Planning in a Non-Stationary Climate

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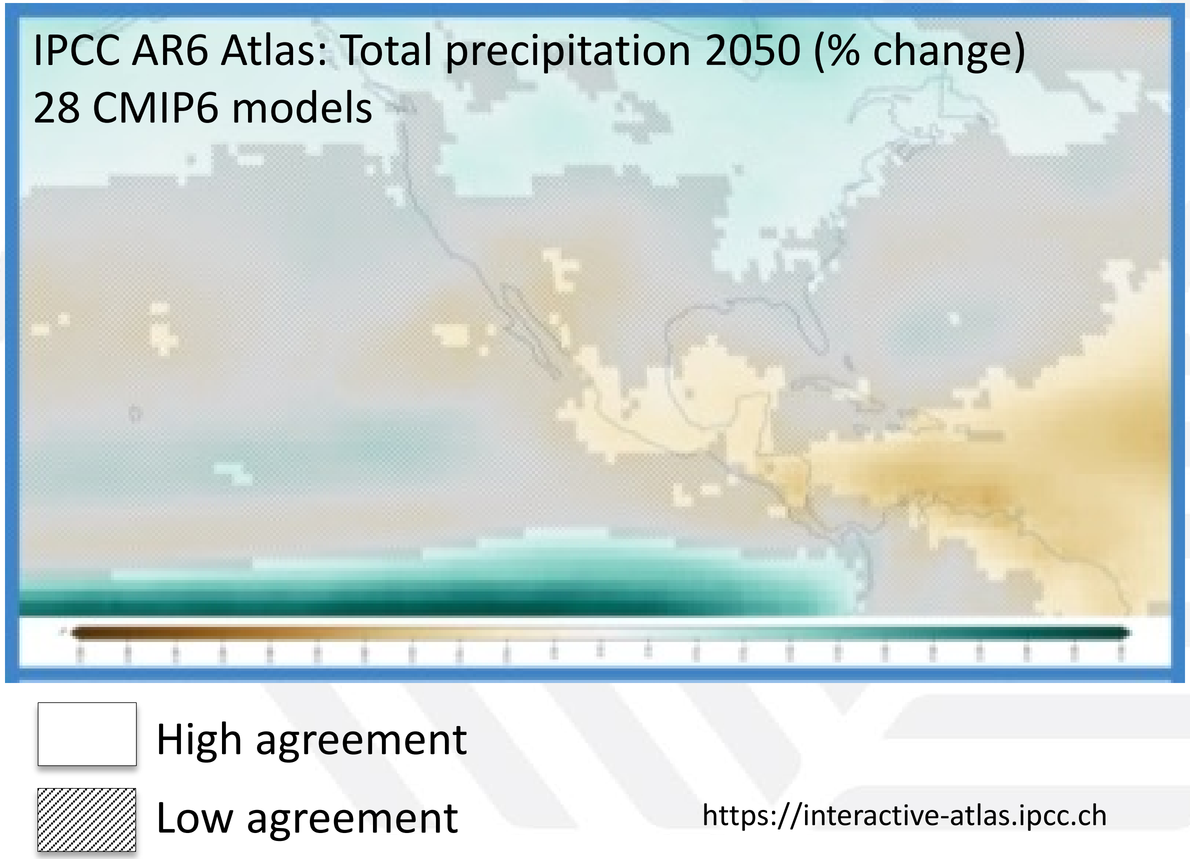
Non-stationarity Changes the Nature of Climate Risk

- Past climate is no longer a good approximation for future climate
- Non-stationarity contributes to:

