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Robust decision-making under uncertainty as a planning tool for resilient cities & regions

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Resilient Cities and Regions:

24th Annual UCLA Lake Arrowhead Symposium

October 20, 2014

How to Plan for Resilience?

A resilient system:

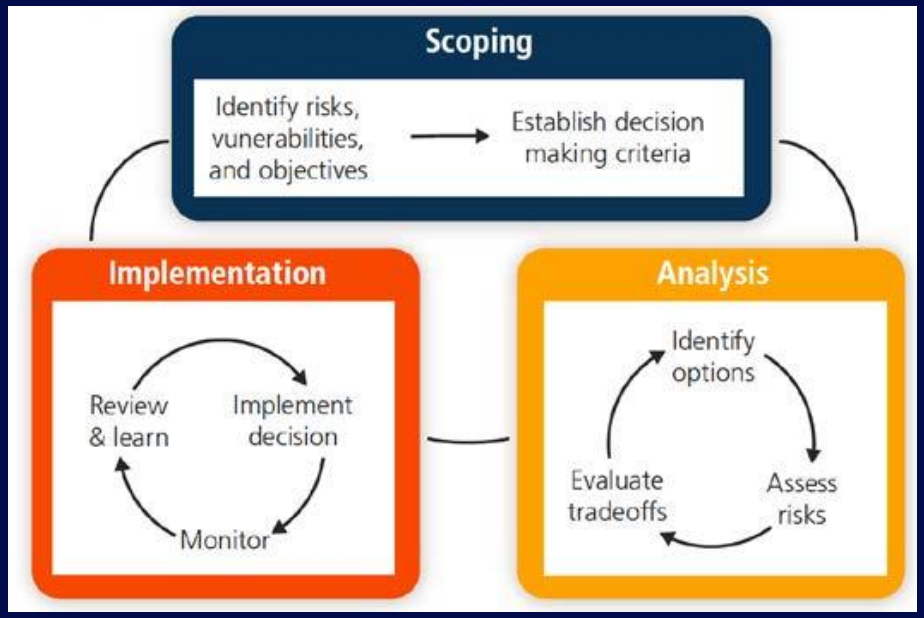
- Retains function after enduring large, often difficult to predict shocks
- Is generally complex and adaptive
- Contains many actors pursuing their own goals

Public planning should be:

- Objective
- Subject to clear rules and procedures
- Accountable to public

What planning frameworks and tools can public agencies use to ensure complex, multi-actor systems efficiently and effectively respond to shocks?

Iterative Risk Management Provides a Framework, But Requires Appropriate Tools



IPCC (2014)

- Quantitative information generally indispensible to good choices
- But commonly used quantitative can prove counter productive for complex and deep uncertainty systems
- New methods, exploiting new information technology and recent cognitive science, can improve decisions under such conditions

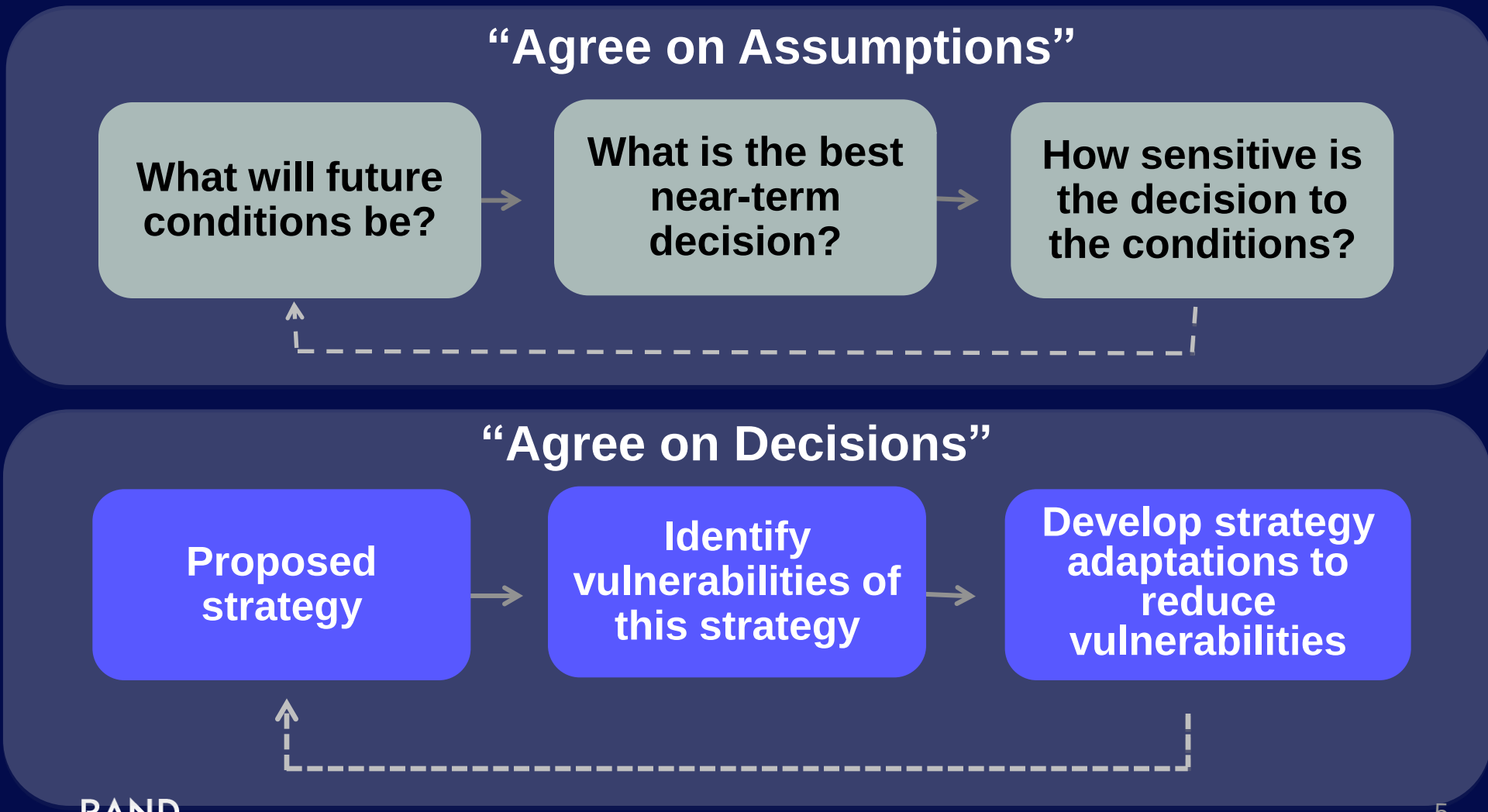
Traditional Risk Assessment Methods Work Well When Uncertainty is Limited

"Agree on Assumptions" Approach"

But under conditions of deep uncertainty:

