Robust Adaptation to Climate Change

A Decision Tree for Water Planning

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Integrated Basin Planning under Uncertainty

- "When we try to pick out anything by itself we find that it is bound fast by a thousand invisible cords that cannot be broken, to everything in the universe. ” *Muir (1869)*

- “All solutions are provisional and local.” *Briscoe (2014)*

- “Everyone has a plan until they get punched in the face” *Mike Tyson (US Heavy Weight Boxer) via Briscoe.*

What is a Water Planner to do?

- Investments in the water sector are potentially significantly impacted by climate change
- Assessment of climate change risks is required
- Climate change may cause the project goals to not be met
- Unclear how to use climate information to aid decisions

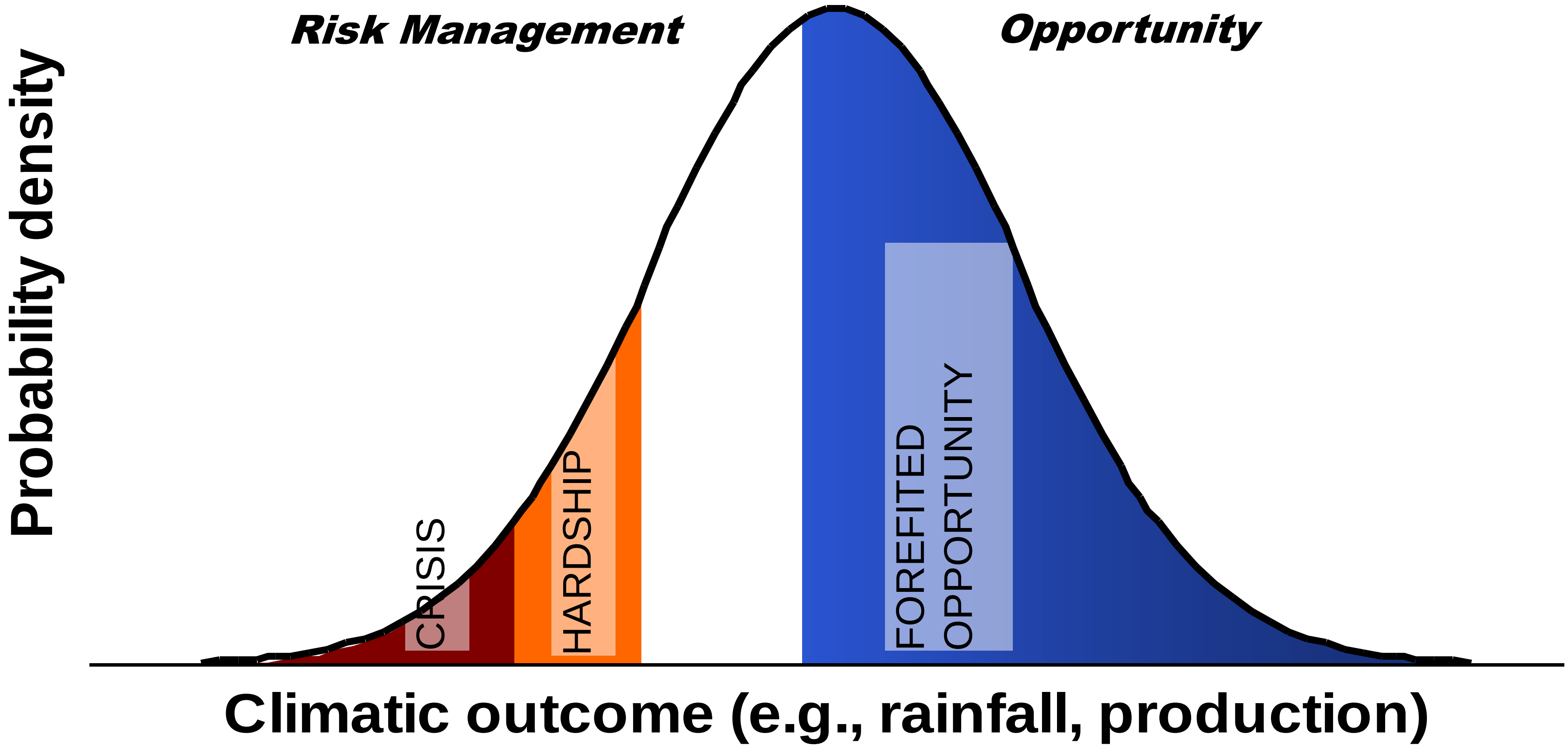
A standard process for Project Evaluation for Climate Risk is needed!

