons of different model parameters using the "Split View" feature.

Examples of Use

Mobile Bay, AL—local and state governments are using the Community Resilience Tool to site oyster reef restoration projects using the Risk Explorer application. The Risk Explorer allows decision makers to assess risk and vulnerability to waves, storms, and other coastal hazards and identify habitat restoration and management priorities that may be most useful for risk reduction.

Puget Sound, WA—used the Community Resilience Tool to visualize potential future potential impacts to infrastructure, such as Interstate 5. The tool is being used by state agencies, county governments, and tribal organizations in the area to make decisions about floodplain management. It also is assisting in bringing in funding for floodplain-related projects.

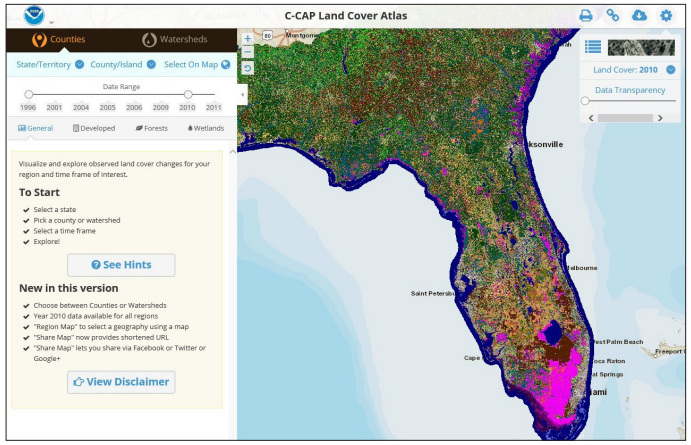
Waterford, CT (Pop. = 20,000)—the Coastal Resilience Program helped planners identify and assess risks and vulnerability to storms. The tool enabled the town to quickly prioritize actions to reduce risk. Now 20 municipalities (coastal and inland) and five regional planning organizations are engaged via the Coastal Resilience Program, reaching 500,000 people.

When & Where to Use

The Coastal Resilience Mapping portal can be used to build awareness, set principles and goals, and define the planning context. Like other visualizers, it may be used with stakeholders to define a preferred exposure analysis projection.

Data types differ slightly between the Florida Keys and the Gulf of Mexico Maps.

NOAA Coastal Change Analysis Program (C-CAP) Land Cover Atlas and Coastal Comparison Tool



Tool/Resource Type:
Visualization Tool (Online Mapper)

Sector(s): **Natural Resources, Agriculture, Built Environment**

Relevant Adaptation Planning Process Phase(s): **Stakeholder Engagement, Scoping / Inventory**

Geographic Scale: **Countywide, Statewide**

Cost: **Data Download = Free;**
Online Viewer = Free;
Online Comparison Tool = Free

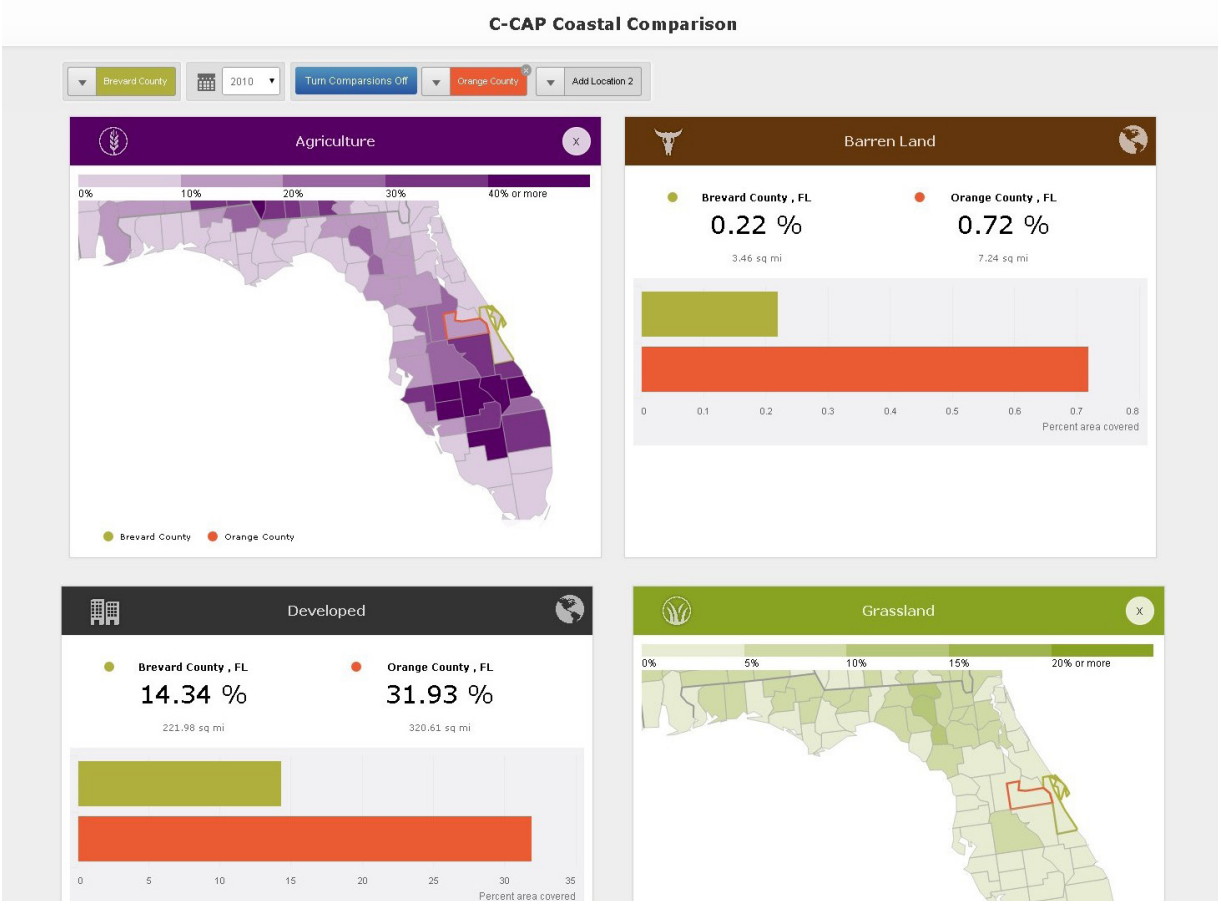
Data Input(s): **None**

Website:
http://coast.noaa.gov/digitalcoast/data/ccapregional

http://coast.noaa.gov/digitalcoast/tools/lca

http://coast.noaa.gov/digitalcoast/tools/ccap-comparison

Developer/Sponsoring Agency:
National Oceanic and Atmospheric Administration



Description

The NOAA Coastal Change Analysis Program (C-CAP) produces a nationally standardized database of land cover and land change information for the coastal regions of the U.S. that can be used to explore changes and trends in land cover that may be caused by sea-level rise. C-CAP products provide inventories of coastal intertidal areas, wetlands, and adjacent uplands with the goal of monitoring these habitats by updating the land cover maps every five years. C-CAP products are developed using multiple dates of remotely sensed imagery and consist of raster-based land cover maps for each date of analysis as well as a file that highlights changes that have occurred and where the changes were located. To utilize, assistance by personnel with GIS experience is recommended.

The C-CAP Land Cover Atlas is an online viewer that provides user-friendly access to regional C-CAP land cover change information. The Atlas eliminates the need for desktop GIS software, or advanced technical expertise, by processing C-CAP data for users and providing access to that distilled information. The tool summarizes general change trends, such as forest losses or new development, and can highlight specific changes of interests, such as marsh losses to open water or evergreen forest losses to new development. The viewer also allows users to determine which areas experience accretion, erosion, or frequently change between the two and decide if implementation of coastal building buffers is warranted.

The C-CAP Coastal Comparison Tool is an interactive tool that compares land cover between different coastal geographies using baseline data from C-CAP that allows users to compare land cover data for a county to the coastal portion of its state and the contiguous U.S. Users can compare counties to assess differences and similarities in land cover and land use practices between multiple locations

Examples of Use

Breton Sound, LA—C-CAP land cover data were used to compare flood conditions in the two-week period following Hurricane Katrina (August 2005) with 2006 conditions to quickly and accurately assess the potential impacts and recovery from the storm. The most prominent changes observed were the dramatic flooding in the weeks following Katrina and the subsequent emergent wetlands. In less than one year, the state experienced a loss of over 150 square miles of estuarine emergency marsh and an increase of over 200 square miles of open water, mostly attributed to Katrina. Future land cover updates will help assess longer-term recovery or additional habitat losses.

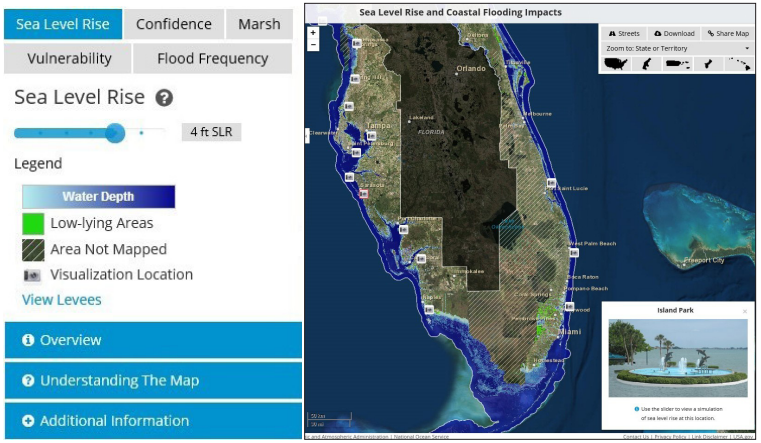
California Coast—a study was conducted to provide an analysis of the current population, infrastructure, and property at risk from projected sea-level rise if no actions are taken to protect the California Coast. This included evaluating the impacts of sea-level rise on wetlands. The land cover in the potential wetland migration zone was analyzed using 2001 land cover data from C-CAP. Each land cover type was rated according to its suitability to support wetland habitat in the future.

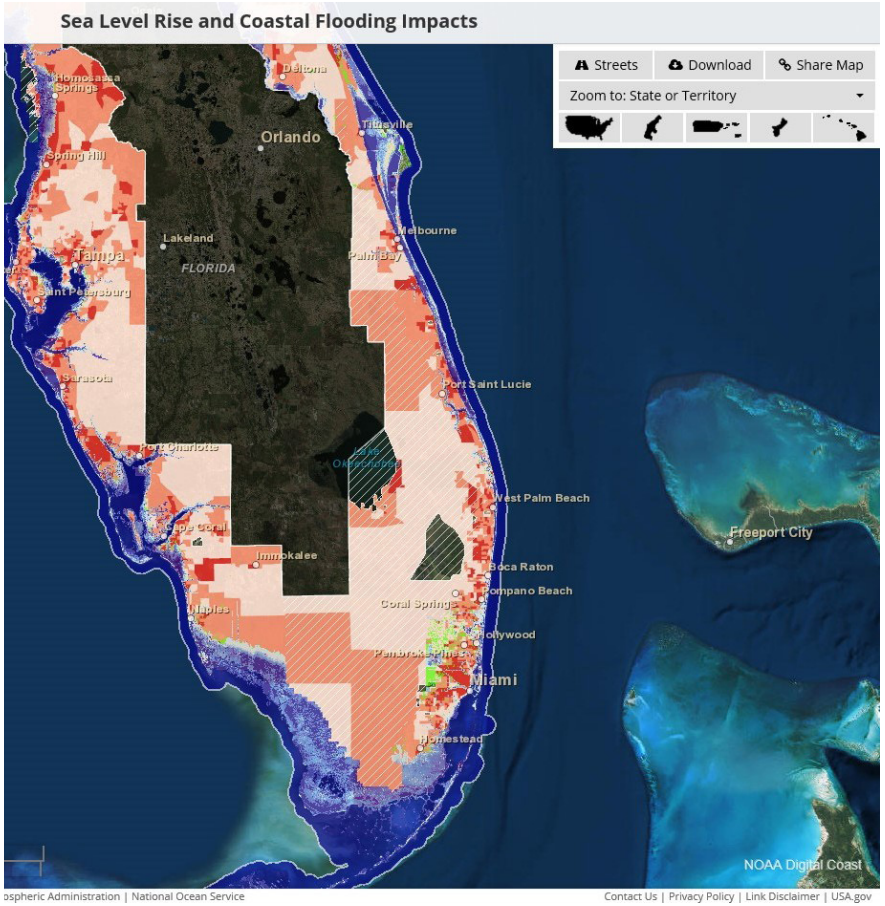
When & Where to Use

The C-CAP tool may be used during the awareness building, goal-setting, and planning context phase.

The tool allows users to compare land cover data for coastal and non-coastal areas, enabling them to explore changes and trends in land cover that may be caused by sea-level rise. It presents data at the county and watershed levels through a raster (pixel based) map.

NOAA Sea-Level Rise and Coastal Flooding Impacts Viewer





Tool/Resource Type: **Visualization Tool (Online Mapper)**

Sector(s): **Natural Resources, Built Environment, Transportation**

Relevant Adaptation Planning Process Phase(s): **Stakeholder Engagement, Scoping / Inventory, Assessment / Analysis**

Geographic Scale: **Local, Regional, Statewide**

Cost: **Data Download = Free; Online Viewer = Free**

Data Input(s): **None**

Website: **http://coast.noaa.gov/digitalcoast/tools/slr**

Developer/Sponsoring Agency: **National Oceanic and Atmospheric Administration**

Description

NOAA's Sea-Level Rise and Coastal Flooding Impacts Viewer is an online viewer that allows users to visualize potential impacts from sea-level rise. Users will select a geography in the viewer and move a slider bar to simulate various sea-level rise scenarios (at one-foot increments, from one to six feet above the average highest tide) to show the corresponding areas that could be impacted by flooding. Simulations that depict how local landmarks could be affected by potential future sea levels are also available anywhere a camera icon is located on the viewer. Additional tabs provide information about marsh impacts, nuisance flood frequency, socioeconomic vulnerability, and mapping confidence levels. To utilize, assistance by personnel with GIS experience is recommended.

Sea-level rise and coastal flooding mapping data for all the states and territories are currently available in the viewer, except for Alaska and Louisiana. However, new elevation data are being constantly collected by various federal, state, and local entities so it is possible that newer data have been collected since the mapping areas were originally populated.

Users can obtain the underlying digital elevation models (DEM) used in the viewer as well as the coastal flood inundation data files. Users will need their own GIS platform to manipulate the digital data or create related image outputs.

Examples of Use

Tybee Island, GA (Pop. = 3,000)—the city identified the areas of the island most vulnerable to sea-level rise using the Sea-Level Rise and Coastal Flooding Impacts Viewer. Once these areas were identified, a plan was developed and actions were prioritized for dealing with the current problems of flooding and frequent high tides as well potential impacts from future sea-level rise. City staff members also used the visual provided by the viewer at public meetings to display vulnerable areas and increase awareness of the impact that future sea-level rise could have on the community.

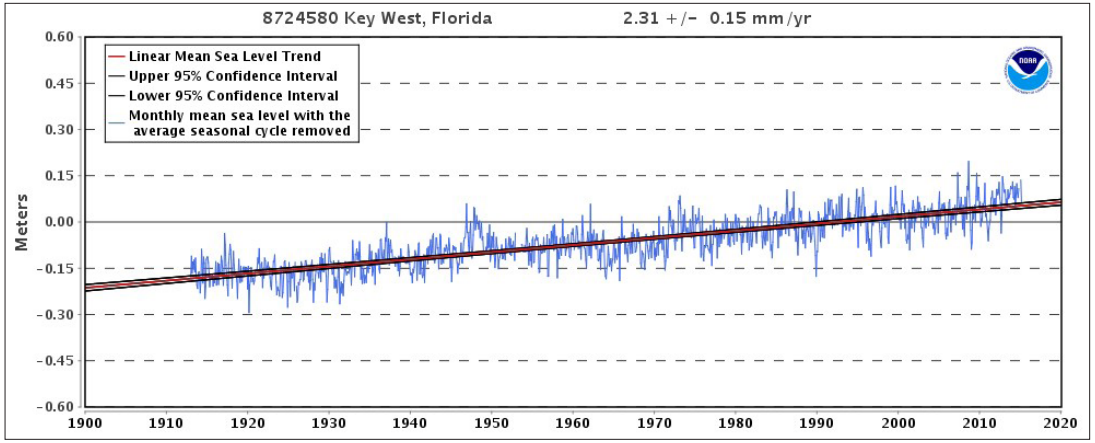
Biloxi, MS (Pop. = 45,000)—a hazards exhibit was set up in a regional shopping mall to help local residents and floodplain managers get a sense of what their town and neighborhoods could experience at various sea-level rise scenarios. Potential flooding impacts were demonstrated using the Sea-Level Rise and Coastal Flooding Impacts Viewer on a large screen at the exhibit. People were able to use the tool to visualize the extent of flooding and zoom in to local landmarks to see a simulation of flooding under various degrees of sea-level rise.

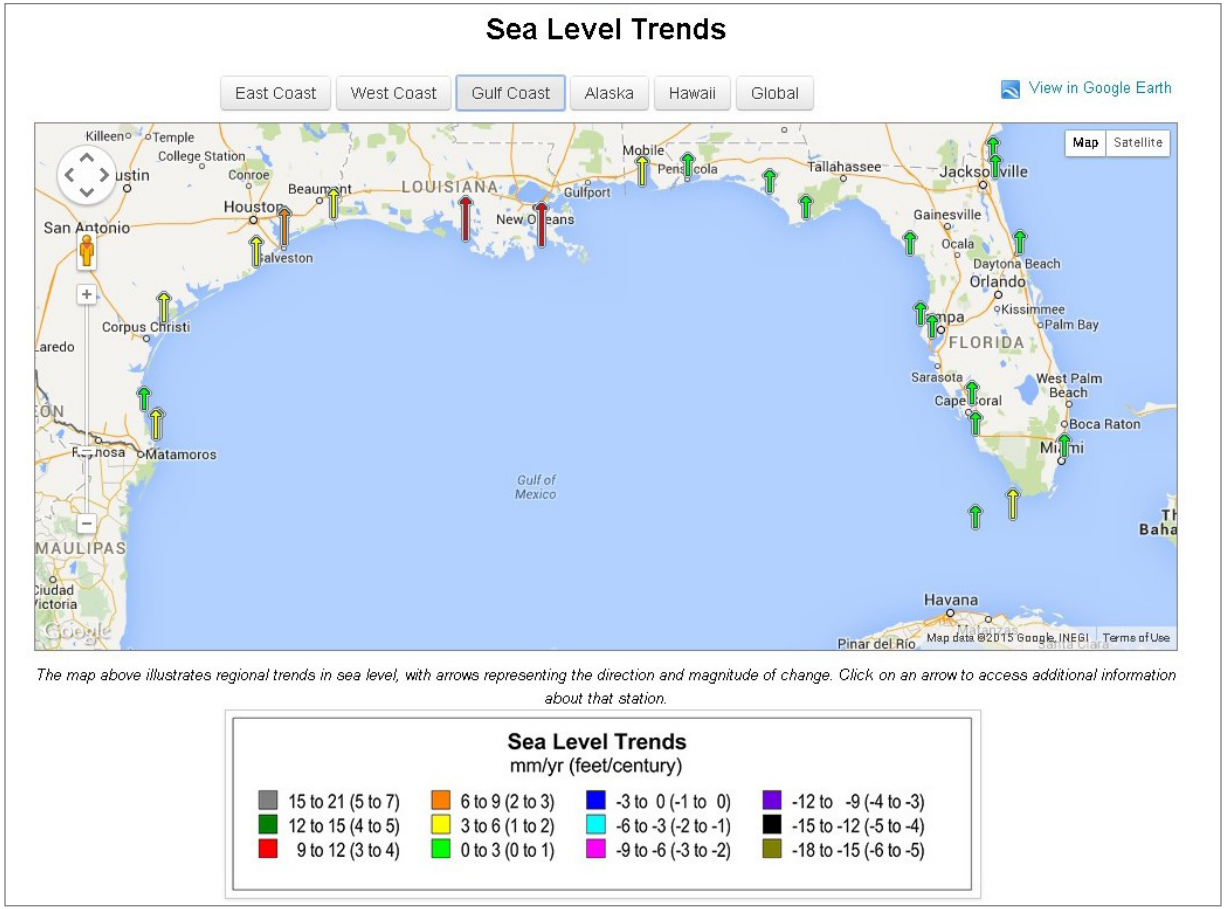
Southeast Florida (Pop. = 5.9 million)—the same methods used to create the Sea-Level Rise and Coastal Flooding Impacts Viewer were used to develop a unified set of methods and criteria for creating sea level inundation maps for the Southeast Florida counties of Monroe, Miami-Dade, Broward, and Palm Beach. After consistent mapping methods were developed, the counties and the South Florida Water Management District worked together to develop a vulnerability assessment of the Southeast Florida region for one, two and three-foot sea-level rise scenarios.

When & Where to Use

The Sea-Level Rise and Coastal Flooding Impacts Viewer allows users to conduct an exposure analysis and visualize how various levels of sea-level rise may impact a coastal community. This tool can also be used to help build awareness and facilitate public engagement during the adaptation planning process, and with the downloadable layers, to conduct a partial vulnerability analysis.

NOAA Sea Level Trends





Tool/Resource Type: **Visualization Tool (Online Mapper)**

Sector(s): **Natural Resources**

Relevant Adaptation Planning Process Phase(s): **Scoping / Inventory, Assessment / Analysis**

Geographic Scale: **Local, Regional**

Cost: **Online Viewer = Free**

Data Input(s): **None**

Website: **http://tidesandcurrents.noaa.gov/sltrends/sltrends.shtml**

Developer/Sponsoring Agency: **National Oceanic and Atmospheric Administration**

Description

NOAA Sea Level Trends is a tool that illustrates regional trends in sea level with arrows representing the direction and magnitude of change. The tool can be used to determine areas which have experienced the highest rates of change and may be most vulnerable to future sea-level rise. To utilize, assistance by personnel with GIS experience is recommended.

The Center for Operational Oceanographic Products and Services has been measuring sea level for over 150 years, with tide stations of the National Water Level Observation Network (NWLON) operating on all U.S. coasts. Changes in Mean Sea Level (MSL), either a sea-level rise or sea level fall, have been computed at 128 long-term water level stations using a minimum span of 30 years of observations at each location. These measurements have been averaged by month to remove the effect of higher frequency phenomena in order to compute an accurate linear sea level trend.

The MSL trends measured by tide gauges that are presented by the Sea Level Trends tool are local relative MSL trends as opposed to the global sea level trend. Tide gauge measurements are made with respect to a local fixed reference level on land; therefore, if there is some long- term vertical land motion occurring at that location, the relative MSL trend measured there is a combination of the global sea level rate and the local vertical land motion. It is important for the user to note that individual location tide gauge measurement values can vary significantly from global average values generally because of the consequences of location specific topography- and geology-related impacts.

Examples of Use

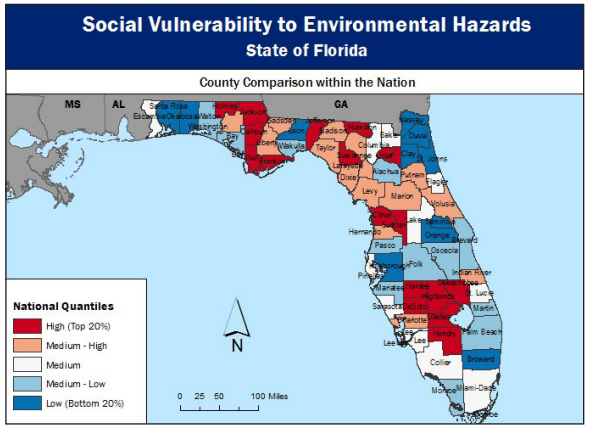
Massachusetts (Pop. = 6.7 million)—The Massachusetts Office of Coastal Zone Management (CZM) developed a guidance document to help coastal communities and others plan for and address potential sea-level rise effects on residential and commercial development, infrastructure and critical facilities, and natural resources and ecosystems. The document includes background information on local and global sea-level rise trends that was obtained from NOAA's Sea Level Trends. This information includes data from three long-term tide gauge stations in Boston, Woods Hole, and Nantucket.

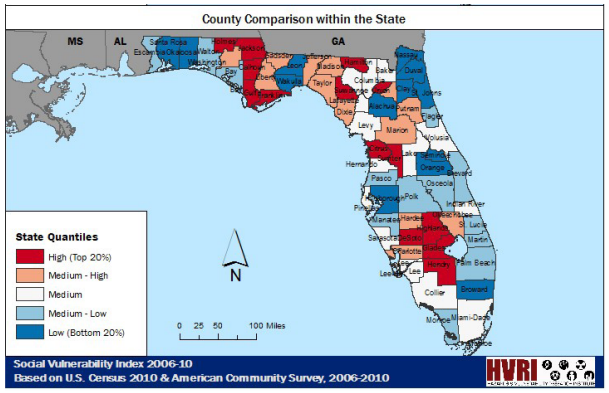
Chesapeake Bay, VA and MD—the Virginia Institute of Marine Science developed a report titled "Chesapeake Bay Land Subsidence and Sea Level Change: An evaluation of past and present trends and future outlook" for the U.S. Army Corps of Engineers Norfolk District. This report included information on Chesapeake Bay Sea Level trends that was obtained from records for 10 of the tide gauge stations included in NWLON network used by NOAA Sea Level Trends. The report found that land subsidence in Chesapeake Bay is likely to continue at or near present rates.

