

Sea Level Rise Adaptation Decision Support Framework Captiva Island, FL

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Dr. Cheryl Hapke (Coastal Science Solutions)

Dr. Dave Revell (Revell Coastal)

Dr. Craig Jones (Integral Consulting)



Adaptation Tool Kit: Sea-Level Rise and Coastal Land Use

How Governments Can Use Land-Use
Practices to Adapt to Sea-Level Rise

GEORGETOWN CLIMATE CENTER
A Leading Resource for State and Federal Policy

Florida Adaptation Planning Guidebook



COASTAL CLIMATE RESILIENCE Urban Waterfront Adaptive Strategies



NYC PLANNING
DEPARTMENT OF CITY PLANNING CITY OF NEW YORK



RISC-KIT

Resilience-Increasing Strategies
for Coasts – Toolkit
www.risckit.eu

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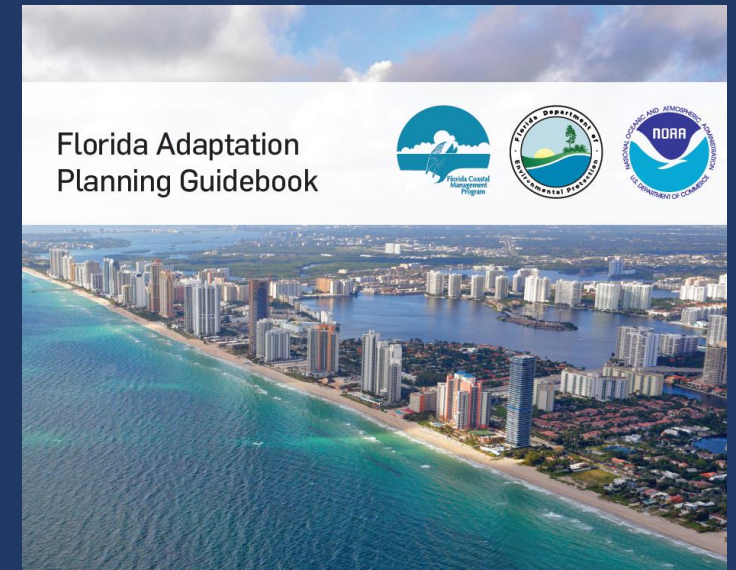


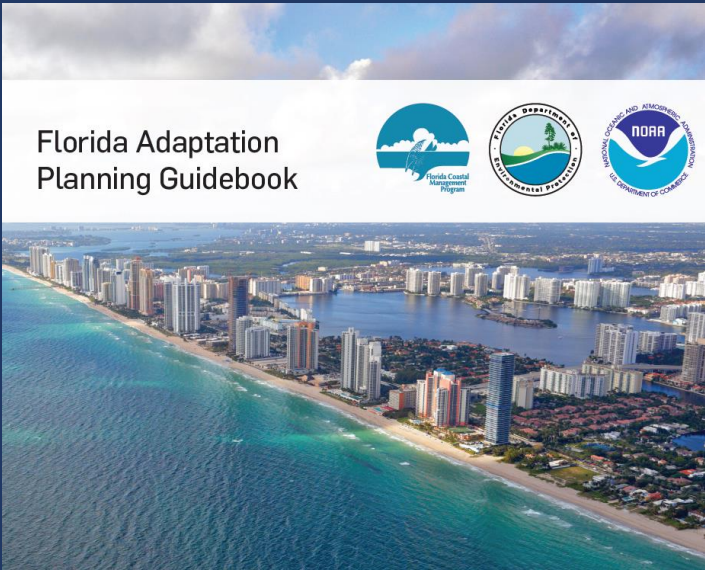
CoastAdapt: an adaptation decision support framework for Australia's coastal managers

J. P. Palutikof¹ • D. Rissik¹ • S. Webb¹ •
Fahim N. Tonmoy^{1,2} • S. L. Boulter¹ • Anne M. Leitch¹ •
A. C. Perez Vidaurre¹ • M. J. Campbell¹

There are LOTS of strategic planning guidelines and examples to choose from

- Regardless of which framework is followed, data from field observations and/or modeling are required to implement a decision support framework
- Some tools/models that generate inputs into a decision-making framework:
 - NOAA sea-level rise viewer
 - Nature Conservancy Coastal Resiliency Mapping Portal
 - ADCIRC Models (SLR + storm surge)
 - USACE Sea Level Change Curve Calculator
 - Wave Watch III
 - Lidar-derived digital elevation models
 - USGS Historical shoreline change rates





Steps to Create Adaptation Plans

CONTEXT

- Assemble a steering committee
- Set guiding principles and motivations
- Establish planning area and describe geographic context
- Define public outreach approach and opportunities for community participation

VULNERABILITY ASSESSMENT

- Conduct an exposure analysis
- Conduct a sensitivity analysis
- Assign focus areas

ADAPTATION STRATEGIES

- Assess adaptive capacities
- Prioritize adaptation needs
- Identify adaptation strategies
- Integrate into existing plans

IMPLEMENTATION STRATEGIES

- Assess implementation capabilities
- Create a schedule of activities, actions, and actors
- Monitor and evaluate