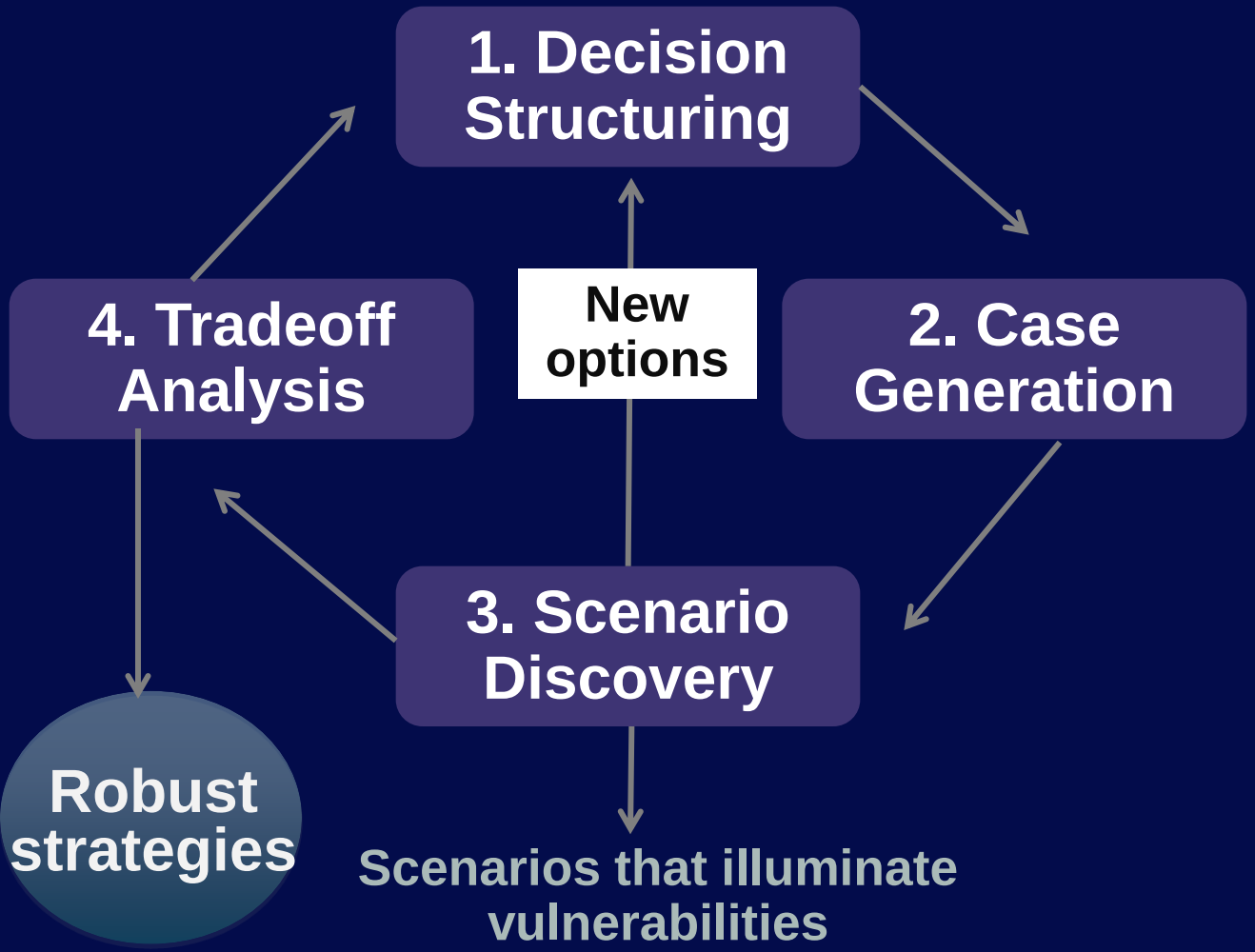
- **Uncertainties are often underestimated**
- **Competing analyses can contribute to gridlock**
- **Misplaced concreteness can blind decisionmakers to surprise**

Under Deeply Uncertain Conditions, Often Useful To Run the Analysis Backwards



Robust Decision Making (RDM) Provides Such an "Agree on Decisions" Approach

RDM is *iterative*; analytics facilitate stakeholder deliberation



Approach Increasingly Used for Water, Flood, and Climate Resilience Planning

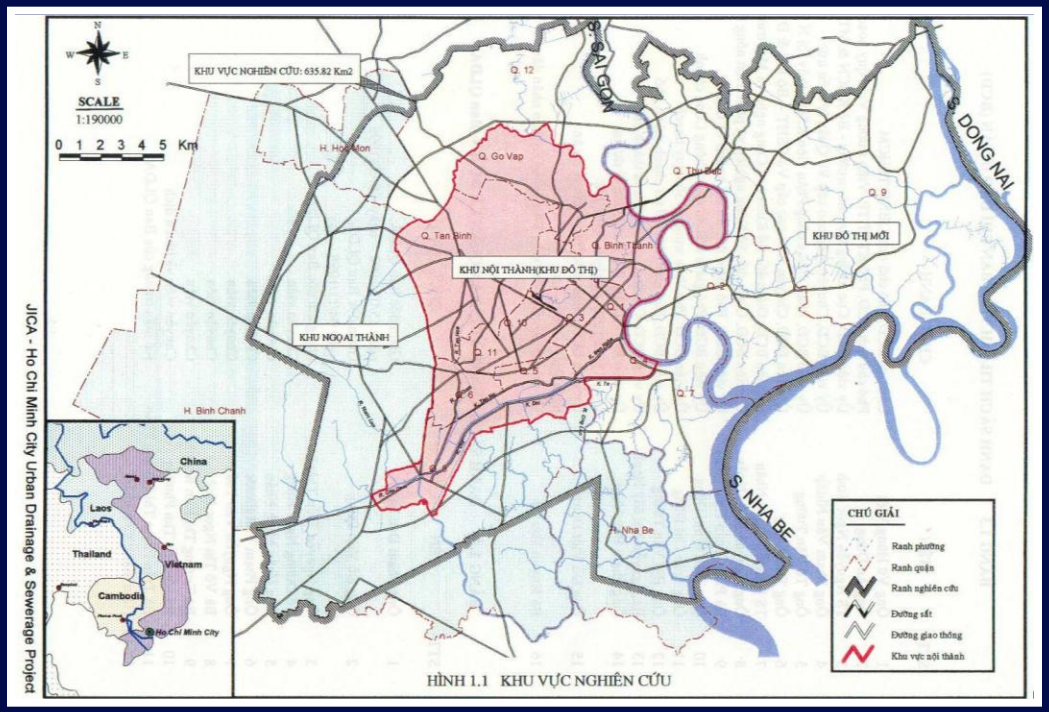
Other applications in:

- Africa (continent wide)
- Vietnam
- Peru
- Sri Lanka

Outline

- **Do the Analysis Backwards**
  - **Flood Risk Management in Ho Chi Minh City**
- **Embed analysis in process of stakeholder engagement**
  - **Adaptive management in Colorado Basin**
- **Observations**
  - **Policy persistence**

Flood Risk Management Study for Ho Chi Minh City Provides an Example



Over 15 years, HCMC has planned multi-billion dollar flood investments using best available projections

Conditions have diverged from projections and the city is at significant risk

How Can HCMC Develop This Plan When Today's Predictions Are No More Likely To Be Accurate?

Today, HCMC seeks an innovative, integrated flood risk management strategy

World Bank WPS-6465 (2013)

Simulation Model Projects Flood Risk From Estimates of Hazard, Exposure, and Vulnerability

