Adaptation Planning at Adaptation Planning Lab (APL)

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ONE BAY Resilient Communities Working Group
Meeting
Dec. 5th, 2014
About APL

• The Adaptation Planning Lab (APL) at the University of Florida primarily investigates adaptive strategies in response to climate change from the empirical and theoretical perspectives.

• APL has been involving numerous faculty members and graduate students in a variety of research projects funded by national and state sponsors.

• APL strives to shed insight on developing efficient and adaptive strategies in an era of changing and somehow unpredictable climate.
Research Themes at the APL

- Exposure Analysis to SLR [Economic Loss]
- Vulnerability Analysis
- Social Behaviors [Population Dynamics]
- Adaptation Strategies [Cost/Benefit analysis]

Coastal Resiliency
Research Projects

Development of Sea Level Rise Adaptation Planning Procedures and Tools Using NOAA Sea Level Rise Impacts Viewer

A Parameterized Climate Change Projection Model for Hurricane Flooding, Wave Action, Economic Damages, and Population Dynamics

A spatial temporal econometric model to estimate costs and benefits of sea level rise adaptation strategies

UF-Sea Level Rise Viewer

Planning for hydrologic and ecological impacts of sea level rise on sustainability of coastal water resources
Vulnerability Analysis
Goals

- Estimate system vulnerabilities
- Identify optimal adaptation

- Conduct cost-benefit analysis of different adaptation strategies

- Establish a policy kit for local planners for adaptation planning

- Develop a regional adaptation planning procedure and decision-support tools
Comparison between Different Dimensions

- Social Impacts:
  - Human vulnerability to hazards, based on population attributes and the built environment, measured by The Social Vulnerability Index (SoVI®) 2005-09, including 42 socioeconomic variables representing income, age, urban and rural, special needs, race, gender, employment, and migration, etc.

- Economic impacts:
  - Employment, wages, and the number of establishments (or businesses) exposed to a hazard are strong indicators of a community’s overall economic impact.

- Infrastructure:
  - Critical infrastructure and key resources
Vulnerability Indicator Processing

- Calculate vulnerable measures:
  - Flooding map (1ft, 2ft, 5ft)
  - Census block group
- Normalization:
  - Density
  - Percentage
- Standardization:
  - Z-score
  - Maximum
- Integrated vulnerability:
  - Map by standard deviation
Social Vulnerability

It shows areas of high human vulnerability to hazards, based on population attributes (e.g., age and poverty) and the built environment, produced by the Hazards and Vulnerability Research Institute at the University of South Carolina.

http://webra.cas.sc.edu/hvri/docs/sovio610_factorsb.pdf
Social Vulnerability
Economic Vulnerability Indicators

- **Business:**
  - Number of businesses within the area

- **Employment:**
  - Number of employment within the area

- **Wages:**

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Scored Importance Scale: 1 (Least Important) to 9 (Most Important)
Economy indicators weight

- Paired Wilcoxon Signed Ranks Test:
  - Wages mean rank 1.54
  - Business mean rank 2.02
  - Employment mean rank 2.44

- Wage ≈ business < employment

- Select number of employment as the economic indicator
Economic Vulnerability
Critical Infrastructure

- Get expert opinion in comparing infrastructure importance from different perspectives: Infrastructure maintenance repair cost, emergency importance, and relocation difficulties
- Infrastructure Types include critical infrastructures listed in “Critical Facilities” published by Florida Division of Emergency Management (2012)
  - Emergency Operation Center
  - Health care facilities
  - Principal transportation facilities
  - Intermodal Distribution Centers
  - Policy and fire department
AHP Method

Prioritize Critical Infrastructure

- Facility Costs 0.352113
  - Emergency Operation Center
    - Health care facilities
- Emergency Role 0.332987
  - Emergency Operation Center
    - Health care facilities
- Relocation Difficulties 0.3149
  - Emergency Operation Center
    - Health care facilities
Infrastructure Vulnerability