Risk or Opportunity?

- Instead of focusing on *risk*, there is an opportunity for developing **robust projects**
- Approaches available that lead to projects that are more robust to climate change and other uncertainties
- Also helpful in addressing contrasting objectives of constituencies
- **Guidance** needed to navigate these approaches

Uncertainty Management

(de Neufville et al., 2004)



Hansen, pers. comm.

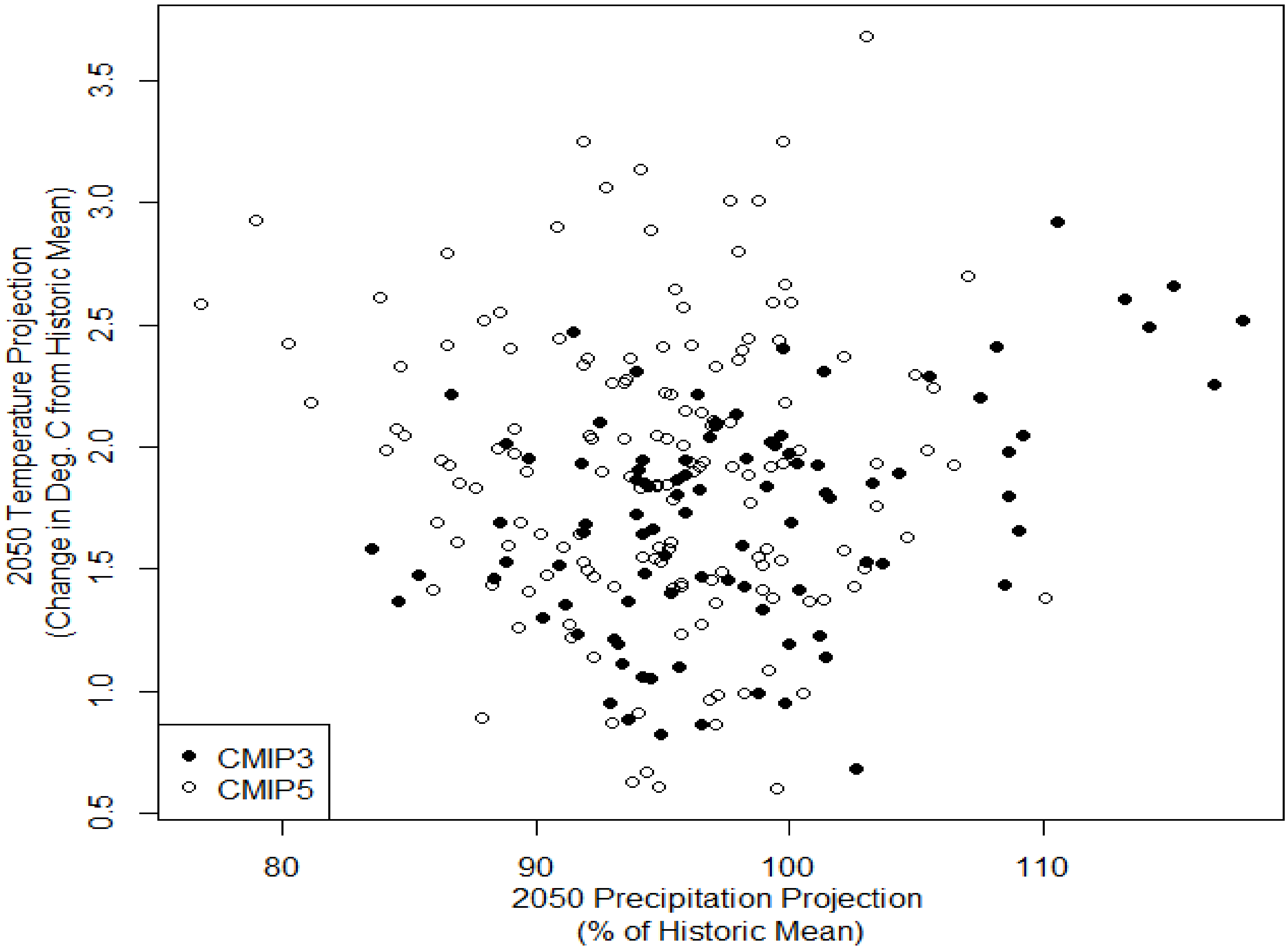
Why is this difficult?