Hazard

- Future rainfall intensity
- Height of the Saigon River

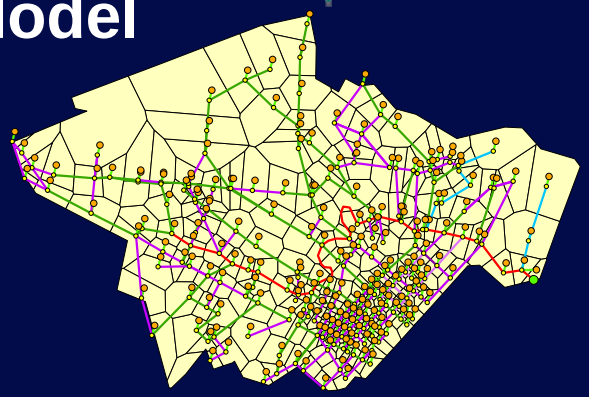
Exposure

- Population in the study area
- Urban form

Vulnerability

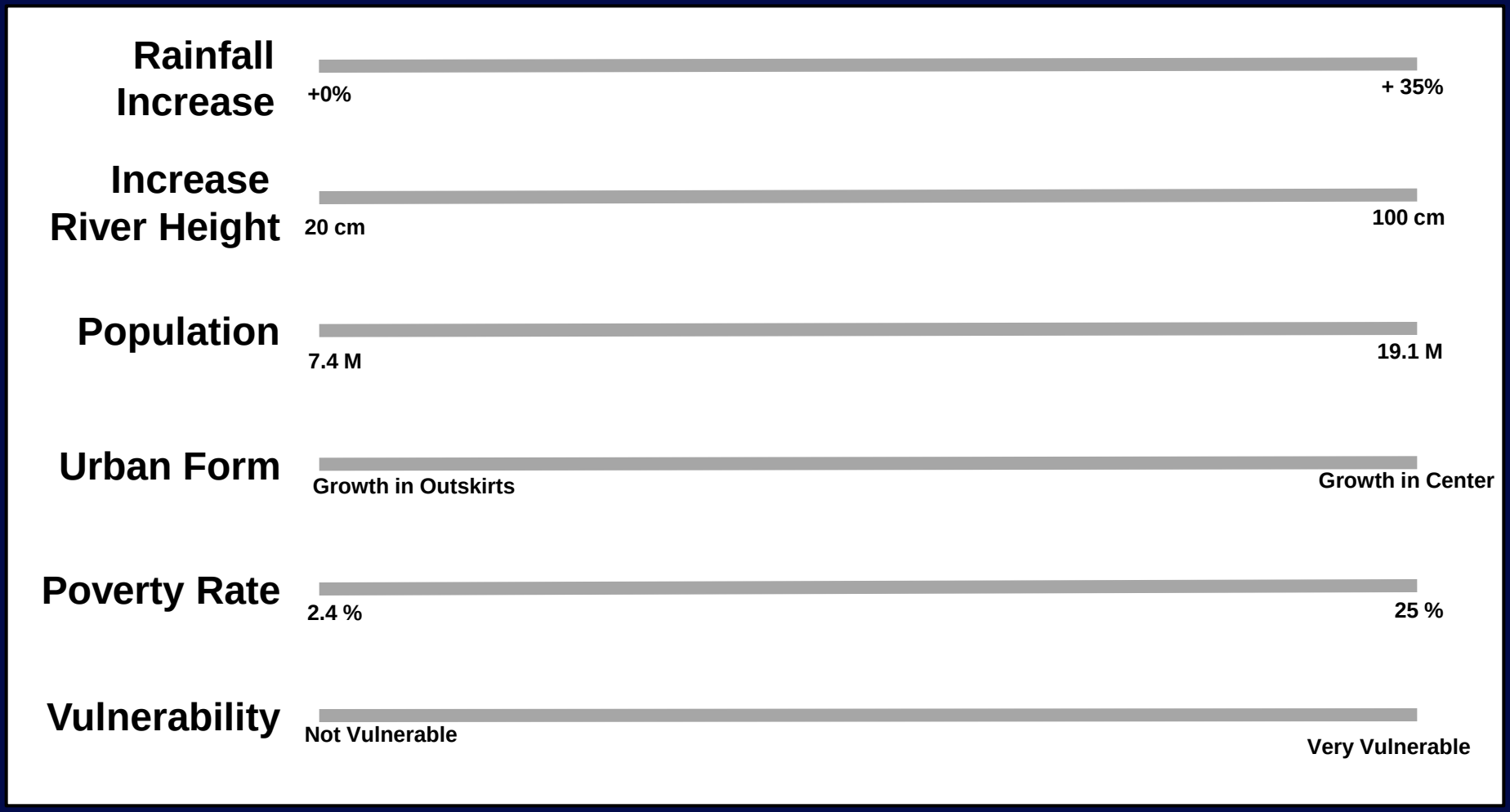
- Vulnerability of population to flood depth

Risk Model

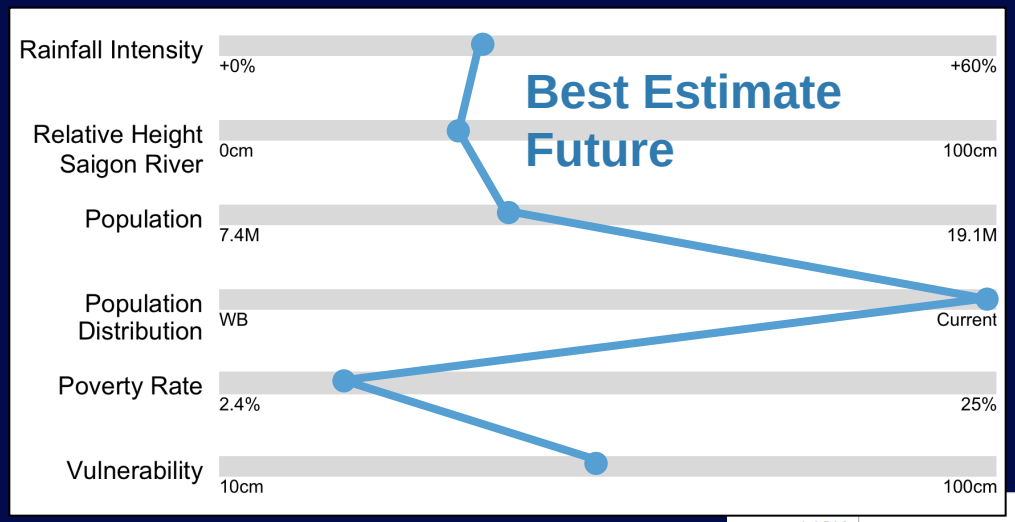


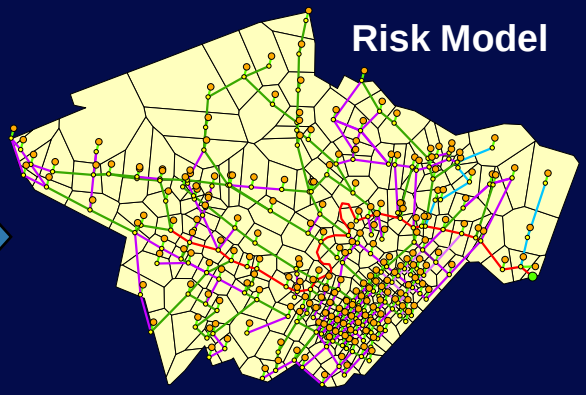
Risk = Expected Number of People Affected By Floods Each year

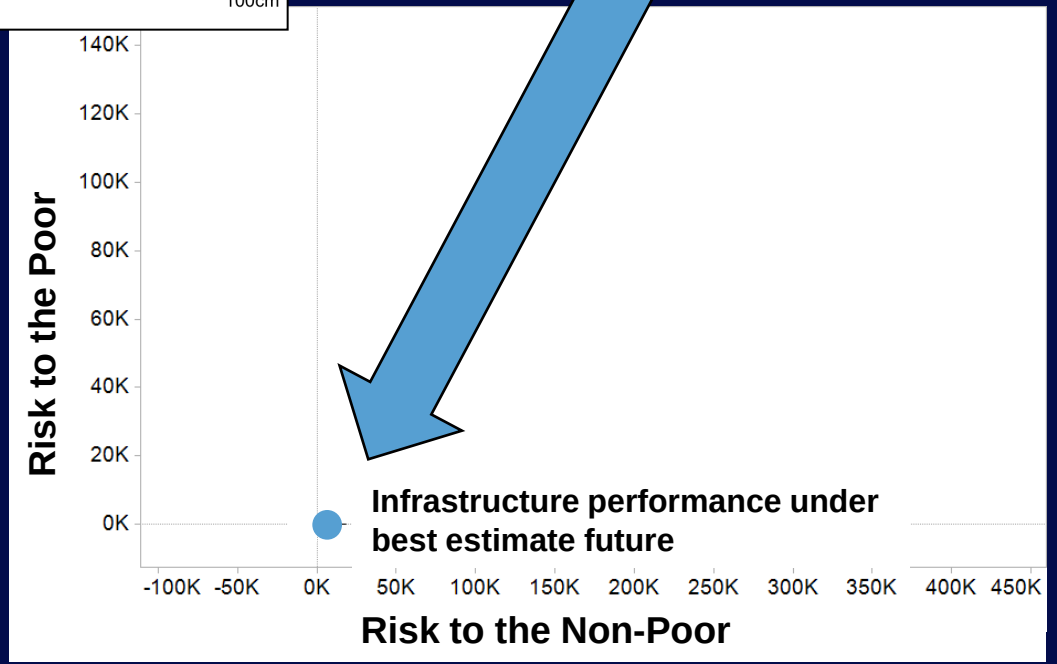
Model Projections Depend on Values of Six Deeply Uncertain Parameters



Traditional Planning Asks "What Will The Future Bring?"