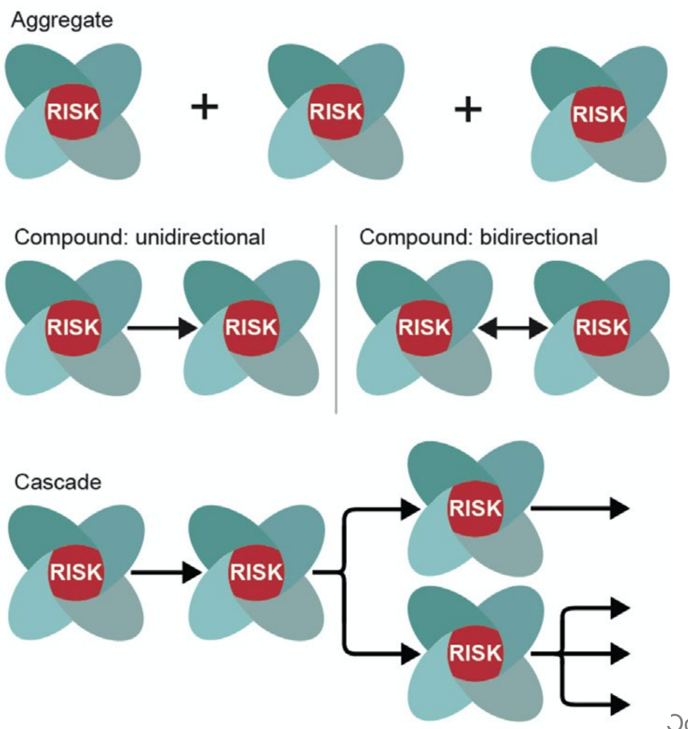
Uncertainty



https://interactive-atlas.ipcc.ch

Complexity

Individual risks product of hazard, exposure, and response
Overall risks can combine and cascade



Simpson et. al. One Earth (2021)

Climate-Related Decisions Pose Both Analytic and Organizational Challenges

Public planning should be:

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

Climate-related decisions involve:

- Incomplete information from new, fast-moving, and sometimes irreducibly uncertain science
- Many different interests and values
- Long-time scales
- Near certainty of surprise

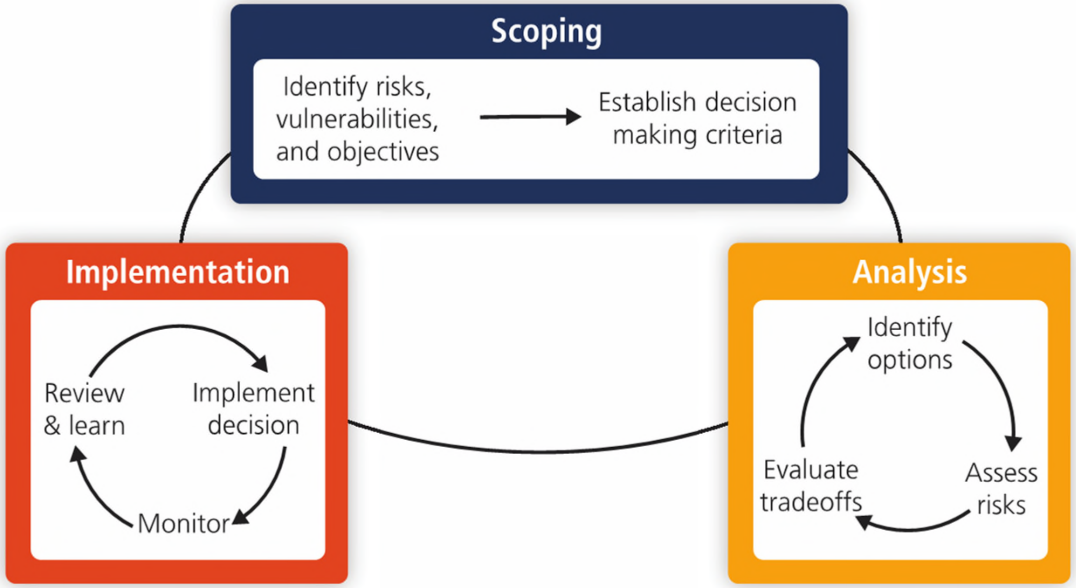
Responses include:

- Update standards and codes
- Use multiple, rather than single forecasts
- Employ adaptive, rather than static strategies and plans

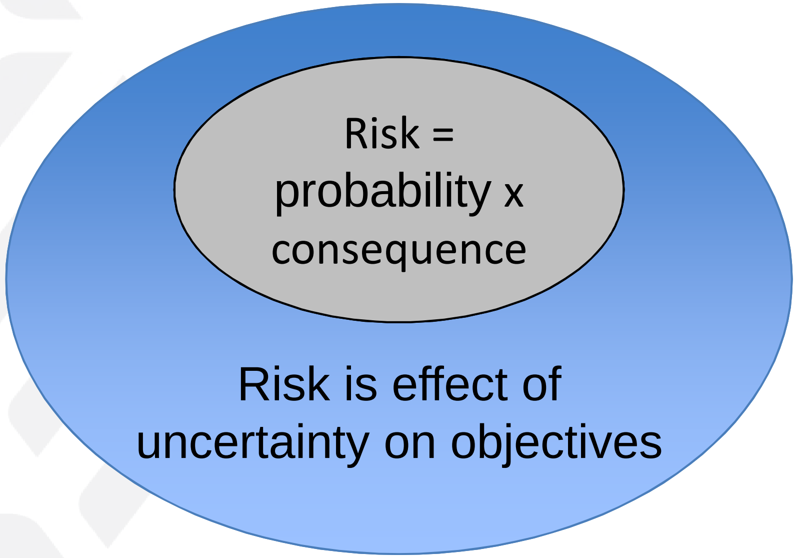
How to make plans more robust and adaptable while preserving public accountability?