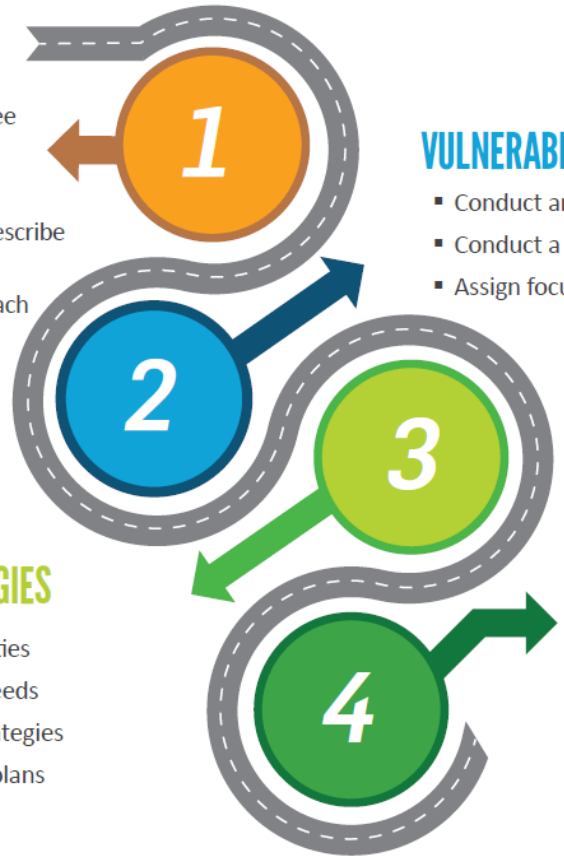
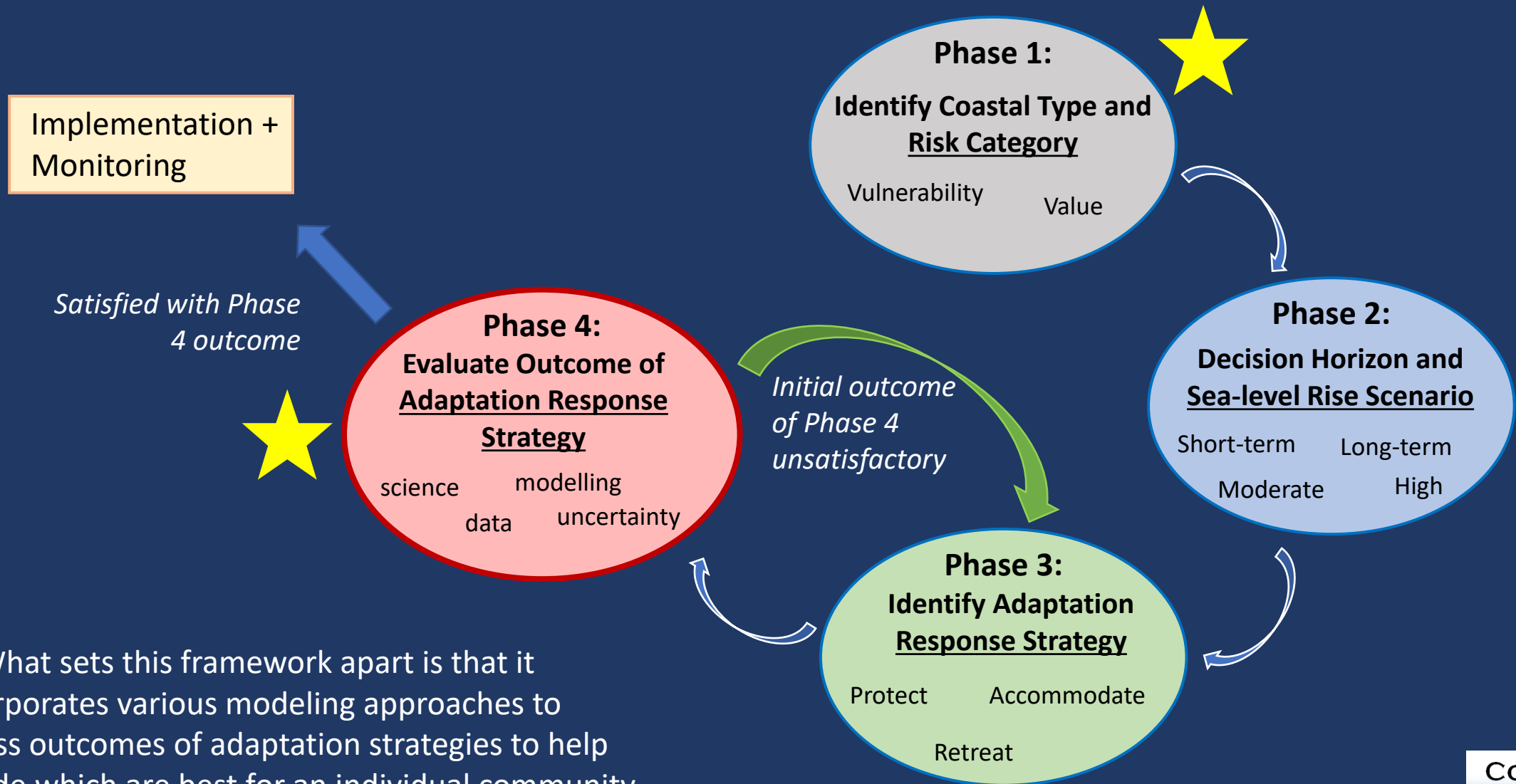


Figure 1. Communities can follow this roadmap of steps to create an adaptation plan.



