Decision Making
in an Uncertain World

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Adaptation Master Class
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Adaptation to Climate Change Poses Both Analytic and Organizational Challenges

• Planning with statistics of future climate based on projections, rather than just replicating recent history, requires
  • Usefully summarizing incomplete information from new, fast-moving, and potentially irreducibly uncertain science
  • Justifying analytic choices to diverse constituencies, many of whom may object to implications of some particular choices

• Solution requires rethinking *how we use* uncertain climate information in our planning

• Recent reports suggest:
  – There are limits to the usefulness of classic risk analysis for climate-related problems
  – Seeking robust strategies may prove a preferable approach
  – *Any* analytic approach should be embedded in appropriate process of stakeholder engagement
Believing Forecasts of the Unpredictable Can Contribute to Bad Decisions

- In the early 1970s forecasters made projections of U.S energy use based on a century of data.
Believing Forecasts of the Unpredictable Can Contribute to Bad Decisions

- In the early 1970s forecasters made projections of U.S energy use based on a century of data

… they all were wrong
Traditional Planning Methods Can Complicate Decisions Under Deep Uncertainty

Traditional analytic methods characterize uncertainties as a prelude to assessing alternative decisions.

Climate change (and many other challenges) confront decisionmakers with deep uncertainty, where:
- They do not know, and/or key parties to the decision do not agree on, the system model, prior probabilities, and/or “cost” function

Decisions can go awry if decisionmakers assume risks are well-characterized when they are not:
- Uncertainties are underestimated
- Competing analyses can contribute to gridlock
- Misplaced concreteness can blind decision-makers to surprise
Robust Decision Making (RDM) Helps Inform Good Decisions Without Reliable Predictions

Key idea – conduct the analysis in reverse order from predict then act:

1. Start with a proposed plan for a specific decision maker
2. Use analytics to identify (multi-attribute) scenarios that describe the future conditions where proposed plan fails to meet its goals
3. Use these scenarios to identify potential actions to address vulnerabilities and evaluate tradeoffs among them
4. Repeat until stakeholders agree the resulting plan is robust across multiple views and unknowns regarding the future
Currently Applying This Approach With Many Resource Management Agencies

Long-term Water Resources Planning

2004
- 2005 California Water Plan (NSF)

2005
- IEUA Climate Adaptation Studies (NSF)

2006
- 2005 California Water Plan (NSF)

2008
- California Water Plans
- MWD Integrated Resource Plan & BRC
- Denver Water Pilot Project
- CO River Study
- Water Resources Foundation
- CO Springs Utilities & NYC
- Sierra Nevada Climate Adaptation Study (PIER)
- Port of L.A. & sea level rise (NSF)

2009
- 2009 Plan
- World Bank Pilots: Mexico, Vietnam, Kosovo

2010
- 2013 Plan
- US ACE Risk Informed Decision Framework
- Gulf Coast Fisheries Study
- Louisiana OCPR Annual Plans & 2012 Master Plan Update
- New Orleans Risk Mitigation Study (NOAA)

Coastal Protection and Restoration

2011
- 2013 Plan
- World Bank Pilots: Mexico, Vietnam, Kosovo
- RAND
- Water Resources Foundation
- CO Springs Utilities & NYC
- Sierra Nevada Climate Adaptation Study (PIER)
- Port of L.A. & sea level rise (NSF)
- Louisiana OCPR Annual Plans & 2012 Master Plan Update
- New Orleans Risk Mitigation Study (NOAA)
Importantly, RDM Consists of Analytic Methods Embedded in a Process of Stakeholder Engagement

Effective climate-related decision support often requires deliberation with analysis, an iterative process that:

- Begins with the many participants to a decision working together to define its objectives and other parameters,
- Working with experts to generate and interpret decision-relevant information, and
- Then revisiting the objectives and choices based on that information.
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• Then revisiting the objectives and choices based on that information.

To address specific cognitive and organizational barriers to good decisions, RDM implements such a process by:

• Beginning with one or more policies under consideration, and an understanding of what would constitute success

• Identifying vulnerabilities of those policies

• Identifying and evaluating potentially robust responses
Helped Inland Empire Utilities Agency (IEUA) Include Climate Change in Their Long-Range Plans

- IEUA currently serves 800,000 people
  - May add 300,000 by 2025
- Water presents a significant challenge
- Current water sources include:
  - Groundwater 56%
  - Imports 32%
  - Recycled 1%
  - Surface 8%
  - Desalter 2%
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Focus of IEUA’s 25 year plan
IEUA Faces a Range of Possible Future Climate Conditions

Summer-time temperature change (2000-2030)

- No change
- Likely range: 0°C to +.1°C
- Hotter: +2.1°C

Winter-time precipitation change (2000-2030)