Address These Challenges with an Expanded Understanding of Risk

Iterative risk management



Broad view of risk



Outline

- ► Challenge of non-stationarity
- ► **Decision Making Under Deep Uncertainty (DMDU)**
- ► Example application
- ► Implications

Traditional Risk Management Works Well When Uncertainty is Limited

"Predict then Act"

What will future conditions be? → What is the best near-term decision? → How sensitive is the decision to the conditions?

Predict

Act

These are sometimes called "optimization methods"

"Predict then Act" Can Break Down When Uncertainties Are Deep

Under conditions of deep uncertainty:

- Uncertainties are often underestimated
- Competing analyses can contribute to gridlock
- Misplaced concreteness can blind decision makers to surprise

Well-characterized uncertainty:

Deep uncertainty occurs when the parties to a decision do not know or do not agree on the likelihood of alternative futures or how actions are related to consequences

Deep uncertainty:

- Future regulatory requirements
- Future technology capabilities
- Today's return period for extreme events

To Inform Decisions Under Deep Uncertainty, Invert the Order of Traditional Analysis

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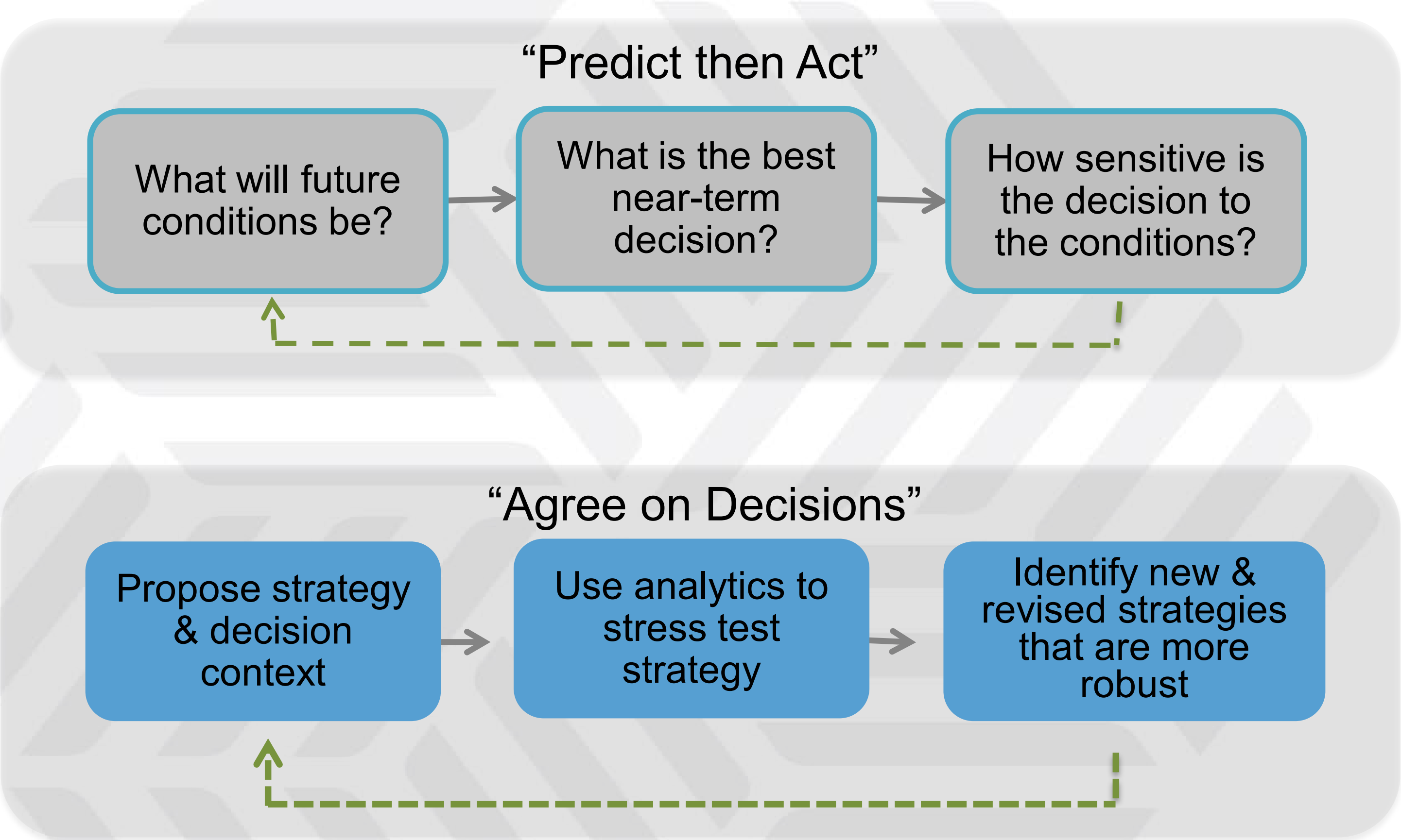
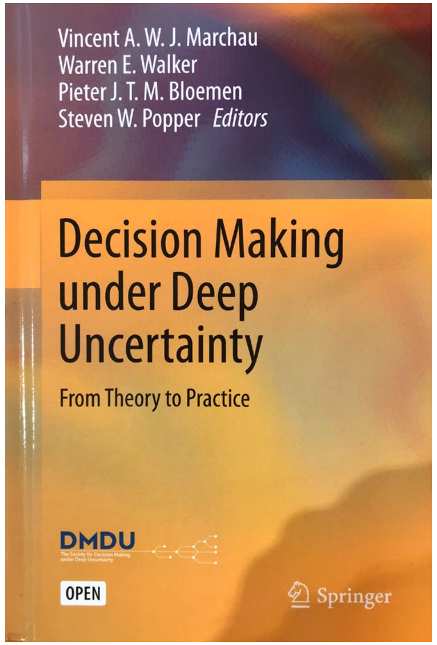