Coastal Community Model-based Decision Support Tool



→ What sets this framework apart is that it incorporates various modeling approaches to assess outcomes of adaptation strategies to help decide which are best for an individual community based on uncertainty tolerance

Phase 1: Coastal Typology Analysis – define Vulnerability and assign Value

- Characterize coastal geomorphology, exposure to hazards (waves, flooding, erosion), shoreline type
- Characterize land-use and density

Generate index and reference maps



Open-ocean beach

Marsh coast

Mangrove coast

Bayside beach

Commercial

Residential

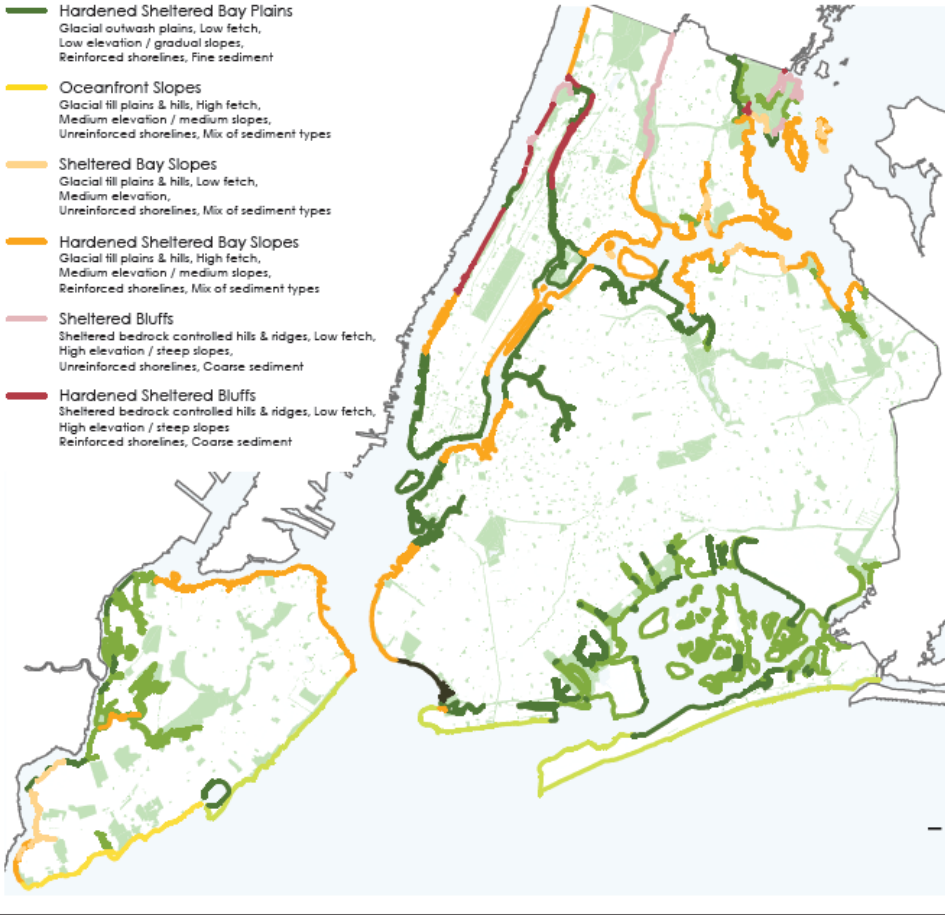
Table 1. Coastal Condition and Risk Category (modified from Volk et al)

Risk and Value	Vulnerability and Hazard		
	High	Moderate	Low
Shoreline vulnerability	High wave energy and high erosion potential	High wave energy and low erosion potential	Low wave energy and low erosion potential
	And/or	Or low wave energy and high to moderate inundation potential	
	High inundation potential	and/or moderate inundation potential	And/or low inundation potential
Developed coast value	Substantial public or private property and infrastructure which are important to the economy or culture	Substantial public or private property and infrastructure which have the potential to become important to the economy or culture	Little public or private property of economic or cultural importance
Natural coast value	Threatened or endangered species habitat, important ecosystems with economic and/or recreational value	Other valuable natural coastal systems	Altered ecosystem that do not have substantial economic or recreational value

COASTAL GEOMORPHOLOGY CATEGORIES

Based on the mapping of geologic landforms, shoreline condition, and wave exposure, nine geomorphology types emerged as representative of the range of factors present in New York City. Each type is a composite of these three factors. These types can be analyzed for their degree of exposure to sudden and gradual coastal hazards.