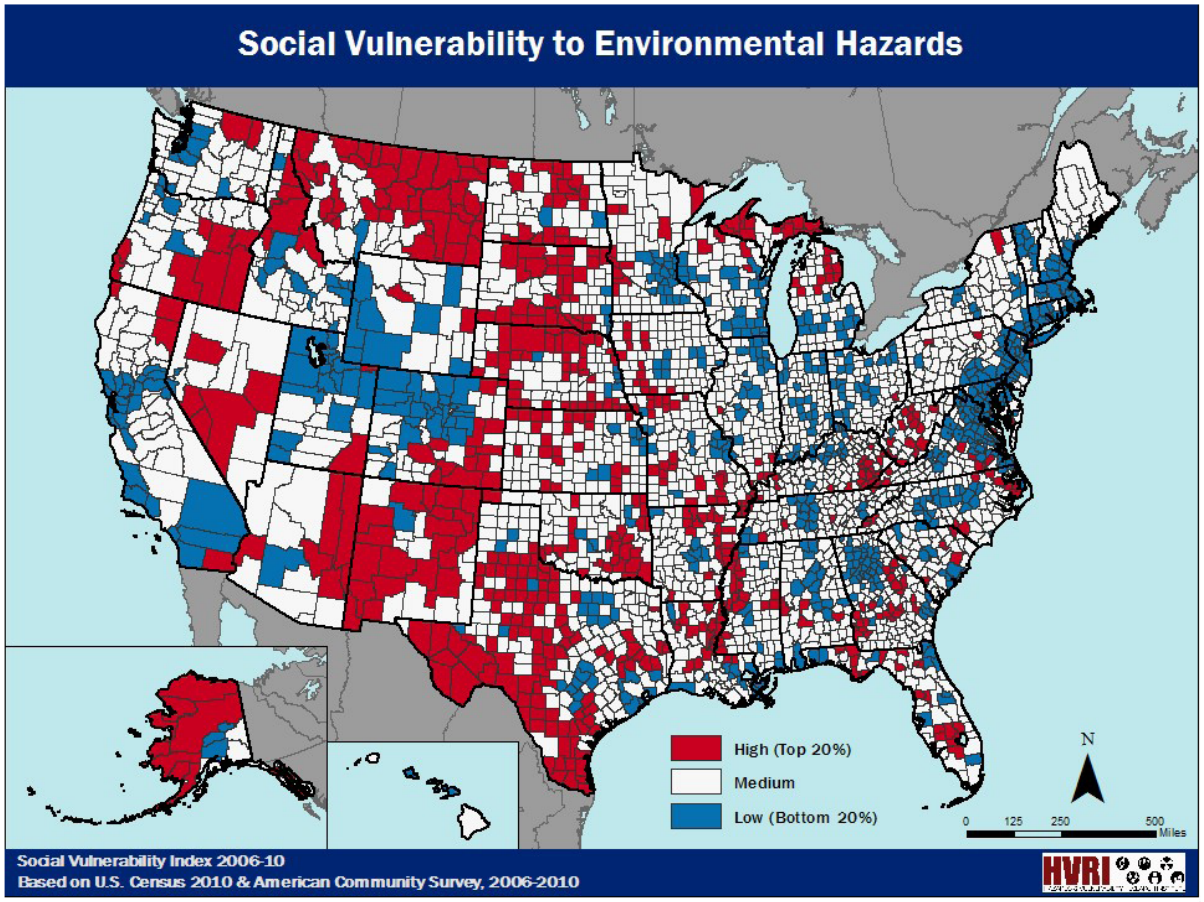
When & Where to Use

The NOAA Sea Level Trends tool illustrates regional trends in sea level and can be used to identify areas that may be most impacted by future sea-level rise. It may be used for community wide awareness building, goal-setting, and decisions about the rate of rise selected for an exposure analysis.

Social Vulnerability Index (SoVI)







Tool/Resource Type: **Visualization Tool (Online Mapper, Data Download)**

Sector(s): **Built Environment**

Relevant Adaptation Planning Process Phase(s): **Scoping / Inventory, Assessment / Analysis**

Geographic Scale: **Census Tract to Countywide**

Cost: **Results = Free; Data Download = Free**

Data Input(s): **None**

Website: **http://webra.cas.sc.edu/hvri/products/sovi.aspx**

Developer/Sponsoring Agency: **University of South Carolina, Hazard and Vulnerability Research Institute**

Description

The Social Vulnerability Index (SoVI) measures the social vulnerability of U.S. counties to environmental hazards, including sea-level rise. The index is a comparative metric that facilitates the examination of the differences in social vulnerability among counties. SoVI graphically illustrates the geographic variation in social vulnerability. It shows users where there is uneven capacity for preparedness and response and where resources might be used most effectively to reduce pre-existing vulnerabilities. To utilize, assistance by personnel with GIS experience is recommended.

The index synthesizes 30 socioeconomic variables, which the research literature suggests contribute to reduction in a community's ability to prepare for, respond to, and recover from hazards. SoVI data sources are primarily from the U.S. Census Bureau.

Generally, SoVI is classified using standard deviations, and SoVI scores that are greater than two standard deviations above the mean are considered the most socially vulnerable, while scores below two standard deviations less than the mean are the least vulnerable. SoVI scores are re-calculated based upon the unit of geographic analysis (country, state, county), and change in relation to the available ranges of values.

County-level SoVI scores and maps are freely available online and census tract-level results can be requested by email. This data is available for the entire nation. Additionally, SoVI GIS data shapefiles at the census tract-level are available for download for all coastal states through NOAA's Digital Coast Data Registry.

Examples of Use

South Carolina (Pop. = 4.8 million)—conducted a social vulnerability assessment using SoVI as part of the state hazards assessment. The SoVI metric at both county and tract levels for the entire state allow planners and emergency managers to quickly identify broad differences across the state and begin to understand (at sub-county levels) the characteristics of their populations and how populations are increasing or decreasing vulnerability. This assessment demonstrates where social vulnerability is concentrated in the state and provides information for individual counties in determining where their resources might be most effectively utilized to enhance preparedness, response, and recovery.

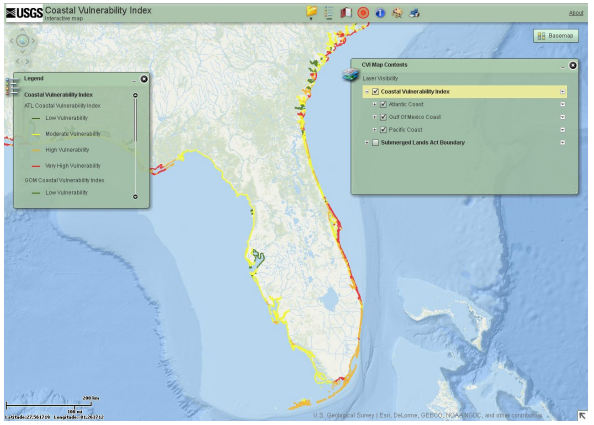
Colorado (Pop. = 5.4 million)—used SoVI to conduct a social vulnerability analysis at the census tract level. Local socioeconomic and demographic data were used to identify spatial patterns in social vulnerability across the state and have been applied to the hazard profiles in the Colorado State Hazard Mitigation Plan.

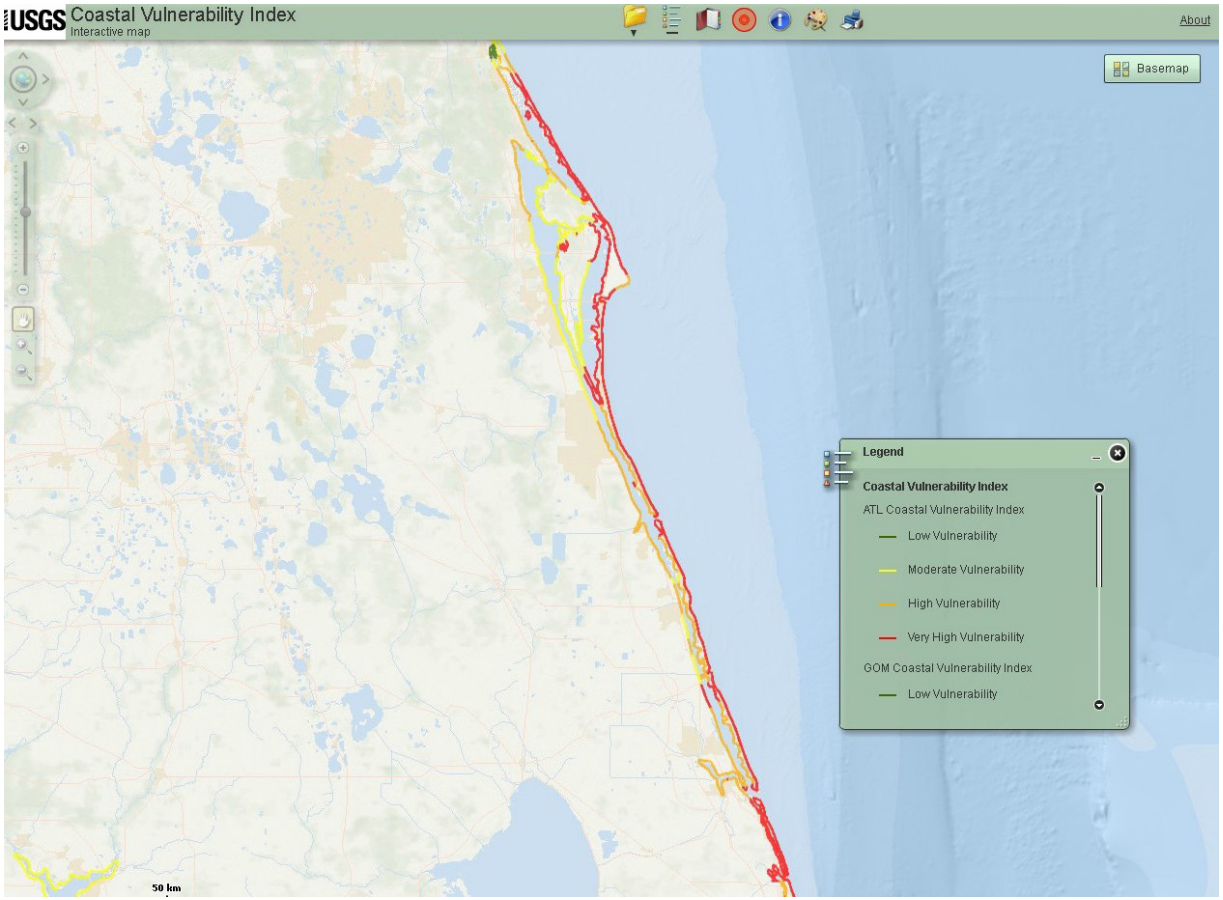
Southeast U.S.—Oxfam America released new maps about the geography and the people of the Southeast U.S., specifically Louisiana and Mississippi. The analysis was adapted from the SoVI index and the maps illustrate how climate hazards pose the most risk to communities that share certain characteristics of social vulnerability, such as poverty, larger populations of elderly or young, and substandard housing stock. The maps assist in identifying hotspots which are at significant risk in the face of four particular climate hazards, including sea-level rise. The research found that coupled with social vulnerability, the bayou parishes in Louisiana are at the highest risk to sea-level rise.

When & Where to Use

SoVI can provide valuable information during the Impacts Analysis phase. Because it shows differences in capacity for preparedness and response as well as areas where resources might be used most effectively, the tool can be used to identify census-tract focus areas where adaptation strategies are merited.

USGS National Assessment of Coastal Vulnerability to Sea-Level Rise: Coastal Vulnerability Index (CVI)





Tool/Resource Type: **Visualization Tool (Online Mapper)**

Sector(s): **Natural Resources**

Relevant Adaptation Planning Process Phase(s): **Scoping / Inventory, Assessment / Analysis**

Geographic Scale: **Local, Regional, Statewide**

Cost: **Map Viewer = Free**

Data Input(s): **None**

Website: **http://coastalmap.marine.usgs.gov/FlexWeb/national/cvi/**

Developer/Sponsoring Agency: **United States Geological Survey**

Description

The USGS National Assessment of Coastal Vulnerability seeks to determine the relative risks due to future sea-level rise for the U.S. Atlantic, Pacific, and Gulf of Mexico coasts. The interactive map, including the CVI, is available online and it is part of the USGS Coastal and Marine Geology Program (CMGP) Interactive Maps. This map includes the Coastal Vulnerability Index (CVI) data layer that expresses the relative vulnerability of the coast to physical changes due to sea-level rise, geomorphology (which indicates the relative susceptibility to erosion of a given shoreline), and shoreline erosion rates (which indicate how the given section of shoreline has been eroding). To utilize, assistance by personnel with GIS experience is recommended.

Through the use of CVI, the relative risk that physical changes will occur as sea-level rises is quantified based on the following criteria: tidal range, wave height, coastal slope, shoreline change, geomorphology, and historical rate of relative sea-level rise. The combination of these variables and the association of these variables to each other furnish a broad overview of regions where physical changes are likely to occur to due to sea-level rise. This approach combines a coastal system's susceptibility to change with its natural ability to adapt to changing environmental conditions, and yields a relative measure of the system's natural vulnerability to the effects of sea-level rise. Users will be able to easily determine which coastlines are the most vulnerable to potential future sea-level rise using this interactive map.

Examples of Use

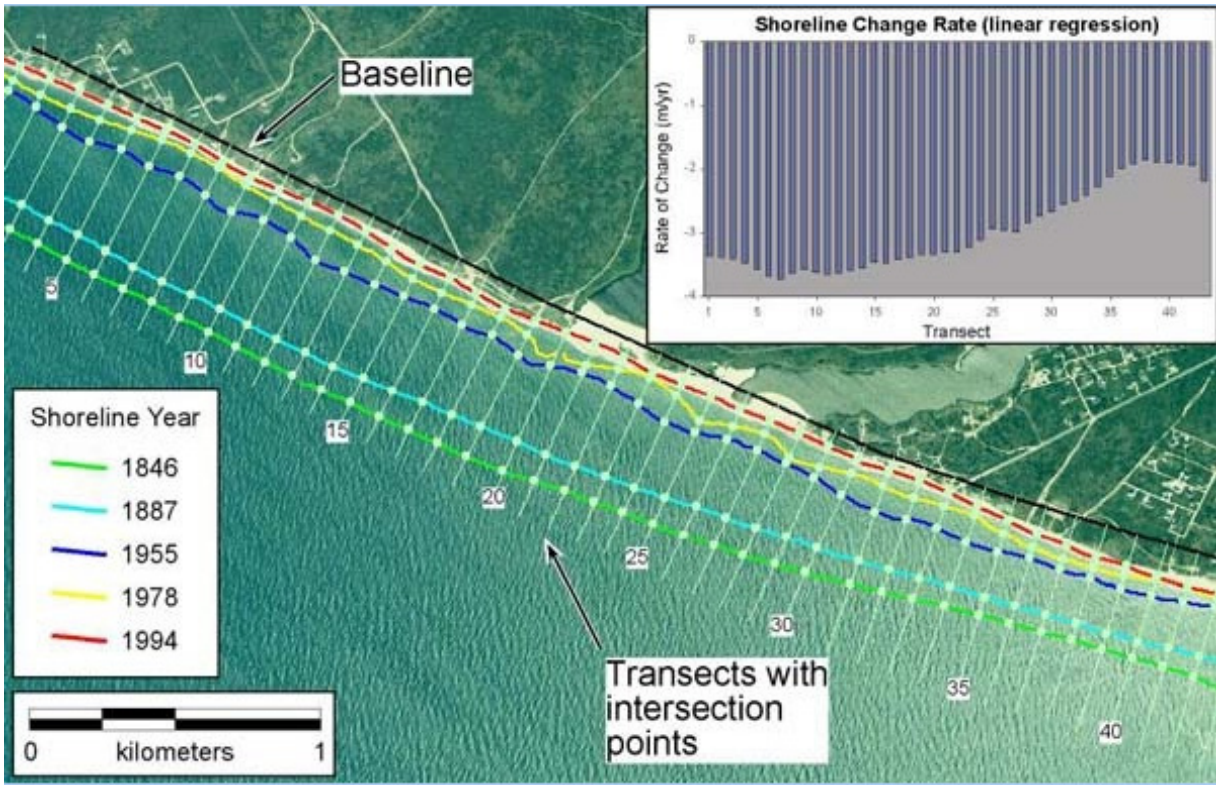
California (Pop. = 38.8 million)—according to studies conducted by the USGS, relative sea level is rising at 2.29 mm/year in the San Francisco-Monterey Bay region. Additionally, in contrast to the northern Pacific coast, the wave energy in this area is moderate to high and decreases as you move down the coast to areas of low wave energy in southern California. This reflects data obtained from the Coastal Vulnerability Index (CVI) which was developed to determine the physical response of the coastline to sea-level rise. Based on this research, the USGS estimates that sea-level rise will have a large, sustained impact on coastal evolution over the next decade. This could potentially result in the loss of cultural, natural, and recreational resources in California's coastal State Parks.

Cape Hatteras National Seashore, NC—A coastal vulnerability index (CVI) was used to map the relative vulnerability of the coast to future sea-level rise within Cape Hatteras National Seashore. The CVI provides insight into the relative potential of coastal change due to future sea-level rise. Over 70 miles of shoreline was evaluated, and, of this total, 26 percent of the mapped shoreline is classified as being at very high vulnerability due to future sea-level rise. Another 24 percent is classified as high vulnerability, 26 percent as moderate vulnerability, and 24 percent as low vulnerability. Ranking will allow coastal managers to define planning focus areas.

When & Where to Use

This tool may be used to describe the planning context, and to inform the exposure analysis. It includes continuous data for the entire coast of Florida, and communities may use the identify tool on their particular stretch of shoreline to examine USGS' six characteristics of sea-level rise. Data download was unavailable at the time of publication of this current resource.

USGS Digital Shoreline Analysis System (DSAS)



Tool/Resource Type:
Visualization Tool (Software)

Sector(s): **Natural Resources**

Relevant Adaptation Planning Process Phase(s): **Scoping / Inventory, Assessment / Analysis**

Geographic Scale: **Shoreline**

Cost: **Software Download = Free**

Data Input(s): **National shoreline data**

Website:
http://pubs.usgs.gov/of/2003/of03-076/

Developer/Sponsoring Agency:
United States Geological Survey

Description

The USGS Digital Shoreline Analysis System (DSAS) can be used to measure coastal erosion and accretion which can assist users determine which areas have experienced the highest rates of change and may be most vulnerable to sea-level rise. DSAS version 2.0 extends the normal functionality of the ESRI's ArcView GIS to include historic shoreline change analysis. The application extension is designed to efficiently lead a user through the major steps of shoreline change analysis in a clearly organized and attractive user interface. To utilize, assistance by personnel with technical modeling experience, including use of GIS software, is recommended.

DSAS facilitates the shoreline change-calculation process, providing both rate-of-change information and the statistical data necessary to establish the reliability of the calculated results. The software will guide users through the steps to define a baseline, generate transects at user-defined intervals along the coast, and calculate rates of change that are based on multiple historic shoreline positions. In addition to measuring shoreline change, the software can be used to measure the positional change over time of river channel boundaries and land cover changes.

It is important for users to note that the calculated measures of change provided by DSAS are only as reliable as the sampling and measurement accuracy associated with the source materials/data used. The resolution of shoreline data derived from various sources may result in inaccuracies.

Examples of Use

Santa Rosa Island, FL—DSAS was used to analyze shoreline data for nearly two dozen historical shoreline positions that were compiled and georeferenced from surveys and aerial photos dating from the 1850s to the present and were used to determine the barrier island's response to storms and sea-level rise. Analysis of the dataset revealed that storms have heavily influenced shoreline position. Shoreline retreat during the period from 1851 to present (2013) has averaged less than one meter per year. Periods of more rapid retreat have been associated with the occurrence of major storms. The historical shoreline data underscore the dominant influence of storm frequency and intensity in determining coastal change.

Assateague Island National Seashore, MD—used DSAS software to calculate shoreline rates of change (m/year) at 20 meter intervals (transects) along the Assateague coast to derive the rate of shoreline change over time. Shoreline change rates on Assateague Island were found to range from greater than 2 m/year of accretion (very low vulnerability to future sea-level rise) to greater than 2 m/year of erosion (very high vulnerability to future sea-level rise).

National Assessment of Shoreline Change Project—DSAS is being used as part of the National Assessment of Shoreline Change Project to calculate rates of long-term and short-term change along open-ocean sandy shores of the conterminous U.S. A primary goal of this work is to develop standardized methods for mapping and analyzing shoreline movement so that internally consistent updates can periodically be made to record shoreline erosion and accretion.

When & Where to Use

DSAS calculations can be used to identify areas, at the sub-community level, that may be most impacted by future sea-level rise. Communities may use this GIS extension during the exposure analysis and impact analysis phases.

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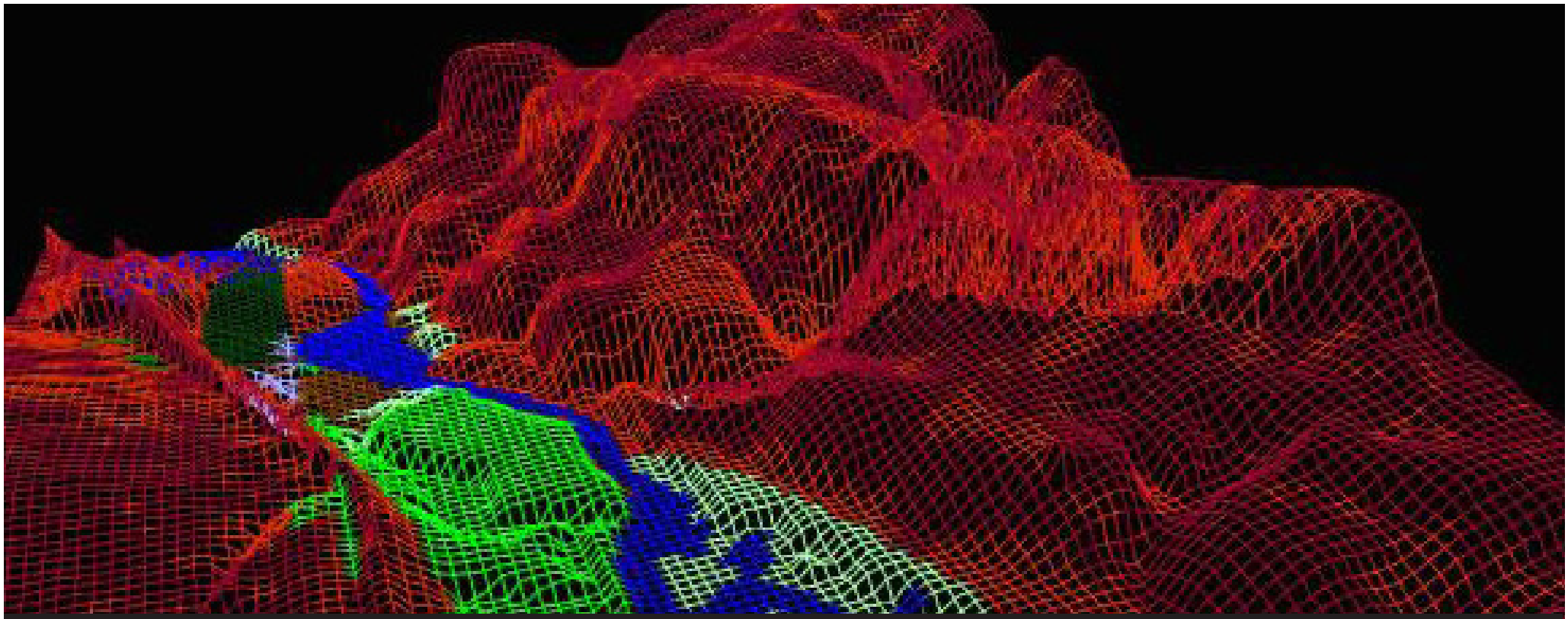
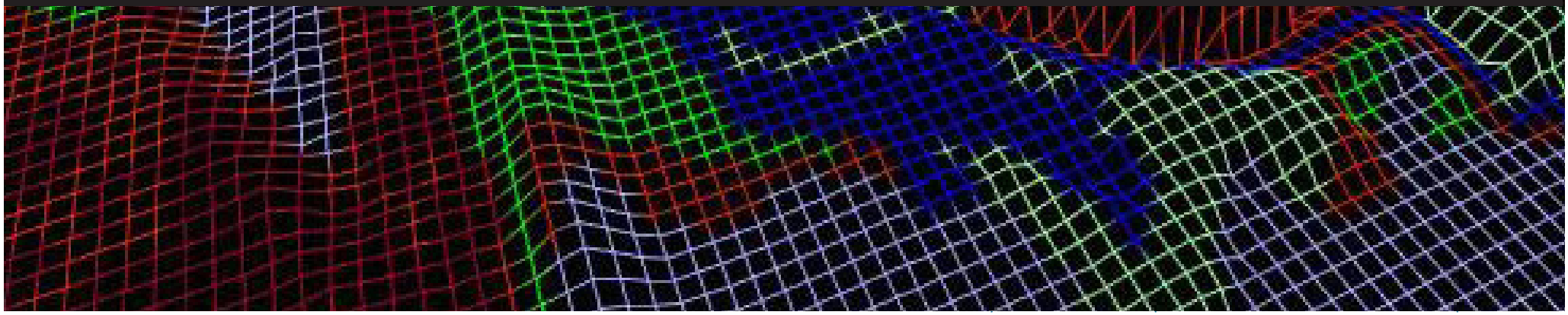
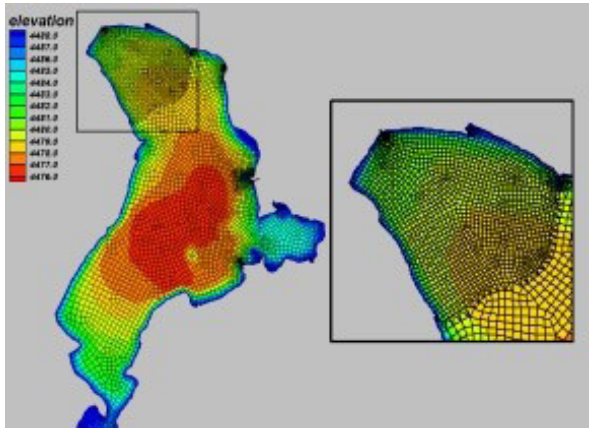


Modeling Tools



ADvanced CIRCulation Model (ADCIRC)



Tool/Resource Type: **Modeling Tool**

Sector(s): **Natural Resources**

Relevant Adaptation Planning Process Phase(s): **Assessment / Analysis**

Geographic Scale: **Deep Ocean, Continental Shelves, Coastal Seas, or Small-scale, Estuarine Systems**

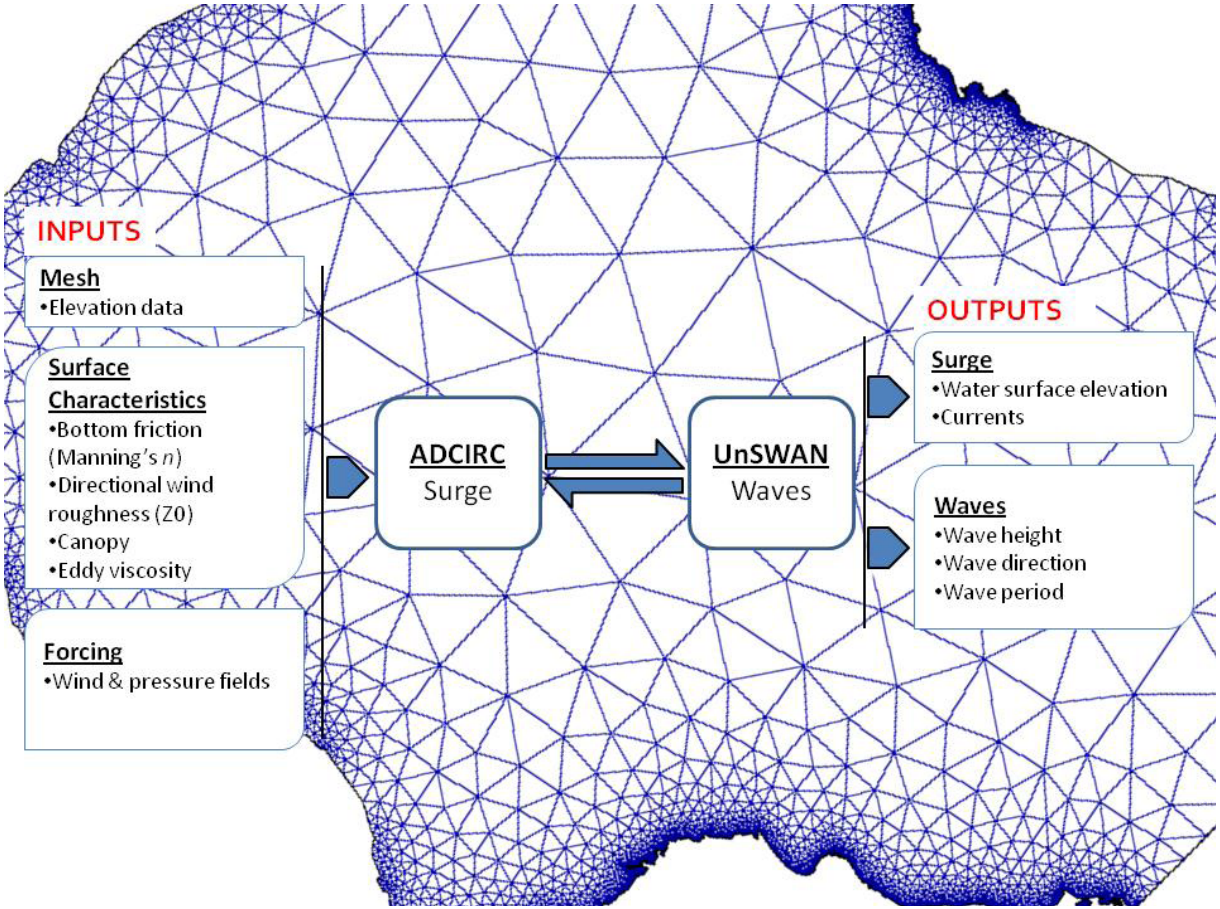
Cost: **ADCIRC Software Component = $3,950; Custom ADCIRC Package = $6,350; SMS Package = $2,400-$47,600; Educational Package Discount = 50% off**

Data Input(s): **Bathymetry, gridded wind measurements across the model domain, freshwater discharge**

Website: **http://adcirc.org/**
http://www.aquaveo.com/software/sms-adcirc

http://www.veritechinc.com/products/sms_adcirc/index.php

Developer/Sponsoring Agency: **University of North Carolina at Chapel Hill, University of Notre Dame, University of Texas at Austin**



Description

The ADvanced CIRCulation Model (ADCIRC) can be used to analyze the effects of sea-level rise on storm surge. Future scenarios can consider a given rate of sea-level rise and determine how much additional inundation is predicted during a storm event compared to inundation under initial conditions. ADCIRC can be applied to coastal oceans, inlets, rivers, and floodplains to solve the equations of motion for a moving fluid on a rotating earth. Typical applications have included prediction of storm surge and flooding, modeling tides and wind driven circulation, larval transport studies, near shore marine operations, and dredging feasibility and material disposal studies. To utilize, assistance by personnel with technical modeling experience, including use of GIS software, is recommended.

