Considerations for the Design and Use of Scenarios that Inform Robust Decisions

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Photo: Salinas Valley, California
How does Climate Science Inform Decisions?

Common Decision Model

Climate Science

Predict

Act

Decision Making under Deep Uncertainty

Climate Science

Evaluate Options

Identify vulnerabilities

Frame Decision
Emission Scenarios

General Circulation Models (GCMs)

Geography Department, U. Oregon

Downscaling

Water System Performance Under Future Climate Scenarios

Hydrologic Model

Greene County, PA
Department of Econ. Development

Wisconsin Valley Improvement Company

Water Resources System Model
How to Use GCM Projections for South Florida?
The Climate Scenario Dilemma

- GCM scenarios explore forcing uncertainty; not designed to explore adaptation uncertainty

- Thus, GCM scenarios are neither true scenario analysis nor predictions

- How would you design a risk assessment process if you started from a blank slate?
Mitigation-oriented climate science

Meet

Adaptation Decision Making
A Climate Informed Decision Analysis

To provide clear guidance for addressing climate change in planning and operations using the best available science and stakeholder inputs

Approach:
• Adopt “scenario neutral” approach within decision analytic framework
• Stress test – multidimensional sensitivity analysis reveals vulnerabilities and comparative advantage of alternatives
• Climate projections enters at end of analysis, to prioritize responses or evaluate best alternatives
Decision Scaling

1. Identify Key Uncertainties

   Define uncertain factors that can affect the system

2. “Stress Test”

3. Evaluate Vulnerabilities

Brown and Wilby, EOS, 2012; Brown et al., WRR, 2012, Poff et al., 2015 Nature Climate Change
Decision Scaling

1. Identify Key Uncertainties

2. “Stress Test”

3. Evaluate Vulnerabilities

Systematic perturbation to characterize response of the system

Brown and Wilby, EOS, 2012; Brown et al., WRR, 2012, Poff et al., 2015 Nature Climate Change
Decision Scaling

1. Identify Key Uncertainties

Data mining to extract scenarios for further analysis. Climate projections inform vulnerabilities

2. “Stress Test”

3. Evaluate Vulnerabilities

Brown and Wilby, EOS, 2012; Brown et al., WRR, 2012, Poff et al., 2015 Nature Climate Change
1. Frame the Analysis for Actionable Science

<table>
<thead>
<tr>
<th>unCertainties</th>
<th>Consequences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Things that we cannot control</td>
<td>How we measure success</td>
</tr>
<tr>
<td>but affect the ability to meet</td>
<td>and failure</td>
</tr>
<tr>
<td>objectives</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Connections</th>
<th>Choices</th>
</tr>
</thead>
<tbody>
<tr>
<td>The definition of the system,</td>
<td>Policies, infrastructure,</td>
</tr>
<tr>
<td>formalized as a model</td>
<td>social consciousness</td>
</tr>
<tr>
<td></td>
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</tr>
</tbody>
</table>
2. Stress Test to define system response

Climate/Weather Generator → Hydrologic Model → System Model

NonClimate Uncertainties

Vulnerability

Robust
Climate Vulnerability Assessment:
California DWR
Worse than Historical

Better than Historical

Current conditions estimate

550 years of simulation at each point
3. Climate Projects define level of concern (risk)
Identify Vulnerability Space

SWP Deliveries Likelihood Space 1996

Change in Temperature (C)

Precipitation (Percent Change from Historic Baseline)
Examples
Decision Scaling Climate Vulnerability Assessment for the California Department of Water Resources Final Report

A Collaborative Study of the Hydrosystems Research Group, University of Massachusetts, Amherst and the California Department of Water Resources

"Snow White Mountains and Blue Watershed," Dr. Qin Qin Liu, DWR Climate Change Program, 2017

May 2019
International Upper Great Lakes Study

- 20% of world’s freshwater
- 40 million people affected
- Multiple Objectives:
  - Ecosystem
  - Navigation
  - Recreation
  - Hydroelectricity Production
  - Coastal real estate
Great Lakes “System”
Climate Change Projections of Net Basin Supply - Lake Superior, 2050
Contours of “Robustness” to a Given Level of Hazard (Historical = 1)

Robustness to Variability

Robustness to Mean changes

Moody and Brown, WRR, 2012
Vulnerability and Climate Projections
Residual Risk according to Projections
Summary Thoughts

Scenario Definition?

• GCM derived scenarios are neither mutually exclusive nor collectively exhaustive
  ➢ Climate Stress Test – systematic sampling to create mutually exclusive and collectively exhaustive scenarios
  ➢ Carefully preserve connections to climate drivers to infer insights on change
  ➢ Allows clear identification of vulnerabilities

Use of GCM Simulations?

• Forecasts of climate change considered unreliable but can be useful
  ➢ Define sampling ranges
  ➢ Used to assess level of concern of the vulnerabilities identified
  ➢ Assign subjective probabilities to ex post scenarios when needed
Thank You

Questions: casey@umass.edu
Figure 1. Schematic flowchart of the daily weather generation process conditional on annual simulations of climate and subject to postprocess distributional adjustments.
Adaptation via Operations?

(Whateley et al., 2014)
### Framing the Analysis for Actionable Science

<table>
<thead>
<tr>
<th>Uncertainties</th>
<th>Investment and Policy Options</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Natural Uncertainties</strong></td>
<td><strong>Upper Arun HP</strong></td>
</tr>
<tr>
<td>Precipitation (intensity, duration, frequency, timing)</td>
<td>335 MW (Q70) – original design</td>
</tr>
<tr>
<td>Temperature (melt/evapotranspiration)</td>
<td>750 MW (Q40) – possible alternative</td>
</tr>
<tr>
<td>Sedimentation</td>
<td>2000 MW (Q25) – possible alternative</td>
</tr>
<tr>
<td>Seismic risk and disasters</td>
<td></td>
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<tr>
<td><strong>Nepal Future System and Operations</strong></td>
<td></td>
</tr>
<tr>
<td>National markets; International agreements; Prices</td>
<td></td>
</tr>
<tr>
<td><strong>Project Variables</strong></td>
<td></td>
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<tr>
<td>Capital costs; Lifetime of the projects; Discount rate</td>
<td></td>
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<tr>
<td><strong>Metrics of Success</strong></td>
<td><strong>Models and Data</strong></td>
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<tr>
<td><strong>Hydropower Performance</strong></td>
<td><strong>Hydrological model</strong></td>
</tr>
<tr>
<td>Net Present Value</td>
<td><strong>UMass Glacio-Hydrologic Model</strong></td>
</tr>
<tr>
<td>Power generation (Dry season; Wet season; Total Annual)</td>
<td><strong>Watershed System</strong></td>
</tr>
<tr>
<td>Run of River Hydropower in R</td>
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</tbody>
</table>

Nepal Hydroelectricity Project - Upper Arun
Family Tree of GCMs

Knutti et al., 2013
GCMs are not Independent and it Matters!

Steinschneider, Brown, Mearns, McCrary (GRL – 2015)
Thank you! Questions?