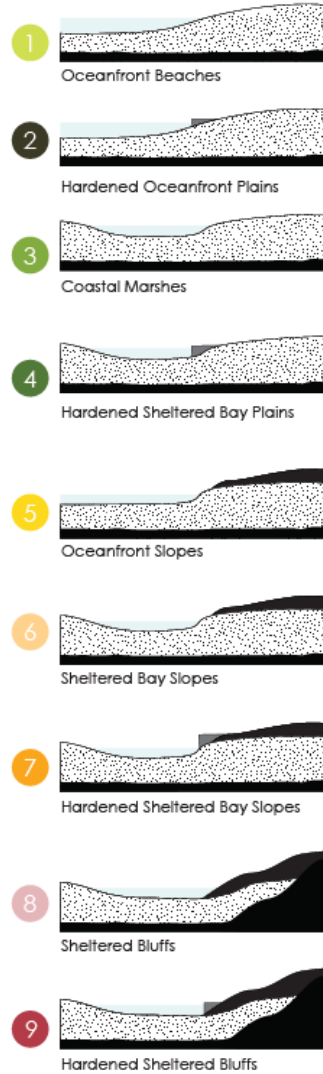
- **Oceanfront Beaches**
Glacial outwash plains, High fetch,
Low elevation / gradual slopes,
Unreinforced shorelines, Fine sediment
- **Hardened Oceanfront Plains**
Glacial outwash plains, High fetch,
Low elevation / gradual slopes,
Reinforced shorelines, Fine sediment
- **Coastal Marshes**
Glacial outwash plains, Low fetch,
Low elevation / gradual slopes,
Unreinforced shorelines, Fine sediment
- **Hardened Sheltered Bay Plains**
Glacial outwash plains, Low fetch,
Low elevation / gradual slopes,
Reinforced shorelines, Fine sediment
- **Oceanfront Slopes**
Glacial fill plains & hills, High fetch,
Medium elevation / medium slopes,
Unreinforced shorelines, Mix of sediment types
- **Sheltered Bay Slopes**
Glacial fill plains & hills, Low fetch,
Medium elevation,
Unreinforced shorelines, Mix of sediment types
- **Hardened Sheltered Bay Slopes**
Glacial fill plains & hills, High fetch,
Medium elevation / medium slopes,
Reinforced shorelines, Mix of sediment types
- **Sheltered Bluffs**
Sheltered bedrock controlled hills & ridges, Low fetch,
High elevation / steep slopes,
Unreinforced shorelines, Coarse sediment
- **Hardened Sheltered Bluffs**
Sheltered bedrock controlled hills & ridges, Low fetch,
High elevation / steep slopes,
Reinforced shorelines, Coarse sediment



COASTAL AREA TYPOLOGIES

GEOMORPHOLOGY CATEGORIES

● HIGH ● MEDIUM ○ LOW

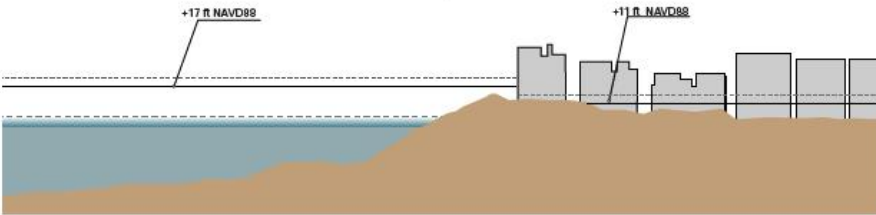
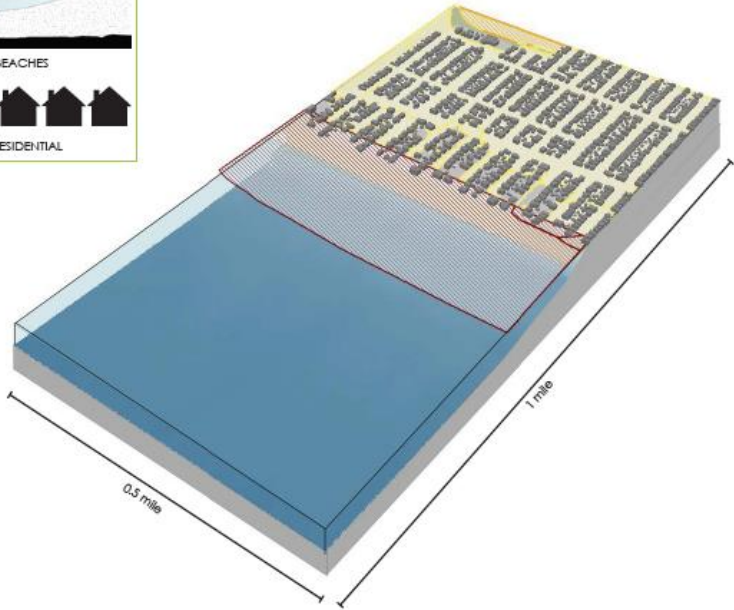


■ Fill plains / hills ■ Outwash plains / Post glacial deposits ■ Bedrock

DEGREE OF EXPOSURE TO COASTAL HAZARDS

	DEGREE OF EXPOSURE TO COASTAL HAZARDS				
	EVENT BASED			GRADUAL	
	Storm Surge	Wave Action	Sudden Erosion	Sea Level Rise	Erosion
1 Oceanfront Beaches	●	●	●	●	●
2 Hardened Oceanfront Plains	●	●	●	●	○
3 Coastal Marshes	●	○	○	●	●
4 Hardened Sheltered Bay Plains	●	○	○	●	○
5 Oceanfront Slopes	●	●	●	●	●
6 Sheltered Bay Slopes	●	○	○	●	●
7 Hardened Sheltered Bay Slopes	●	○	○	●	○
8 Sheltered Bluffs	○	○	○	○	●
9 Hardened Sheltered Bluffs	○	○	○	○	○