ADCIRC is a highly-vetted, physics-based circulation model that is commonly utilized as the standard coastal storm surge model by the U.S. Army Corps of Engineers and Federal Emergency Management Agency (FEMA). Non-U.S. Army Corps of Engineer users can obtain ADCIRC in the Surface- Water Modeling System (SMS) distribution available through Aquaveo (provides all new development and support) and Veri-Tech (licensed vendor). However, knowledge of the SMS software is practically required for new ADCIRC users.

The advantage of using ADCIRC over other storm surge models is that input conditions can include all or part of wind stress, tides, wave stress, and river discharge to make the model output more accurate. Disadvantages include the matter in which input/output affects model performance since each output file must be written sequentially and usability is not ideal.

Examples of Use

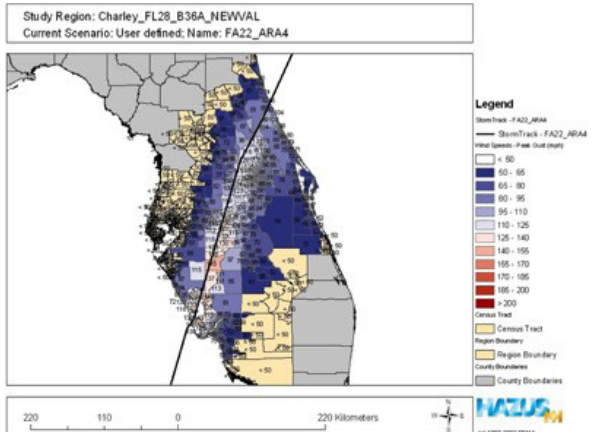
Corpus Christi Bay Area, TX—the ADCIRC model was used to analyze the effects of future landscapes and sea-level rise on storm surge. Future scenarios include changes in land cover type in the area as well as a sea-level rise rate for 2050 and 2100 conditions. The 2050 simulation predicted an addition of 936 square miles of inundation to the initial conditions (in 2006) along the entire coast of Texas during a hypothetical storm scenario. The 2100 simulation predicts an increase of 2,046 square miles of inundation along the entire coast of Texas, which is double the area impacted when compared to the 2050 scenario.

Galveston Bay and Jefferson County Area, TX—the ADCIRC model was used to conduct a storm surge analysis of sea-level rise. The simulation of Hurricane Ike for the base condition (in 2004) produced a peak surge of approximately 19 feet. The same Hurricane Ike simulation was applied to the future scenario models and the maximum surge was computed. The maximum surge for the 2050 scenario varied throughout the region from a minimum of approximately 1.3 feet offshore to a maximum of approximately 6 feet (compared to the analyzed sea-level rise value of 1.343 feet). The maximum surge for 2100 scenario also showed variation throughout the region from a minimum offshore to a maximum of 8 feet (compared to the analyzed sea-level rise value of 3.039 feet).

When & Where to Use

ADCIRC can model tide and storm surge elevations and velocities for areas encompassing the deep ocean, continental shelves, coastal seas, and small-scale estuarine systems. Simulations can also be run to determine how sea-level rise will impact future storm surge inundation. ADCIRC is useful for exposure and impact analyses.

Hazus-MH



Tool/Resource Type:
Modeling Tool

Sector(s): **Built Environment, Transportation, Energy**

Relevant Adaptation Planning Process Phase(s): **Assessment / Analysis**

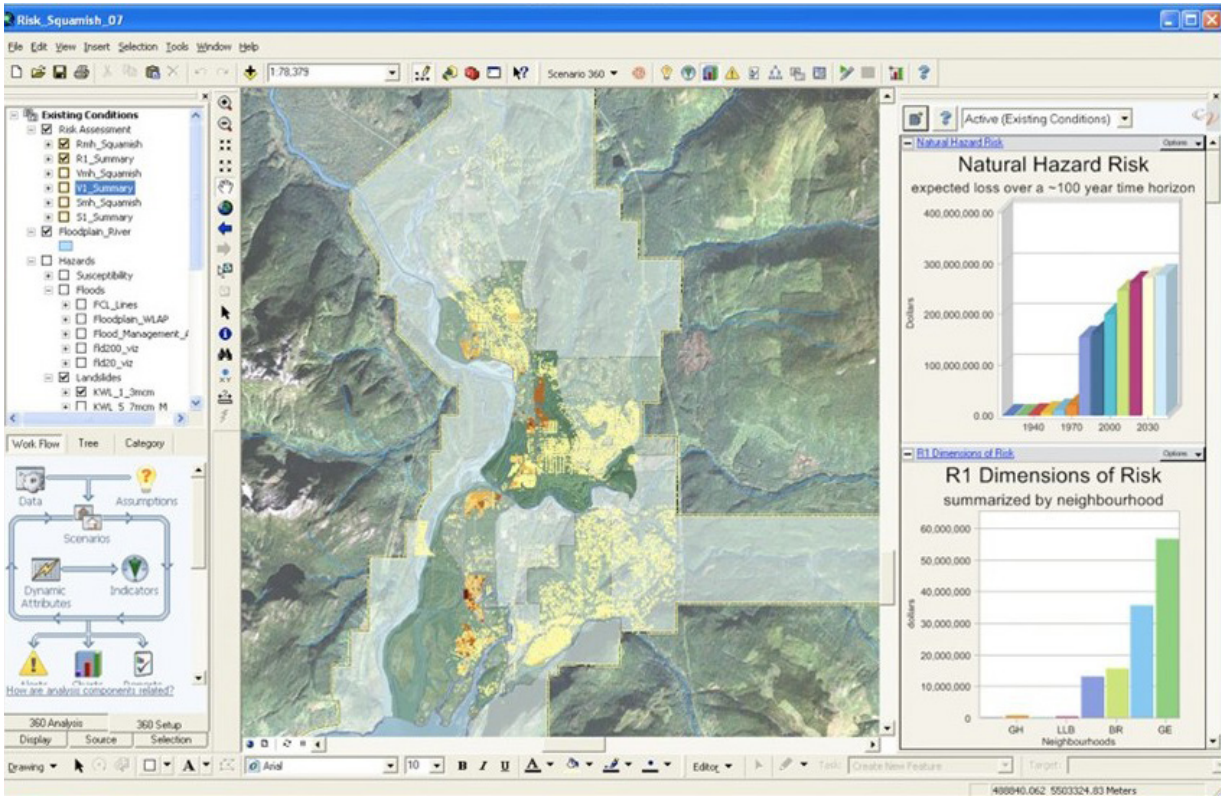
Geographic Scale: **Local, Regional, Statewide**

Cost: **Software Download = Free**

Data Input(s): **None (contains all necessary data but users can supply additional data, such as specific building data, soil maps, and stream gauges)**

Website:
http://www.fema.gov/hazus

Developer/Sponsoring Agency:
Federal Emergency Management Agency



Description

Hazus-MH is a risk assessment methodology for analyzing potential losses from hazards. Although it is not specifically designed for sea-level rise planning applications, many communities have used Hazus-MH to assess potential losses due to sea-level rise by using the flood model. The flood analysis portion of Hazus-MH can incorporate coastal flooding and riverine flooding models and generate flood footprints that are used to calculate economic, social, and infrastructure impacts. The flood footprints from the inundation models can be substituted in Hazus-MH and the impacts of sea-level rise can be calculated based on the new inundation information. To utilize, assistance by personnel with technical modeling experience, including use of GIS software, is recommended.

In addition to estimating the physical damage, economic loss, and social impacts of sea-level rise, users will be able to visualize the spatial relationships between populations, assets, and resources and sea-level rise using the Hazus-MH software.

It is important to consider that the Hazus-MH flood model performs its analysis at the census block level with small numbers of buildings. Damage analysis of a small number of buildings makes the flood model more sensitive to rounding errors so results should be used with suitable caution. Additionally, while Hazus-MH can be used to estimate losses for an individual building, the results must be considered as an average for a group of similar buildings. Nominally similar buildings are often noted to experience vastly different damage and losses during a natural hazard. Another consideration is that the embedded databases and assumptions used to characterize the lifeline (e.g., transportation, utilities) systems in a study region are necessarily incomplete and oversimplified; therefore, when using embedded inventories, accuracy of losses associated with lifelines may be less than losses from the general building stock.

Examples of Use

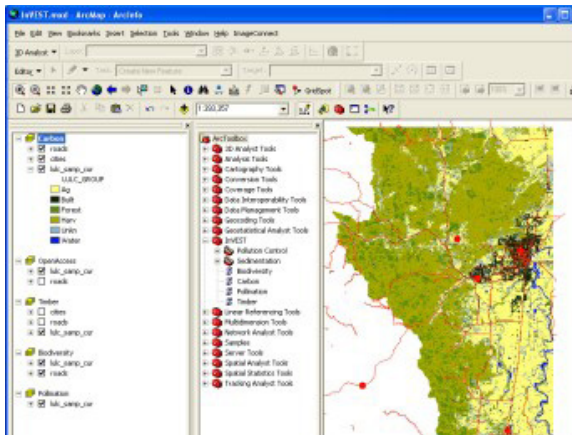
Galveston Bay Region, TX (Pop. = 4.7 million)—calculated the socio-economic impact of sea-level rise using Hazus-MH. The Hazus-MH flooding module was used to analyze the effects of two sea-level rise scenarios on the Galveston Bay community (made up of Harris, Galveston, and Chambers counties). For each of the two scenarios, the software was used to estimate the impact on displaced population; expected number of buildings impacted; building-related economic loss; industrial, hazardous, superfund, and solid waste; and water treatment plants.

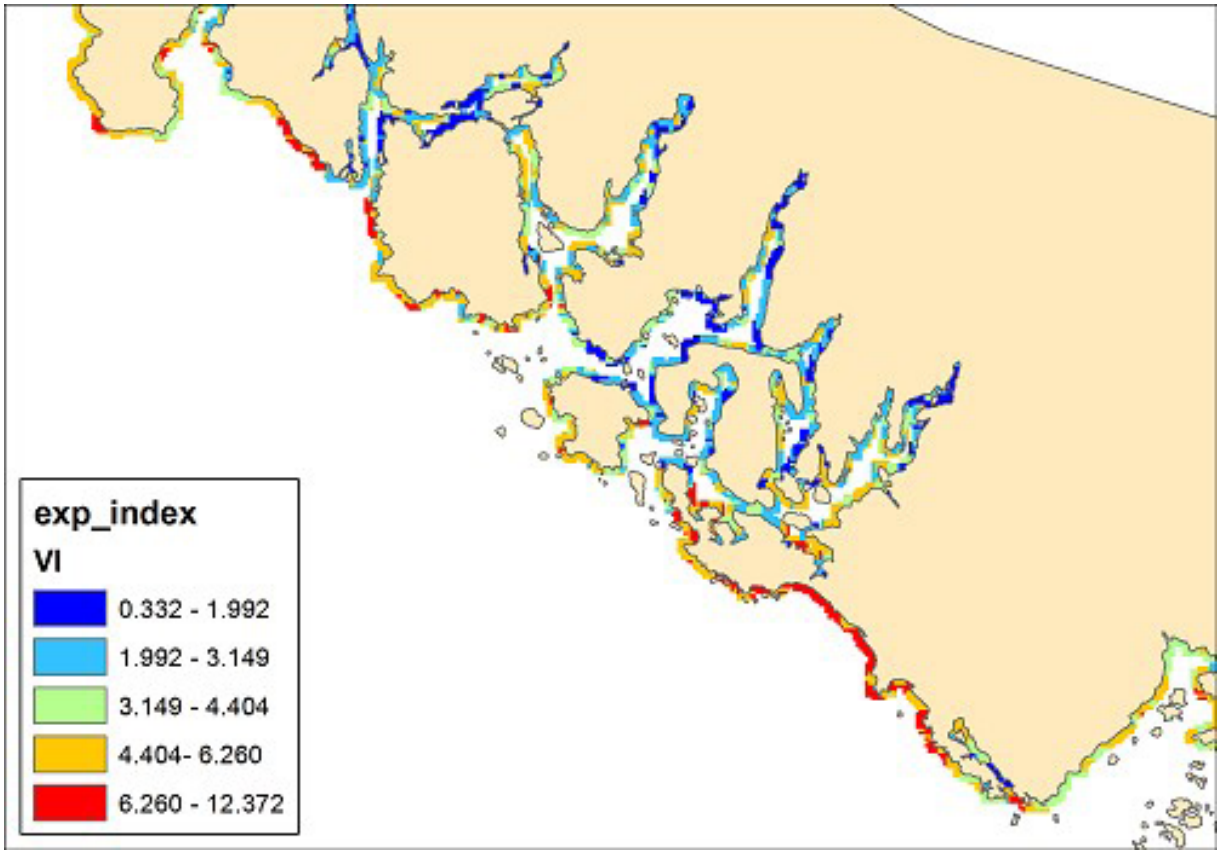
Long Island, NY (Pop. = 7.7 million)—estimated economic loss per census block due to flooding from storm surge and sea-level rise using the Hazus-MH flood model software. Economic loss was determined based on the value of estimated building damage (replacement value) under different storm surge and sea-level rise conditions.

When & Where to Use

Hazus-MH can be used to perform exposure, impact, and adaptive capacity analyses on parcels. With sufficient computing power, property level dollar impacts of future coastal flooding may be provided for the entire community.

Integrated Valuation of Environmental Services and Tradeoffs (InVEST)





Tool/Resource Type: **Modeling Tool**

Sector(s): **Natural Resources, Agriculture, Energy**

Relevant Adaptation Planning Process Phase(s): **Assessment / Analysis Strategy / Scenario Development**

Geographic Scale: **Local, Regional, Statewide, Global**

Cost: **Software Download = Free**

Data Input(s): **Spatial data and parameter values (much of the data are included within the software, users can input data more specific to the region)**

Website: **http://www.naturalcapitalproject.org/InVEST.html**

Developer/Sponsoring Agency: **Natural Capital Project**

Description

Integrated Valuation of Environmental Services and Tradeoffs (InVEST) is a suite of software models that is used to map and model ecosystem services and their variation under different management and climate scenarios. The Coastal Vulnerability Model (CVM), part of the multi- dimensional InVEST tool, can be used to calculate a vulnerability index for the impacts of erosion and inundation on coastal communities that accounts for projected change in sea level. By showing the areas where coastal populations are threatened and highlighting the relative role of natural habitat at reducing exposure, the model can be used to investigate how some management action or land use change can affect the exposure of human populations to erosion and inundation. To utilize, assistance by personnel with technical modeling experience, including use of GIS software, is recommended.

InVEST is most effectively used within a decision-making process that begins by identifying different management options. Decision makers develop future scenarios to show, for example, where sea-level rise may impact a community, and InVEST can estimate how the current distribution and value of relevant ecosystem services are likely to change under alternative futures. Results can be shared with stakeholders and policy makers to inform upcoming decisions.

The software can be run using ESRI's ArcGIS or other GIS software and the User's Guide is a comprehensive resource for technical and general users of InVEST models and results. Of note, data for some models can be difficult to obtain. As an example, many models use annual average data and depending on the model used, scale (data resolution) can be a limiting factor.

Examples of Use

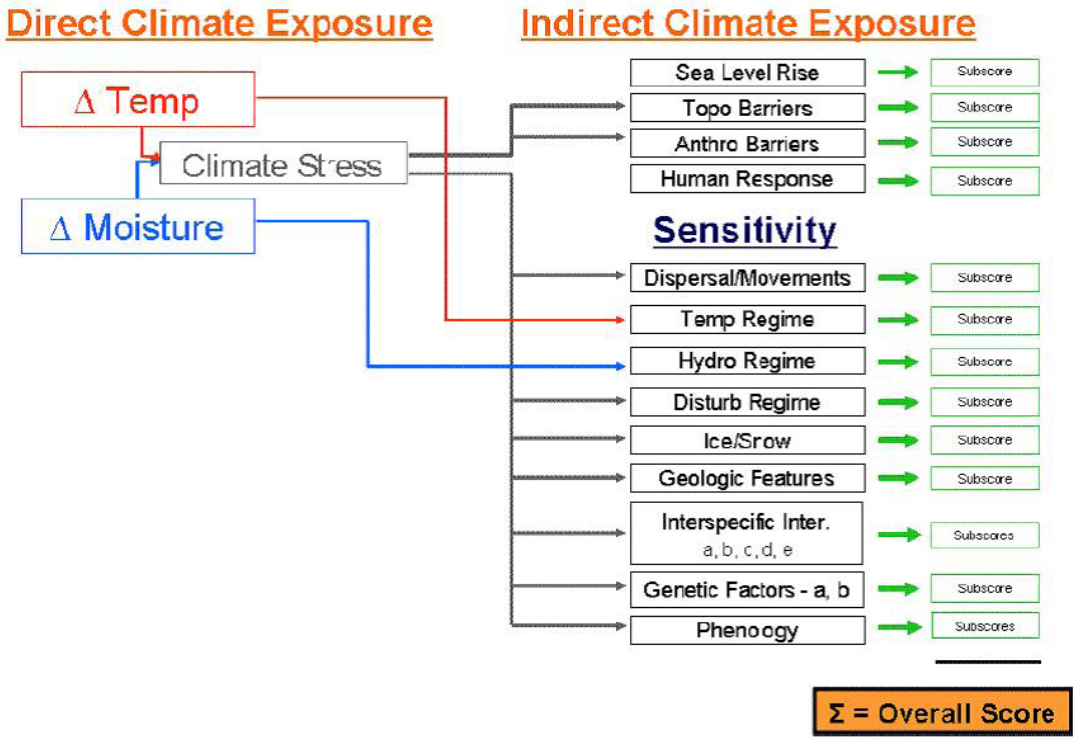
Placencia, Belize (Pop. = 750)—used InVEST to assess the ecosystem service impacts and possible costs and benefits of alternative adaptation scenarios. InVEST was able to account for expected costs related to sea-level rise, including changes in annual catch of spiny lobster and expected property damage from erosion and storms.

Yucatan, Mexico (Pop. = 2 million)—used the InVEST Coastal Vulnerability model to help understand how modifications of the biological and physical environment can affect coastal exposure to storm-induced erosion and flooding. The output was a qualitative Vulnerability Index, which differentiated areas with relatively high or low exposure to erosion and inundation during storms. The results found that sea-level rise will have a greater negative impact on costal vulnerability in those areas with medium-to-low coastal vulnerability values. This information can help coastal managers, planners, landowners, and other stakeholders identify regions of greater risk to coastal hazards.

When & Where to Use

InVEST can be used to determine how natural areas, sea-level rise, and the community at large, will interact. It is useful as a vulnerability assessment and adaptation strategy prioritization tool.

NatureServe Climate Change Vulnerability Index (CCVI)



Tool/Resource Type: **Modeling Tool**

Sector(s): **Natural Resources**

Relevant Adaptation Planning Process Phase(s): **Assessment / Analysis**

Geographic Scale: **Regional**

Cost: **Software Download = Free**

Data Input(s): **Species-specific sensitivity or life history data, data on exposure to climate change, land use data**

Website: **http://www.natureserve.org/conservation-tools/climate-change-vulnerability-index**

Developer/Sponsoring Agency: **NatureServe**

Species	Natural barriers	Anthropogenic barriers	Dispersal & movements	Historical thermal niche	Physiological thermal niche	Historical hydrological niche	Physiological hydrological niche	Dependence on ice/snow	Restriction to geological feature	Dietary versatility	Genetic variation	Index Score
Aplodontia rufa	Inc	N	Inc	SI	SI	Inc-SI	N	N	N	N	U	EV
Rhinichthys osculus oligoporus	N	N	Inc	N	N	GI-Inc	GI	N	N	N	U	HV
Limenitis archippus lahontani	N	N	Inc	N	SI	SI	GI	N	N	Inc	U	HV
Ochotona princeps	GI-Inc	N	SI	SI-N	N	SI-N	N	N	Inc	N	U	HV
Sorex palustris	Inc	N	Inc	N	SI	SI-N	GI-Inc	N	N	N	U	HV
Oncorhynchus clarkii henshawi	N	N	N	N	Inc-SI	SI	Inc-SI	N	N	N	U	HV
Rana pipiens	N	N	N	N	SI	SI	GI-Inc	N	N	N	U	MV
Draba cusickii var. *pedicellata*	N	N	Inc	N	SI-N	SI	N	N	SI	N/A	U	MV
Leucosticte atrata	GI	N	Dec	SI	U	SI	N	SI	Inc-SI	N	U	MV
Populus tremuloides	N	N	GI	N-SD	Inc	SI-N	SI	N	N	N/A	SD	MV
Asclepias eastwoodiana	N	N	SI	N	N	SI	Inc	N	N	N/A	U	PS
Phrynosoma platyrhinos	N	N	N	N	SD	Inc-SI	N	N	N	SI	U	PS
Quiscalus mexicanus	N	SD	Dec	N	N	N	N	N	N	SD	U	IL

Description

The NatureServe Climate Change Vulnerability Index (CCVI) is an Excel-based tool that identifies plant and animal species that are particularly vulnerable to the effects of climate change and can help assess the relative vulnerability of species of interest occurring on the coast that are affected by sea-level rise. Using the index, users apply readily available information about a species' natural history, distribution, and landscape circumstances to predict whether a species will likely experience a range contraction and/or population reductions due to climate change. To utilize, assistance by personnel with experience using Microsoft Excel is recommended.

The index separates vulnerability into two primary components: a species' exposure to climate change within a particular assessment area and its inherent sensitivity to climate change. The tool then gauges 20 scientifically documented factors and indicators of these components as well as documented responses to climate change where they exist. While the index calculates anticipated increases or declines in populations of individual species, the index also accommodates inherent uncertainties about how species respond within their ecological contexts. However, the tool is not a substitute for an in-depth vulnerability assessment of high profile species.

Exposure to sea-level rise is considered only in cases where all or a portion of the range within the assessment area may be subject to the effects of a 0.5 to 1 meter sea-level rise and the consequent influence of storm surges. Sea-level rise is a factor related to indirect exposure to climate change that is not weighted by the exposure measures in the index. The magnitude of sea-level rise within an assessment area will reflect global rather than local changes.

The tool is only designed for terrestrial and aquatic plants and animals in the contiguous 48 U.S.

Examples of Use

Florida (Pop. = 19.9 million)—a case study using CCVI was developed to inform conservation planning for species in Florida. The report was prepared for the Florida Fish and Wildfire Conservation Commission. CCVI was used to identify factors contributing to vulnerability to climate change for a set of species occurring in Florida. Exposure to sea-level rise assessed by estimating the percentage of the species' range that occurs at low elevations (<1 meter suggested) was one of the parameters used in the CCVI.

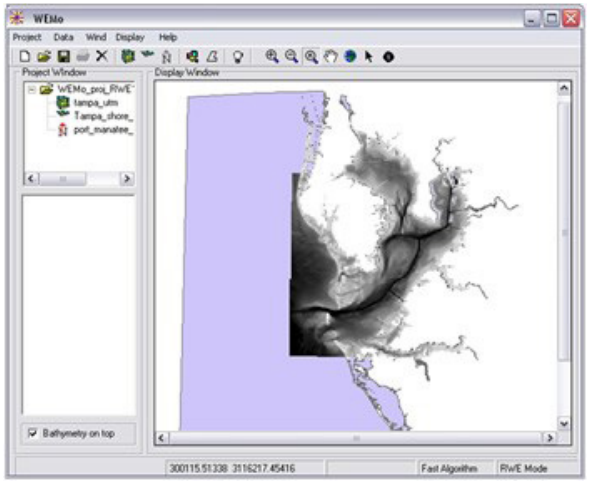
California (Pop. = 38.8 million)—conducted a climate change vulnerability assessment for rare plants in California using CCVI. The assessment considered direct and indirect climate exposure factors as well as ecological sensitivity to model the rare plant species' predicted range size change and overlap. Sea-level rise was one of the indirect climate exposure factors considered during the assessment. The assessment found that of the 156 rare plants, 99 are classified as "vulnerable" to climate change.