Integrated Infrastructure Vulnerability under 1 ft Sea Level Rise Scenario
Census Block Group in Tampa Bay Region

Legend
1ft Vulnerability
1ftinrain
- < .5 Std. Dev. (Not Vulnerable)
- 0.5 - 1.5 Std. Dev. (Low Vulnerability)
- 1.5 - 2.5 Std. Dev. (Medium Vulnerability)
- > 2.5 Std. Dev. (High Vulnerability)
Computing Integrated Vulnerability Index

Integrated Vulnerability Index

- Internal Adaptation Capability
  - Social Vulnerability
- Economic Vulnerability
- Employment
- Infrastructure Vulnerability
  - Emergency Operation Center
  - Health care facilities
  - Principal transportation facilities
  - Fuel Distribution centers
  - Police and fire department
Integrated Vulnerability
UF SLR Viewer

UF Sea Level Rise and Coastal Flooding Viewer:
http://plaza.ufl.edu/dengyujunn11/SLR7.o.html
Major Findings

- With no sea level rise or low sea level rise, social vulnerability is the most influential components in determining the overall vulnerability.
- As sea level rises, the influence of employment and infrastructure will become more significant.
- Although social, economic, and infrastructure are weighted equally in the integrated vulnerability calculation, the influences of social, economic, and infrastructure differ by location and time due to the difference in level of exposure.
Adaptation Strategies to SLR
[Cost/Benefit Analysis]
Research Objectives

- Whether adaptation of sea level rise adaptive strategies is more cost-efficient than no action? If it is, which adaptive strategies are more cost-efficient than others?
- How to better capture the indirect economic impacts of sea level rise and its adaptation strategies?
- What is the best time (tipping point) to take adaptation actions?
Research flow chart

Pre-defined sea level rise scenarios

Calculate cost efficiency of each strategy on predefined scenarios

Calculate and identify tipping point

Conclusion and policy implication
Case study area-Hillsborough County, FL

- A good case to study sea level rise adaptation
  - Densely populated (1,229,226 as of 2010)
  - Large amount of wetlands
  - Experience hurricanes and frequent storm surges
- The County is divided into 39 EAZs. The delineation of EAZ is based on Evacuation Analysis Zone created by Tampa Bay Regional Planning Council
Quantification of Benefits

Benefit quantification for variables without spatial pattern:

- Travel time delay
- Building damages
- Change of wetland ecosystem services
Travel time delay

- Transportation network congestion delays the users’ travel time which is considered to have monetary values.
  - First of all, the delayed travel time has opportunities cost that can be utilized to do other things rather than spending times in traffic queues.
  - Secondly, the delayed travel time can actually have economic cost if the travelers are late for work.

- Florida Standard Urban Transportation Modeling Structure (FSUTMS) is developed to serve as the standard transportation model for the State of Florida. The FSUTMS models are developed based on Cube software, a transportation modeling software.
Results

<table>
<thead>
<tr>
<th>Sea level rise</th>
<th>1 foot</th>
<th>2 feet</th>
<th>5 feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total travel time delay per day (in million $)</td>
<td>1.12</td>
<td>1.61</td>
<td>1.92</td>
</tr>
<tr>
<td>Total value of travel time delay per year (in million $)</td>
<td>409</td>
<td>577</td>
<td>701</td>
</tr>
</tbody>
</table>
Wetland services

- The value of wetland products can be captured by market with monetary values. However, the values of their services are greatly underestimated since the market cannot directly assign values to those services.
- The calculation is based on the average value for different ecosystem services provided by Gulf of Mexico Ecosystem Service Valuation Database (http://www.gecoserv.org/).