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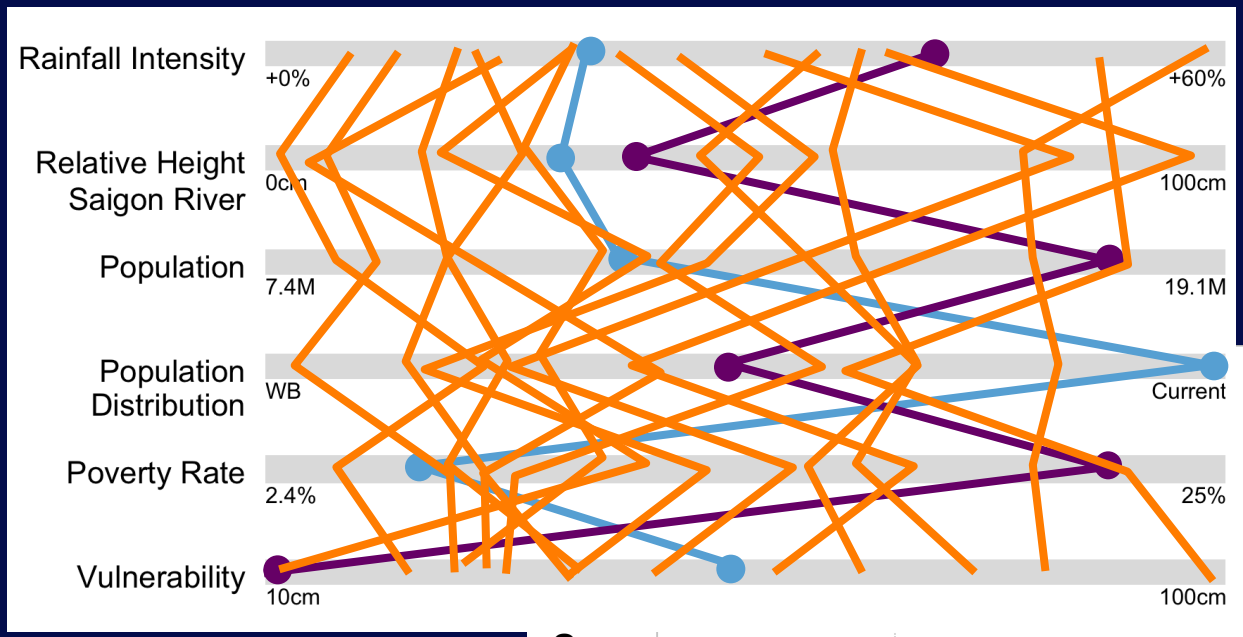
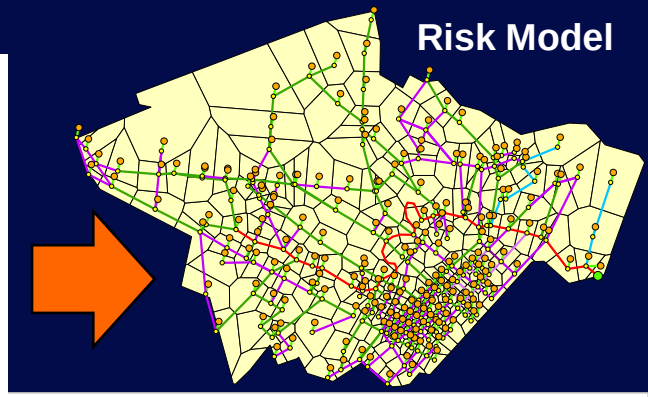
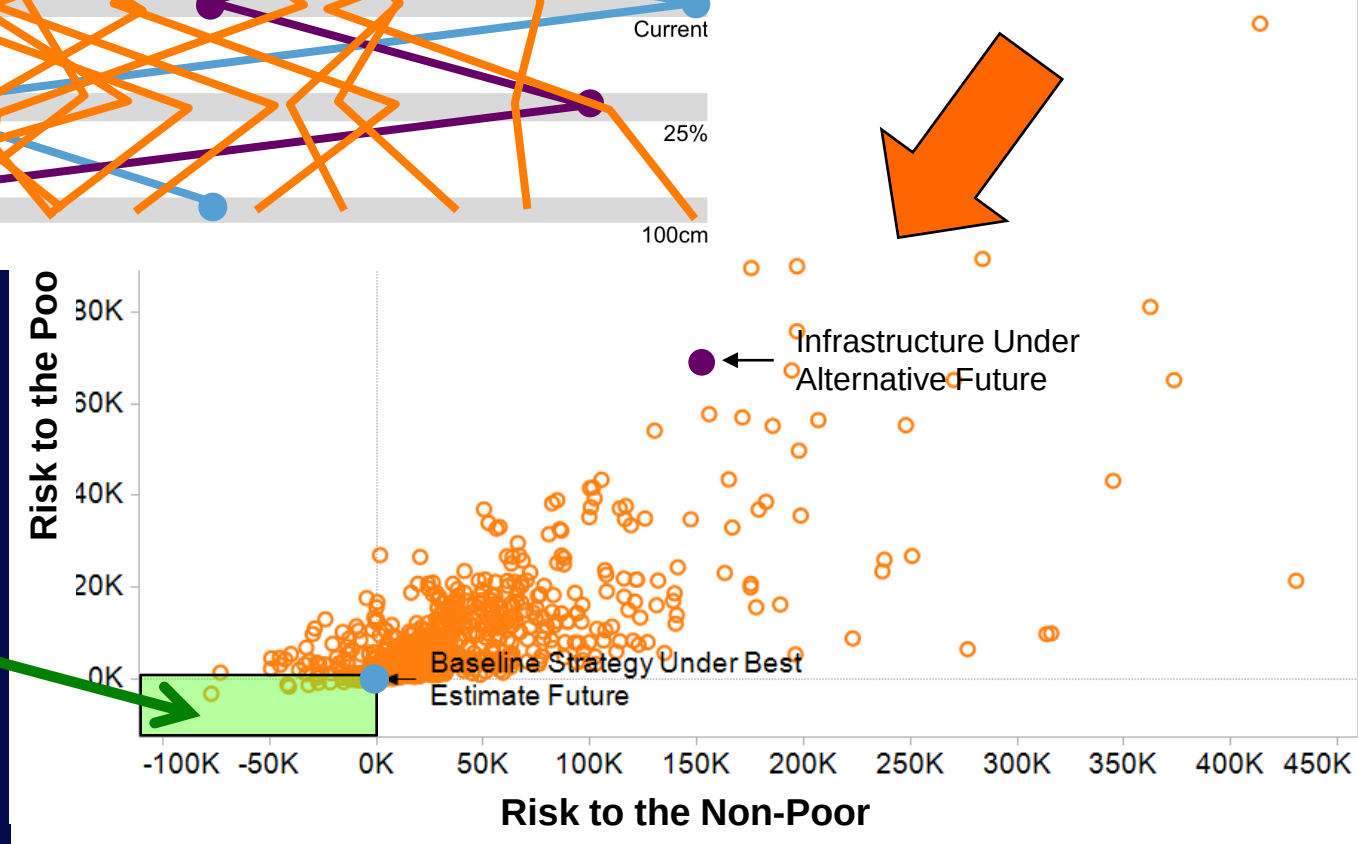
We Run HCMC's Infrastructure Plan Through 1000 Different Combinations of Conditions







What factors best distinguish this region, where risk is reduced for both poor and non-poor?