- Much drier: -19%
- Likely range: 0%
- Wetter: +8%

Results based on statistical summary of 21 of the world’s best Global Climate Models
Simulation Model Assesses Performance of IEUA Plans in Alternative Scenarios

Scenario A
Plan generates **surpluses** in benign future climate

Scenario B
Plan suffers **shortages** in adverse future climate

Temp: +0.7°C Precip: +3%

Temp: +1.6°C Precip: -10%

Groves et al. (2007)
Many Uncertain Factors Could Impact the Performance of Current IEUA Plan

| Natural Processes | • Future temperatures  
|                   | • Future precipitation  
|                   | • Changes in groundwater processes |
| Performance of Management Strategies | • Development of aggressive waste-water recycling program  
|                                           | • Implementation of groundwater replenishment |
| Costs of Future Supplies and Management Activities | • Imported supplies  
|                                                          | • Water use efficiency |
“Scenario Maps” Help Decision Makers Visualize a Plans’ Vulnerabilities

Current IEUA plan forever

<table>
<thead>
<tr>
<th>Scenario A</th>
<th>Scenario B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benign climate</td>
<td>Adverse climate</td>
</tr>
<tr>
<td>$3.3 billion in supply cost</td>
<td>$3.4 billion in supply cost</td>
</tr>
<tr>
<td>$0 in shortage cost</td>
<td>$1.9 billion in shortage cost</td>
</tr>
</tbody>
</table>

Choose candidate strategy

Identify vulnerabilities

Identify & assess options

“Scenario Maps” Help Decision Makers Visualize a Plans’ Vulnerabilities

Consider options
Identify vulnerabilities
Assess alternative responses

Current IEUA plan forever

(200 Scenarios)
“Scenario Maps” Help Decision Makers Visualize a Plans’ Vulnerabilities

Current IEUA Plan Forever

Current plan generates high costs in 120 of 200 Scenarios

PV shortage cost ($ billions)

PV supply cost ($ billions)

$3.75 billion cost threshold

Consider options
Identify vulnerabilities
Assess alternative responses
Statistical “Scenario Discovery” Analysis Identifies Scenario Where Existing Plan Fails

These three factors explain 70% of vulnerabilities of IEUA’s current plans:

1. **Natural Processes**
   - Future temperatures
   - Future precipitation
   - Changes in groundwater processes

2. **Performance of Management Strategies**
   - Development of aggressive waste-water recycling program
   - Implementation of groundwater replenishment

3. **Costs of Future Supplies and Management Activities**
   - Imported supplies
   - Water use efficiency

Consider options
Identify vulnerabilities
Assess alternative responses
What Should IEUA Do Now, and What Can They Wait to Do Later?

- Act now to augment 2005 Plan?
  - NO
  - Monitor, and take additional action if supplies drop too low
- YES
  - Implement additional efficiency, recycling, and replenishment
- In 2015, 2020, 2025, ....
  - Monitor, and take additional action if supplies drop too low
  - Consider options
    - Identify vulnerabilities
    - Assess alternatives
Just Allowing the Current UWMP to Update Reduces Vulnerable Cases Substantially

Consider options
Identify vulnerabilities
Assess alternatives

Number of Cases (PV Costs > $3.75 billion)

Current UWMP Forever
UWMP with updates

0 10 20 30 40

120

Static options
Update options
Compare Alternative Plans With Different Mixes of “Act Now” vs. “Act Later”

Consider options
Identify vulnerabilities
Assess alternatives

Current UWMP Forever
UWMP with updates
UWMP + DYY and recycling with updates
UWMP + replenishment with updates
UWMP + efficiency
UWMP + efficiency with updates
UWMP + all enhancements

Number of Cases (PV Costs > $3.75 billion)

Economic Costs Decrease, But Unquantified Opportunity Costs Increase

Static options
Update options
Compare Alternative Plans With Different Mixes of “Act Now” vs. “Act Later”

IEUA chose to accelerate their dry-year yield and recycling programs, and adapt as needed down the road.
Such Robust Adaptive Plans Also Proving Useful at the Regional Level

Metropolitan Water District of Southern California is using these approaches:

- Planning staff identifies early warning indicators needed to implement their adaptive management Integrated Resources Plan.
- Blue Ribbon Committee looks out 50 years to “identify and recommend new business models and strategies that will help the region meet its long-range water needs.”
Some Key Ideas for Adaptation Planning

• Approach described here uses sophisticated analytic tools within a specific process of stakeholder engagement

• Key idea is even more broadly applicable:
  • Use analysis to identify vulnerabilities of specific plans and compare robust responses
    • See for instance, suite of approaches described by World Resources Institute: http://www.worldresourcesreport.org/decision-making-in-depth/managing-uncertainty

**Encourage policy makers to change the question from “What will the future bring?” to “What steps can we take today to most assuredly shape the future to our liking?”**


www.rand.org/ise/projects/improvingdecisions/
Thank you!