<table>
<thead>
<tr>
<th>Type</th>
<th>Beach value</th>
<th>Freshwater value</th>
<th>Mangrove value</th>
<th>Marine open water</th>
<th>Salt water value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>195,838</td>
<td>61,959</td>
<td>125,991</td>
<td>2,913</td>
<td>28,629</td>
</tr>
</tbody>
</table>

Unit: dollar per ha
SLAMM Simulation

No sea level rise

1 foot sea level rise

2 feet sea level rise

5 feet sea level rise
### Results

Total values of five major types of wetlands (value in millions)

<table>
<thead>
<tr>
<th>Sea level rises</th>
<th>1 foot</th>
<th>2 feet</th>
<th>5 feet</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total value</strong></td>
<td>$2,014</td>
<td>$2,115</td>
<td>$2,252</td>
</tr>
<tr>
<td><strong>Value loss</strong></td>
<td>-$47</td>
<td>-$148</td>
<td>-$285</td>
</tr>
</tbody>
</table>

Unit in million dollars
Building damages

- As sea level rises, coastal buildings are vulnerable to both inundation and frequent flooding caused by sea level rise. However, quantification of coastal building damages is complicated because of the limited data and knowledge.

- Hazus model is employed to calculate building damages. It is a risk assessment tool to use various models to estimate potential losses from different natural hazards, including earthquakes, floods, and hurricanes.
Results

<table>
<thead>
<tr>
<th>Sea level rise</th>
<th>1 foot</th>
<th>2 feet</th>
<th>5 feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Values of building damages</td>
<td>$3,381</td>
<td>$4,128</td>
<td>$5,319</td>
</tr>
</tbody>
</table>

Unit in million dollars
Spatial econometric models

Spatial econometric models are always employed to capture spatial effects, which are represented by spatial dependence: spatial interaction and spatial error.

\[ y = \rho W_y + X\beta + \varepsilon \]
\[ \varepsilon = \lambda W\varepsilon + \mu \]

Where, \( y \) is dependent variable; \( X \) is independent variable; \( \rho \) and \( \lambda \) are spatial coefficients; \( W \) is weight matrix specifying the relations between spatial units; \( \varepsilon \) and \( \mu \) are error terms.
Area categorization

Directly impacted

Indirectly impacted

1 foot

2 feet

5 feet
Quantification for the Loss of Land Value

- Average land value per square kilometer for each EAZ is selected to represent property value since it is shown with significant spatial autocorrelation.

<table>
<thead>
<tr>
<th>Moran’s I statistic</th>
<th>Expectation</th>
<th>Variance</th>
<th>Standard deviation</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.526230637</td>
<td>-0.0263158</td>
<td>0.007478512</td>
<td>6.3894</td>
<td>8.326e-11</td>
</tr>
</tbody>
</table>
**Model Results**

\[ AvLND = \rho \cdot AvLND + \alpha \cdot PopDens + \beta + \varepsilon \]

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std.Error</th>
<th>z-value</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>W_AVLND</td>
<td>0.5997456</td>
<td>0.08026037</td>
<td>7.472501</td>
<td>0.0000000</td>
</tr>
<tr>
<td>POPDENSo</td>
<td>17194.12</td>
<td>1978.786</td>
<td>8.689228</td>
<td>0.0000000</td>
</tr>
<tr>
<td>CONSTANT</td>
<td>-1.393851e+007</td>
<td>4900879</td>
<td>-2.844083</td>
<td>0.0044541</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sea level rise</th>
<th>1 foot</th>
<th>2 feet</th>
<th>5 feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct loss</td>
<td>2,217</td>
<td>2,481</td>
<td>4,345</td>
</tr>
<tr>
<td>Indirect loss</td>
<td>4,189</td>
<td>10,292</td>
<td>11,391</td>
</tr>
<tr>
<td>Total loss</td>
<td>6,406</td>
<td>12,773</td>
<td>15,736</td>
</tr>
</tbody>
</table>
Quantification of Loss of Business

- This study estimates business loss by linking the employment to business revenue. Since existing literatures suggest a close relationship between the percentage of payroll to gross revenue, this study uses the expenditure on payrolls to proximate the business revenue (Harris 1999).