OCEANFRONT BEACHES / LOW DENSITY RESIDENTIAL

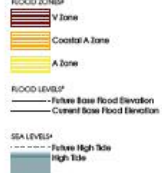


LAND USE / DENSITY FACTORS

Building Types	1-2 story Detached Homes 1-2 story Semi-detached Homes Community Facilities
Open Space	Beach Neighborhood Park
Infrastructure	Roads
Built Area	1.7 M ft ² Floor Area 1 M ft ² Ground Floor Area
Land Area	7 M ft ² Total Land Area 3.9 M ft ² Total Lot Area (excluding water)
Density	0.5 Dwelling Units Per Acre 0.45 FAR ¹

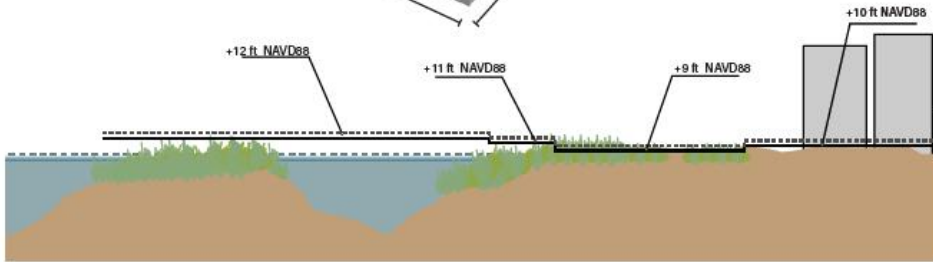
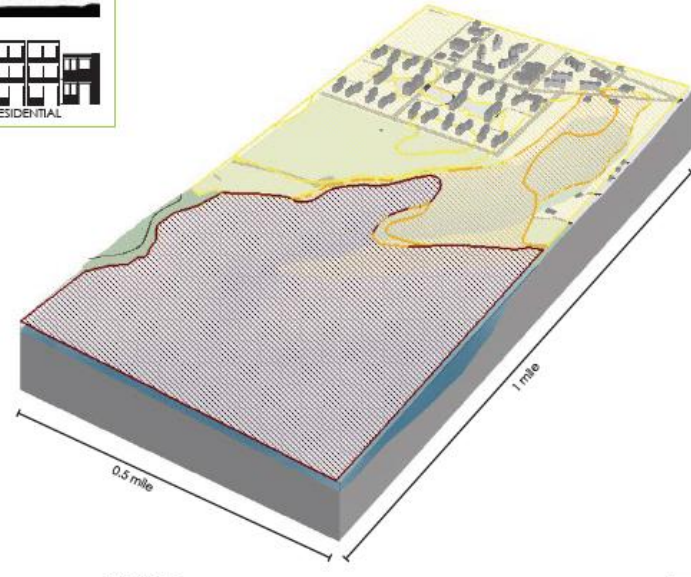
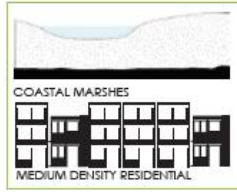
HAZARD EXPOSURE

EVENT-BASED	Storm Surge (High)	●
	Storm Surge (Low)	●
	Wave Force	●
GRADUAL	Sudden Erosion	●
	Frequent Flooding due to Sea Level Rise	☉ ²
	Gradual Erosion	☉



¹ FAR based on total floor area over total lot area, excluding open space, vacant, and unknown land uses.
² The beach may be regularly inundated due to increasing sea level rise, but developed areas are on ground above the expected heights of sea level rise.
³ Source: FEMA Preliminary Work Maps, June 2013
⁴ Source: NPCC, 90th Percentile Projections, 2013
⁵ Vertical exaggeration in sections

COASTAL MARSHES / MEDIUM DENSITY RESIDENTIAL

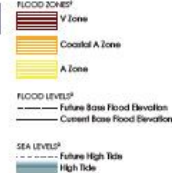


LAND USE / DENSITY FACTORS

Building Types	High-Rise Residential Buildings Low-Rise Commercial Buildings Community Facilities Marinas
Open Space	Wetlands Active Recreation parkland Unimproved parkland
Infrastructure	Roads
Built Area	2 M ft ² Floor Area 400,000 ft ² Ground Floor Area
Land Area	7.5 M ft ² Total Land Area 2.8 M ft ² Total Lot Area (excluding water)
Density	13 Dwelling Units Per Acre 0.75 FAR ¹