Such approaches are called Decision Making Under Deep Uncertainty (DMDU)



Kalra, N., S. Hallegatte, R. Lempert, C. Brown, A. Fozzard, S. Gill and A. Shah (2014). Agreeing on Robust Decisions: A New Process for Decision Making Under Deep Uncertainty. WPS-6906, World Bank.

Consider an Example Application

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City of Los Angeles developed an extensive plan of infrastructure investments and policies to meet federal water quality standards on the Los Angeles River*

Question: Can this expensive plan still meet water quality goals in a changing climate and, if not, what can be done about it?

** Study focuses on Tujunga sub-watershed: 225 square miles (165 sq. miles Los Angeles National Forest + 60 sq. miles urbanized San Fernando Valley floor)*

A. Tariq et. al., (2017) "A Climate Stress Test of Los Angeles' Water Quality Plans," Climatic Change

Let's Use One DMDU Approach — Robust Decision Making (RDM) — to Answer this Question

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Checklist of steps in RDM process

☑ Frame the decision challenge, including:

- What are we trying to achieve?
- What actions might we take to achieve our goals?
- What uncertainties affect achieving our goals?

☐ Stress test proposed strategies over a wide range of futures

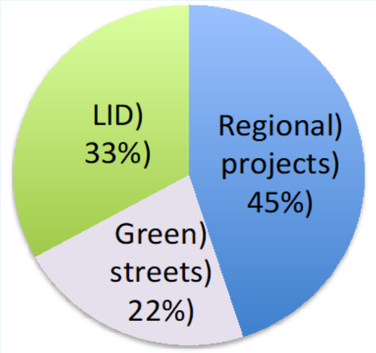
- Identify most important factors affecting whether we meet or miss our goals

☐ Identify new or revised strategies that meet our goals over a wider range of relevant futures

RDM Begins with Decision Framing

Decision makers and stakeholders deliberate over key factors in analysis

The Plan



Optimal distribution of BMPs
(best management practices)
assuming we know future climate!

GOALS
- Meet water quality requirements
- Do so in a cost-effective way

UNCERTAINTIES
- Climate change
- Land use

Strategy & Context → Stress Test → New & Revised Strategies

Stress Test LA's Water Quality Plans

Checklist of steps in RDM process

- [x] Frame the decision challenge, including:
  - What are we trying to achieve?
  - What actions might we take to achieve our goals?
  - What uncertainties affect achieving our goals?
- [x] Stress test proposed strategies over a wide range of futures
  - Identify most important factors affecting whether we meet or miss our goals
- [ ] Identify new or revised strategies that meet our goals over a wider range of relevant futures