- Total business revenue = (Total number of employment * average personal income) / 30%.
Model of employment density

- After testing different representation of employments, the density variable turns out to have significant spatial dependence.

<table>
<thead>
<tr>
<th>Moran’s I statistic</th>
<th>Expectation</th>
<th>Variance</th>
<th>Standard deviate</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.540344467</td>
<td>-0.026315789</td>
<td>0.006963554</td>
<td>6.7906</td>
<td>5.584e-12</td>
</tr>
</tbody>
</table>
Model results

\[ \text{EmpDens} = \rho \text{EmpDens} + \alpha \text{PopDens} + \beta + \epsilon \]

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std.Error</th>
<th>z-value</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>W_EMPDEN</td>
<td>0.5926498</td>
<td>0.07449083</td>
<td>7.95601</td>
<td>0.00000000</td>
</tr>
<tr>
<td>POPDENS0</td>
<td>1.559869</td>
<td>0.160632</td>
<td>9.710822</td>
<td>0.00000000</td>
</tr>
<tr>
<td>CONSTANT</td>
<td>-1318.593</td>
<td>393.0426</td>
<td>-3.354834</td>
<td>0.0007942</td>
</tr>
</tbody>
</table>

Rising sea levels

<table>
<thead>
<tr>
<th>Rising sea levels</th>
<th>1 foot</th>
<th>2 feet</th>
<th>5 feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct employment loss</td>
<td>25,341</td>
<td>25,633</td>
<td>50,523</td>
</tr>
<tr>
<td>Indirect employment loss</td>
<td>-65,316</td>
<td>219,849</td>
<td>365,746</td>
</tr>
<tr>
<td>Total employment loss</td>
<td>-39,975</td>
<td>245,482</td>
<td>416,269</td>
</tr>
<tr>
<td>Total business loss (million $)</td>
<td>-$6,103</td>
<td>$37,480</td>
<td>$63,555</td>
</tr>
</tbody>
</table>
Quantification of Cost for adaptation strategies
Strategy framework
Constructing sea walls

- Building sea walls is a straightforward adaptation strategy to protect built-up environment but can damage natural systems.

<table>
<thead>
<tr>
<th>Adaptation scenarios</th>
<th>Scenario 1</th>
<th>Scenario 2</th>
<th>Scenario 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total costs (in million $)</td>
<td>3,737</td>
<td>2,206</td>
<td>1,533</td>
</tr>
</tbody>
</table>
Establishing living shoreline

The coastal areas of Hillsborough County are dominated by wetlands rather than recreational beaches. Therefore, living shoreline can fit the
Calculation

<table>
<thead>
<tr>
<th>Scenario 1</th>
<th>Scenario 2</th>
<th>Scenario 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total costs (in millions $)</td>
<td>3,085</td>
<td>1,846</td>
</tr>
</tbody>
</table>
Conservation easement

- Conservation easement is one type of rolling easement which enables coastal society to gradually adapt to rising sea levels while enabling ecosystems to migrate inland.
- World Resources Institute suggests that each acre protected with a conservation easement costs on average $2,000 (World Resources Institute 2002) in the year 2002.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Total cost (in millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario 1</td>
<td>$113</td>
</tr>
<tr>
<td>Scenario 2</td>
<td>$83</td>
</tr>
<tr>
<td>Scenario 3</td>
<td>$78</td>
</tr>
</tbody>
</table>
Structural elevation

- This specific strategy involves the elevation of vulnerable buildings as well as the elevation of vulnerable roads.

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>Scenario 1</th>
<th>Scenario 2</th>
<th>Scenario 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total adaptation costs (in millions)</td>
<td>$9,115</td>
<td>$4,215</td>
<td>$3,048</td>
</tr>
</tbody>
</table>

King Tide 2010 Swan Slough
Avoid further investment

- This strategy is the retreat response for sea level rise. That is, employing policies and zoning ordinances to avoid further development in these vulnerable areas to minimize risks and prepare for an eventual retreat and clear the way for wetland migration.