Arctic Alaska—used CCVI to conduct a climate change vulnerability assessment for arctic breeding birds to help guide climate-informed wildfire management in the region. The assessment compared the added vulnerability posed by climate change projected for 2050 in the Alaska portion of the Arctic Landscape Conservation Cooperative (LCC). The CCVI integrated information on species sensitivity, direct exposure to projected atmospheric changes in climate, and indirect exposure factors including sea-level rise. The CCVI results ranked two species as highly vulnerable, seven as moderately vulnerable, and five as likely to increase.

When & Where to Use

CCVI can be utilized to conduct impact analyses on species and parts of the natural environment. With appropriate data, it may apply to sub-community, whole community, or regional areas. Outputs can be used to prioritize adaptation focus areas, taking into consideration habitat migration and preservation needs.

NOAA Wave Exposure Model (WEMo)



Tool/Resource Type: **Modeling Tool**

Sector(s): **Natural Resources**

Relevant Adaptation Planning Process Phase(s): **Assessment / Analysis**

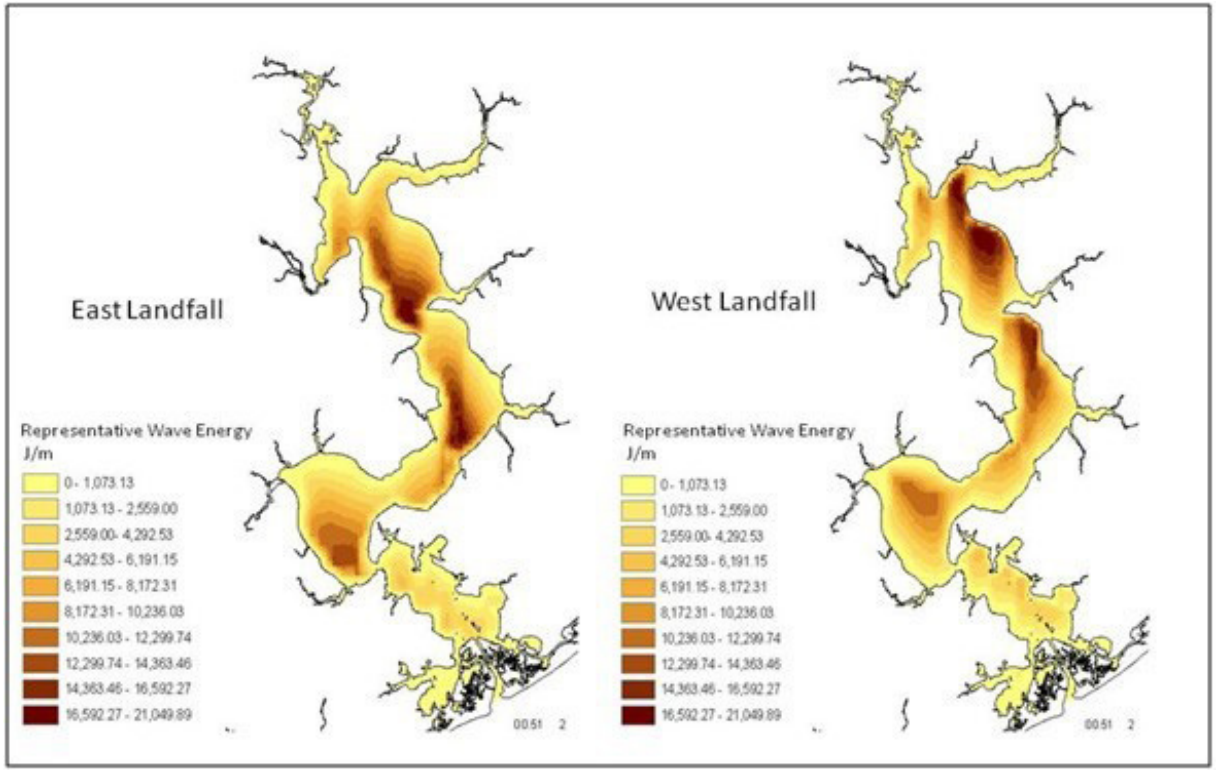
Geographic Scale: **Regional**

Cost: **Software Download = Free**

Data Input(s): **Bathymetry grid data, shoreline coverage data, wind data**

Website: **http://coast.noaa.gov/digitalcoast/tools/wemo**

Developer/Sponsoring Agency: **National Oceanic and Atmospheric Administration**



Description

WEMo is a free tool that estimates wave energy and its effects on ecosystem functions as well as on developed coastal and inland-water areas. The tool was designed to provide quantitative forecasts of wave energy in estuarine environments without the need for extensive advanced physical models. WEMo works in a GIS format in association with ESRI's ArcGIS and requires users to have basic knowledge of GIS. As such, assistance operating this tool by personnel with GIS experience is recommended.

WEMo calculates actual wave height and derived wave energy while taking into consideration wind generation and local water depth characteristics, such as shoaling and dissipation from breaking waves. It also provides predictions of seafloor sediment movement. WEMo could be used to hindcast the possible influence of hydrodynamics on shoreline and wetland habitat change as well as to represent future sea-level rise scenarios.

Potential applications include modeling seagrass exclusion areas (i.e., areas where wave energy is too high for persistent seagrass habitat), the potential for restoration of seagrass, submersed and shoreline habitat landscape pattern, shoreline susceptibility to hurricanes and other extreme wind events, and effect of shoreline structures on habitat.

WEMo offers a quick estimation of wave exposure at a very low computation cost. However, it does not account for complicated wave processes nor does the model account for remotely-forced ocean swells. The software is more suited for comparing sites under seemingly-like conditions.

Examples of Use

New River Estuary, NC—used WEMo to hindcast the wind wave energy distribution of the New River Estuary during Hurricane Isabel (2003). Two hurricane simulations were run for the area, first by passing the hurricane along its actual path with a landfall east of the New River Estuary, and second by passing the same storm to the west of the estuary. The simulations produced a geographically accurate description of wave energy in three-hour time steps, revealing the changing exposure of the region as a consequence of landfall location. The simulations were then applied to the development of a shoreline management plan. When joined with other factors such as storm surge modeling, the findings are useful to local emergency agencies and the public in anticipating the relative exposure of shoreline property.

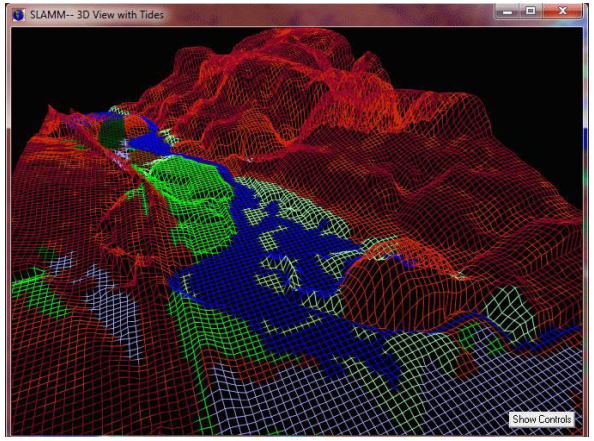
Carteret County, NC (Pop. = 68,000)—used WEMo to understand the link between marsh distribution and wave energy generated by extreme winds. Marsh coverage maps were created from aerial imagery and used to randomly select marsh sites. The width of the marsh was calculated for each site, and wave energy was estimated using WEMo. Sites were divided into five zones ranging from high to low wave energy, and marsh occurrence and width versus wave energy was plotted. The marsh coverage maps are being used for restoration projects in the high wave energy areas where considering the anticipated landscape pattern (narrow fringing marshes) of restored salt marshes is necessary for the best project design.

Camp Lejeune, NC (Pop. = 19,000)—used WEMo to determine the wave exposure of the shoreline to help understand the relationship between shoreline change, composition, and processes. The results were incorporated into a Shoreline Management Plan.

When & Where to Use

WEMo provides quantitative values of wave energy for locations not in the open ocean. It can be used to estimate wave energy in coastal regions or in inland waters to gauge susceptibility of developed areas and determine wave effects on ecosystem function. WEMo can also be used to represent future sea-level rise scenarios.

Sea Level Affecting Marshes Model (SLAMM)



Tool/Resource Type:
Modeling Tool

Sector(s): **Natural Resources**

Relevant Adaptation Planning Process Phase(s): **Assessment / Analysis**

Geographic Scale: **Local**, **Regional**

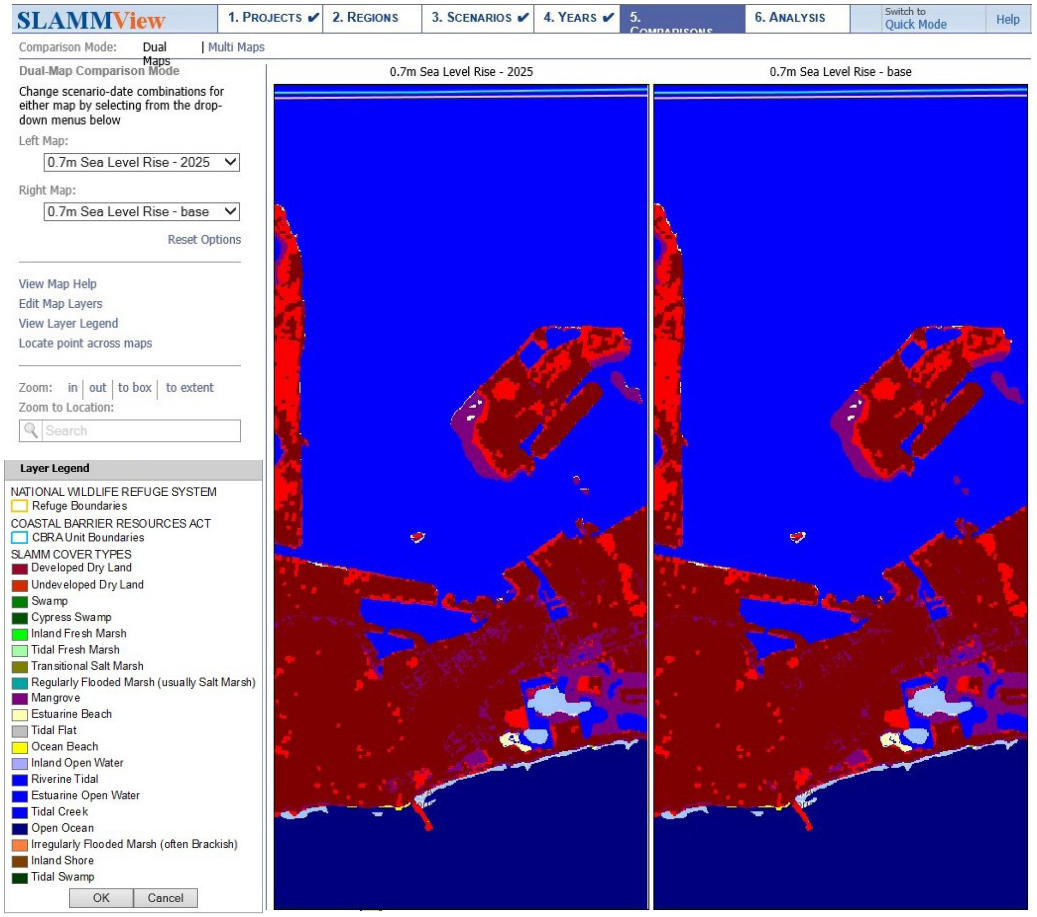
Cost: **Software Download = Free; Online Viewer = Free**

Data Input(s): **National Wetlands Inventory data, digital elevation data, optional datasets include: protected area/dike data and site parameters to change water depth, accretion rates, erosion rates, and many more**

Website:
http://warrenpinnacle.com/prof/SLAMM/index.html

http://www.slammview.org/slammview2/auto.rcp

Developer/Sponsoring Agency:
Warren Pinnacle Consulting, Inc.



Description

The Sea Level Affecting Marshes Model (SLAMM) simulates wetland conversion and shoreline modification resulting from long-term sea-level rise. As such, the tool can be used for projecting the effects of sea-level rise on the distribution of coastal wetlands and the landcover found within coastal areas. It identifies potential changes in both extent and composition of wetland types and accounts for inundation, subsidence, soil saturation, erosion, accretion, and barrier island overwash. SLAMM also integrates a uncertainty module to provide best and worst case sea-level rise scenarios and provides likelihood and confidence statistics accounting for uncertainty in future sea-level rise, future erosion rates, and feedbacks between marsh vertical-accretion rates and sea-level rise. Although SLAMM is able to simulate the dominant processes involved in wetland conversions and shoreline modifications during long- term sea-level rise, the model's complexity is limited and its outputs are simplifications that are only as reliable or accurate as the information used as inputs. To utilize, assistance by personnel with technical modeling experience, including use of GIS software, is recommended.

Summary tables provide the means to present the large volume of geospatially-referenced, gridded output from SLAMM in a condensed form; however, the spatial context of where the changes occur is lost. The SLAMM-View 2.0 web-mapping application facilitates the examination and evaluation of differences between pairs of output from the SLAMM model and makes the data geospatially accessible for users. The pairs of output are either from different dates within the same sea-level rise scenario or from the same date from different scenarios.

Examples of Use

Cook Inlet, AK—used SLAMM to simulate the dominate processes involved in wetland conversions and shoreline changes during long-term sea-level rise. It was found that the wetland habitat in the study region does not appear to be particularly vulnerable to sea-level rise and most impacts that were noted do not occur until after about a 1.5 meter rise in sea level, which some studies suggest may occur by 2100.

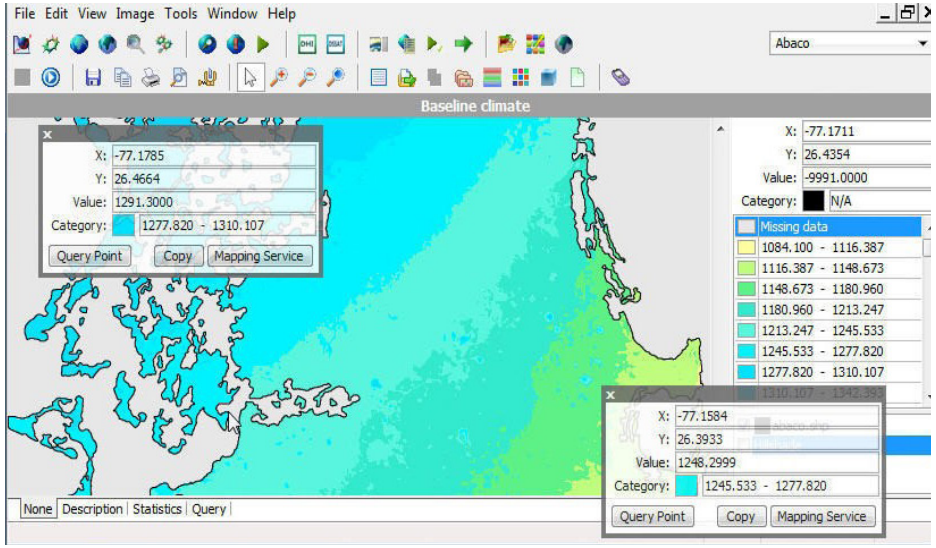
Southeastern Louisiana—conducted a study to investigate the potential impact of current and accelerating sea-level rise rates on key coastal wetland habitats in southeastern Louisiana using SLAMM. Results indicate a range of potential wetland losses by 2100 under the lowest sea-level rise scenario to the highest sea-level rise scenario. The model results suggest that one area of particular concern is the potential vulnerability of the region's baldcypress-water tupelo swamp habitat which is projected to become permanently flooded under all modeled scenarios for sea-level rise.

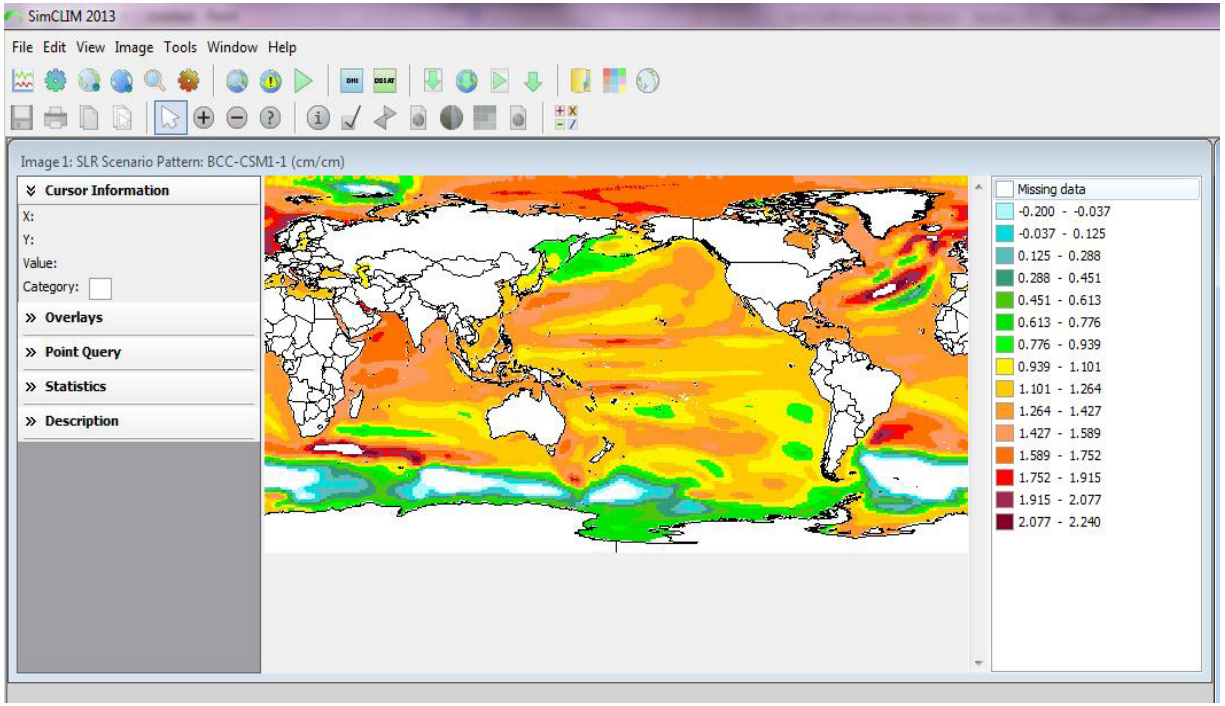
Waccamaw National Wildlife Refuge, SC—used SLAMM to map predicted distributions of wetlands within the refuge and the nearby North Inlet-Winyah Bay National Estuarine Research Reserve if sea level were to rise 1 meter over a 100-year period. SLAMM has typically been run at a regional scale; however, for this study, local accretion rates, tidal information, habitat data, and locally-available LIDAR data were used, resulting in more site-specific marsh migration predictions. The SLAMM outputs predicted that some of the tidally influenced freshwater wetlands that are key habitats for the swallow-tailed kite and black bear will be lost as sea-level rises. The outputs were used to help target areas for conservation.

When & Where to Use

SLAMM and SLAMM View 2.0 can be utilized throughout the first half of the adaptation process – from awareness building, through exposure and impact modeling. The extent of its analysis is determined by data for landcover and a digital elevation model, and can be applied to the whole community.

Simulator of Climate Change Risks and Adaptation Initiatives (SimCLIM)





Tool/Resource Type: **Modeling Tool**

Sector(s): **Natural Resources, Agriculture, Built Environment**

Relevant Adaptation Planning Process Phase(s): **Assessment / Analysis**

Geographic Scale: **Local, Regional, Statewide, Global**

Cost: **Annual Seat License = $149 to $6,000 per (depending on user); Downscaled AR5 Spatial Areas = $150 to $300; 6-Week Trial Version = Free**

Data Input(s): **National Wetlands Inventory data, digital elevation data, optional datasets include: protected area/dike data and site parameters to change water depth, accretion rates, erosion rates, and many more**

Website: **http://www.climsystems.com/simclim/**

Developer/Sponsoring Agency: **CLIMsystems Ltd.**

Description

The Simulator of Climate Change Risks and Adaptation Initiatives (SimCLIM) software can be used to model local (site specific) sea-level rise. SimCLIM can create scenarios, and project impacts, of sea level change. The program contains generators for sea-level rise which are regularly updated and consistent with the latest Assessment Reports of the Intergovernmental Panel on Climate Change (IPCC). Areas of potential inundation can be identified using the tool's custom-built GIS tools along with digital elevation data. SimCLIM also includes a simulation model of shoreline changes for beach and dune systems, which takes into account storm effects, local sea level trends , and lag effects in order to produce time-dependent response of the shoreline to sea-level rise at selected sites. To utilize, assistance by personnel with technical modeling experience, including use of GIS software, is recommended.

SimCLIM allows users to input their own data and models and customize the system for their purposes. The software also has the capacity for both spatial and site time-series analyses that can be applied from local to global scales. Formats include spatial images, time-series projections, and graphical and tabular output.

There are several limitations and uncertainties in the methods employed to develop SimCLIM. First, the historical observation data values presented in the software must be viewed as best estimates since historical data observations are not compiled appropriately for use in climate modeling. Also, there is an underlying uncertainty in the projections of future climate change and precipitation which may affect the accuracy of the modeling.

Training sessions on how to use the tool are held regularly depending on demand, but take place in New Zealand. Webinars are also held to reach a larger range of end users. There are no specific requirements for using the tool; however, the program requires a license.

Examples of Use

Republic of Marshall Islands (Pop. = 53,000)—used a customized version of the SimCLIM Open Framework software modeling system to conduct an analysis of sea-level rise and storm surge as well as the associated impacts.

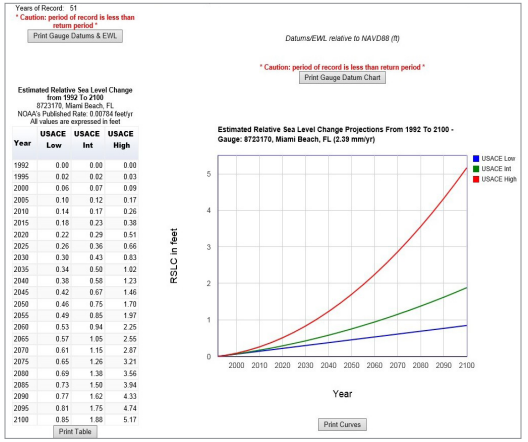
Alexandria, VA (Pop. = 149,000)—used a customized version of the SimCLIM Open Framework software modeling system to analyze storm sewer capacity issues, identify problem areas, develop and prioritize solutions, and provide support for public outreach and education. The software was used to help evaluate cost and risk of different mitigation scenarios and different assumptions for rain design storms and sea-level rise in 2050 and 2100.

Pacific Basin—applied the SimCLIM modeling system to a range of scenarios for the entire Pacific Basin, including sea-level rise, as part of a larger study for Small Island Developing States.

When & Where to Use

The key output of SimCLIM is the ability to analyze scenarios of sea level changes as well as sectoral impacts, mainly for water, ecosystems, and agriculture. It is therefore useful for exposure and impact analyses, and can be applied at the community level, by sector.

USACE Sea Level Change Curve Calculator



Tool/Resource Type: **Modeling Tool**

Sector(s): **Natural Resources, Agriculture, Built Environment**

Relevant Adaptation Planning Process Phase(s): **Scoping / Inventory, Assessment / Analysis**

Geographic Scale: **Local**

Cost: **Online Calculator = Free; Excel Calculator Download = Free**

Data Input(s): **Base flood elevation, project start and end years, interval year**

Website: **http://www.corpsclimate.us/ccaceslcurves.cfm**

Developer/Sponsoring Agency: **United States Army Corps of Engineers**

USACE Sea Level Change Curve Calculator (2014.88.1)

Item	Display
SLC Curve Chart	☑
SLC Curve Table	☑
Gauge Datum Chart	☑
Gauge Datum Table	☑
SLC Curves	☑
SLC Table	☑
NOAA EWL Chart	☑
Gauge Map	☑

Project Name: Enter Project Name

Select NOAA Gauge: Select NOAA Gauge

FEMA BFE (ft): ? Information: 0 (NAVD88) Search for BFE here

Project Start Year: 1992

Interval Year: 5

Project End Year: 2100

Output Units: ◉ Feet ○ Meters

Output Datum: ○ LMSL ◉ NAVD88

Output Agency: ◉ USACE ○ NOAA ○ Both

SLC Rate: ◉ Published ○ Regionally Corrected or User Entered: (ft/yr) Display Data

EWL Type: ◉ Highs ○ Lows

EWL Source: ◉ NOAA (GEV) ○ USACE (Percentile)

Chart Size: Height: 600 Width: 800 Display Data

Plot EWL/BFE/Tides: None — Select Curve: USACE High

Critical Elevation #1 (ft): 0 — NAVD88 - Description:

Critical Elevation #2 (ft): 0 — NAVD88 - Description:

User's Index (ft): ? 0 — Description:

Datum Shift to MSL: 0(ft)

Click on project area. The nearest NOAA gauge will be used to develop RSLC curves based on ER 1100-2-8162, Incorporating Sea Level Change in Civil Works Programs, 31 Dec 2013 and NOAA Technical Report OAR CPO-1, Global Sea Level Rise Scenarios for the United States National Climate Assessment, Dec 2012

*** note - there may be factors other than proximity to consider when selecting a gauge ***

Compliant
Inactive
< 40yrs

Description

The U.S. Army Corps of Engineers (USACE) Sea Level Change Curve Calculator was developed to support screening and assessing the vulnerability of USACE projects to the effects of sea level change. However, the tool can also be used to produce the amount of predicted sea level change for any location along the U.S. coast from 1992 forward.

The tool is a web-based interface that allows users to identify a NOAA tide station reference and generate relative sea level change curves and tabular data in five-year intervals for a selected project start year over the project life span. The output includes projections based on 1 and 1.5 meter curves plus a "historic trend" projection based on the tide gauge record for the selected tide station. The tool provides information on estimating the effects of sea-level rise on special flood hazard area (SFHA) 1 percent annual flood elevations, a way of accounting for sea-level rise in coastal storms and coastal flooding scenarios.

Since the outputs produced are specific to a tide station, use for evaluating surrounding areas may be limited. There also may be factors other than proximity to consider when selecting a gauge, such as rate of subsidence or uplift for that area of coastline.

Examples of Use

Hillsborough County, FL (Pop. = 1.3 million)—the USACE Sea Level Change Curve Calculator is built into FDOT's Sea Level Scenario Sketch Planning Tool. Since the Hillsborough County Metropolitan Planning Organization's 2040 Long Range Transportation Plan Needs Assessment used the Sketch Planning Tool's "high" 2040 scenario (current mean sea level plus 14 inches) to illustrate sea-level rise and help estimate disruption to the entire county and its transportation needs.

Southeast Florida—the Southeast Florida Regional Climate Compact (signed by Broward, Miami-Dade, Palm Beach, and Monroe counties) utilized the USACE Sea Level Change Curve Calculator when creating the regional unified sea-level rise projection. This unified sea-level rise projection for Southeast Florida projects a one foot rise in sea level above the 2010 levels to occur in the 2040-2070 time period with a two foot rise possible by 2060. Uncertainties exist in precisely predicting future sea-level rise rates and acceleration beyond 2060.

