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U.S. Department of Transportation
Federal Highway Administration

FHWA Climate Resilience Pilot Program:

South Florida

The Federal Highway Administration's (FHWA)'s Climate Resilience Pilot Program seeks to assist state Departments of Transportation (DOTs), Metropolitan Planning Organizations (MPOs), and Federal Land Management Agencies (FLMAs) in enhancing resilience of transportation systems to extreme weather events and climate change. In 2013-2015, nineteen pilot teams from across the country partnered with FHWA to assess transportation vulnerability to extreme weather events and climate change and evaluated options for improving resilience. For more information about the pilot programs, visit: **http://www.fhwa.dot.gov/environment/climate_change/adaptation/**.

Broward Metropolitan Planning Organization (MPO), Miami-Dade MPO, Palm Beach MPO, and the Monroe County Planning and Environmental Resources Department partnered to conduct a detailed vulnerability assessment of transportation infrastructure in a four-county region in South Florida. The region's flat, coastal landscape makes it among the most vulnerable in the country to the effects of sea level rise, storm surge, and rain-driven inundation. This study conducted a detailed geospatial analysis and developed a system to determine vulnerability scores for "regionally significant" road and rail segments in the region. Moreover, the study recommended several ways for partner agencies to incorporate the vulnerability results into their normal decision-making processes such as transportation planning, project prioritization, project rehabilitation or reconstruction, new project design, system operations, and system maintenance.

Scope

The project study area covered Broward, Miami-Dade, Palm Beach, and Monroe Counties, all located in southeast Florida. The assessment focused on the area's regionally significant freeways, arterials, and rail (as defined by the Southeast Florida Transportation Council) and their vulnerability to three climate stressors: sea level rise, storm surge and related flooding, and heavy precipitation and related flooding.

Objectives

The project defined five key objectives to guide the analysis:

- Provide member agencies with the ability to analyze adaptation strategies.
- Identify adaptation projects and strategies.
- Apply a vulnerability framework and provide feedback to the planning process.
- Incorporate climate change throughout agency decision-making processes.
- Strengthen institutional capacity to address climate change risk within partner agencies.

A flooded road in Fort Lauderdale.
Photo credit: Art Seitz.

A severely eroded beach in South Florida.
Photo credit: Art Seitz.

A flooded and damaged beach patrol tower.
Photo credit: Art Seitz.

Approach

This project took a geographic information system (GIS)-intensive approach to determine vulnerability scores for individual segments of the roads and rail lines analyzed. Then, the project team recommended several adaptation strategies, designed to integrate consideration of climate change risks into everyday decision-making processes at the partner agencies. The project also established a technical advisory committee representing 32 agencies to provide guidance on the overall technical approach and study recommendations.

Compile and clean data. This project had the benefit of several available datasets—ranging from elevation data derived from light detection and ranging (LiDAR), Federal Emergency Management Agency (FEMA) flood zone maps, sea level rise inundation maps, and data on the regional transportation network. However, compiling, reconciling, and cleaning these datasets took considerable resources—in terms of GIS expertise as well as computer processing time. Necessary data processing steps included:

- Combining FEMA flood maps for each regional jurisdiction into a single geodatabase
- Compiling a horizontally and vertically accurate spatial representation of the transportation network
- Determining correct bridge deck elevations using LiDAR source data or manual overrides
- Translating all datasets into the most accurate topographic elevation data available (e.g., correcting FEMA flood maps based on LiDAR elevation data)
- Identifying network segments to apply in vulnerability analysis (e.g., road segments defined by intersections with other regionally significant routes and rail segments broken into segments of uniform length)

Calculate vulnerability scores. Following the FHWA Vulnerability Assessment Framework and examples from other projects (e.g., U.S. DOT's Gulf Coast Study Phase 2), the South Florida team defined vulnerability as a function of three components or categories—exposure, sensitivity, and adaptive capacity—and calculated vulnerability scores for each segment using indicators of each category.

Exposure – The project team used three indicators to calculate each segment's exposure score: (i) the percentage of the segment permanently inundated by sea level rise, (ii) its current "flood inundation exposure index," and (iii) its future flood inundation exposure index. The *current* flood inundation exposure index reflects whether an asset is currently inundated in the FEMA 100-year flood plain and the depth of that inundation. The *future* flood inundation exposure index reflects the distance from the segment to the closest existing FEMA flood zone, and the difference in elevation between that segment and the FEMA flood zone.