Public purchase

- The purchase is a typical property acquisition strategy, which asks local government to determine the most vulnerable properties and raise funds to purchase the property and assist the owners at risk to relocate.

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>Scenario 1</th>
<th>Scenario 2</th>
<th>Scenario 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investment avoidance</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Public purchase</td>
<td>$3,729,475,919</td>
<td>$2,481,457,430</td>
<td>$2,217,021,826</td>
</tr>
</tbody>
</table>
Action time points

- Action time points are defined as the year when a sea level rise adaptation strategy is implemented.

3 action scenarios
### Cost efficiency under Scenario 1

<table>
<thead>
<tr>
<th>Strategies</th>
<th>Sea wall</th>
<th>Living shoreline</th>
<th>Elevation</th>
<th>Easement</th>
<th>Public purchase</th>
<th>Avoidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total benefits</td>
<td>$86,533</td>
<td>$87,103</td>
<td>$79,234</td>
<td>-$82,119</td>
<td>-$82,119</td>
<td>-$86,675</td>
</tr>
<tr>
<td>Total costs</td>
<td>$3,737</td>
<td>$3,086</td>
<td>$9,116</td>
<td>$113</td>
<td>$3,729</td>
<td>$0</td>
</tr>
<tr>
<td>B/C ratio</td>
<td>23</td>
<td>28</td>
<td>9</td>
<td>-728</td>
<td>-22</td>
<td>NA</td>
</tr>
<tr>
<td>Net benefits</td>
<td>$82,795</td>
<td>$84,017</td>
<td>$70,119</td>
<td>-$82,23</td>
<td>-$85,849</td>
<td>-$86,675</td>
</tr>
</tbody>
</table>

Unit in million $
### Cost efficiency under Scenario 2

<table>
<thead>
<tr>
<th>Strategies</th>
<th>Sea wall</th>
<th>Living shoreline</th>
<th>Elevation</th>
<th>Easement</th>
<th>Public purchase</th>
<th>Avoidance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total benefits</strong></td>
<td>$80,702</td>
<td>$81,178</td>
<td>$67,183</td>
<td>-$80,67</td>
<td>-$80,677</td>
<td>-$80,821</td>
</tr>
<tr>
<td><strong>Total costs</strong></td>
<td>$2,207</td>
<td>$1,846</td>
<td>$4,216</td>
<td>$83</td>
<td>$2,481</td>
<td>$0</td>
</tr>
<tr>
<td><strong>B/C ratio</strong></td>
<td>37</td>
<td>44</td>
<td>16</td>
<td>-976</td>
<td>-33</td>
<td>NA</td>
</tr>
<tr>
<td><strong>Net benefits</strong></td>
<td>$78,49</td>
<td>$79,332</td>
<td>$62,96</td>
<td>-$80,75</td>
<td>-$83,158</td>
<td>-$80,821</td>
</tr>
</tbody>
</table>

Unit in million $
## Cost efficiency under Scenario 3

<table>
<thead>
<tr>
<th>Strategies</th>
<th>Sea wall</th>
<th>Living shoreline</th>
<th>Elevat-ion</th>
<th>Easement</th>
<th>Public purchase</th>
<th>Avoidance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total benefits</strong></td>
<td>$30,099</td>
<td>$30,373</td>
<td>$28,892</td>
<td>-</td>
<td>$28,604</td>
<td>-$28,604</td>
</tr>
<tr>
<td><strong>Total costs</strong></td>
<td>$1,533</td>
<td>$867</td>
<td>$3,049</td>
<td>$78</td>
<td>$2,217</td>
<td>$0</td>
</tr>
<tr>
<td><strong>B/C ratio</strong></td>
<td>20</td>
<td>35</td>
<td>9</td>
<td>-366</td>
<td>-13</td>
<td>NA</td>
</tr>
<tr>
<td><strong>Net benefits</strong></td>
<td>$28,566</td>
<td>$29,506</td>
<td>$25,843</td>
<td>-</td>
<td>-30,821</td>
<td>-$28,686</td>
</tr>
</tbody>
</table>