When & Where to Use

This tool can be used to calculate the rates of sea level change by selecting the closest NOAA tide gauge to the location of interest. It is useful during the planning context and exposure analysis phase for its sea-level rise projection information. It may also be utilized during adaptation project prioritization, to calculate sea-levels based upon adaptation project lifespans.

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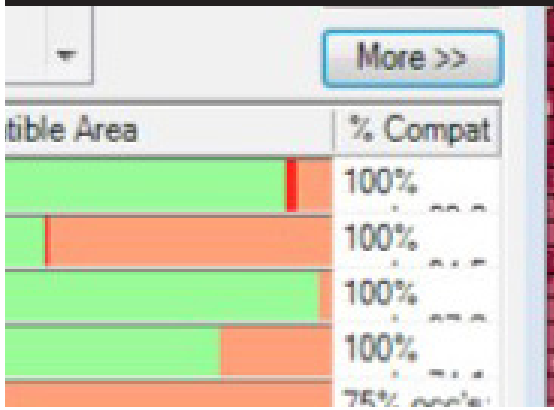
Decision Support Tools



Beach-fx

Tool/Resource Type:
Decision Support Tool (Software)

Sector(s): **Natural Resources, Built Environment**

Relevant Adaptation Planning Process Phase(s): **Assessment / Analysis, Strategy / Scenario Development**

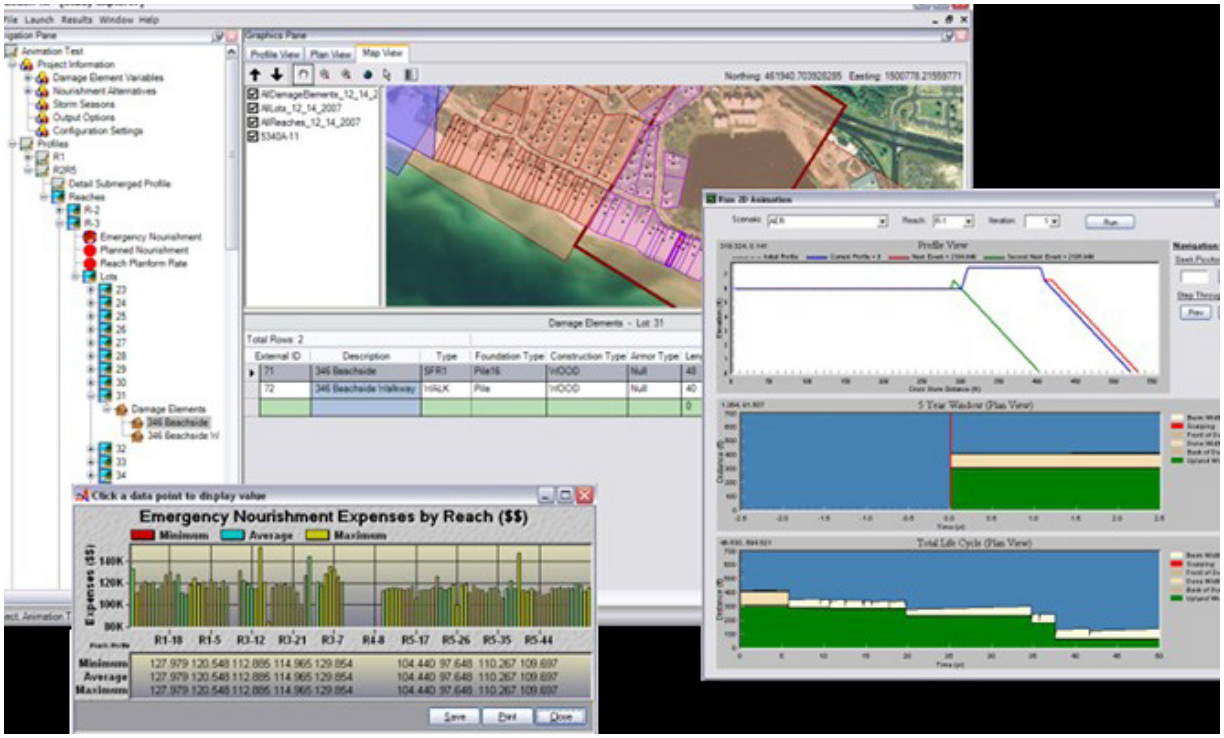
Geographic Scale: **Local, Regional, Statewide**

Cost: **Software Download = Free**

Data Input(s): **Coastal area description; plausible storm events; vulnerable infrastructure inventory; morphology response estimates; erosion, inundation, and wave impact design parameters**

Website: **http://hera.pmcl.com/beachfx/default.aspx**

Developer/Sponsoring Agency:
United States Army Corps of Engineers



Description

Beach-*fx* is a comprehensive, analytical modeling software that can be used to evaluate the physical performance and economic benefits and costs of shore protection projects, including sea-level rise adaptation projects. Beach-*fx* provides a realistic evaluation of shore protection projects and estimates the costs and benefits of alternative project designs. The software is used to evaluate proposed project alternatives in comparison with a "no-action" (i.e., with-out project) alternative. Currently, the U.S. Army Corps of Engineers (USACE) uses Beach-*fx* to assess the performance of beach nourishment projects and the influence of rising sea levels during their planning analysis. To utilize, assistance by personnel with technical modeling experience, including use of GIS software, is recommended.

Beach-*fx* simulates the impacts of shore protection projects based upon their expected lifespan, and reaction to hazard events (e.g., hurricanes). The software is a data-driven model that relies on databases describing the coastal area under study that are populated by users as well as a suite of historically-based plausible storm events that can impact the area, an inventory of infrastructure that can be damaged, and estimates of the response of beach profile configurations to each storm in the plausible storm suite, together with damage driving parameters for erosion, inundation, and wave impact damage.

The analyses that Beach-*fx* makes are a combination of meteorology, coastal engineering, and economic evaluations that trigger an action based on the occurrence of previous events. As a data-driven transparent model, its technical framework incorporates: inherent risk and uncertainty associated with shore protection, represented coastal processes, and combination of engineering and economic behavior.

Examples of Use

Walton County, FL (Pop. = 60,000)—used Beach-*fx* to investigate, analyze, and recommend solutions to provide for hurricane and storm damage projection along the coastline of the county. The tool was used to estimate the average annual costs and benefits of with and without project alternatives.

Bogue Banks, NC—conducted a storm damage reduction study for the Bogue Banks shoreline in Carteret County. Beach-*fx* was used to develop and evaluate planned nourishment alternatives for the study area. Since Beach-*fx* allows for sea-level rise to be specified for a project, it was set to a rate of 0.0084 feet per year based on the long term sea-level rise measurement calculated at the Beaufort Inlet NOAA Tide gauge. The economic output from Beach-*fx* was used to select the optimum plan.

When & Where to Use

Beach-*fx* can be used during the adaptation strategy prioritization phase, on a project-by-project basis. Once adaptation strategies are proposed, the tool may be used to determine which projects will have the greatest economic returns.

Coastal Adaptation to Sea-Level Rise (COAST)

Tool/Resource Type:
Decision Support Tool

Sector(s): **Natural Resources, Agriculture, Built Environment, Transportation, Energy**

Relevant Adaptation Planning Process Phase(s): **Stakeholder Engagement, Scoping / Inventory, Assessment / Analysis, Strategy / Scenario Development**

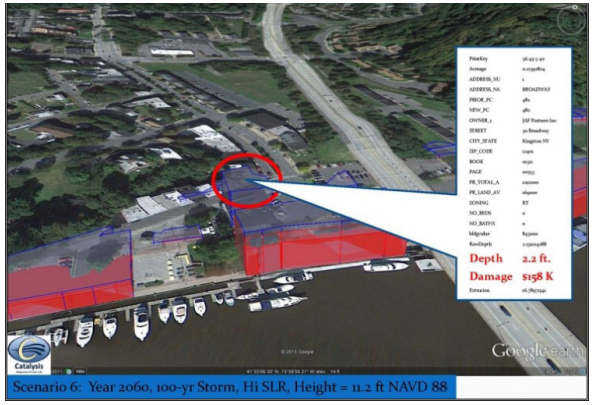
Geographic Scale: **Project Level**

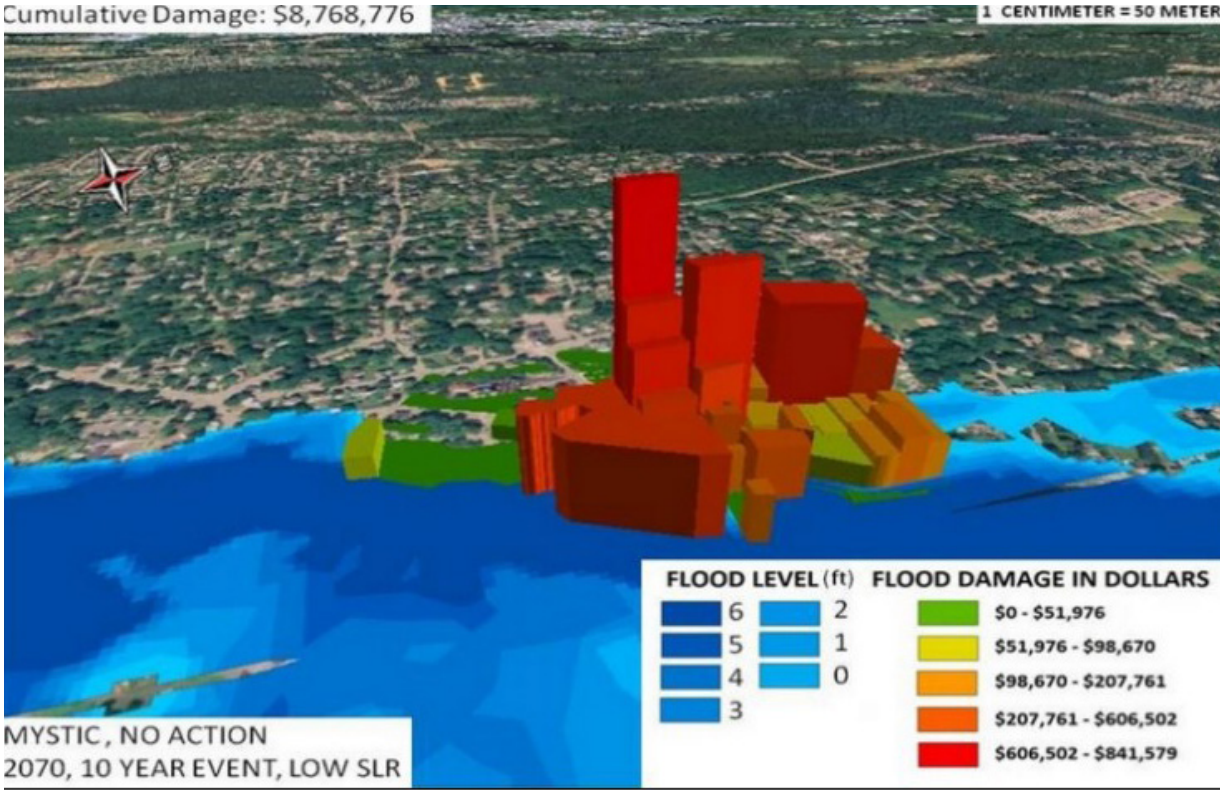
Cost: **SoftwareDownload = Free;**

Data Input(s): **Tide gauge data; local real estate, economic activity, infrastructure, natural resources, and human health data; candidate adaptation actions**

Website:
https://www.bluemarblegeo.com/products/COAST.php

Developer/Sponsoring Agency:
Developed at the University of Southern Maine with funds. EPA, and in collaboration with partners at Battelle, the Maine Geologic Survey, the University of New Hampshire, and Blue Marble Geographics





Description

The Coastal Adaptation to Sea-level rise Tool (COAST) helps users answer questions in regards to the costs and benefits of actions and strategies to avoid damages to assets from sea-level rise through 3D visualizations. COAST is a software product that predicts damages from varying amounts of sea-level rise and storms of various intensities and evaluates relative benefits and costs of adaptive response strategies. To utilize, assistance by personnel with technical modeling experience, including use of GIS software, is recommended.

Users will input tide gauge data and locally derived data on vulnerable assets, such as real estate, economic activity, infrastructure, natural resources, and human health, as well as possible adaptation actions wherever possible. The software will then model adaptation actions for a given location under a selected sea-level rise scenario and storm event. Comparing multiple future scenarios provides stakeholders an opportunity to select their expectation of future conditions and visualize damages under action versus no-action scenarios.

Outputs are 3D spatial data representing damage from sea-level rise and storm surge that can be loaded and viewed in Google Earth as well as tables showing cumulative expected damages for the selected vulnerable assets under the adaptation scenarios that allow cost-benefit analysis of candidate adaptation actions. The files can also be converted to shapefiles for use with ESRI's ArcGIS. Depending on user skill sets and the nature of assets and adaptation actions being modeled, consulting assistance may be required.

Examples of Use

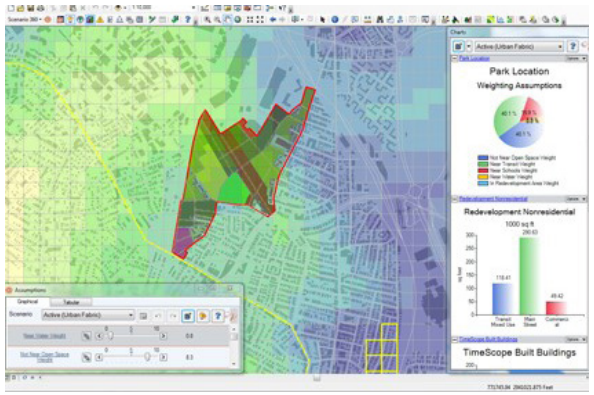
Groton, CT (Pop. = 9,000)—created a no-adaptation-action scenario for 1 meter sea-level rise and a 10-year flood event in 2070 for a portion of downtown Mystic Seaport. A graphic output was created to represent cumulative expected lost real estate and building contents value. Adaptation actions subsequently modeled in this location included installing a hurricane barrier, elevating a road, and building dikes, each of which could provide some protection to the vulnerable areas. Each adaptation action was represented in a map to show reduced or eliminated damage. This was an effective way to visually show up-front and maintenance costs of hard-structure approaches versus expected damages from particular inundation events.

Portland, ME and the Hampton/Seabrook Estuary, NH (Pop. = 66,000 and 24,000)— used COAST in their sea-level rise adaptation planning processes. Both communities and stakeholders examined potential impacts of sea-level rise and storm surge if no action is taken, specifically the costs and benefits of specific actions the communities might take to protect vulnerable assets they have prioritized. The communities also identified appropriate time horizons, sea-level rise thresholds, and storm surge frequencies and intensities to simulate. The 3D visualizations of avoided costs and expected damage were used to support the adaptation planning process and help stakeholders identify specific action steps to implement.

When & Where to Use

COAST, the ArcGIS add-in, can be utilized to conduct exposure and impact analyses applying to parcel-level data, for the entire community. It may also be used to prioritize adaptation strategies based upon their site-specific benefits.

CommunityViz



Tool/Resource Type:
Decision Support Tool

Sector(s): **Natural Resources, Agriculture, Built Environment, Transportation, Energy**

Relevant Adaptation Planning Process Phase(s): **Stakeholder Engagement, Scoping / Inventory, Assessment / Analysis, Strategy / Scenario Development**

Geographic Scale: **Local, Regional, Statewide**

Cost: **30-Day Trial = free; Government/Non-Profit Use = $875; Commercial Use = $1,400**

Data Input(s): **GIS layers (e.g., parcels, zoning, roads, environmentally sensitive**

Website:
http://placeways.com/communityviz/index.html

Developer/Sponsoring Agency:
Placeways LLC

Description

CommunityViz is a tool for the purposes of visualizing and communicating possible future land use change scenarios driven by sea-level rise. It is a GIS software that helps visualize, analyze, and communicate about important land use decisions by creating 2D and 3D visual models that show the implications of various planning decisions and scenarios. To utilize, assistance by personnel with technical modeling experience, including use of GIS software, is recommended.

Users can sketch and experiment with hypothetical scenarios and view the impacts of proposed changes. Concerning adaptation planning, the tool can illustrate the impacts of creating sustainable development patterns and limit building in areas vulnerable to sea-level rise. The software can also be used to help conduct risk and impact assessments such as counting buildings affected by potential floods or storm surge. This tool is not intended for engineering-level design and is best used for plans and directional decisions. There is no built-in data and relatively little built-in modeling so users must be knowledgeable to set up scenarios.

Since CommunityViz relies on GIS, communities without robust GIS programs and skilled practitioners may be unable to use the software. Some training and time is required even for advanced GIS users to learn the software.

This tool can also be integrated with other analytical tools such as N-SPECT and NatureServe Vista as a way to help a community visualize the results of potential adaptive management responses to sea-level rise.

Examples of Use

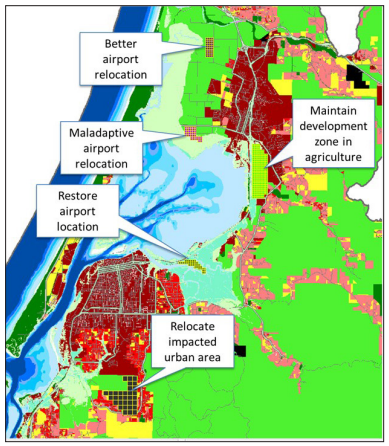
Cape Cod, MA (Year-round Pop. = 220,000)—Held a scenario planning pilot workshop that was built around CommunityViz. Four future scenarios were created for Cape Cod in 20 years using population growth forecasts and present-day land use and transportation plans. Alternatives used combinations of development, transportation system improvements, and transportation programs. CommunityViz allowed participants to see results of different scenarios like population served by new transit, and new growth in vulnerable areas.

Houston/Galveston Region, TX (Pop. = over 6 million)—Held a public outreach and education workshop for coastal resiliency. The centerpiece of the workshop was a hands-on tabletop sketching exercise using CommunityViz software. Participants sketched alternative growth scenarios to track the likely implications for a range of issues such as housing, economics, environment, hurricane risk, and water quality

When & Where to Use

CommunityViz may be used to depict future scenarios at the community-wide, and site-specific scale. Within the adaptation planning process, it can be used to evaluate potential future adaptation strategies that impact land use decisions driven by sea-level rise. The tool can also be used for building awareness and facilitating public engagement during the initial phase in the planning

NatureServe Vista



Tool/Resource Type: **Decision Support Tool**

Sector(s): **Natural Resources, Agriculture, Built Environment, Transportation, Energy**

Relevant Adaptation Planning Process Phase(s): **Stakeholder Engagement, Scoping / Inventory, Assessment / Analysis, Strategy / Scenario Development**

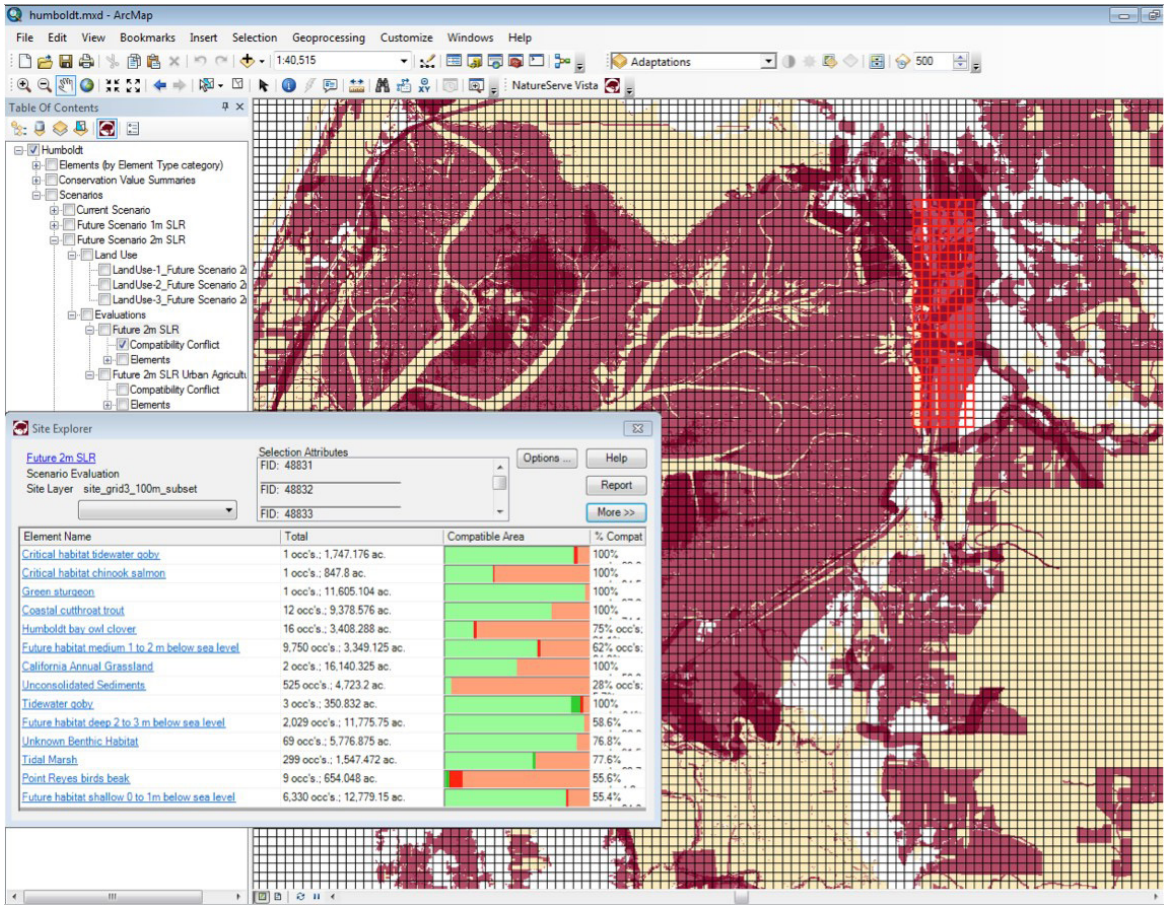
Geographic Scale: **Local, Regional**

Cost: **Software Download = Free**

Data Input(s): **Spatial data representing the elements to be conserved, represented, or restored; land cover and land policy scenario data**

Website: **http://www.natureserve.org/conservation-tools/natureserve-vista**

Developer/Sponsoring Agency: **NatureServe**



Description

NatureServe Vista enables users to create, analyze, implement, and monitor land use and resource management scenarios that achieve conservation goals. The tool is a spatial decision support system that can be used to conduct cumulative effects assessments, mitigation planning, and conservation planning. To utilize, assistance by personnel with technical modeling experience, including use of GIS software, is recommended.

Users can evaluate ecological, urban, and agricultural resources under current conditions and assess the impacts to those resources from various sea-level rise scenarios. The software can then be used to demonstrate the impact of mitigation and sea-level rise adaptation strategies. However, since this software is a raster-based platform, it will not be able to maintain precision of small features, such as point and linear features. Scale may also be a limiting factor although the software has previously been applied to projects 40,000 square miles in size.

This software is an ESRI ArcGIS extension designed to support non-GIS and non-conservation experts to assist integration of conservation with other assessment and planning activities. However, NatureServe Vista covers a broad suite of functions and requires the support of experts to build the database and train users in its analytical and planning functions. In addition to the Vista user's manual, fact sheet, and FAQs, NatureServe provides complete technical support, training, and consulting services.

Examples of Use

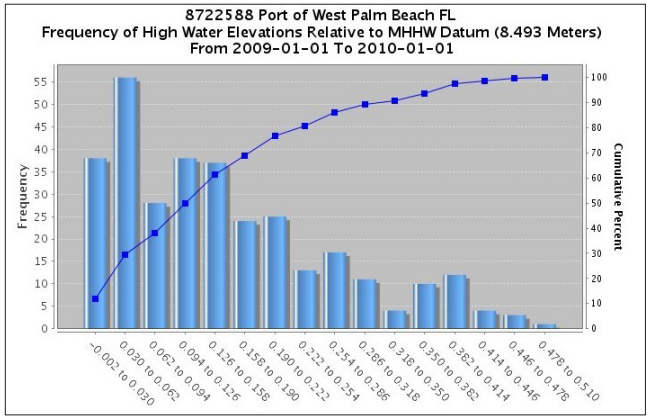
Humboldt Bay, CA (Pop. = 80,000)—used Vista to evaluate a variety of ecological, urban, and agricultural resources under current conditions and assess the impacts to these resources from urban expansion and sea-level rise scenarios of 1 and 2 meter inundation. Vista was then used to demonstrate the impact of mitigation and adaptation strategies through finding appropriate sites to: 1) relocate the airport and other inundated development; 2) conduct restoration; and, 3) conserve areas that should not be developed.

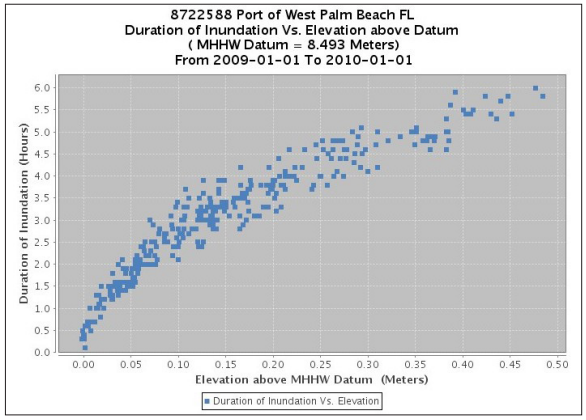
Eastern Shore of Virginia and Fisherman Island National Wildlife Refuges, VA—Conducted scenario assessment using Vista to assess and summarize expected changes to resources resulting from stressors, including sea-level rise, at four future time steps between 2010 and 2100. The results of these scenario evaluations indicated that most coastal resources (overwash flats, Northeastern Beach Tiger Beetle Populations, salt flats) and marshes are predicted to be impacted soonest and to the greatest extent. Maritime Upland forests were also found to be among those habitats showing the greatest degrees of conflict with sea-level rise. Vista was also used to develop a map of one exemplary strategy to address the resources with greatest potential conflicts in the scenario evaluations and meet conservation and management goals identified in the existing Comprehensive Conservation Plan (CCP).

When & Where to Use

NatureServe Vista can be used to show which resources and developed areas are potentially at risk to sea-level rise, through an impact analysis. It can also be used as a decision support tool at the site-scale for prioritizing strategies since it enables users to illustrate potential mitigation and adaptation options and determine which alternatives best achieve planning objectives.