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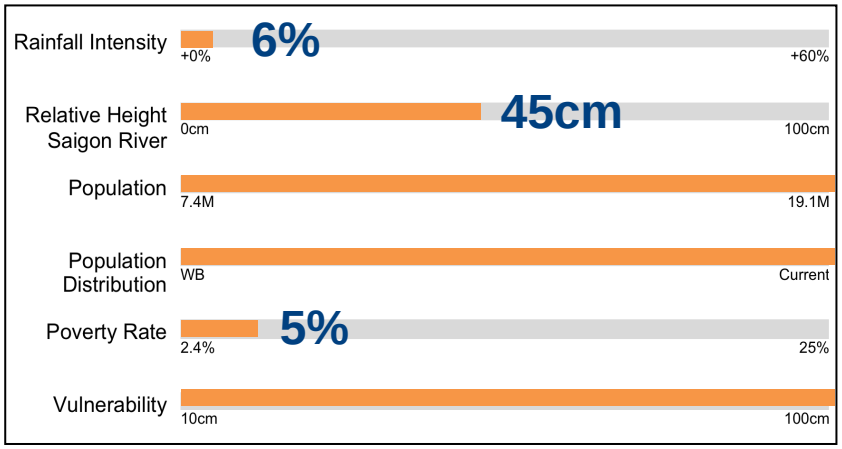
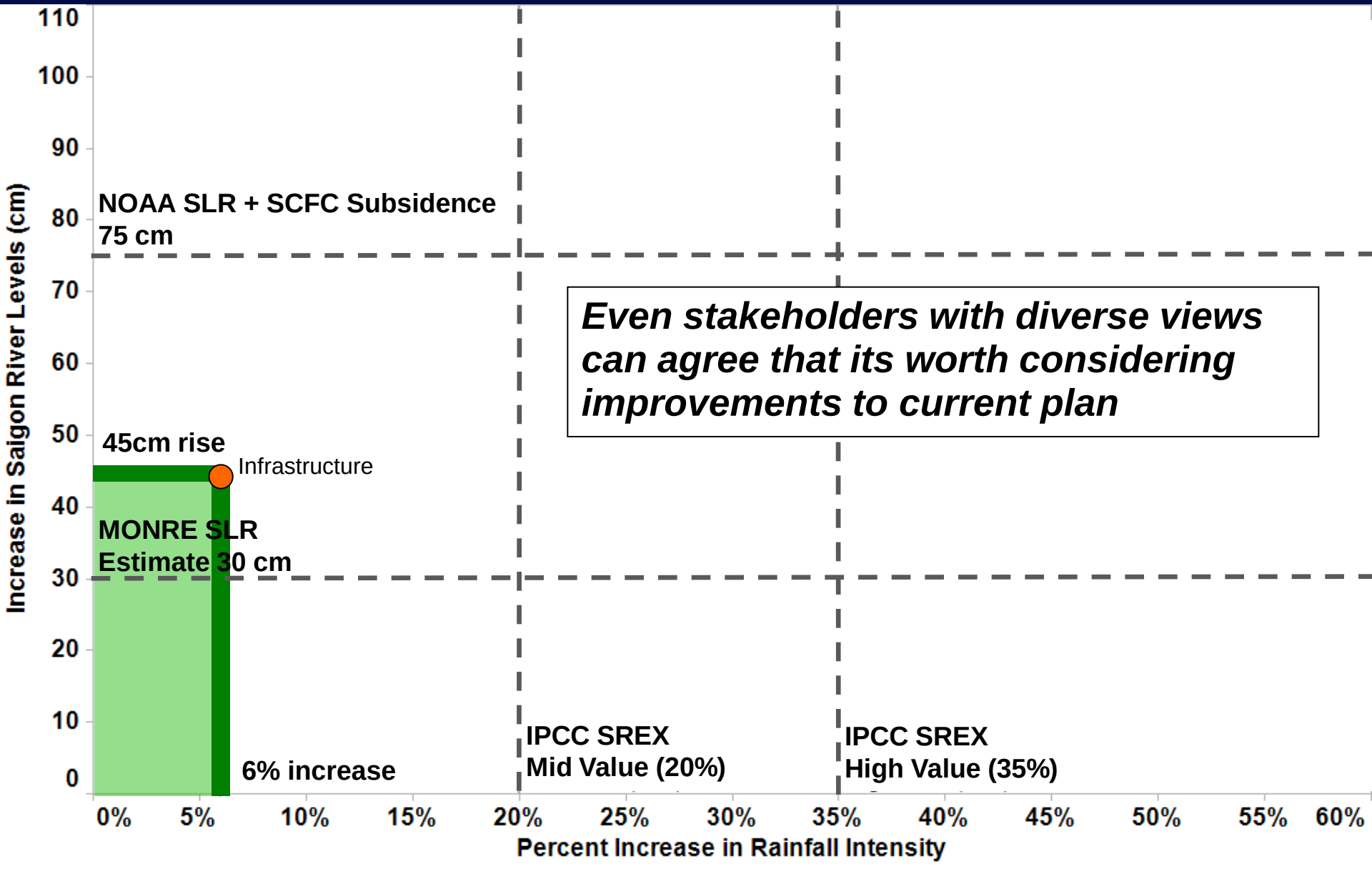
1. Under What Future Conditions Is HCMC's Infrastructure Vulnerable?

Infrastructure fails to reduce risk when:

- **> 6% increase in rainfall intensity,**
- **> 45 cm increase in river height, OR**
- **> 5% poverty rate**



2. Are Those Conditions Sufficiently Likely To Warrant Improving HCMC's Plan?



We Consider A Range of Options for Integrated Flood Risk Management

“Soft Options”

1. Rely on current infrastructure

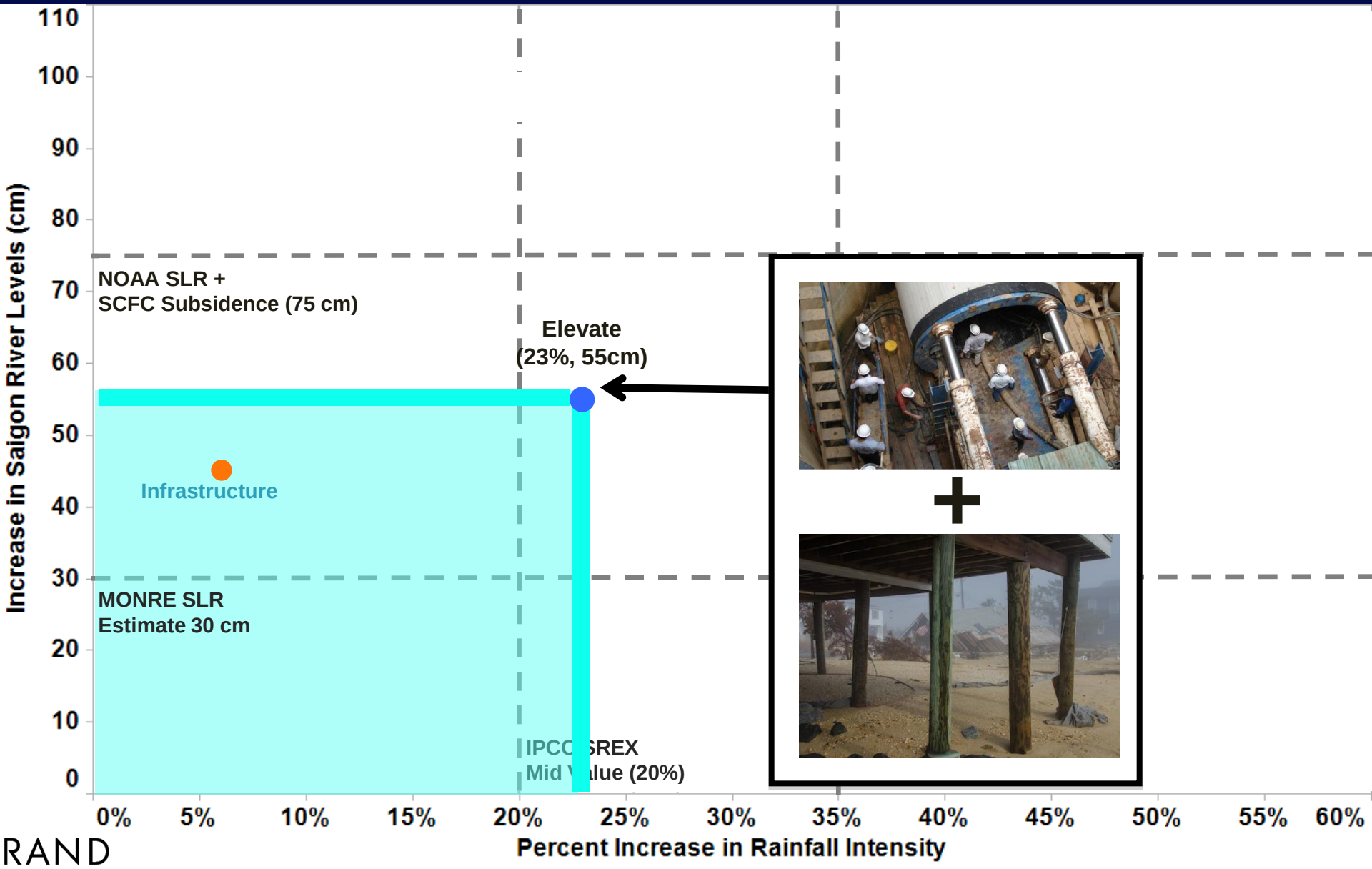
2. Raise Homes

4. Manage Groundwater

3. Relocate Areas

5. Capture Rain Water

How Will Adding "Soft" Options Improve Our Strategy?