Generate Cases that Stress Test Strategy in Each of Many Plausible Futures

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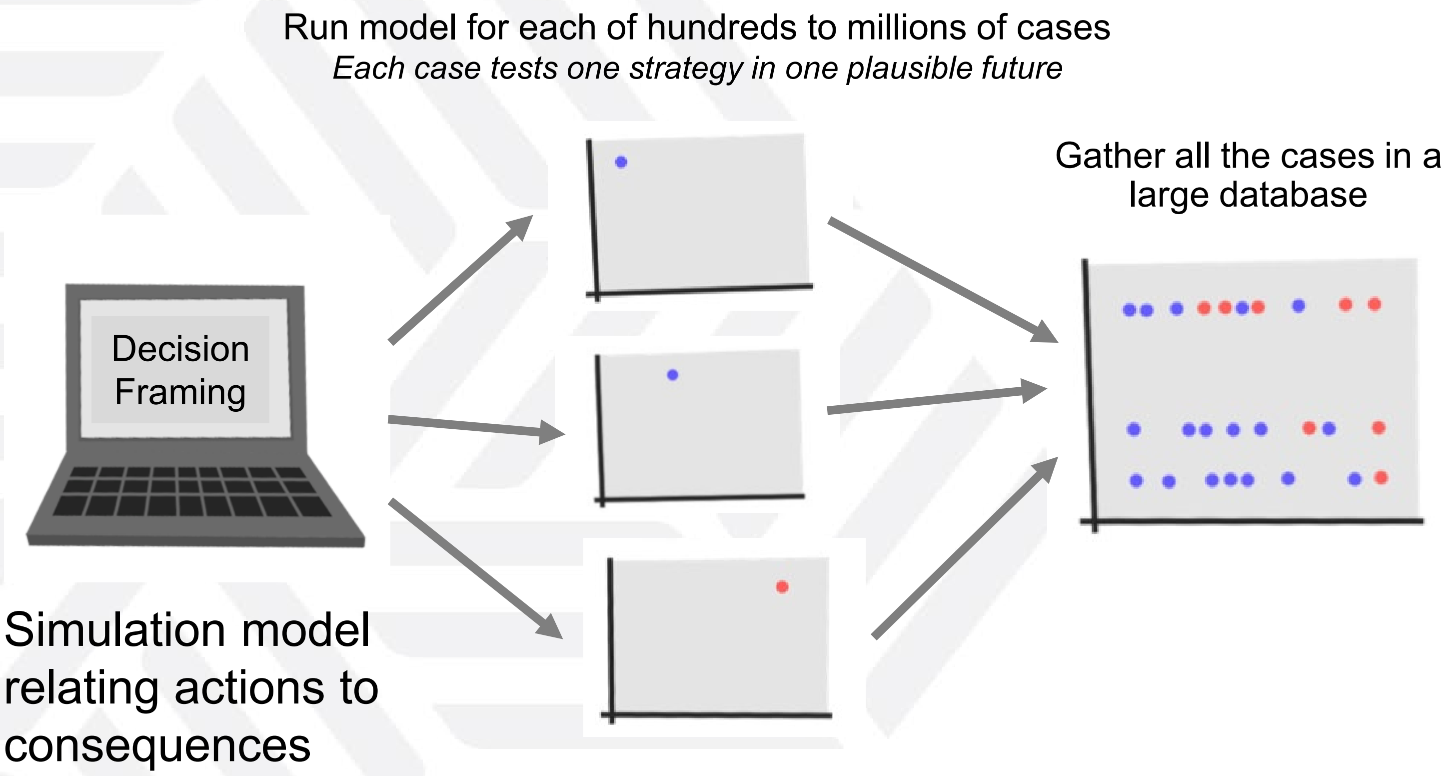
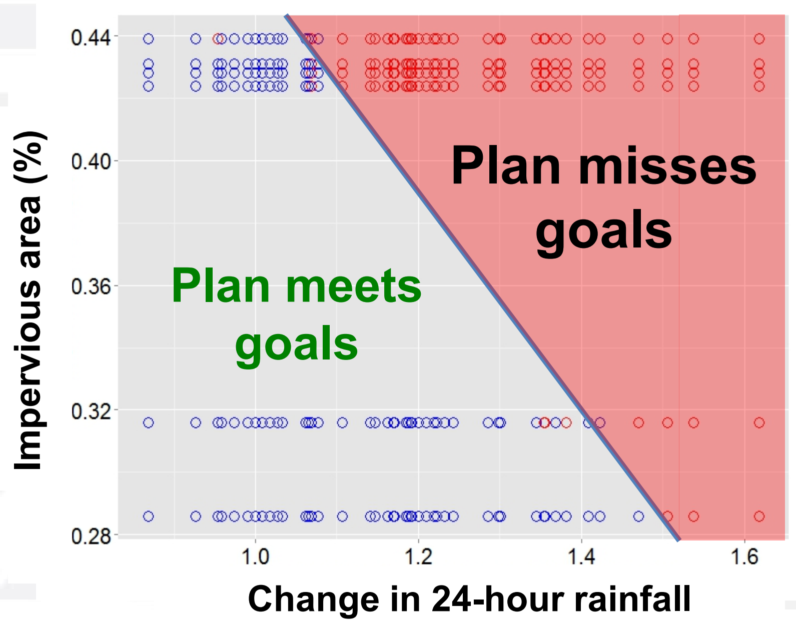