NOAA Inundation Analysis Tool





Tool/Resource Type: **Decision Support Tool**

Sector(s): **Natural Resources**

Relevant Adaptation Planning Process Phase(s): **Assessment / Analysis, Strategy / Scenario Development**

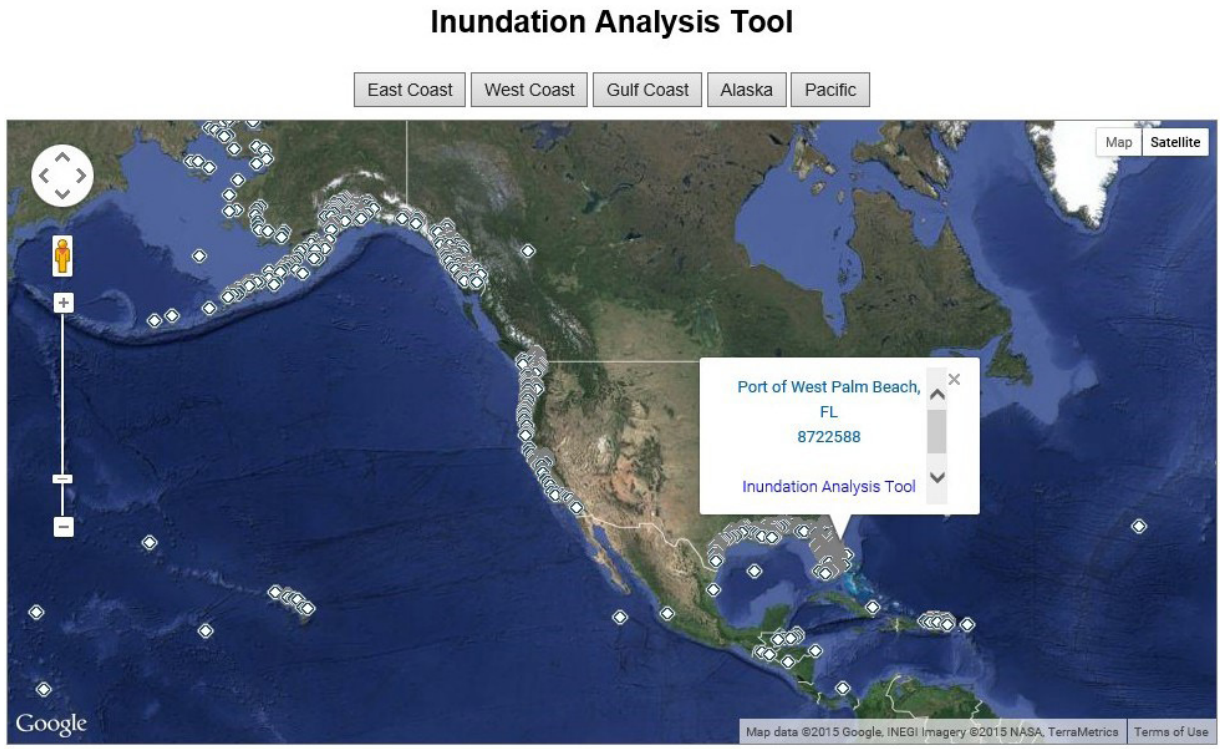
Geographic Scale: **Local**

Cost: **Online Tool = Free;**

Data Input(s): **Reference elevation, data range for evaluation**

Website: **http://tidesandcurrents.noaa.gov/inundation/**

Developer/Sponsoring Agency: **National Oceanic and Atmospheric Administration (NOAA)**



Please click on the diamond to access additional information about that station.

Description

The NOAA Inundation Analysis Tool is an online tool that can be used to create scenarios of sea-level rise. The scenarios compare how many high tides and total hours of inundation would have been experienced during a selected time period assuming a given amount of sea-level rise versus the historical data. The tool employs data collected at NOAA tide gauge stations to provide statistical summaries of the historical frequency and duration of observed high waters. It captures normal changes in water levels from gravitational forces exerted by the moon, sun, and Earth's rotation as well as irregular changes associated with coastal storms and other meteorological events. To utilize, assistance by personnel with some coastal science experience is recommended.

After selecting a gauge, users will select a span of time and a water depth relative to a defined reference point. For example, the tool can be used to determine how many times a particular gauge has been over one meter higher than normal. Users can then compare the number of high tides and total inundation hours expected during that time period assuming different amounts of sea-level rise compared to the observed historical data. However, it is not easy for users to determine what time periods of data are available at each gauge without submitting a data query to check.

The Inundation Analysis Tool outputs include a data table, a histogram showing frequency of occurrence relative to threshold elevation, a histogram showing frequency of duration of inundation, and an X-Y scatter plot showing frequency of elevation versus duration of inundation for each event. Since these statistical outputs are station specific, use for evaluating surrounding areas may be limited. Furthermore, the length, seasonality, datum, and measurement errors of the data record result in some uncertainty of individual analysis results.

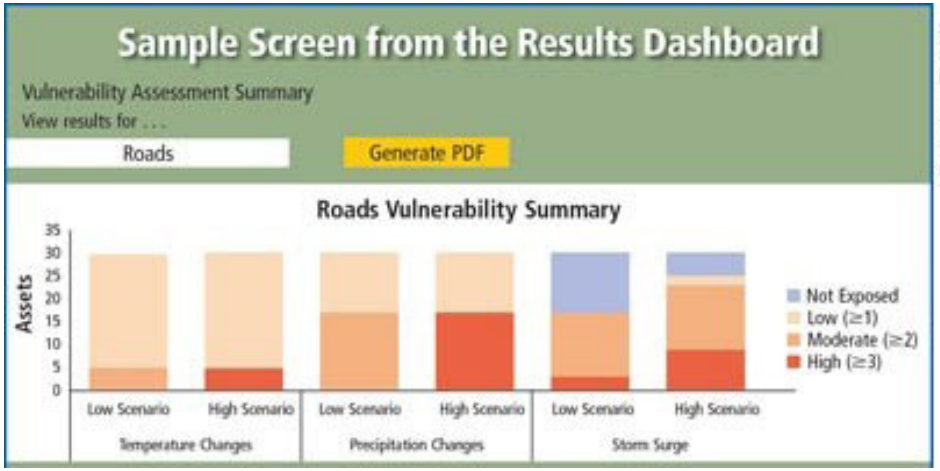
Examples of Use

Charleston, SC (Pop. = 128,000)—the Inundation Analysis Tool was used to calculate sea-level rise scenarios for Charleston Harbor and the vicinity. Using the flood threshold as defined by the Charleston Weather Forecast Office, the mean lower low water (MLLW) datum was calculated for the tide gauge that serves Charleston Harbor. This water level was then used as the "User Specified Elevation" to conduct the inundation analysis from January 1, 2012 to January 1, 2013. The results found that 27 high tides exceeded the threshold for a total of 46 hours of inundation. To create scenarios of increased sea-level rise, 0.5 meters and 1.0 meters were subtracted from the MLLW to represent the whole base shifting up with sea-level rise while the flooding threshold stays the same, thereby making the flood threshold a smaller number. Using the same time period dates, the analysis found 469 high tides at flood stage for a total of 1,344.5 hours of inundated with 0.5 meters of sea-level rise and 697 high tides at flood stage for a total of 3,751.6 hours of inundation with 1.0 meter of rise. Results similar to these, can be used by coastal communities to track the cumulative impacts of sea-level rise and determine how a community has already been impacted by sea level variations.

When & Where to Use

The Inundation Analysis Tool can be used during the planning context phase to gather information about historic inundation frequencies and durations. It is site-specific, although tidal gauge measurements may be applied to the nearest community.

U.S. DOT Vulnerability Assessment Scoring Tool (VAST)



Source: FHWA.

Tool/Resource Type: **Decision Support Tool**

Sector(s): **Transportation**

Relevant Adaptation Planning Process Phase(s): **Assessment / Analysis, Strategy / Scenario Development**

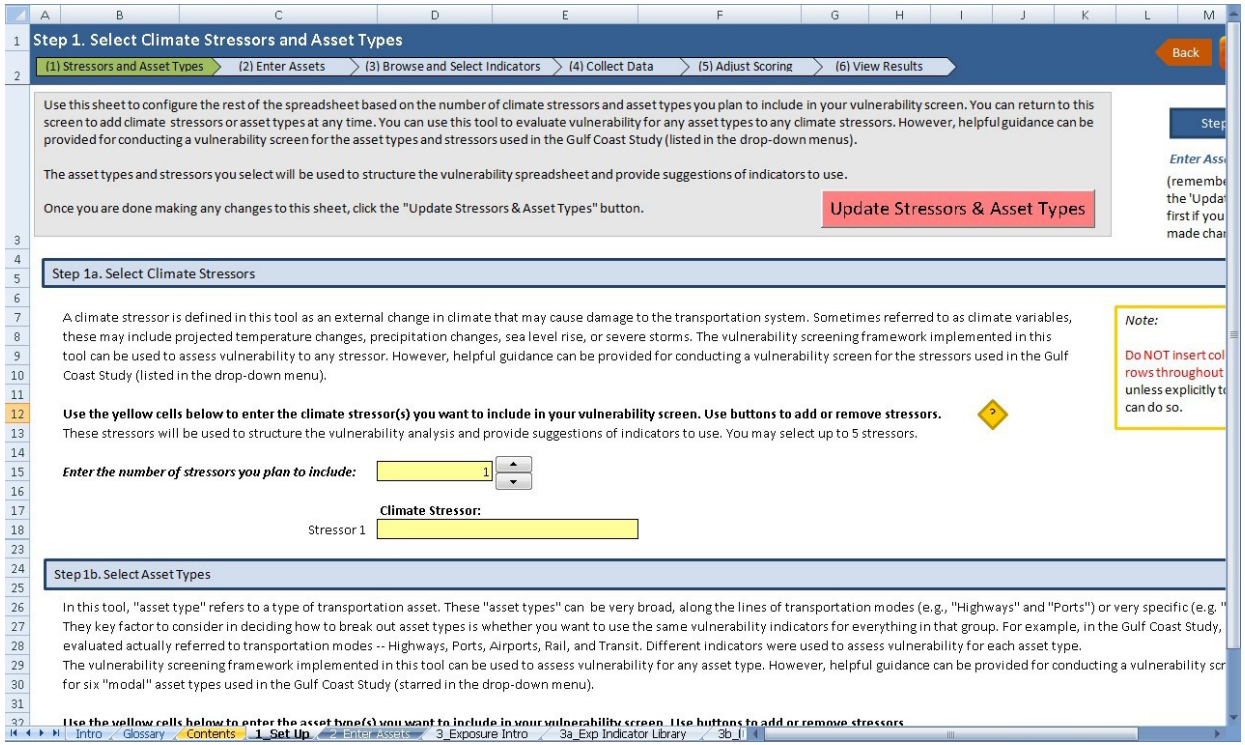
Geographic Scale: **Local, Regional, Statewide**

Cost: **Excel Download = Free;**

Data Input(s): **Asset inventory, climate information/stressors**

Website: **http://www.fhwa.dot.gov/environment/climate_change/adaptation/publications_and_tools/**

Developer/Sponsoring Agency: **United States Department of Transportation**



Description

The Vulnerability Assessment Scoring Tool (VAST) is intended for state departments of transportation (DOT), metropolitan planning organizations (MPO), and other agencies interested in assessing how components of their transportation system may be vulnerable to climate stressors, including sea-level rise. The tool is a spreadsheet tool that was developed by the U.S. DOT to provide a framework for conducting a quantitative, indicator-based vulnerability screening for vulnerability. To utilize, assistance by personnel with transportation planning experience is recommended.

VAST enables users to calculate the vulnerability score of an asset as a function of exposure, sensitivity, and adaptive capacity. The score is derived from a series of indicators. For example, the vertical elevation of a coastal bridge's deck could be an indicator of the structure's sensitivity to sea-level rise. Therefore, the approach involves collecting information about indicators of each vulnerability component and operationalizing that information into relative vulnerability scores. This can be done for any combination of climate stressors and asset types.

The tool is designed to be highly flexible and users can choose from a set of indicators or make their own and adjust the scoring system based on a variety of factors, such as expert judgment, stakeholder input, or established thresholds. In addition, VAST is designed to be a transparent tool that helps users to decide which factors are most important and then apply those factors systematically to the data collected. However, it is important to remember that this type of broad, screening-level approach will inevitably have limitations.

Examples of Use

Anne Arundel County and Somerset County, MD (Pop. = 556,000 and 26,000 respectively)—the Maryland State Highway Administration used VAST to determine a vulnerability score for all structures (bridges and culverts), identify the 10 most vulnerable assets to each climate stressor, and produce maps and tables showing the most vulnerable structures.

Mobile, AL (Pop. = 195,000)—used VAST to prioritize assets for a detailed vulnerability assessment, quickly determine sensitivity of a diverse set of assets to climate stressors, and efficiently rate vulnerability across a large number of assets. The assessment found that all transportation modes except airports have assets highly vulnerable to sea-level rise and storm surge. However, public transit was found to have low vulnerability due to flexibility of the bus system and pipelines were also found to have low vulnerability as most are buried.

When & Where to Use

VAST helps users derive a vulnerability score for a given transportation asset at any scale, from a road segment to bridge to airport. It can assist with impact analysis at the single-asset level scale.

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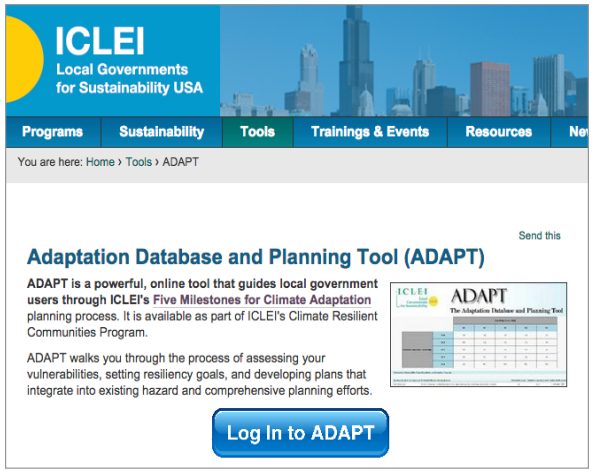
Database of Resources

Adaptation Database for Planning Tool (ADAPT)



- Tool/Resource Type: **Database of Resources**
- Sector(s): **Natural Resources, Agriculture, Built Environment**
- Relevant Adaptation Planning Process Phase(s): **Scoping / Inventory, Strategy / Scenario Development**
- Geographic Scale: **Municipal Level**
- Cost: **Trial to ICLEI member local governments (requires log in) = Free**
- Data Input(s): **Data to assess vulnerabilities and risks**
- Website: **http://www.icleiusa.org/tools/adapt**
- Developer/Sponsoring Agency: **International Council for Local Environmental Initiatives-Local Governments for Sustainability**

Description

ADAPT is an online tool that guides local government users through ICLEI's Five Milestones for Climate Adaptation planning process. It is available as part of ICLEI's Climate Resilient Communities Program. The five milestones for climate adaptation include conduct a climate resiliency study (vulnerability assessment), set preparedness goals, develop a climate preparedness plan, publish and implement preparedness plan, and monitor and reevaluate resiliency. However, ADAPT is a proprietary tool and use is limited to ICLEI member local governments. To utilize, assistance by personnel with community planning experience is recommended.

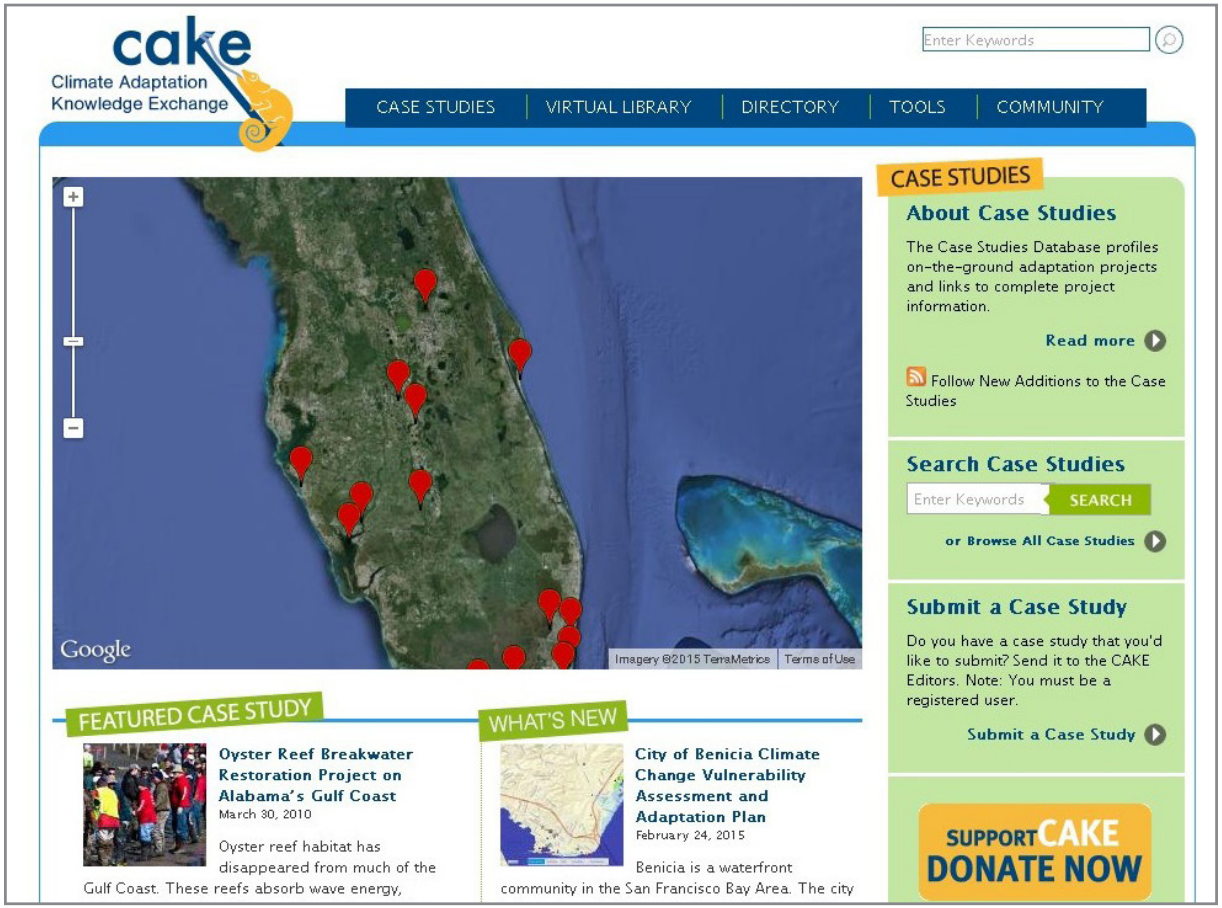
ICLEI is the leading global network devoted to local governments engaged in sustainability, climate protection, and clean energy initiatives.

ADAPT walks users through the process of assessing their community's vulnerabilities, setting resilience goals, and developing plans that integrate into existing hazard and comprehensive planning efforts. ADAPT allows users to input data to assess vulnerabilities and risks. ADAPT consists of six modules: getting started; conducting a resiliency study; setting preparedness goals; creating a preparedness plan; implementing a preparedness plan, and monitoring, evaluating, and re-assessing the plan.

When & Where to Use

ADAPT is an online database that guides local government users through ICLEI's Five Milestones for Adaptation planning framework. The 'tool' proposes an adaptation planning process at the community scale. Local governments may gain access to ICLEI, and may refer to this tool for guidance at all phases while conducting their adaptation planning process.

Climate Adaptation Knowledge Exchange (CAKE)



Tool/Resource Type: **Database of Resources**

Sector(s): **Natural Resources, Built Environment**

Relevant Adaptation Planning Process Phase(s): **Scoping / Inventory, Strategy / Scenario Development**

Geographic Scale: **Local, Regional, Statewide**

Cost: **Online Database = Free**

Data Input(s): **None**

Website: **http://www.cakex.org/**

Developer/Sponsoring Agency: **EcoAdapt, Island Press**

Description

The Climate Adaption Knowledge Exchange (CAKE) includes a database of tools to help explore climate change information and make adaptation decisions (including those related to sea-level rise); case studies of adaptation projects; a virtual library with literature and information focusing on adaptation and adaptation planning; and a directory of people/organizations engaged in climate change adaptation. It also houses community forums for the discussion of current issues in climate adaptation.

The Tools section of CAKE directs users to the tools available online to help process information and make adaptation decisions. Within each tool entry, users can also find related Case Studies, Virtual Library resources, and Directory entries in the green sidebar; these links provide users with more detailed information about how and by whom a tool has been used. Users can also recommend other key tools or resources for inclusion in the database, especially those that can be linked to projects to demonstrate how the tool has been used.

The Case Studies Database has been developed to provide quick access to information about on-the-ground adaptation projects. Interviews and surveys are used to synthesize how people are preparing for or responding to climate change. The information collected is compiled into case studies and shared through CAKE.

The Virtual Library is a complete, managed repository of documents relating to adaptation. It gathers the information relevant to adaptation appearing in traditional conservation journals, grey literature and reports, books on a range of subjects, videos, and state, local, and regional action plans in one place. There are filters to help users clearly target their search to help ensure they can find and access the information for which they are looking. Users can also contribute or recommend items to be included in the library.

The Directory includes people and organizations practicing on-the-ground adaptation. Users can see who is working on projects in a region or area of interests, how to contract practitioners for more information, and where to find them. If users have questions about a specific case study or method being used, they can simply click on their directory profile and find relevant contact information. The CAKE Directory is an open resource to find professionals engaged and/or interested in climate change adaptation and all CAKE users are invited to register and fill out a profile page.

When & Where to Use

CAKE's "case studies" may be utilized during context-phase activities such as for stakeholder engagement and description of the planning context. They include resources that apply to scales from the national to the site-specific. Its "tools" section includes resources for all phases, namely exposure analysis, funding surveys, and prioritization of strategies.

Ecosystem-Based Management (EBM) Tools Network and Database

Tool/Resource Type: **Database of Resources**

Sector(s): **Natural Resources, Agriculture, Built Environment, Transportation, Energy**

Relevant Adaptation Planning Process Phase(s): **Scoping / Inventory**

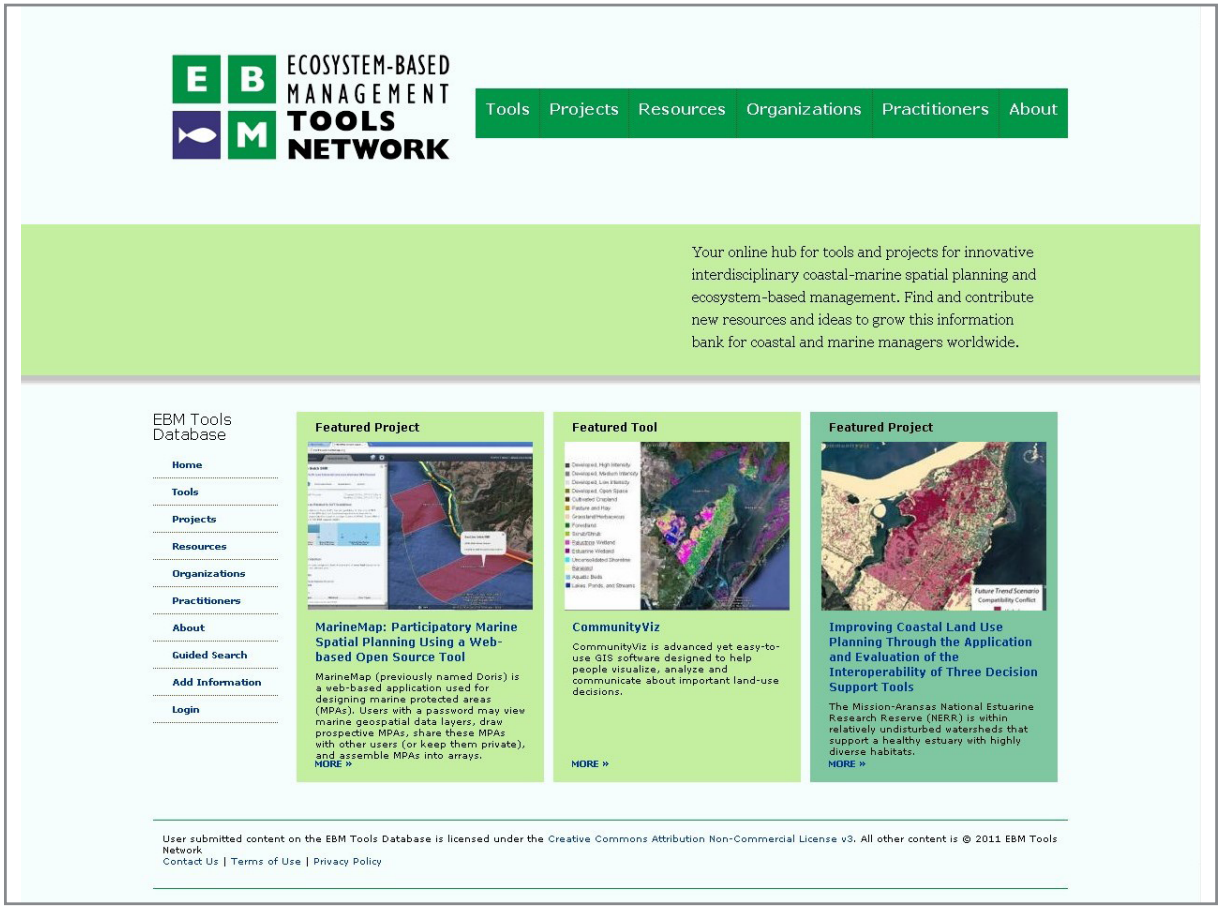
Geographic Scale: **Local, Regional, Statewide**

Cost: **Online Database = Free**

Data Input(s): **None**

Website: **https://ebmtoolsdatabase.org/**

Developer/Sponsoring Agency: **Ecosystem-Based Management (EBM) Tools Network, coordinated by NatureServe**



Description

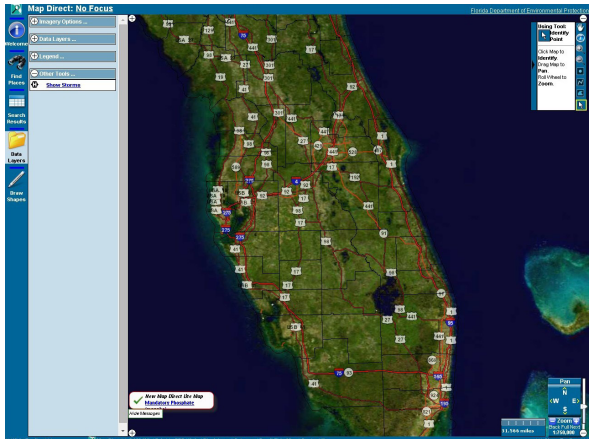
The Ecosystem-Based Management (EBM) Tools Network and Database is an online hub for tools and projects that involve coastal-marine spatial planning and ecosystem-based management. The EBM Tools Network's mission is to promote healthy ecosystems and communities through the use of tools that help incorporate ecosystem-based thinking into management decisions. Ecosystem-based management tools are methods and software that help practitioners incorporate scientific and socioeconomic information into decision making. EBM tools can help develop models of ecosystems, generate scenarios illustrating the consequences of different management decisions on natural resources and the economy, and facilitate stakeholder involvement in the planning processes. The EBM Tools Network is currently focusing on tools for: vulnerability assessment and adaptation planning, ecosystem-based coastal and marine spatial planning, and integrated land-sea planning to minimize the impacts of land use on coastal and marine environments.