HAZARD EXPOSURE

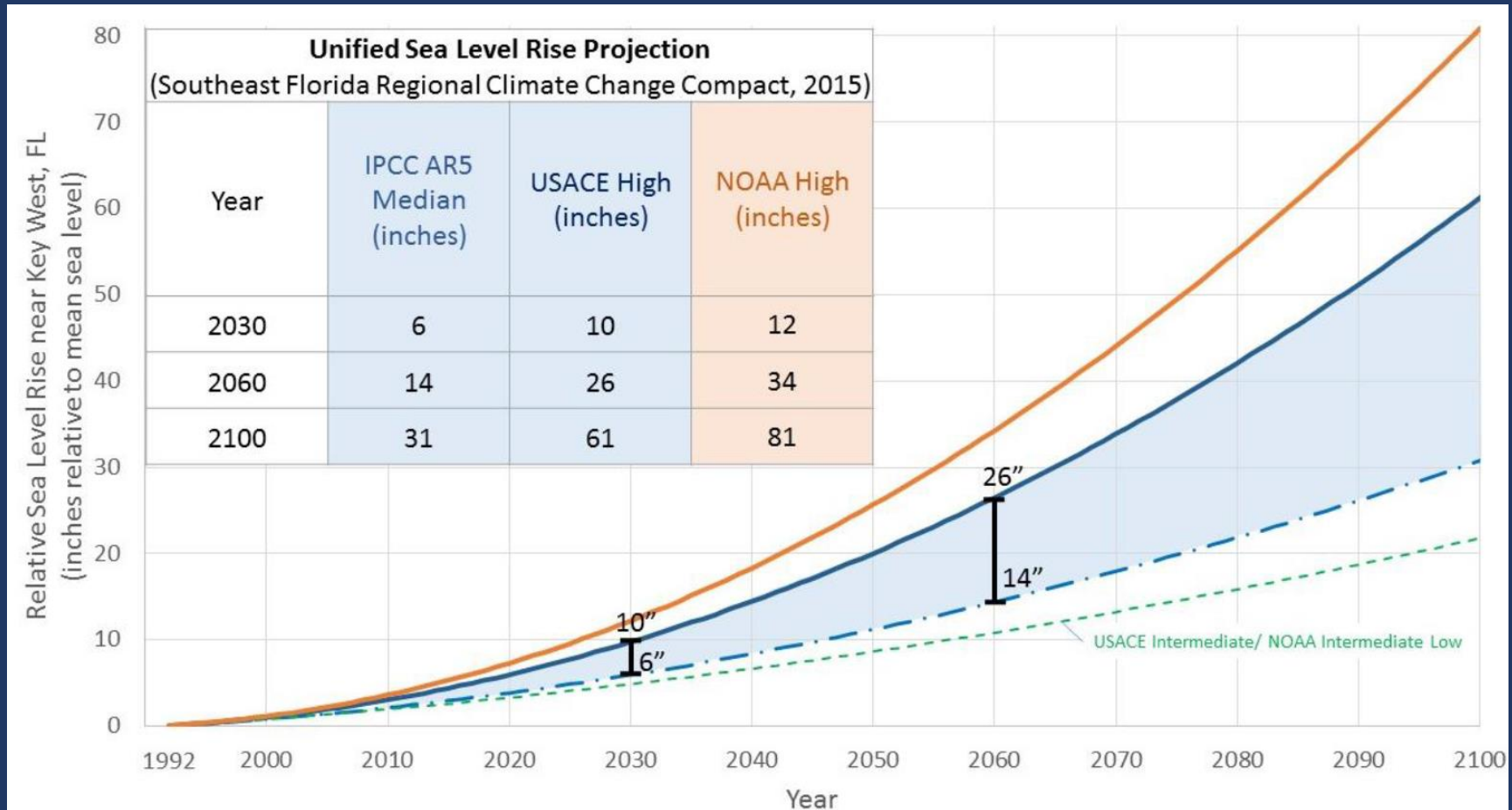
EVENT-BASED	Storm Surge (High)	●
	Storm Surge (Low)	●
	Wave Force	○
GRADUAL	Sudden Erosion	●
	Frequent Flooding due to Sea Level Rise	☉ ²
	Gradual Erosion	●



¹ FAR based on total floor area over total lot area, excluding open space, vacant, and unknown land uses.
² Source: FEMA Preliminary Work Maps, June 2013
³ Source: NPCC, 90th Percentile Projections, 2013

Phase 2: Decision Horizon and Sea-level Rise Scenario

- Identify time horizons for adaptive management and decision making
→ 10, 20, 30 years
- Choose sea-level rise scenario: which curve to use?



Phase 3: Adaptation Response Strategy

Do nothing



Protect

- Nourishment
- Berm-building
- Living shorelines
- Marsh/mangrove restoration
- Sandbags
- Oyster restoration

- Seawalls
- Bulkheads
- Revetment



Accommodate

- Elevate buildings
- Flood-proof buildings
- Elevate land & roads
- Increase setbacks for new construction
- Replacing vegetation with salt-tolerant