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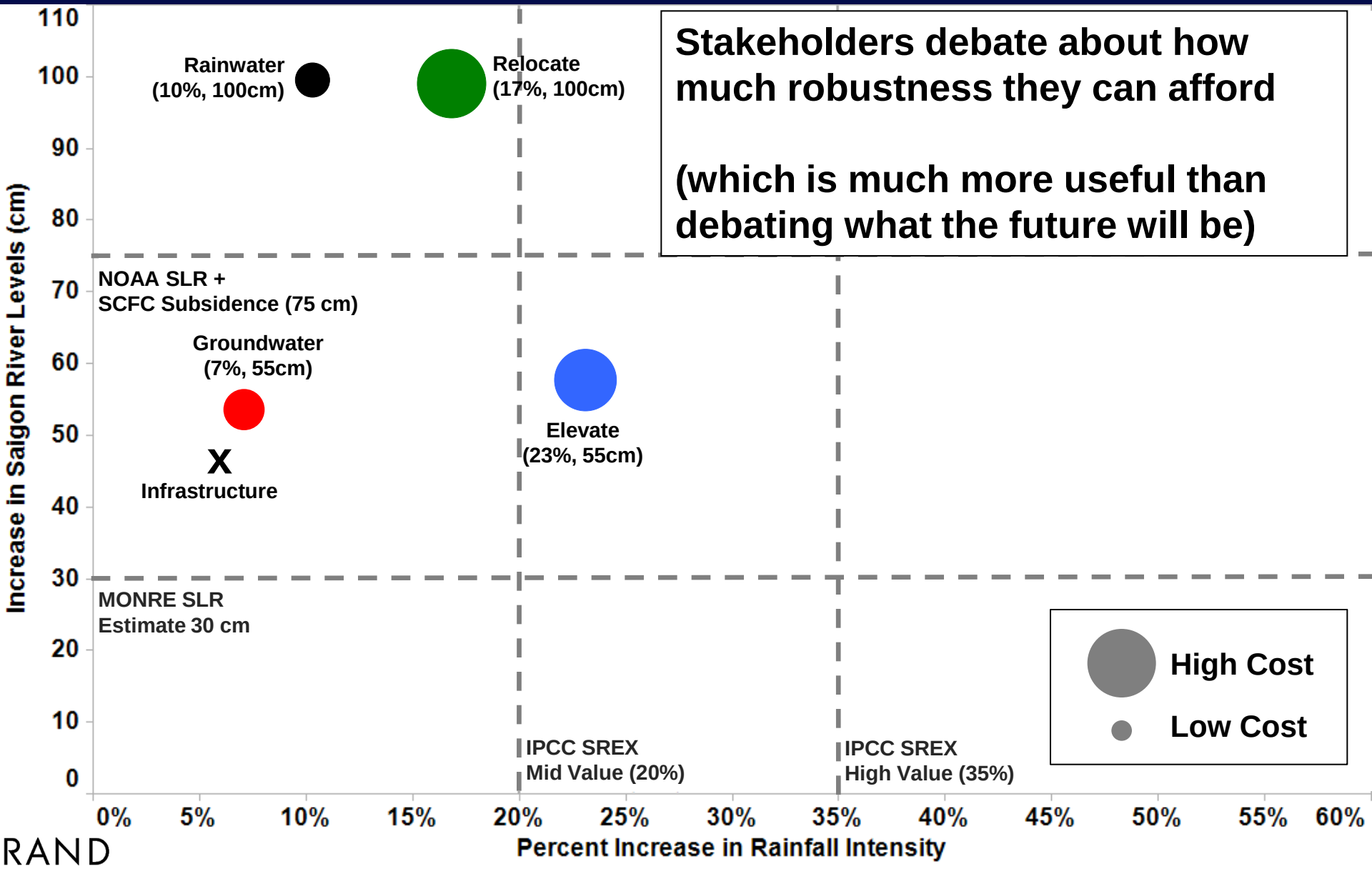
What Are Tradeoffs Between Robustness And Cost?



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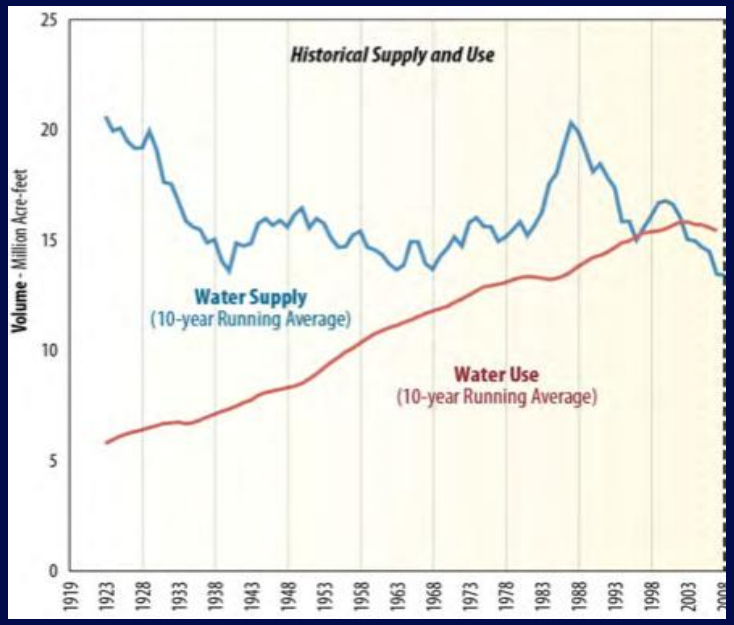
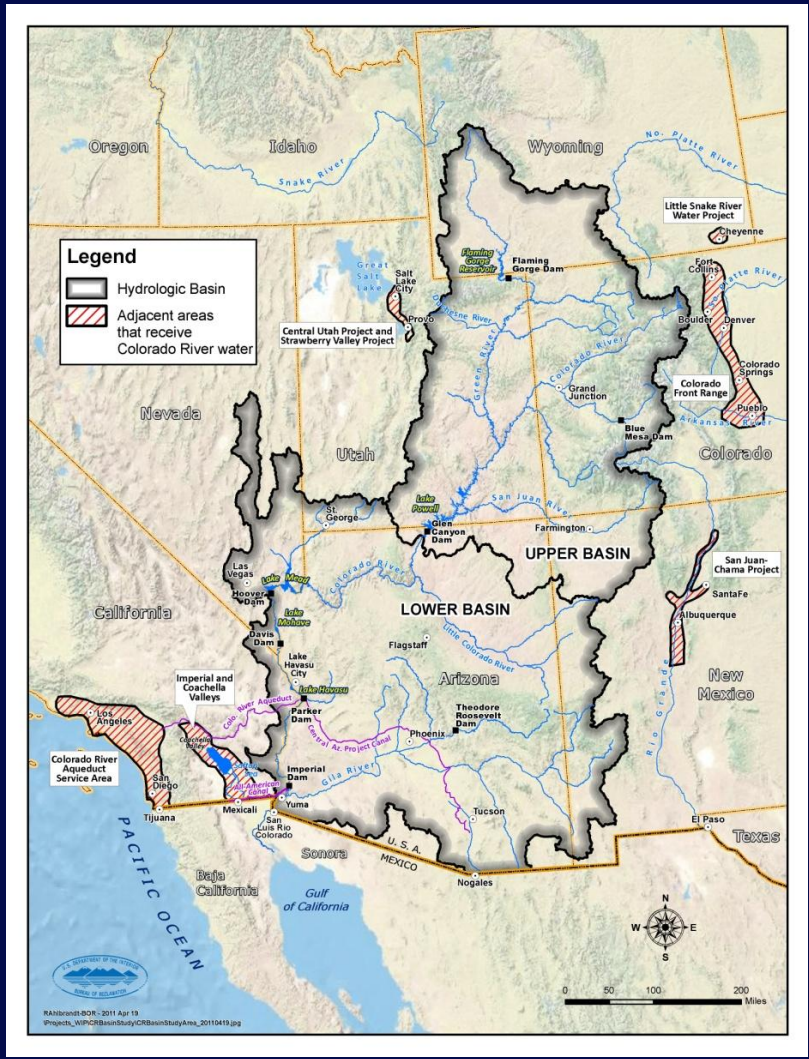
Approach Used to Help Develop Adaptive Management Plans for Colorado River Basin