Unit in million $
Strategy assignment

Legend
Shoreline
Adaptation Strategy
- sea wall
- living shore
- easement
- elevation
- purchase
- avoidance
Planning areas
Social Behaviors
[Population Dynamics]
Sample Survey Results

Sea Level Rise Planning Status in Tampa Bay Region

Responsibility, Funding, Planning Scenario
Who is Responsible for SLR Planning

Your Agency's Responsibility to Consider SLR in Planning?

- Yes: 89%
- No: 11%

Exception

- An Attorney (Citizen groups)
- One Planning/Zoning Employees (City/County/State Government Officials)
Agencies with Primary Responsibility for SLR Adaptation Planning (Three choices)

- County government officials: 77%
- City/town government officials: 59%
- State government officials: 41%
- U.S. Congress: 23%
- Other agencies: 18%
- Corporations: 9%
- State legislators: 9%
- Citizen groups: 5%

Other agencies: Department of Environment Protection, Water Management District Regional Planning Council
Implications for SLR Decision Support Tool Development

- Almost all of the agencies think they should take some responsibility to take sea level rise into planning practice.
  - City, County Planners, zoning, land use development managers
  - Private engineering firms
  - Environmental protection department
  - Transportation planning and management department
  - Local government officials

- County government officials, city government officials, and state government officials are rated as the top three most responsible ones for sea level rise adaptation planning.

- Adaptation for sea level rise will focus at local levels, with county planning and governments as the most possible primary responsible agencies.

- Multidisciplinary and Multi-agencies nature
Funding for Adaptation Plan Development

Does your agency have funding to develop adaptation plans?

- Yes: 88%
- No: 12%

Budget Range

- EPA Tampa Bay Estuary Program – about $50,000 for coastal habitat impact assessment
- Hernando County – Part of the County Comprehensive Plan Update
Funding for Implementation of Adaptation Plan

Does your agency have funding to develop adaptation plans?

- Yes: 94%
- No: 6%

- Budget Range
  - EPA Tampa Bay Estuary Program – About $50,000 to implement high-priority habitat restoration or protection projects
Majority of the respondents (90%) believe sea level rise is rising.

Most of them (70%) think sea level rise will start to have impacts in Tampa Bay region in no more than 25 years.
However, over half of the agencies do not consider sea level rise as a very serious issue for future planning.
Current Adaptation Planning Practice

- About one-fifth of the agencies do not have any plan or action.
- One-fifth of the agencies include sea level rise in their comprehensive plan.
- Ten percent include SLR in their building codes or land use plan.
- Other plans that include sea level rise are coastal zone plan, hazards plan, zoning plan, Comprehensive Conservation and Management Plan, and Land Development Code - Flood Prevention & Protection Areas.

<table>
<thead>
<tr>
<th>Plan</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comprehensive plan</td>
<td>23%</td>
</tr>
<tr>
<td>No plan or action</td>
<td>18%</td>
</tr>
<tr>
<td>Land use plan</td>
<td>9%</td>
</tr>
<tr>
<td>Building codes</td>
<td>9%</td>
</tr>
<tr>
<td>Zoning plan</td>
<td>5%</td>
</tr>
<tr>
<td>Coastal zone plan</td>
<td>5%</td>
</tr>
<tr>
<td>Hazards plan</td>
<td>5%</td>
</tr>
<tr>
<td>Design guidelines</td>
<td>0%</td>
</tr>
</tbody>
</table>
Current Adaptation Planning Practice

- Majority of the agencies do not have adaptation plan with a specific planning time range at the moment.
- Among the agencies with adaptation plans, the most common adaptation plan time range is 25 years.
Is there sufficient information to support sea level rise planning and adaptation?