Sensitivity – For roads, bridge scour rating and substructure condition rating served as indicators of sensitivity, or the capacity of the asset to deal with changes in a climate stressor. The project team did not evaluate sensitivity for rail assets, since no relevant data were available.

Adaptive capacity – To capture adaptive capacity—the ability of the transportation network to deal with the loss of an impacted asset—the team considered average annual daily traffic and detour length for roads, and Tri-Rail ridership for rail.

Vulnerability – The South Florida team then calculated vulnerability scores for each segment as a weighted average of its exposure, sensitivity, and adaptive capacity. The weights applied are shown in Figure 1. The team chose to weight exposure higher than the other categories.

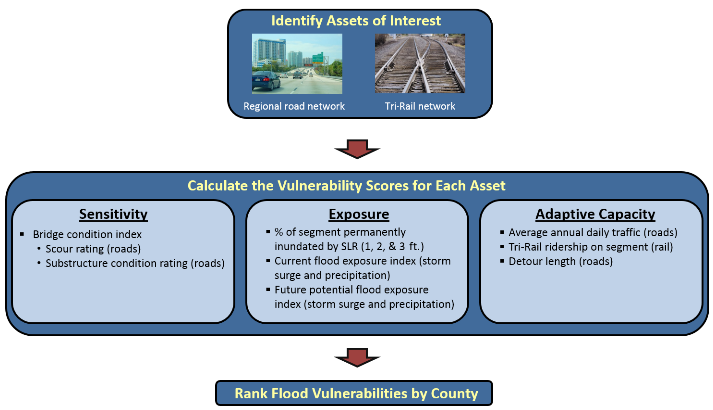

Figure 1. Vulnerability Assessment Approach

Link results to decision-making. Finally, the project team identified five types of major transportation decision-making processes in the region that are directly related to the potential disruptions from future inundation: transportation planning and prioritization, rehabilitation or reconstruction of existing facilities in high risk areas, new facilities in new rights-of-way in high risk areas, system operations, and systems maintenance. For each of these decision-making areas, the project team recommended ways to integrate knowledge of climate change vulnerabilities into those decisions.

Key Results & Findings

The vulnerability assessment data analysis resulted in vulnerability scores for each regionally significant road and rail segment in the four-county study area. An example output of the analysis is shown for Miami-Dade County in Figure 2.