2012 Bureau of Reclamation study, in collaboration with seven states and other users:

- **Assessed future water supply and demand imbalances over the next 50 years**
- **Developed and evaluated opportunities for resolving imbalances**

Groves et. al. (2014)

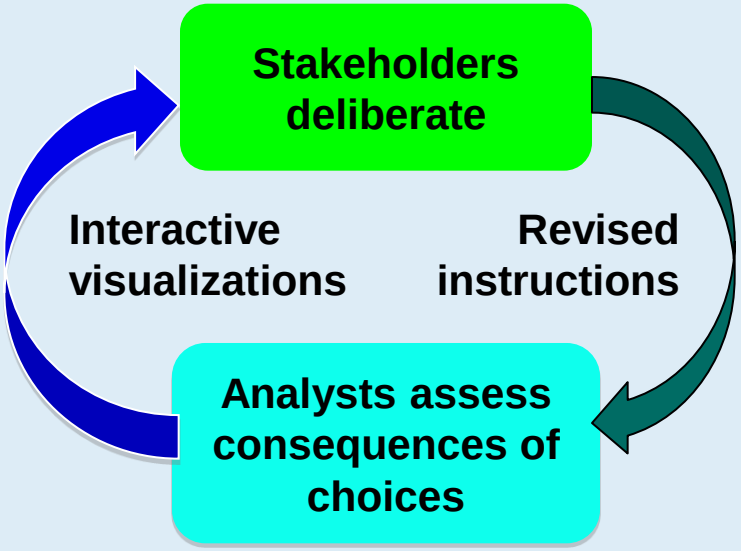
RDM Supports a "Deliberation with Analysis" Process of Stakeholder Engagement

3. Identify policies that address these vulnerabilities

1. Start with proposed policy and its goals

In Colorado

Dozens of workshops with many stakeholders over two years



4. Evaluate whether new policies are worth adopting

2. Identify futures where policy fails to meet its goals

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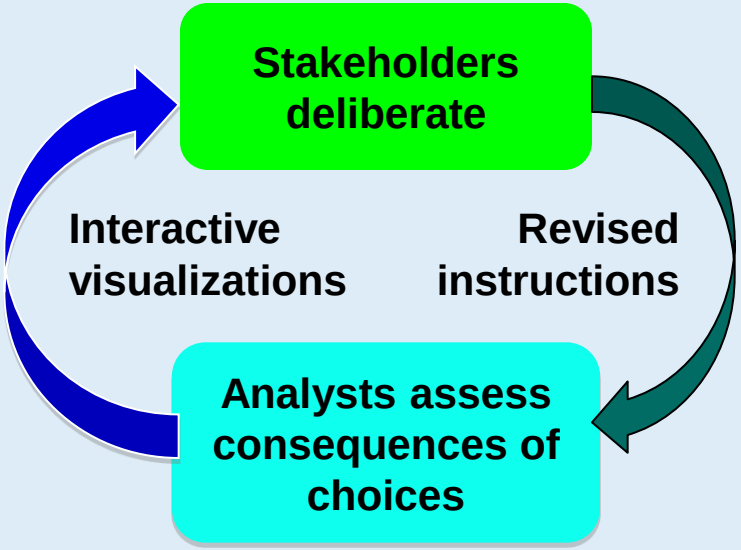
In Colorado

Dozens of workshops with many stakeholders over two years



Process helped generate consensus on potential risks and provides structure for developing adaptive management plans

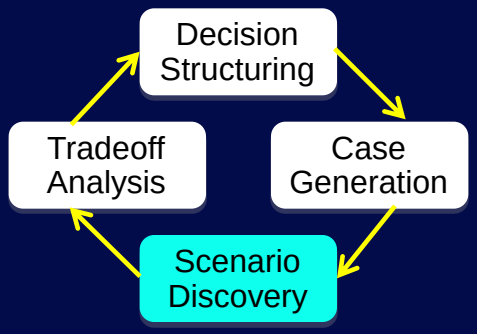
Stress-Tested Current Management Plans Over a Wide Range of Plausible Futures

24,000 futures

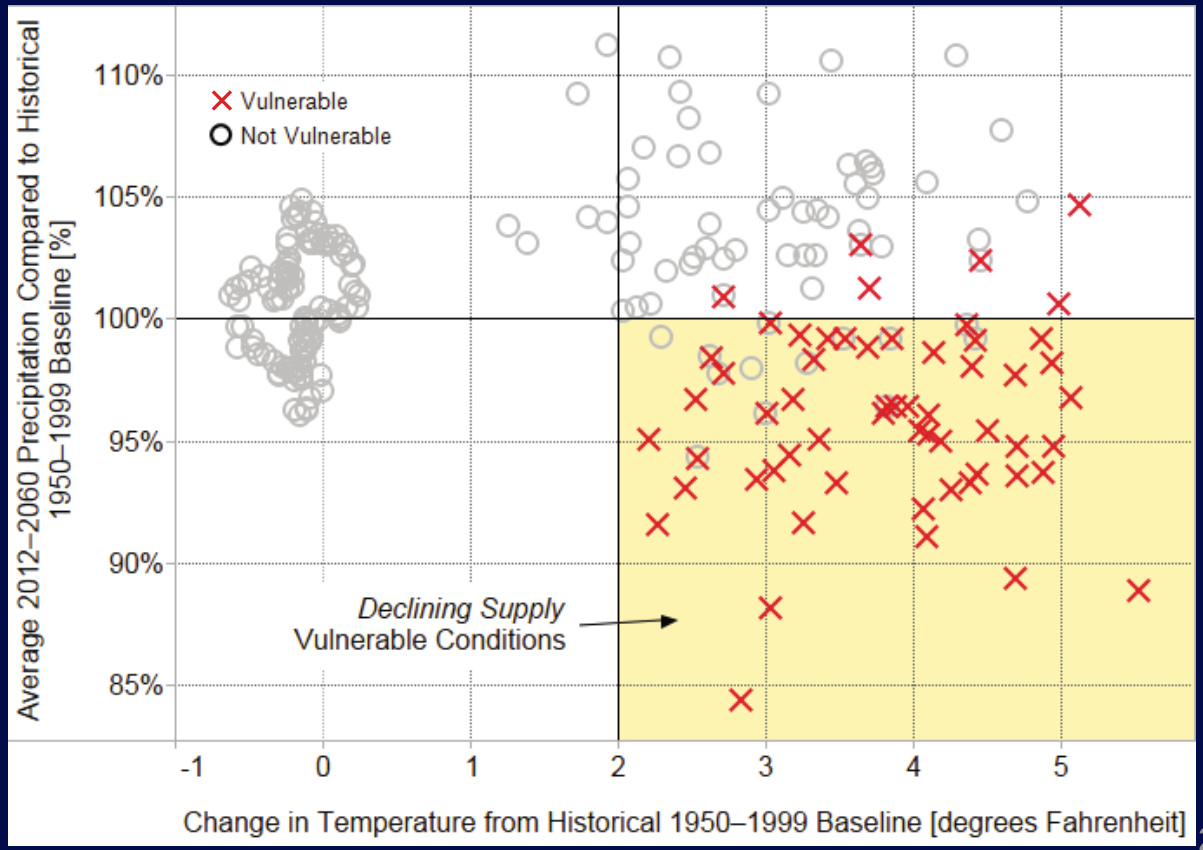
Climate projections
- Recent historic
- Paleo records
- Model projections
- Paleo-adjusted model projections

Demand projections

Future river management



Statistical analysis of database of model runs suggests that current plans fall short if:
- **Temperature greater than 2° F**
- **Any decrease in precipitation**