Retreat

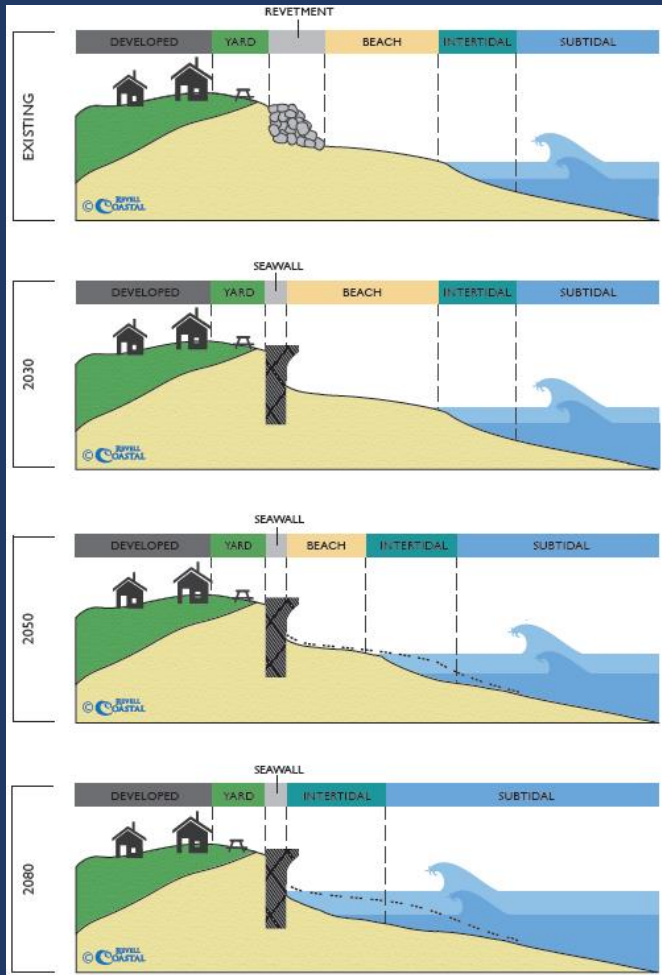
- Limit expansion of development
- No rebuilding after storms
- Rebuilding restrictions after storms
- Buy-outs



Phase 4: Modelling to Assess Outcome of Response Strategy

- Explore effectiveness of alternative adaptation response measures
- Determine likely timeframe in which a decision or a new decision will need to be made (i.e. trigger point)

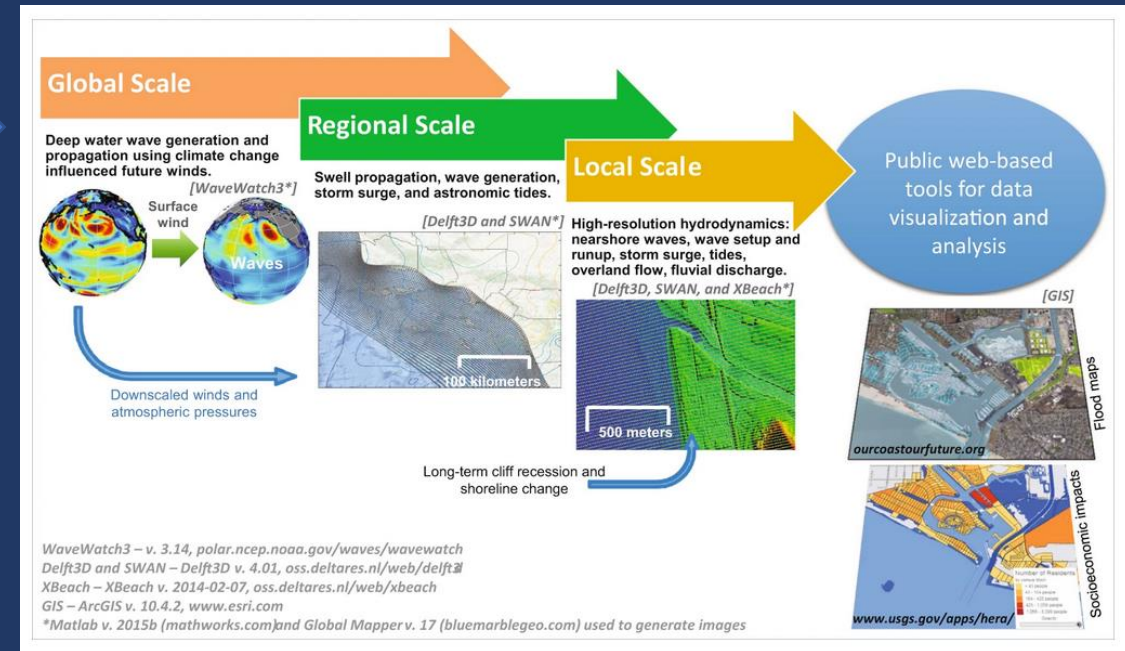
Conceptual models to gauge time, effectiveness, and consequences