Strategy & Context → Stress Test → New & Revised Strategies

Summarize Stress Test Runs with Policy-Relevant Scenarios

- Study stress tested Tujunga water quality implementation plan over 47 climate times 6 land use = 282 futures



Computer algorithms and visualization help separate all the model runs into two sets of futures:

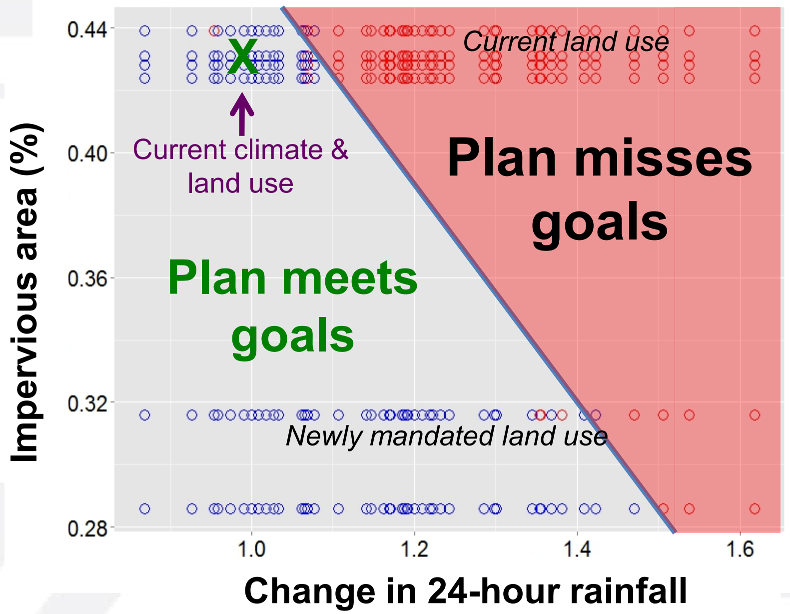
- In one set LA's water quality plan generally meets its regulatory goal
- In the second set LA's water quality plan generally fails to meet its regulatory goal

The algorithms and visualizations also identify the combination of uncertainties *most important* in distinguishing these two sets of futures

Strategy & Context → Stress Test → New & Revised Strategies

Summarize Stress Test Runs with Policy-Relevant Scenarios

These two scenarios provide policy-relevant information



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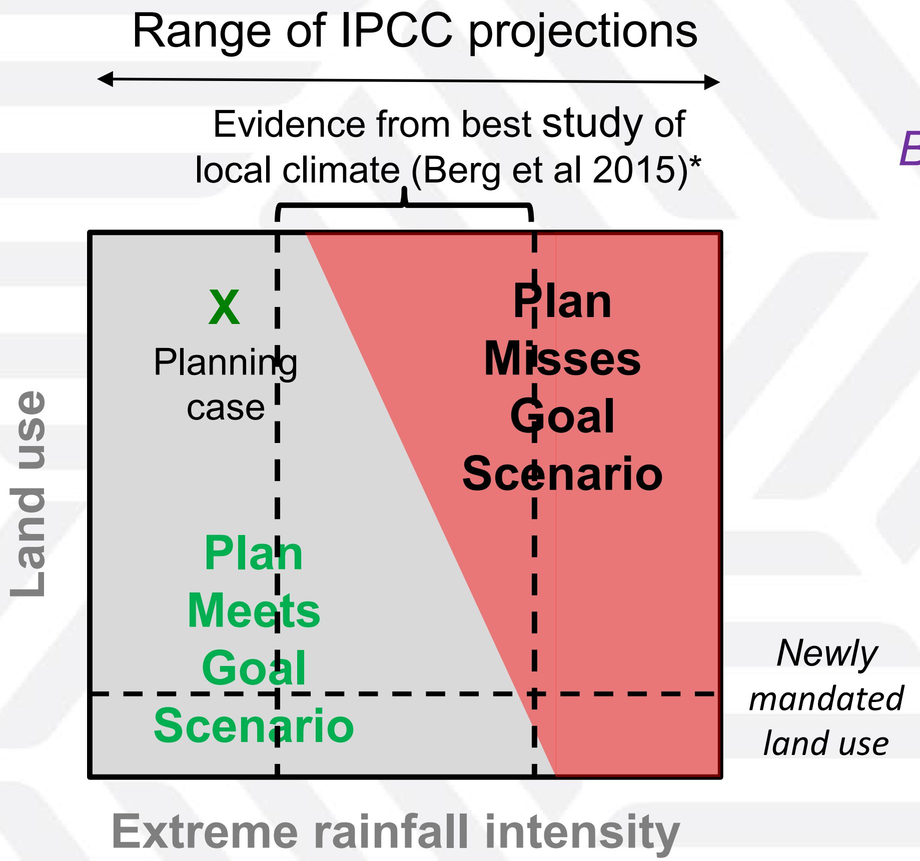
Climate change puts LA at risk of missing water quality goals, but successfully implementing storm water master plan eliminates this climate risk