The database organizes information and resources in five areas: Tools, Projects, Resources, Organizations, and Practitioners. Tools are methods and software/web tools to improve decision making; Projects are case studies representing a wide range of geographic locations, ecosystems, planning processes, tools, and outcomes; Resources include publications, toolkits, databases, and other resources to promote interdisciplinary coastal-marine spatial planning and ecosystem-based management; Organizations identify companies and organizations providing assistance with interdisciplinary coastal-marine spatial planning and ecosystem-based management including consultation, resources, and/or project management; and Practitioners lists professionals offering a tool, service, or resource to promote inter-disciplinary coastal-marine spatial planning and ecosystem-based management. Users are invited to add information about their own EBM tools, projects and resources.

When & Where to Use

The EBM Tools Network may be referred to during the Context and Vulnerability Analysis phases. Communities may search for case studies and tools to help expand the knowledge of their planning context, and conduct exposure and impact analyses.

FL DEP Map Direct Gateway



Tool/Resource Type: **Database of Resources**

Sector(s): **Natural Resources, Agriculture, Built Environment, Transportation**

Relevant Adaptation Planning Process Phase(s): **Scoping / Inventory**

Geographic Scale: **Local, Regional, Statewide**

Cost: **Online Map Viewer = Free; Data Download = Free**

Data Input(s): **None**

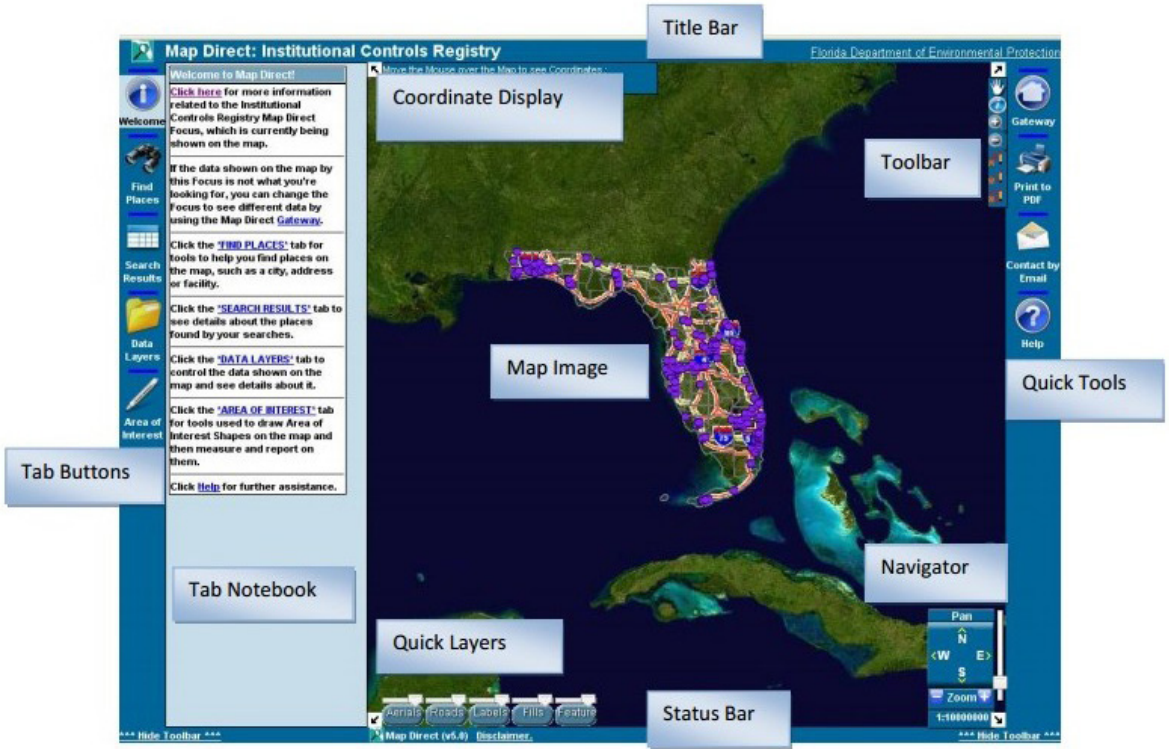
Website: **http://ca.dep.state.fl.us/mapdirect/gateway.jsp**

Developer/Sponsoring Agency: **Florida Department of Environmental Protection**

Map Direct **Quick Start** **8/31/2010**

1 General Appearance

The appearance of the Map Direct screen is shown below.



Description

The Florida Department of Environmental Protection's (FL DEP) Map Direct is a web-based map that uses information in FL DEP databases to provide locations and information for DEP facilities and sites. Map Direct is a powerful interactive mapping website that enables the user to display locations and data layers on a map including DEP regulated facilities, FEMA flood zones, land use/land cover, aerial photography, elevation, USGS quad maps, and much more. FL DEP's Map Direct Gateway is a resource for viewing and downloading GIS data. There are at least 58 base maps that can be used by state agencies, regional partners, and local governments. Base maps relevant to sea-level rise adaptation include: coastal access locations; coastal construction control line (CCCL); 2014 Property Appraiser Parcels; the location of state-owned buildings (Facility Inventory Tracking System (FITS)); the location of potable water wells and drinking water wells; conservation lands or waters; wastewater facilities; location of regulated storage tanks; and Florida Natural Areas Inventory data.

The Map Direct application replaces a number of existing single-purpose web mapping applications with a single integrated application with extensive capabilities. This integration enhances overall ease of use and will result in lower software development and maintenance costs for users. Map Direct has geolocation support to show current location, support for using other GIS Web Services (including those on ArcGIS Online), and better support for phones and tablets as well as desktop browsers. Map Direct will work in most major browsers. Data sites and sources, both from FL DEP as well as other agencies, can be followed to review available water data on a variety of subjects in a variety of formats and, in some cases, to manipulate and download the data.

Map Direct GIS interactive web application serves a variety of nonprofits and other associations and contains over 400 GIS layers from Water, Waste, Environmental Assessment, Air, State lands, Parks and Rec. Access can be achieved by any user with internet capabilities. Data layers are inventoried into categorizations to view applicable data. Imagery options are available. Map Direct does have the option to show historical and current storms. Find places and search results are available to obtain more detailed data. Map Direct allows the option to draw shapes on the GIS map and displayed datasets to customize the maps and datasets.

When & Where to Use

Map Direct provides access to a large number of FL DEP data layers and imagery layers, provides buffer analysis capabilities, provides "drill-down" reporting capabilities, and provides general data browsing. The Map Direct application replaces a number of existing single-purpose web mapping applications into a single integrated application with extensive capabilities.

Florida Natural Areas Inventory (FNAI)

Tool/Resource Type:
Database of Resources

Sector(s): **Natural Resources**

Relevant Adaptation Planning Process Phase(s): **Scoping / Inventory**

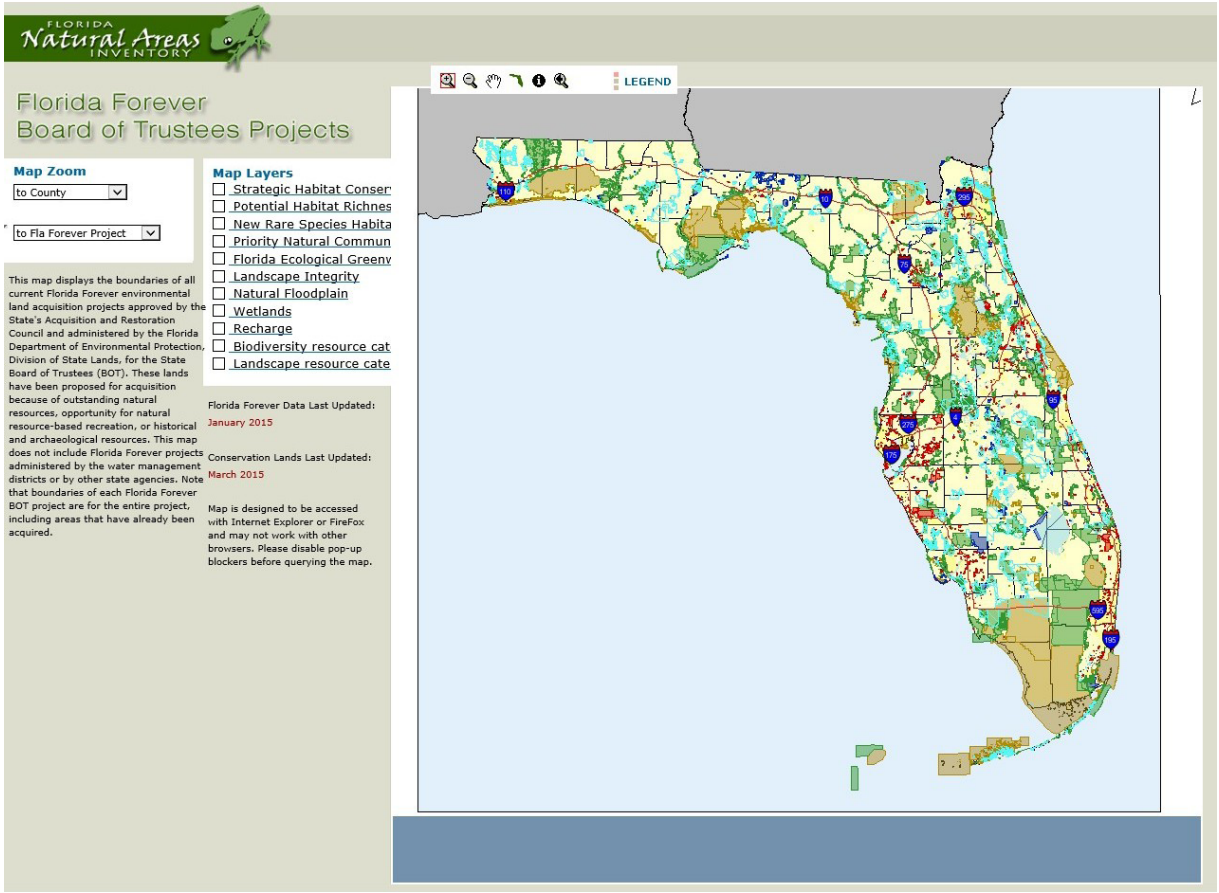
Geographic Scale: **Local, Regional, Statewide**

Cost: **GIS Data Download = Free; Online Map Viewers = Free**

Data Input(s): **None**

Website:
http://www.fnai.org/index.cfm

Developer/Sponsoring Agency:
Florida Natural Areas Inventory, administered by Florida State University



Description

The Florida Natural Areas Inventory (FNAI) offers spatial datasets and interactive maps that promote conservation of Florida's biological diversity, including sea-level rise adaptation. FNAI collects, interprets, and disseminates ecological information critical to the conservation of Florida's biological diversity. FNAI staff continually build and maintain a comprehensive database of the biological resources of Florida that are maintained in a GIS database for mapping and analysis. FNAI also serves as the primary source for information on Florida's conservation lands.

FNAI and its partners are working to develop a Florida Cooperative Land Cover Map (CLC) using ecologically-based statewide land cover from existing sources and expert review of aerial photography. The CLC map is revised continuously with new versions released every 6 to 12 months, and it incorporates major revisions to natural coastal land cover and natural communities potentially affected by sea-level rise. The statewide CLC map is available for download as either an ESRI File Geodatabase Feature Class or 15m Raster. This data allows users to identify natural communities that are potentially affected by sea-level rise.

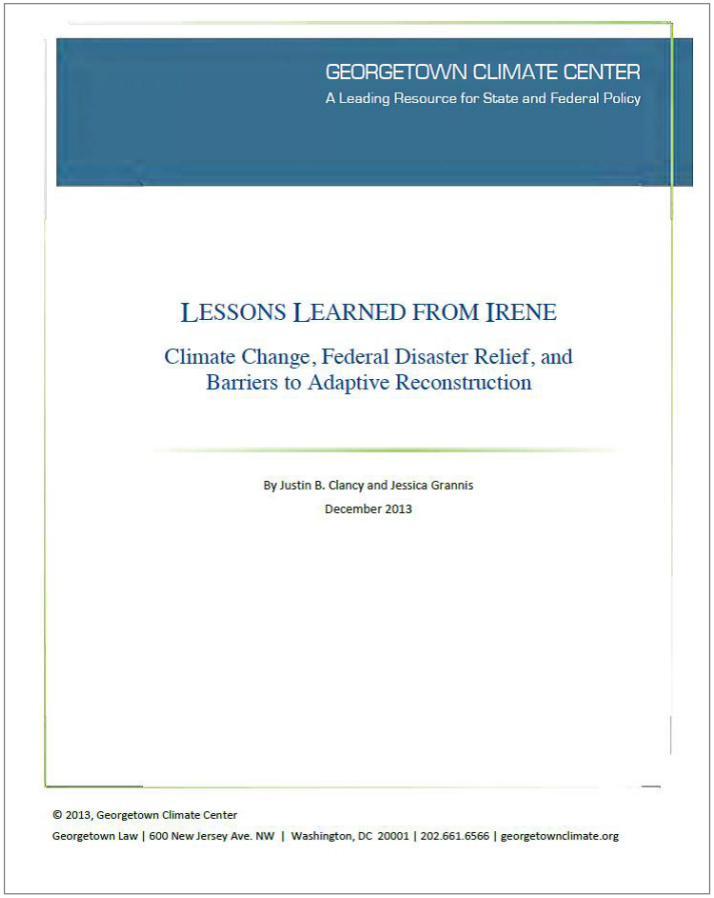
The Critical Lands and Waters Identification Project (CLIP) identifies those lands and waters in the state of Florida that are critical to the conservation of Florida's natural resources. CLIP is a GIS database of statewide conservation priorities for a broad range of natural resources, including biodiversity, landscape function, surface water, groundwater, and marine resources. CLIP allows users to visualize the location of critical habitats.

The Florida Forever Projects Map displays the boundaries of all current Florida Forever environmental land acquisition projects approved by the state's Acquisition and Restoration council and administered by the Florida Department of Environmental Protection, Division of State Lands, for the State Board of Trustees. These lands have been proposed for acquisition because of outstanding natural resources, opportunity for natural resource-based recreation, or historical and archeological resources. The Florida Forever Projects Map allows users to identify lands that have been acquired by the state for preservation. Communities interested in acquiring properties can use the map viewer to identify possible acquisitions adjacent to existing protected properties.

When & Where to Use

The FNAI database provides downloadable data that will assist communities to describe their planning context and conduct impact analysis (for natural areas). These can be performed at the asset-class scale, or the community scale.

Georgetown Climate Center



Tool/Resource Type:
Database of Resources

Sector(s): **Natural Resources, Built Environment, Transportation, Energy**

Relevant Adaptation Planning Process Phase(s): **Scoping / Inventory, Strategy / Scenario Development**

Geographic Scale: **Local, Regional, Statewide**

Cost: **Online Database = Free**

Data Input(s): **None**

Website:
http://www.georgetownclimate.org/

Developer/Sponsoring Agency:
Georgetown Law

Description

The Georgetown Climate Center provides sea-level rise and flood-related work products intended to assists state and local governments become better prepared to cope with the threats posed by rising sea levels and higher storm surges. The Center is a nonpartisan organization that seeks to advance climate, energy, and transportation policies in the U.S.

The Center's Adaptation Clearinghouse identifies and maintains a list of sea-level rise resources for policymakers and provides a list of resources, expert organizations, assessments, and sample plans for the coastal sector.

The Center's Adaptation Tool Kit explores 18 different land-use tools that can be used to preemptively respond to the threats posed by sea-level rise to both public and private coastal development and infrastructure. The Adaptation Toolkit strives to assists governments in determining which tools to employ to meet their unique socio-economic and political contexts.

The Georgetown Climate Center also strives to help communities meet challenges by addressing the legal barriers that communities face when adapting to rising sea levels and seeks to help localities prepare for the potential increased frequency, scope, and severity of heat events and extreme weather. In addition, the Center strives to assists communities in spending disaster relief funds wisely by preparing for the next big storm—not just rebuilding to meet the status quo.

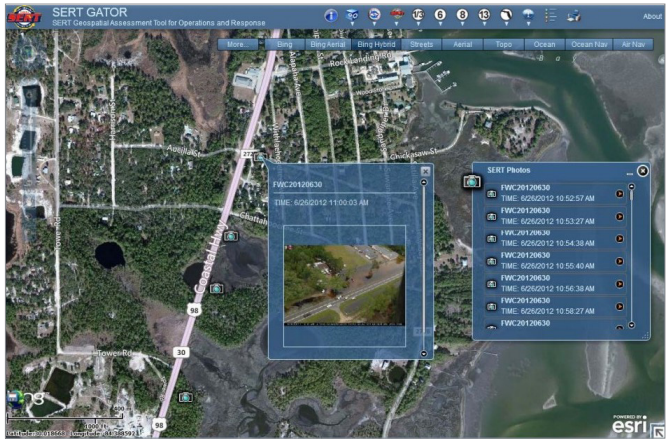
Examples of Use

Virginia (Pop. = 8.3 million) – The Georgetown Climate Center prepared and supported a case study that analyzes Virginia local governments' authority to use existing land use powers to adapt to the impacts of sea-level rise and flooding. Specifically, this study looks at local authority to implement policy options identified in Virginia's Climate Action Plan. State and local government officials can reference the study for help in determining how local government land use powers may be used as part of an adaptation plan.

When & Where to Use

The Climate Center can assist communities to define their planning context. The Adaptation Tool Kit is useful toward the creation of adaptation strategies. The information may be asset-specific, or community wide.

Geospatial Assessment Tool for Operations and Response (GATOR)



Tool/Resource Type: **Database of Resources**

Sector(s): **Natural Resources, Agriculture, Built Environment, Transportation, Energy**

Relevant Adaptation Planning Process Phase(s): **Scoping / Inventory**

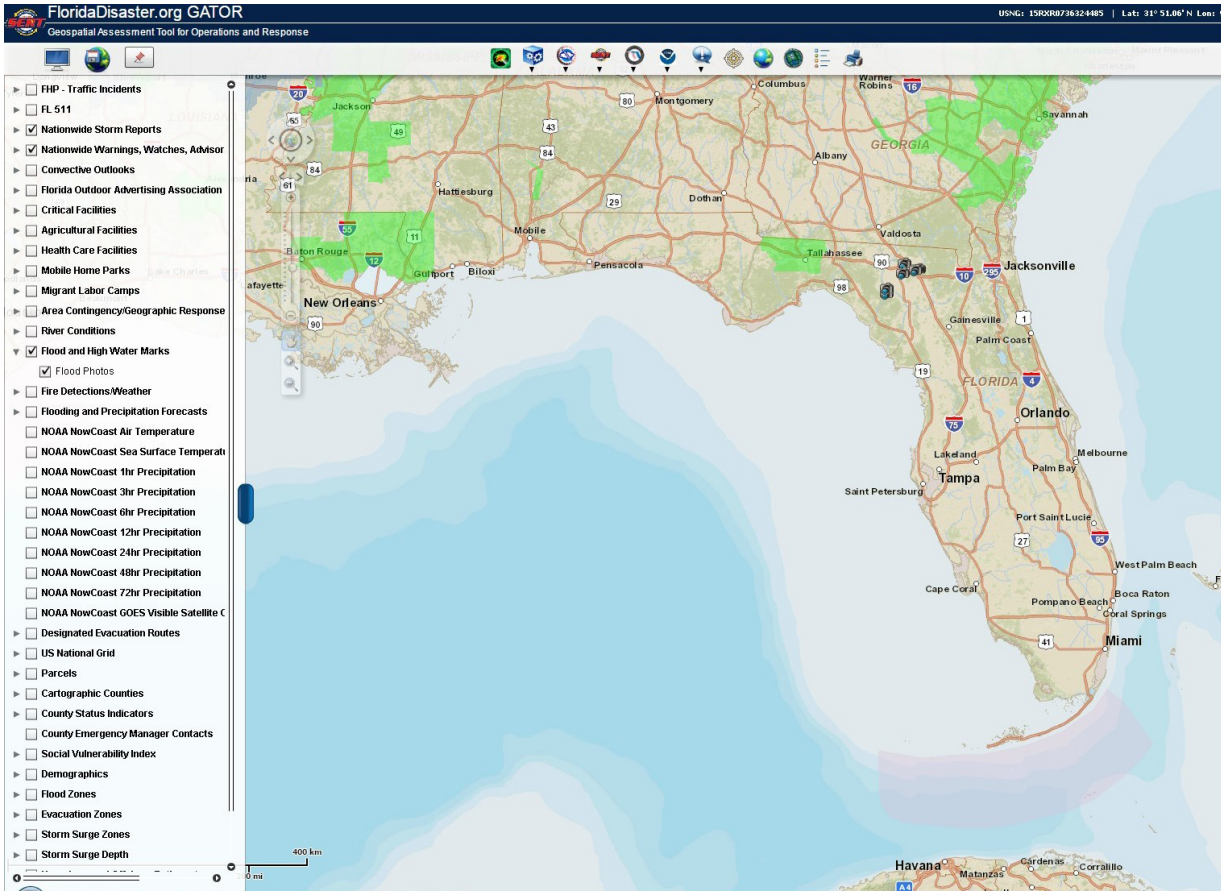
Geographic Scale: **Local, Regional, Statewide**

Cost: **Online Map Viewer = Free**

Data Input(s): **None**

Website: **http://map.floridadisaster.org/GATOR/map.html**

Developer/Sponsoring Agency: **Florida Division of Emergency Management, Florida State Emergency Response Team**



Description

The Geospatial Assessment Tool for Operations and Response, or GATOR, is an interactive web mapping tool for the display of geographic information to support emergency preparedness, operations, and response. GATOR is the flagship situational awareness application for the Florida Division of Emergency Management and the State Emergency Response Team. Real-time data like weather radar, weather watches and warnings, and tropical storm tracks are displayed along with base map data like roads, facilities, and aerial photographs. To bring in additional demographic, infrastructure, economic, and environmental data, direct access to NOAA's Coastal County Snapshots was added to the interface. To utilize, assistance by personnel with GIS and Emergency Management skills is recommended.

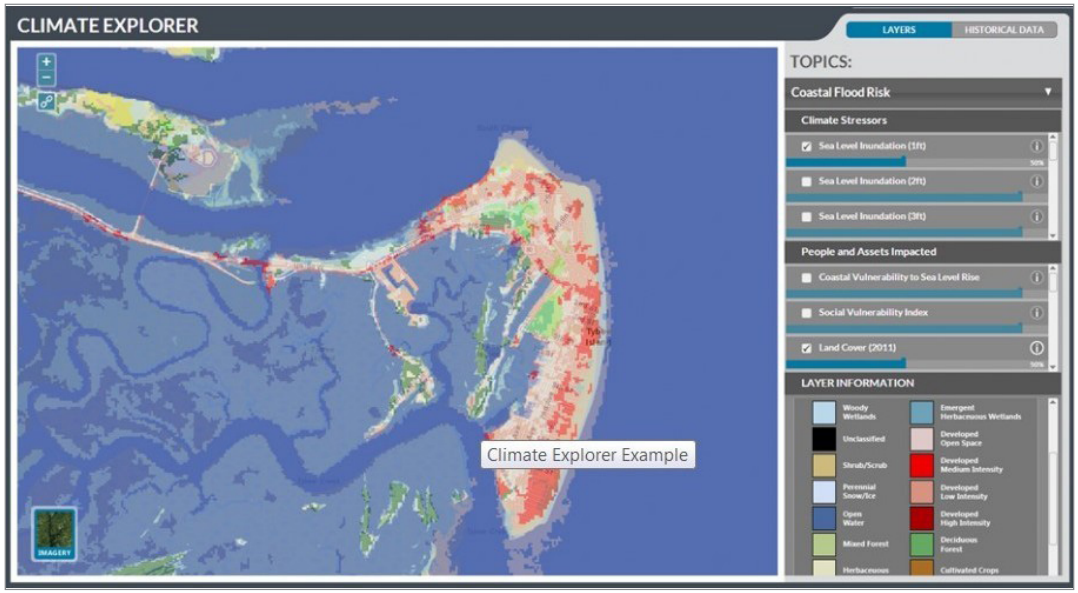
The GATOR website provides a mapping utility for users that outlines disaster situations around Florida. The map can either be used to see broad geographic areas or can be focused on particular neighborhoods. Tools allow the user to select particular geographic areas and determine the demographic make-up up impacted areas. Live maps, satellite maps, street maps, and nautical charts provide alternate means of determining impact of a pending disaster. When a disaster is in progress RECON data provides up-to-the-minute information. Various layers of mapping allow data on a variety of topics, including location of power plants, vessel t racking, critical facilities, storm surge zones, and natural resources.

This tool may be useful for quickly visualizing data that could be incorporated into a community's discussion of guiding principles and motivations and also into a vulnerability assessment. Storm surge zones, storm surge depth, hurricane evacuation zones, demographic information by census tract and block group, social vulnerability index, migrant labor camps, mobile home parks, and health care facilities are examples of the available data that may be useful during the adaptation planning process. It is important to note that many of these data layers are not readily available for viewing elsewhere, which makes this resource unique when trying to understand spatial distribution or potential vulnerabilities. Users can also export maps from the viewer as well as identify useful data and contact the respective data holder for data transfer.

When & Where to Use

GATOR can be used to visualize flood hazard data that informs a community's goal setting, description of the planning context, vulnerability assessment, and (thanks to its live disaster mapping) Monitoring and Evaluation. Information is displayed at the statewide level, although county-level data can be activated by the "Flood Exposure Profile" button.