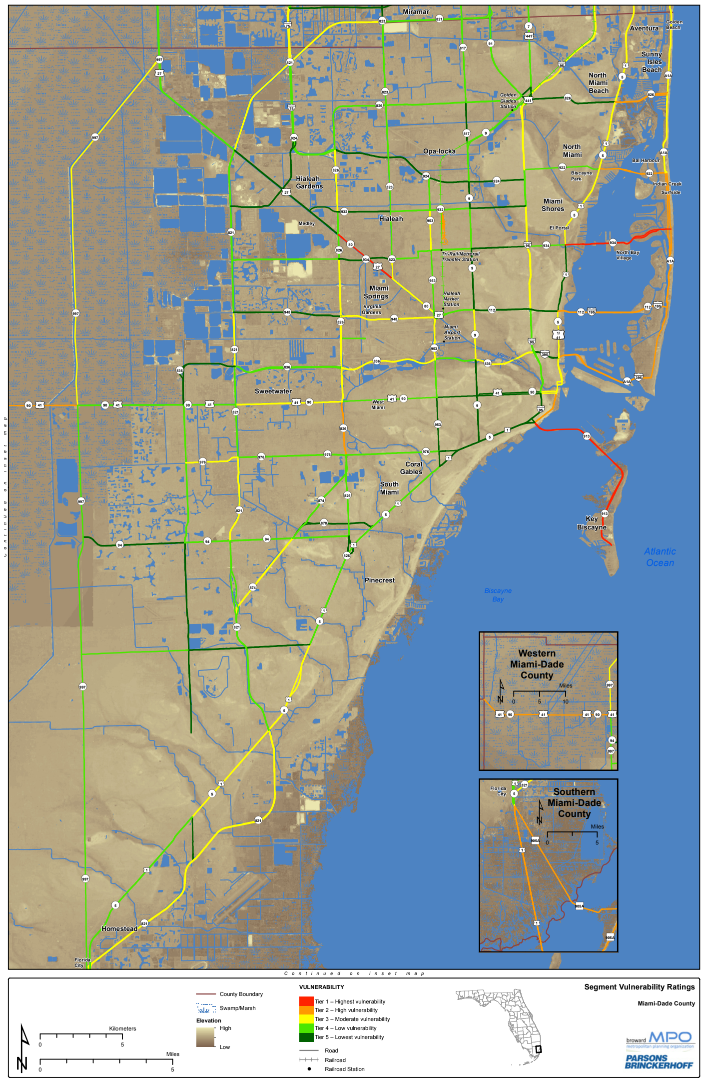

Figure 2. Vulnerability Assessment Results for Miami-Dade County (red = highest vulnerability, orange = high vulnerability, yellow = moderate vulnerability, light green = low vulnerability, dark green = lowest vulnerability)

The project team's recommendations for linking this information to decision-making include:

Transportation policy, planning, and project prioritization

- Add a goal statement explicitly related to climate change resilience into long range transportation plans.
- Identify climate change-related prioritization criteria that can be used as part of the project priority/ programming process (e.g., Is the project located in an area of high risk? or To what extent does the project enhance transportation system resilience?).
- Identify and apply performance measures to promote transportation system resiliency (e.g., number of weather-related disruptions).
- Apply tools to identify and assess continuing climate change-related impacts.

Rehabilitation or reconstruction of existing facilities in high risk areas

- Consider new road and transit design approaches and standards to minimize potential disruption due to extreme weather events (e.g., profile elevation).
- Near coastal areas and over the long term, consider sea level rise a "given" in coastal facility design.
- Redesign drainage systems to handle larger flows.
- Harden or armor key infrastructure components (e.g., embankments or bridge piers) against additional extreme weather-related stresses.
- Incorporate early warning indicators into asset and maintenance management systems.

New facilities on new rights-of-way in high risk areas

- Apply design criteria or consider realignments or relocation away from high risk areas.

Operations

- Identify pre-planned detour routes around critical facilities whose disruption or failure would cause major network degradation.
- Coordinate with Florida DOT and emergency responders to identify strategies to deal with risks.

Maintenance

- Harden sign structures and traffic signal wires to avoid significant disruptions and maintenance demands.
- Keep culverts and drainage structures debris free and maintained to handle flow.

"One of the key challenges in the technical analysis was that various agencies applied different representations of the South Florida land form in their systems… The study spent considerable time coordinating with various agencies to assess risks in their respective jurisdictional area and to identify the varying data sources potentially available to conduct the vulnerability assessments."

– South Florida Climate Change Vulnerability Assessment and Adaptation Pilot Project Final Report

Lessons Learned

Data availability and quality are critical. Climate adaptation studies need to consider what types of data will be needed, what types of data are available, and what surrogates can be used if data are inadequate or unavailable. Transportation agencies should collect relevant data (e.g., bridge approach elevation, size of hydraulic openings) periodically or as part of normal activities to streamline future risk analyses.

Database integration is difficult, but also critical. A regional analysis like this project requires consistent and combined data sets. Although the number of relevant studies that preceded this one was an advantage, it also created significant challenges to combine the data so they could be used in a single analysis. The data used in this project required substantial "cleaning" and quality control before they could be used in calculations.

Establish agreements among participating agencies early in the process. The multi-agency technical advisory committee provided an important source of input and guidance for this study. However, marshalling the resources of many different agencies (even just to participate in the planning process) can be challenging. For future projects, agreements and understandings among the major participants should be put in place as early as possible.

Establish a long-term commitment to ongoing climate adaptation planning. Given the long timeframe and uncertainty of climate change stressors, and the longevity of many transportation assets, the climate change adaptation process cannot be a one-time effort, but rather something that happens continuously over time and is integrated into the normal planning and decision-making processes.

Next Steps

Following this project, member agencies intend to consider the study's recommendations and incorporate climate change into their ongoing decision-making processes. Among the recommendations identified above, possible next steps include:

- Identify implications for areas and projects of concern in long range transportation plans.
- Discuss capital investment priorities and consider identified risks.
- Coordinate other policy responses (e.g., development) with climate risk considerations.

For More Information

Final report available at:
www.fhwa.dot.gov/environment/climate/adaptation/2015pilots/

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