Strategy & Context → Stress Test → New & Revised Strategies

Should Decision Makers Worry?

Compare Available Science to The "Plan Misses Goal" Scenario



Bottom line:

- *We looked at two ways to estimate the probability of extreme precipitation events*
- *Both indicate Los Angeles' water quality implementation plan may fail to meet regulatory standards if the climate changes (or has changed)*

Strategy & Context → Stress Test → New & Revised Strategies

Identify More Robust Strategies

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Checklist of steps in RDM process

☑ Frame the decision challenge, including:

- What are we trying to achieve?
- What actions might we take to achieve our goals?
- What uncertainties affect achieving our goals?

☑ Stress test proposed strategies over a wide range of futures

- Identify most important factors affecting whether we meet or miss our goals

☑ Identify new or revised strategies that meet our goals over a wider range of relevant futures

Stress Test Results Suggest Using a Robust, Adaptive Water Quality Implementation Plan

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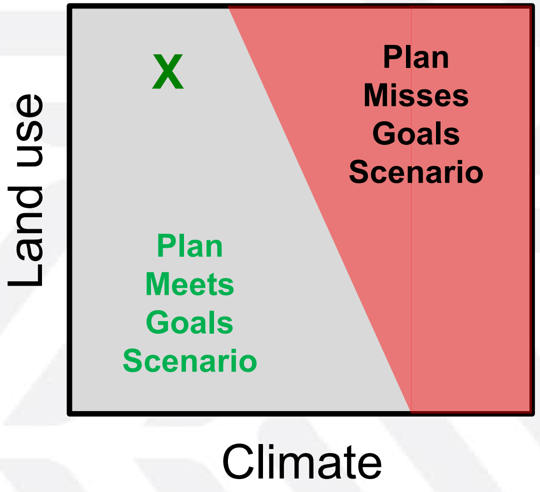
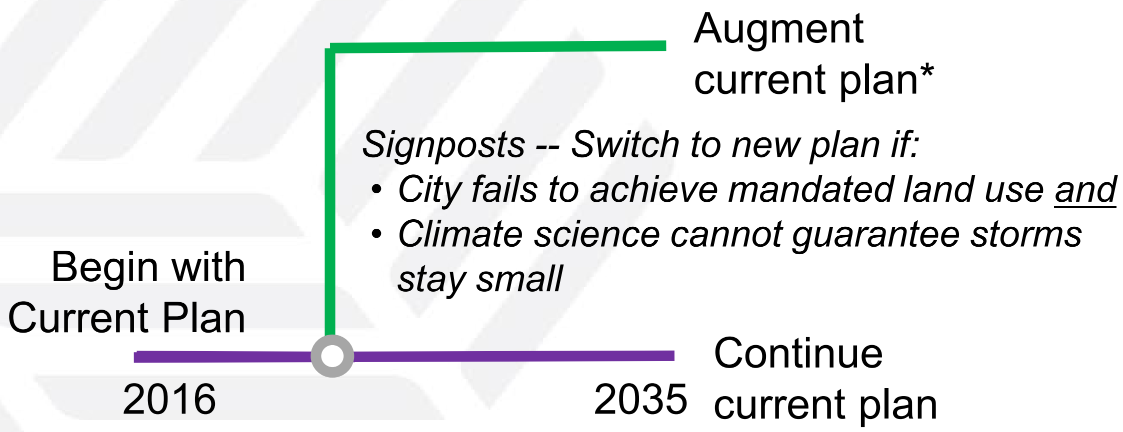
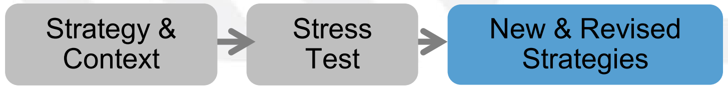
Consider an adaptive plan consisting of
- Near-term actions,
- Signposts to monitor, and
- Contingent actions if signposts are observed