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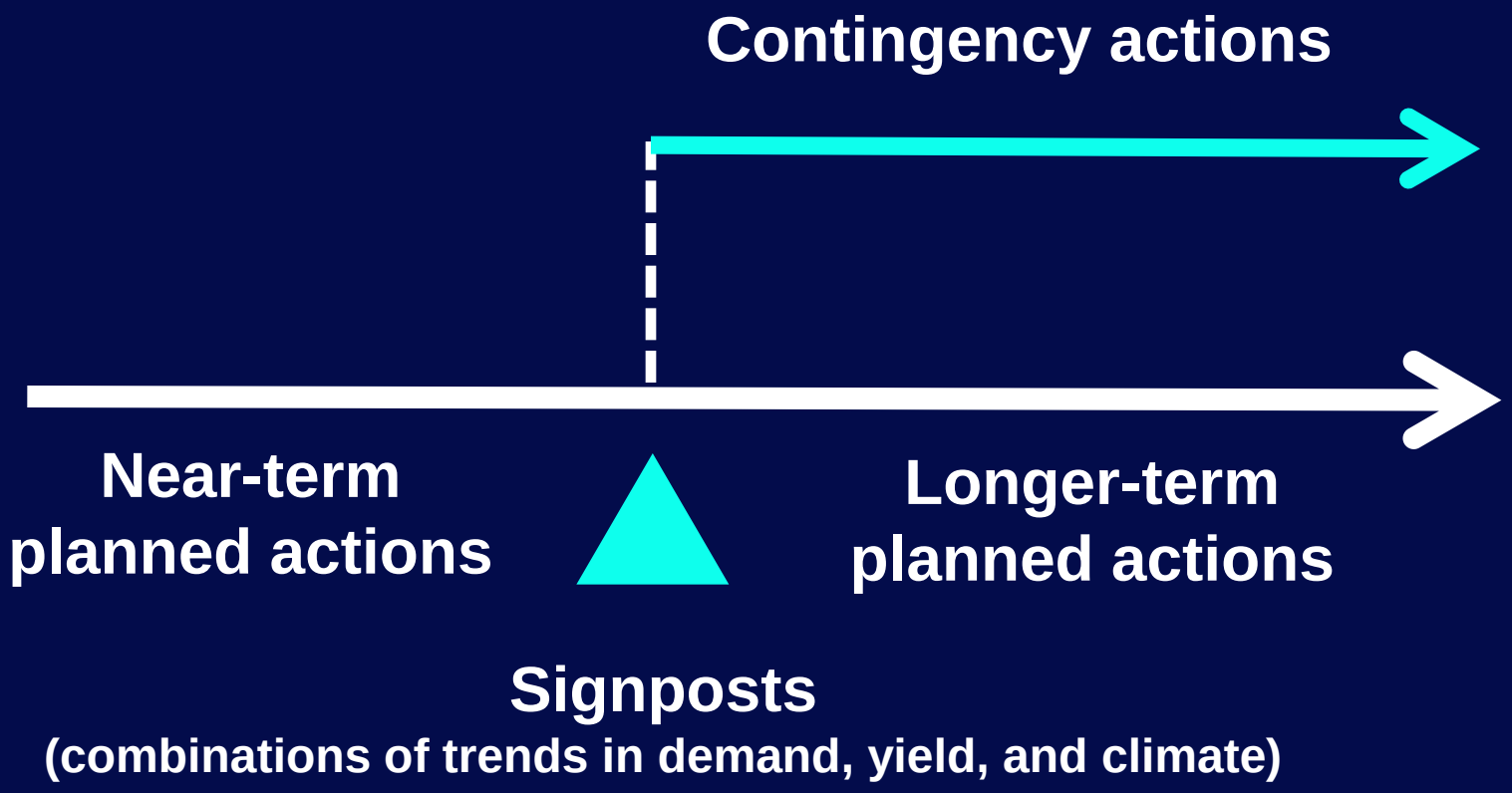
Can Use These Scenarios To Identify Actions and Signposts For Adaptive Plan



Analysis Can Support Deliberation Regarding Near- and Longer-Term Actions

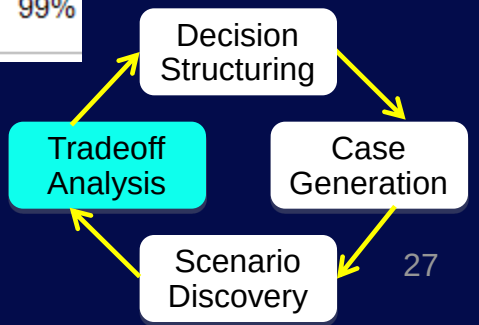
Option Category	Option Group	Conditions: All Traces	Low Historical Supply	Declining Supply
Ag. Conservation	Ag Conservation with Transfers	100%	100%	100%
Desalination	Desal-Groundwater	99%	100%	100%
	Desal-Salton Sea	81%	92%	100%
	Desal-Yuma	100%	100%	100%
Energy WUE	Energy Water Use Efficiency	20%	35%	93%
M & I Conservation	M&I Conservation	93%	93%	98%
Reuse	Reuse-Industrial	42%	65%	99%
	Reuse-Municipal	53%	72%	96%
Watershed Management	Watershed-Weather Mod	59%	67%	99%

Minimum Delay (years)
0
5
10
15
21

Contingent Actions

Initial Actions

Initial Actions (depend on beliefs)



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RDM-based Deliberation with Analysis Approach Addresses Many Attributes of Adaptive Strategies

ATTRIBUTES	HOW RDM MIGHT CONTRIBUTE
Attributes of policies themselves	
1. Forward looking	
2. Automatic policy adjustment	
3. Integrated policies	
Attributes of context in which policies are developed and implemented	
4. Iterative review and continuous learning	
5. Multi-stakeholder deliberation	
6. Diversity of approaches	
7. Decentralized decision-making	

Fischbach et. al., (in review)

RDM-based Deliberation with Analysis Approach Addresses Many Attributes of Adaptive Strategies

ATTRIBUTES	HOW RDM MIGHT CONTRIBUTE
Attributes of policies themselves	
1. Forward looking	Enable useful consideration of the near-term implications of a large multiplicity of plausible futures
2. Automatic policy adjustment	Identify and evaluate alternative combinations of shaping actions, hedging actions, and signposts.
3. Integrated policies	Improve ability to consider multiple system elements, which often have differing levels of uncertainty
Attributes of context in which policies are developed and implemented	
4. Iterative review and continuous learning	Help understand the conditions under which adaptive strategies may succeed or fail
5. Multi-stakeholder deliberation	Embed analysis in process of deliberation with analysis that recognizes multiple worldviews; demands clear explication of reasoning, logic, and values; and facilitates iterative assessment
6. Diversity of approaches	Can help with experimental design in cases where variation is planned as part of active adaptive management
7. Decentralized decision-making	Can help jurisdictions at multi-levels develop plans without certainty about the actions of other jurisdictions

Fischbach et. al., (in review)

How Do Near-Term Policy Choices Affect Long-Term Greenhouse Gas Emissions Pathways?

- Some policy reforms dissipate in a few years, others persist for generations
  - The latter often create constituencies that favor their continuation
- A new agent-based, game theoretic simulation model
  - Tracks co-evolution of an industry sector, its technology base, shifting political coalitions, and resulting pressures on future government policy choices
  - Compares how today's choices regarding alternative policy architectures influence long-term emission reduction trajectories
- Can significantly increase long-term de-carbonization rate by
  - Recycling carbon price revenue to firms based on market share
  - Choice of agency that administers carbon price

Isley (2014); Isley et. al. (submitted)

Observations

- Planning for resilience may require a new methods and tools for decision support, able to address
  - Deep uncertainty and surprise
  - Multiple actors with differing goals and world views
  - Complex systems
- Robust Decision Making methods may help address these challenges by:
  - Embedding analytics in a “deliberation with analysis” process of stakeholder engagement
  - Running the analysis “backwards” to identify vulnerabilities of plans and robust responses

More Information

http://www.rand.org/pardee/

http://www.rand.org/methods/rdmlab

Thank you!