Broad range of models that vary in complexity

Statistical

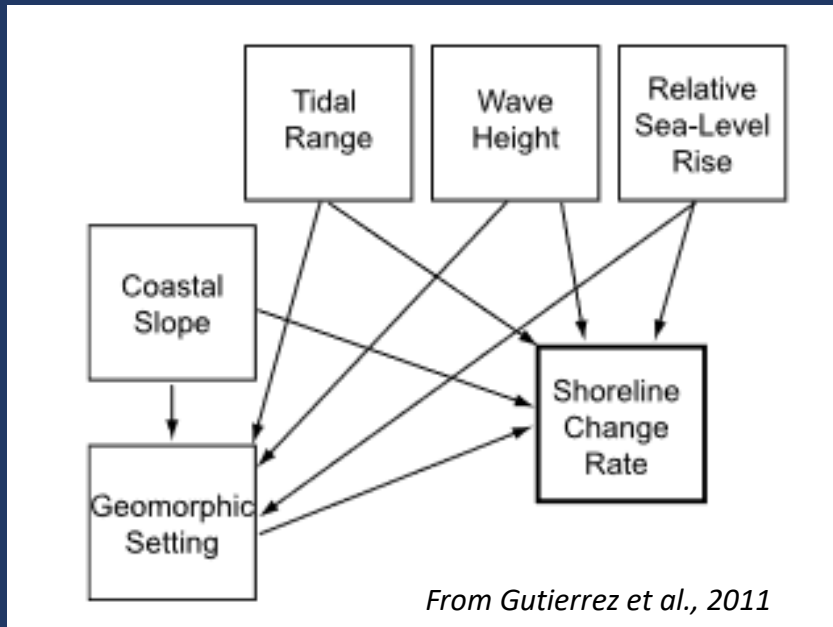
Complex models for forecasting sea level rise on vegetated coasts (SLAMM) and storm + sea-level rise on open-ocean coasts (CoSMoS)



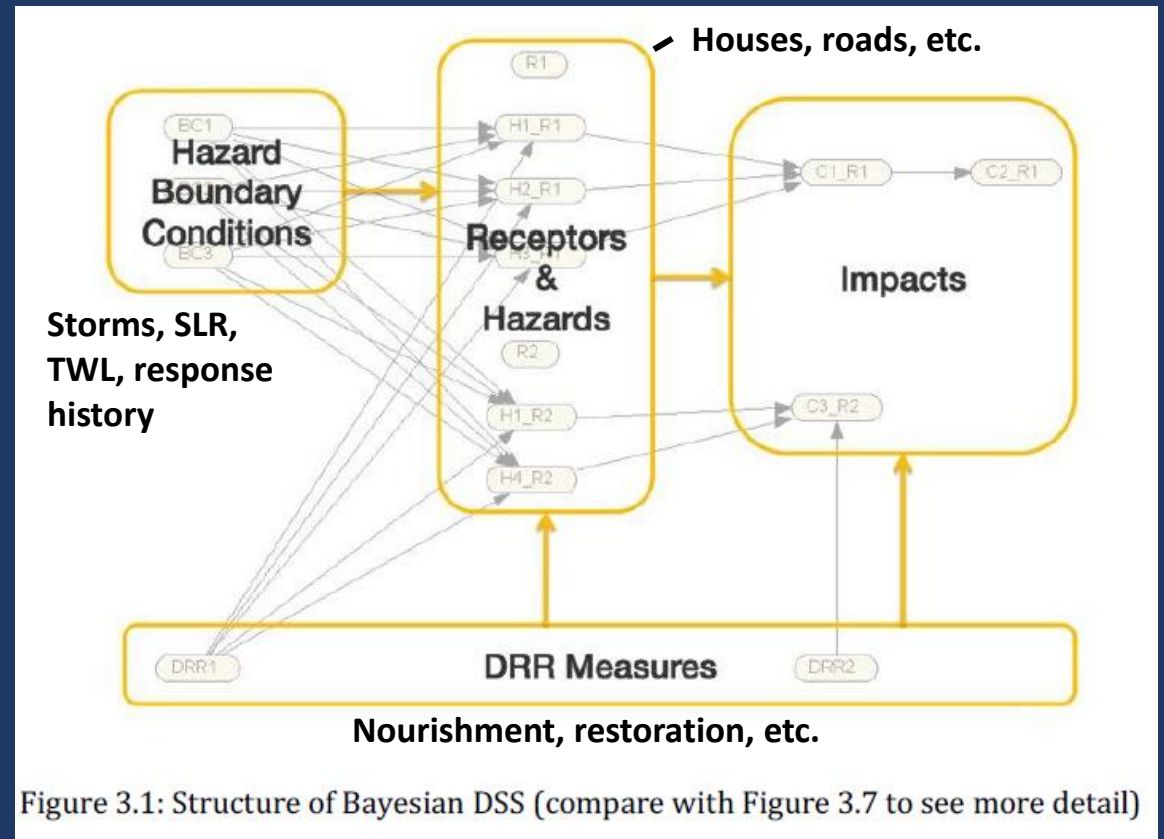
Bayesian Network models

- provide a probability distribution of outcomes based on data and user inputs
- require some data but do not need to be data-intensive – inferences are made using expert knowledge
- are not static; can be updated

BN that predicts shoreline change vulnerability to SLR:



RISC-IT D3.3 Bayesian Decision Support System (2015)



Available Modeling Tools

	Description	Pros	Cons
Conceptual	Global model of transport pathways and processes based on data and understanding of dynamics	Useful tool to communicate complex processes and serves as basis understanding of the system as a whole	Only as good as available information and understanding of processes
Analytical	Simple mathematical calculation	Easy to compute	Limited ability to represent spatially and temporally varying conditions
Empirical	Uses basic physical principles, while primarily relying on available observations	Computationally cheaper to run compared to numerical models	Simplified approximation of processes
Numerical	Solves physical transport equations at discretized model locations	Sophisticated model that resolves complex physical process over time and space	Can be computationally expensive to run



Coastal Community Model-based Decision Support Tool