U.S. Climate Resilience Toolkit



Tool/Resource Type: **Database of Resources**

Sector(s): **Natural Resources, Agriculture, Built Environment, Transportation**

Relevant Adaptation Planning Process Phase(s): **Stakeholder Engagement, Scoping / Inventory, Strategy / Scenario Development**

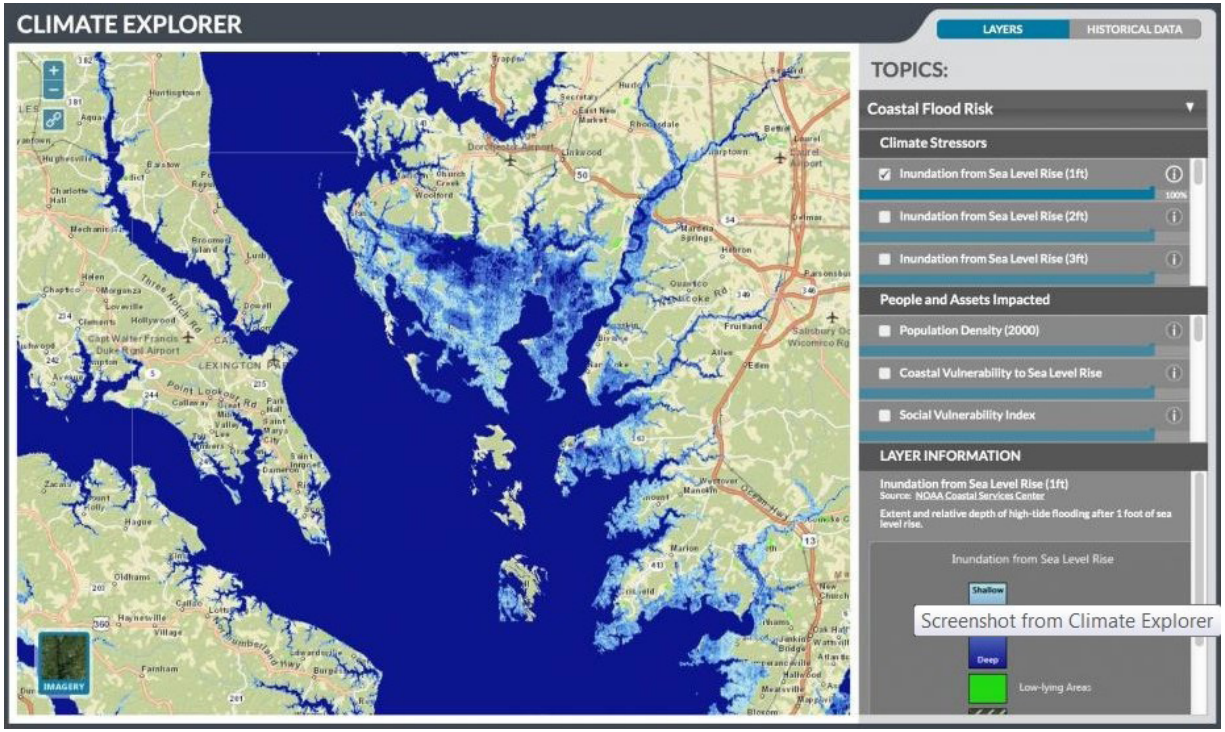
Geographic Scale: **Local, Regional, Statewide**

Cost: **Online Database = Free**

Data Input(s): **None**

Website: **http://toolkit.climate.gov/**

Developer/Sponsoring Agency: **National Oceanic and Atmospheric Administration**



Description

The U.S. Climate Resilience Toolkit contains multiple tools that can be used to estimate, simulate, visualize, and monitor sea-level rise and impacts throughout the country. Depending on the users' location and information needs, a tool can be selected to estimate and examine current and/or potential impacts related to sea-level rise.

The Toolkit provides resources and a framework for understanding and addressing climate issues that impact people and their communities. The Toolkit includes scientific tools, information, and expertise to help users manage their climate-related risks and opportunities and improve their resilience to extreme events. The site is designed to serve interested citizens, communities, businesses, resource managers, planners, and policy leaders at all levels of government.

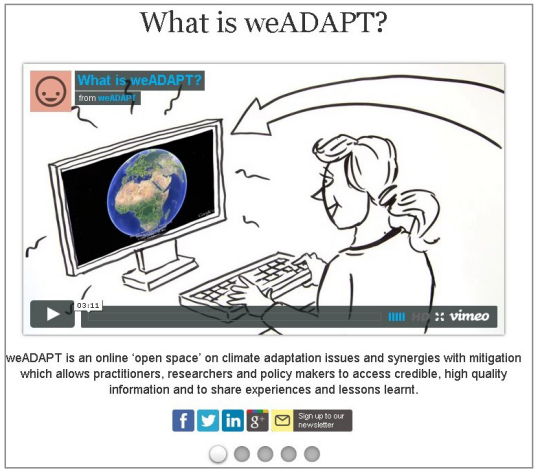
The Toolkit offers the following resources to help address identified issues and opportunities: Steps to Resilience; Taking Action stories; a catalog of freely available tools; Climate Explorer; topic narratives; pointers to free, federally-developed training courses; maps highlighting the locations of centers of where federal and state agencies can provide information; and the ability to search the federal government's entire climate science library and filter results according to interests.

Climate Explorer is a research application that was built to support the U.S. Climate Resilience Toolkit. It is an interactive tool that offers visualizations for exploring maps and data related to the toolkit's Taking Action case studies. Map layers in the tool represent geographic information available through the webpage climate.data.gov. Each layer's source and metadata can be accessed through its information icon. Users can also view coastal flood risk data including inundation from 1, 2, and 3 foot sea-level rise as well as the population density, coastal vulnerability to sea-level rise, and social vulnerability index. Users are also able to produce and interact with graphs showing daily observations and long-term averages from the historical data tab.

When & Where to Use

The U.S. Climate Resilience Toolkit can be utilized to explain a community's planning context. The Climate Explorer can be utilized to build awareness and facilitate decisions about a preferred exposure analysis scenario. The scale is statewide, although communities may adjust the scale to near site-specific resolution.

weADAPT



Tool/Resource Type: **Database of Resources**

Sector(s): **Natural Resources, Built Environment**

Relevant Adaptation Planning Process Phase(s): **Scoping / Inventory, Strategy / Scenario Development**

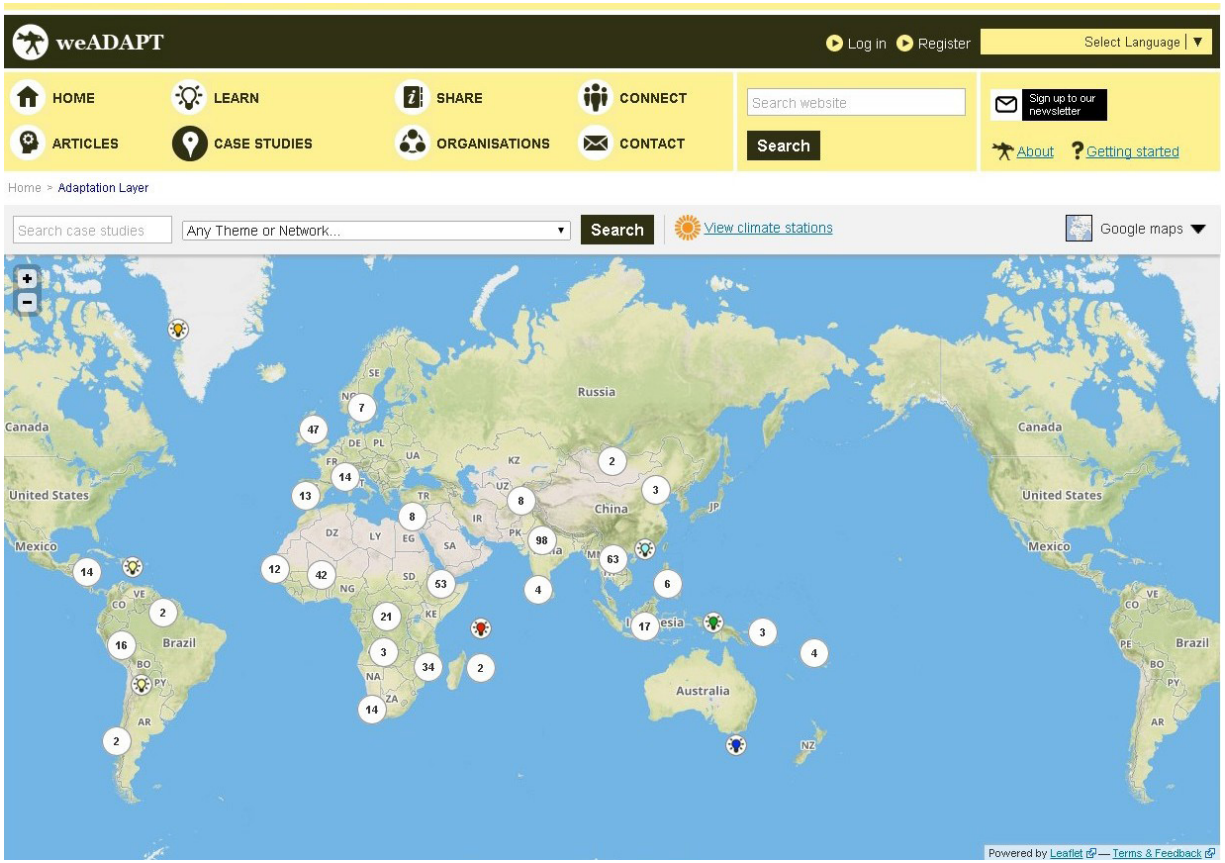
Geographic Scale: **Local, Regional**

Cost: **Online Database = Free (when registered)**

Data Input(s): **None**

Website: **https://weadapt.org**

Developer/Sponsoring Agency: **Stockholm Environment Institute**



Description

weADAPT is an online forum on climate adaptation issues which allows users to share experience, tools, case studies, and other information. The site includes over 192 articles and case studies that relate to sea-level rise and its impacts. The platform is designed to facilitate learning, exchange, collaboration, and knowledge integration by providing users with opportunities to learn, share, and connect.

Users can find information using the themes, networks, and projects categories to browse articles, case studies, tools, or methods of interest or through a key word search. Users can also share content on weADAPT by creating an article. The two main types of articles are short case studies and project summaries or more detailed articles. Users can include information about their latest project, reports, published articles, case studies, and other relevant information in their articles. Sharing articles on weADAPT can help potential collaborators and sponsors find users' work as well as help users connect with other users. Users can search the weADAPT online community based on name, organization, or interest to find and connect to people doing similar work. The Adaptation Layer also allows users to view projects that are operating in similar fields or that are located in the same geographic area. Social media channels are also used to increase communication between users.

To research sea-level rise, users can enter key words in the search tool to locate applicable information and data results, such as relevant websites and case studies. The website provides a platform that helps users to find the information for which they are looking.

When & Where to Use

weADAPT can assists communities to form a steering committee (with non-local experts), set goals, and receive advice from other communities concerning all adaptation plan phases. The nature of the website is geared towards communication about adaptation projects on a worldwide scale.

Sea-Level Rise Vulnerability Tools/Resources Inventory Matrix

Tool/Resource Name	Purpose	Sector(s)	Adaptation Planning Process Phase(s)	Geographic Scale	Cost	Data Input(s)	Website
Visualization Tools							
CanVis	This tool allows users to create photo-realistic simulations for visualizing the potential impacts from coastal development and sea-level rise.	Natural Resources, Built Environment	Stakeholder Engagement, Assessment / Analysis	Determine by horizontal width and depth of view shown in digital photograph uploaded by user	Software Download = Free	Digital photograph	http://coast.noaa.gov/digitalcoast/tools/canvis
Climate Central's Surging Seas	This tool includes an interactive Risk Finder and Submergence Risk Map. The Risk Finder shows populations, infrastructure, and assets exposed to coastal flooding aggravated by different sea levels, as determined by the user (i.e., 1 to 10 feet of rise). The Submergence Risk Map is a tool that depicts sea-level rise scenarios.	Natural Resources, Built Environment, Transportation	Stakeholder Engagement, Scoping / Inventory, Assessment / Analysis	Local, Regional, Statewide	Online Map Viewer = Free Data Download = Free	None	http://sealevel.climatecentral.org/
FDOT Sea Level Scenario Sketch Planning Tool	This tool allows for visualization of potentially inundated areas due to sea level rise, identification of transportation facilities potentially at risk from sea-level rise inundation, report creation to summarize and prioritize impacted infrastructure, and the ability to create custom inundation surfaces.	Transportation	Stakeholder Engagement, Scoping / Inventory, Assessment / Analysis	Local, Regional, Statewide	Online Map Viewer = Free Data Download = Free Sea-Level Rise Inundation Surface Calculator Download = Free	None	http://sls.geoplan.ufl.edu/
The Nature Conservancy Coastal Resilience Mapping Portal	This tool provides users with access to interactive tools to visualize future flood risks from sea-level rise and storm surge.	Natural Resources, Agriculture, Built Environment, Transportation	Stakeholder Engagement, Scoping / Inventory, Assessment / Analysis	Local, Regional, Statewide	Online Map Viewer = Free	None	http://maps.coastalresilience.org/network/

Tool/Resource Name	Purpose	Sector(s)	Adaptation Planning Process Phase(s)	Geographic Scale	Cost	Data Input(s)	Website
NOAA Coastal Change Analysis Program (C-CAP) Land Cover Atlas and Coastal Comparison Tool	The NOAA C-CAP program produces a Nationally standardized database of land cover and land change information for the coastal regions of the U.S. that can be used to explore changes and trends in land cover that may be caused by sea-level rise. The Land Cover Atlas and Coastal Comparison Tool are two products that allow users to easily access the C-CAP data.	Natural Resources, Agriculture, Built Environment	Stakeholder Engagement, Scoping / Inventory	Countywide, Statewide	Data Download = Free Online Viewer = Free Online Comparison Tool = Free	None	http://coast.noaa.gov/digitalcoast/data/ccapregional http://coast.noaa.gov/digitalcoast/tools/lca http://coast.noaa.gov/digitalcoast/tools/ccap-comparison
NOAA Sea-Level Rise and Coastal Flooding Impacts Viewer	This tool is an online viewer that allows users to visualize potential impacts from sea-level rise.	Natural Resources, Built Environment, Transportation	Stakeholder Engagement, Scoping / Inventory, Assessment / Analysis	Local, Regional, Statewide	Online Viewer = Free Data Download = Free	None	http://coast.noaa.gov/digitalcoast/tools/slr
NOAA Sea Level Trends	This tool illustrates regional trends in sea level with arrows representing the direction and magnitude of change. This can be used to determine areas which have experienced the highest rates of change and may be most vulnerable to future sea-level rise.	Natural Resources	Scoping / Inventory, Assessment / Analysis	Local, Regional	Online Map Viewer = Free	None	http://tidesandcurrents.noaa.gov/sltrends/sltrends.shtml
Social Vulnerability Index (SoVI)	This tool measures the social vulnerability of U.S. counties and census tracts to environmental hazards, including sea-level rise.	Built Environment	Scoping / Inventory, Assessment / Analysis	Census Tract to Countywide	Results = Free Data Download = Free	None	http://webra.cas.sc.edu/hvri/products/sovi.aspx

Sea-Level Rise Vulnerability Tools/Resources Inventory Summary Table (Continued)

Tool/Resource Name	Purpose	Sector(s)	Adaptation Planning Process Phase(s)	Geographic Scale	Cost	Data Input(s)	Website
USGS National Assessment of Coastal Vulnerability to Sea-Level Rise: Coastal Vulnerability Index (CVI)	This tool maps the Coastal Vulnerability Index (CVI) data layer, which expresses the relative vulnerability of the coast to physical changes due to sea-level rise, geomorphology, and shoreline erosion rates.	Natural Resources	Scoping / Inventory, Assessment / Analysis	Local, Regional, Statewide	Online Map Viewer = Free	None	http://coastalmap.marine.usgs.gov/FlexWeb/national/cvi/
USGS Digital Shoreline Analysis System (DSAS)	This tool can be used to measure coastal erosion and accretion, which can help users determine the areas that have experienced the highest rates of change and may be most vulnerable to sea-level rise.	Natural Resources	Scoping / Inventory, Assessment / Analysis	Shoreline	Software Download = Free	National shoreline data	http://pubs.usgs.gov/of/2003/of03-076/
Modeling Tools							
ADvanced CIRCulation Model (ADCIRC)	This tool can be used to analyze the effects of sea-level rise on storm surge. Future scenarios can consider a given rate of sea-level rise and determine how much additional inundation is predicted during a storm event compared to that under initial conditions.	Natural Resources	Assessment / Analysis	Deep Ocean, Continental Shelves, Coastal Seas, or Small-scale Estuarine Systems	ADCIRC Software Component = $3,950 Custom ADCIRC package = $6,350 SMS Package = $2,300-$47,000; Educational Package Discount = 50% off	Bathymetry, gridded wind measurements across the model domain, freshwater discharge	http://adcirc.org/ http://www.aquaveo.com/software/sms-adcirc http://www.veritechinc.com/products/sms_adcirc/index.php

Sea-Level Rise Vulnerability Tools/Resources Inventory Summary Table (Continued)

Tool/Resource Name	Purpose	Sector(s)	Adaptation Planning Process Phase(s)	Geographic Scale	Cost	Data Input(s)	Website
Hazus-MH	This tool is a risk assessment methodology for analyzing potential losses. Although it is not specifically designed for sea-level rise planning applications, many communities have used it to assess potential losses due to sea-level rise.	Built Environment, Transportation, Energy	Assessment / Analysis	Local, Regional, Statewide	Software Download = Free	None (contains all necessary data but users can supply additional data, such as specific building data, soil maps, and stream gauges)	http://www. fema. gov/hazus
Integrated Valuation of Environmental Services and Tradeoffs (InVEST)	This tool is a suite of software models that is used to map and model ecosystem services and their variation under different management and climate scenarios. The Coastal Vulnerability Model can be used to calculate a vulnerability index for the impacts of erosion and inundation on coastal communities that accounts for projected change in sea-level rise.	Natural Resources, Agriculture, Energy	Assessment / Analysis, Strategy / Scenario Development	Local, Regional, Statewide, Global	Software Download = Free	Spatial data and parameter values (much of the data are required within the software, users can input data more specific to the region)	http://www.naturalcapitalproject.org/InVEST.html
NatureServe Climate Change Vulnerability Index (CCVI)	This is an Excel-based tool that identifies plant and animal species that are particularly vulnerable to the effects of climate change and can help assess the relative vulnerability of species of interest occurring on the coast that may be impacted by sea-level rise.	Natural Resources	Assessment / Analysis	Regional	Software Download = Free	Species-specific sensitivity or life history data, data on exposure to climate change, land use data	http://www.natureserve.org/conservation-tools/climate-change-vulnerability-index
NOAA Wave Exposure Model (WEMo)	This is a free tool that estimates wave energy and its effects on ecosystem functions as well as on developed coastal and inland-water areas.	Natural Resources	Assessment / Analysis	Regional	Software Download = Free	Bathymetry grid data, shoreline coverage data, wind data	http://coast.noaa.gov/digitalcoast/tools/wemo

Sea-Level Rise Vulnerability Tools/Resources Inventory Summary Table (Continued)

Tool/Resource Name	Purpose	Sector(s)	Adaptation Planning Process Phase(s)	Geographic Scale	Cost	Data Input(s)	Website
Sea Levels Affecting Marshes Model (SLAMM)	This tool simulates wetland conversion and shoreline modification resulting from long-term sea-level rise. As such, the tool can be used for projecting the effects of sea-level rise on the distribution of coastal wetlands and the geomorphic configuration of coastal areas.	Natural Resources	Assessment / Analysis	Local, Regional	Software Download = Free Online Viewer = Free	National Wetlands Inventory data, digital elevation data, optional datasets include: protected area/ dike data and site parameters to change water depths, accretion rates, erosion rates, and many more	http://warrenpinnacle.com/prof/SLAMM/index.html http://www.slammview.org/slammview2/
Simulator of Climate Change Risks and Adaptation Initiatives (SimCLIM)	This tool can be used to model site-specific sea-level rise. The tool can create scenarios and project impacts of sea-level rise.	Natural Resources, Agriculture, Built Environment	Assessment / Analysis	Local, Regional, Statewide, Global	Annual Seat License = $149 to $6,000 (depending on user) Downscaled AR5 Spatial Areas = $150 to $300 6-Week Trial Version = Free	Additional regional climate variables (optional)	http://www.climsystems.com/simclim/
USACE Sea Level Change Curve Calculator	This tool can be used to calculate the amount of predicted sea level change for any location along the U.S. coast from 1992 forward. Results are shown as a graph.	Natural Resources, Built Environment, Transportation	Scoping / Inventory, Assessment / Analysis	Local	Online Calculator = Free Excel Calculator Download = Free	Base flood elevation, project start and end years, interval year	http://www.corpsclimate.us/ccaceslcurves.cfm

Sea-Level Rise Vulnerability Tools/Resources Inventory Summary Table (Continued)

Tool/Resource Name	Purpose	Sector(s)	Adaptation Planning Process Phase(s)	Geographic Scale	Cost	Data Input(s)	Website
Decision Support Tools							
Beach-*fx*	This tool is a comprehensive analytical framework for evaluating the physical performance and economic benefits and costs of shore protection projects, including sea-level rise adaptation projects.	Natural Resources, Built Environment	Assessment / Analysis, Strategy / Scenario Development	Local, Regional, Statewide	Software Download = Free	Coastal area description; plausible storm events; vulnerable infrastructure inventory; morphology response estimates; erosion, inundation, and wave impact design parameters	http://hera.pmcl.com/beachfx/default.aspx
Coastal Adaptation to Sea-Level Rise Tool (COAST)	This software helps users answer questions in regards to the costs and benefits of actions and strategies to avoid damages to assets from sea-level rise, through 3D visualizations.	Natural Resources, Agriculture, Built Environment, Transportation, Energy	Stakeholder Engagement, Scoping / Inventory, Assessment / Analysis, Strategy / Scenario Development	Project Level	Software Download = Free	Tide gauge data; local real estate, economic activity, infrastructure, natural resources, and human health data; candidate adaptation actions	https://www.bluemarblegeo.com/products/COAST.php
CommunityViz	This tool provides a means for visualizing and communicating possible future land use change scenarios driven by sea-level rise.	Natural Resources, Agriculture, Built Environment, Transportation, Energy	Stakeholder Engagement, Scoping / Inventory, Assessment / Analysis, Strategy / Scenario Development	Local, Regional, Statewide	30-Day Trial =Free; Gov't/ Non-Profit = $875; Commercial = $1,400	GIS layers (e.g., parcels, zoning, roads, environmentally sensitive areas), demographics, future population projections, future land use plans or proposals	http://placeways.com/communityviz/index.html

Sea-Level Rise Vulnerability Tools/Resources Inventory Summary Table (Continued)

Tool/Resource Name	Purpose	Sector(s)	Adaptation Planning Process Phase(s)	Geographic Scale	Cost	Data Input(s)	Website
NatureServe Vista	This tool enables users to create, analyze, implement, and monitor land use and resource management scenarios that achieve conservation goals.	Natural Resources, Agriculture, Built Environment, Transportation, Energy	Stakeholder Engagement, Scoping / Inventory, Assessment / Analysis, Strategy / Scenario Development	Local, Regional	Software Download = Free	Spatial data representing the elements to be conserved, represented, or restored; land cover and land policy scenario data	http://www.natureserve.org/conservation-tools/natureserve-vista
NOAA Inundation Analysis Tool	This is an online tool that can be used to create scenarios of increased sea-level rise. The output may be used to compare how many high tides and total hours of inundation would have been experienced during a selected time period assuming a given amount of sea-level rise, versus the historical data.	Natural Resources	Assessment / Analysis, Strategy / Scenario Development	Local	Online Tool = Free	Reference elevation, data range for evaluation	http://tidesandcurrents.noaa.gov/inundation/
U.S. DOT Vulnerability Assessment Scoring Tool (VAST)	This tool is intended for state DOTs, MPOs, and other agencies interested in assessing how components of their transportation system may be vulnerable to climate stressors, including sea-level rise.	Transportation	Assessment / Analysis, Strategy / Scenario Development	Local, Regional, Statewide	Excel Download = Free	Asset inventory, climate information/ stressors	http://www.fhwa.dot.gov/environment/climate_change/adaptation/publications_and_tools/
Databases of Resources							
Adaptation Database for Planning Tool (ADAPT)	This is an online tool that guides local government users through ICLEI's Five Milestones for Adaptation planning process.	Natural Resources, Agriculture, Built Environment	Scoping / Inventory, Strategy / Scenario Development	Municipal Level	Trial to ICLEI member local governments (requires log in) = free	Data to assess vulnerabilities and risks	http://www.icleiusa.org/tools/adapt

Sea-Level Rise Vulnerability Tools/Resources Inventory Summary Table (Continued)

Tool/Resource Name	Purpose	Sector(s)	Adaptation Planning Process Phase(s)	Geographic Scale	Cost	Data Input(s)	Website
Climate Adaptation Knowledge Exchange (CAKE)	This resource includes a database of tools to help process information and make adaptation decisions (including sea-level rise); case studies of adaptation projects; a visual library with literature and information focusing on adaptation and adaptation planning; and a directory of people/organizations engaged in adaptation.	Natural Resources, Built Environment	Scoping / Inventory, Strategy / Scenario Development	Local, Regional, Statewide	Online Database = Free	None	http://www.cakex.org
Ecosystem-Based Management (EBM) Tools Network and Database	This database is an online hub for tools and projects featuring innovative interdisciplinary coastal-marine spatial planning and ecosystem-based management.	Natural Resources, Agriculture, Built Environment, Transportation, Energy	Scoping / Inventory	Local, Regional, Statewide	Online Database = Free	None	https://ebmtools database.org/
FL DEP Map Direct Gateway	This resource access to a large number of FL DEP data layers and imagery layers, provides buffer analysis capabilities, provides "drill-down" reporting capabilities, and provides general data browsing. The Map Direct application replaces a number of existing single-purpose web mapping applications into a single integrated application with extensive capabilities.	Natural Resources, Agriculture, Built Environment, Transportation	Scoping / Inventory	Local, Regional, Statewide	Online Map Viewer =Free Data Download = Free	None	http://ca.dep.state.fl.us/mapdirect/gateway.jsp

Sea-Level Rise Vulnerability Tools/Resources Inventory Summary Table (Continued)

Tool/Resource Name	Purpose	Sector(s)	Adaptation Planning Process Phase(s)	Geographic Scale	Cost	Data Input(s)	Website
Florida Natural Areas Inventory (FNAI)	This organization offers services and products, including spatial datasets and maps, that promote conservation of Florida's biological diversity, including sea-level rise adaptation.	Natural Resources	Scoping / Inventory	Local, Regional, Statewide	GIS Data Download = Free Online Map Viewer = Free	None	http://www.fnai.org/index.cfm
Georgetown Climate Center	This organization provides publically-available sea-level rise and flood-related work products intended to help state and local governments become "cost-smart" or better prepared to cope with the threats posed by rising sea levels..	Natural Resources, Built Environment, Transportation, Energy	Scoping / Inventory, Strategy / Scenario Development	Local, Regional, Statewide	Online Database = Free	None	http://www.georgetownclimate.org/
Geospatial Assessment Tool for Operations and Response (GATOR)	This is an interactive web mapping tool for the display of geographic information to support emergency preparedness, operations, and response, with data applicable to sea-level rise vulnerability analysis.	Natural Resources, Agriculture, Built Environment, Transportation, Energy	Scoping / Inventory	Local, Regional, Statewide	Online Map Viewer = Free	None	http://map.floridadisaster.org/GATOR/map.html
U.S. Climate Resilience Toolkit	This database contains multiple tools that can be used to estimate, simulate, visualize, and monitor sea-level rise and impacts throughout the country.	Natural Resources, Agriculture, Built Environment, Transportation	Stakeholder Engagement, Scoping / Inventory, Strategy / Scenario Development	Local, Regional, Statewide	Online Database = Free	None	http://toolkitclimate.gov/
weADAPT	This database is an online forum on adaptation issues which allows practitioners, researchers, and policy makers to access information and to share experiences and lessons learned with the weADAPT community.	Natural Resources, Built Environment	Scoping / Inventory, Strategy / Scenario Development	Local, Regional	Online Database = Free (when registered)	None	https://weadapt.org