Vulnerability analysis informs signposts





* Used optimization to identify augmented plan



Should Decision Makers Adopt This Adaptive Plan?

Compare tradeoffs for three alternatives over multiple objectives and multiple scenarios

	Plan Meets Goals Scenario	
	Water quality	Cost
Begin with Augmented Plan	Yes	Highest
Begin with Current Plan, prepare to adjust	Yes	Slightly higher
Current Plan	Yes	Lowest

Start with one scenario

Strategy & Context → Stress Test → New & Revised Strategies

Help Decisionmakers to Compare Tradeoffs Among Alternative Strategies

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The strategies perform very differently across the two scenarios

	Plan Meets Goals Scenario		Plan Misses Goals Scenario	
	Water quality	Cost	Water quality	Cost
Begin with Augmented Plan	Yes	Highest	Yes	Lowest
Begin with Current Plan, prepare to adjust	Yes	Slightly higher	Yes	Slightly higher
Current Plan	Yes	Lowest	No	Highest

The adaptive "Begin with current plan, but prepare to adjust" plan, represents a "low regret" strategy

In general, a robust strategy is one that:

- Performs well over a wide range of plausible futures,
- Keeps options open, or
- Trades some optimal performance for less sensitivity to broken assumptions

Strategy & Context → Stress Test → New & Revised Strategies

DMDU Can Help Ensure Plans Meet Goals, Even When Uncertainties Are Deep

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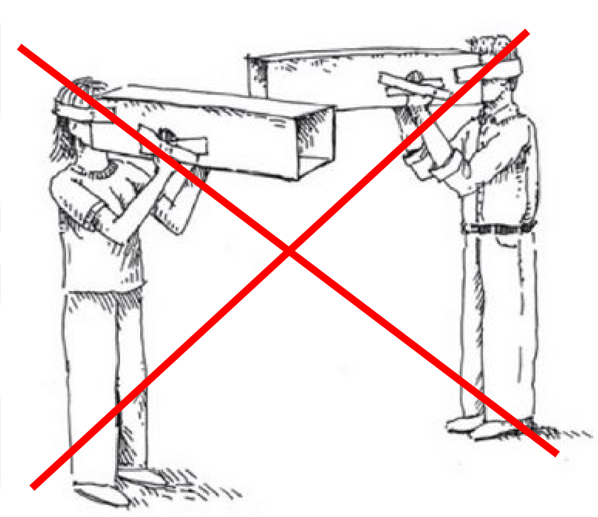
Basic DMDU principles

1. Consider multiple futures, not one single future, in your planning. Choose these futures to stress test your organization's plans
2. Seek robust plans that perform well over many futures, not optimal plans designed for a single, best-estimate future
3. Make your plans flexible and adaptive, which often makes them more robust

Plan over multiple futures



DMDU can generate robust and adaptive plans that:

- Perform well over a wide range of plausible climate futures
- Meet other goals
- Provide accountability to the public

Questions states can ask (in a non-stationary climate)

- To what extent are utilities currently planning for current and future change in the climate? To what extent are utilities planning for climate-related changes in their service areas and beyond? If so, how?
- How are utilities currently stress-testing resource plans? Are climate-related variables being used in stress tests? What additional climate stress test factors can be used?
- How can utilities take more of a flexible, adaptive planning approach, given climate uncertainty? What types of signposts can be used to flag when adaptations should be implemented?
- How can utilities, regulators, and stakeholders appropriately consider the results of stress tests and come to consensus on robust and flexible responses?

Resources for more information

- Society for Decision Making Under Deep Uncertainty: https://www.deepuncertainty.org
- IPCC Interactive atlas: https://interactive-atlas.ipcc.ch
- DMDU handbook: https://link.springer.com/book/10.1007/978-3-030-05252-2
- RAND:
  - https://www.rand.org/topics/robust-decision-making.html
  - https://www.rand.org/pardee.html

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Thank you!