- Not at all
- Detailed and sufficient for adaptation planning
- Too much, confusing information

- Majority of the respondents think there is not adequate information and tools to support sea level rise planning and adaptation.
- Although it may not be the reason for no action or no plan (half of the agencies with no plan think there is detailed and sufficient information for adaptation planning), agencies with plans and actions do need more information to further support their planning and adaptation practice.
Who are getting involved in SLR planning?

**Institution**
- Environmental/Park Agency: 9%
- City Agency: 23%

**Number of Planning Employees by Agencies**
- Small size (Planning employees <=5): 19%
- Medium size (6 to 10): 29%
- Large size (more than 30): 52%
User Group Implications

- Users dominated by city/county agencies.
- Planners is the major user group.
- Multiple agencies participation is involved.
  - Diversity of agencies, department
  - Diversity of positions (planners, senior professionals, managers, directors, council members)
User Group Implications

Distance to Sea based on Zipcode
- within 1 mile
- 4-7 miles
- more than 10 miles

- Participators in sea level rise adaptation planning
  - Spatially wide spread, inland concerns about sea level rise also
  - Near coastal area more concerned
Adaptation Scenarios

- Highly related with the location of the jurisdiction

<table>
<thead>
<tr>
<th>Distance to Sea (miles)</th>
<th>Build dikes, seawalls etc.</th>
<th>Build up marsh areas and non-structural Shore nourishment</th>
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Other (6): Transfer of Development Rights Program from high risk to low risk areas
## Adaptation Scenarios

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Adaptation Scenario

- Near Sea (< 1 miles)
  - Most Feasible:
    - Discourage building new structures in areas at risk from sea level rise
    - Change building codes and regulations to reduce risk in flood prone areas
  - Least Feasible:
    - Allow beaches and wetlands to naturally migrate inland (Doing nothing scenario)

- Medium distance (4-7 miles)
  - Most Feasible:
    - Discourage building new structures in areas at risk from sea level rise
    - Change building codes and regulations to reduce risk in flood prone areas
  - Least Feasible:
    - Elevate infrastructures and facilities at risk

- Long Distance (>10 miles)
  - Most Feasible:
    - Discourage building new structures in areas at risk from sea level rise
    - Elevate infrastructures and facilities at risk
    - Change building codes and regulations to reduce risk in flood prone areas
  - Least Feasible:
    - Purchase land at risk of sea level risk and frequently flooded properties.
Research Needs

- Research need to be further explored to support adaptation planning Ranking
  - Actions that can be taken to reduce impacts of sea level rise (Policy toolkit)
  - Tools to compare the costs and benefits of different adaptation strategies (adaptation Evaluation)
  - Tools to communicate and engage the public and decision makers on the issue of sea level rise (education)

<table>
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<tr>
<th>Category</th>
<th>Percentage</th>
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<td>Actions that can be taken to reduce impacts of sea level rise</td>
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<tr>
<td>Tools to compare the costs and benefits of different adaptation strategies</td>
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<td>Tools to communicate and engage the public and decision makers on the issue of sea level rise</td>
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<td>Current or potential impacts of sea level rise</td>
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<td>Funding sources to address sea level rise in Tampa</td>
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<td>Sea level rise in general</td>
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Future Research

- Changes in environmental conditions will necessitate the movement of people from coastal areas—the very places that have been attractive forces for development in these Gulf States since the 1800s (Mulkey 2007). These shifts in population and development activities are expected to impact local economic activities affecting land uses and economic growth in these coastal states in the long run. So we have two major research questions.

- What are the impacts of inundation due to sea level rise on local residents and businesses?
- How to predict the population relocation if the primary residences of affected population are permanently inundated due to sea level rise?
Thanks!!

http://tampaslr.wordpress.com/