- How will the science improve decisions?

- Usual mode of engagement: Prediction - centric
  - Science reduces the uncertainty affecting the decision
  - E.g., Science: the most likely future condition is A
    - Decision – under Future A, Option 1 is my best choice

- Mode of engagement under climate change
  - Science characterizes uncertainty (*may increase*)
  - E.g., Science: here is a wide range of possible futures, and we're not sure they delimit the true range
    - Decision – um …

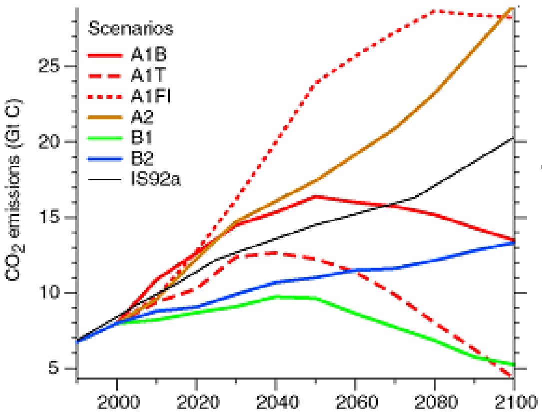
Now What?



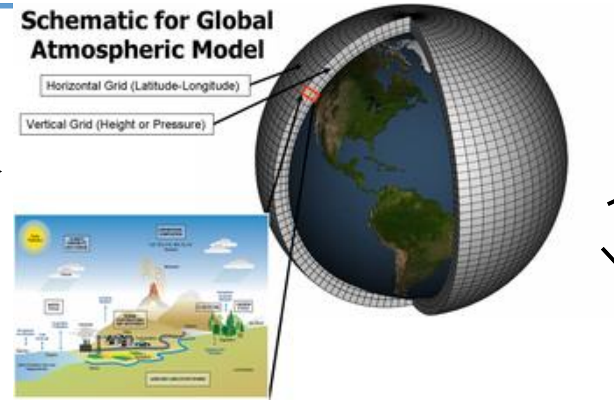
2050 Temperature Projection
(Change in Deg. C from Historic Mean)
0.5
1.0
1.5
2.0
2.5
3.0
3.5
80
90
100
110
2050 Precipitation Projection
(% of Historic Mean)
CMIP3
CMIP5

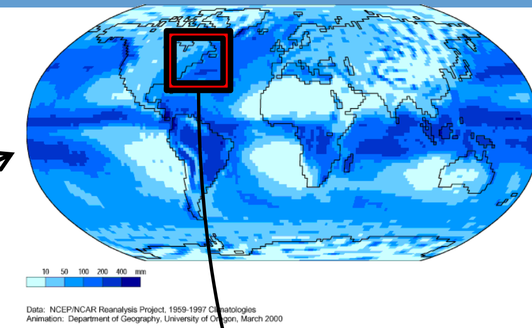
Geography Department, U. Oregon

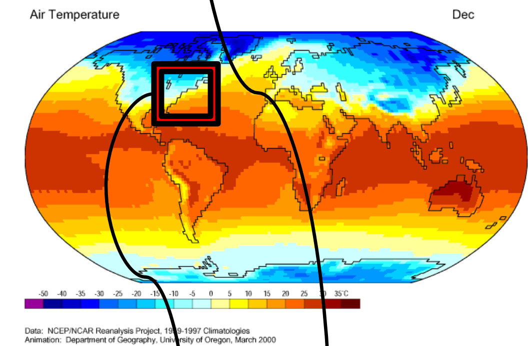
Emission Scenarios



General Circulation Models (GCMs)

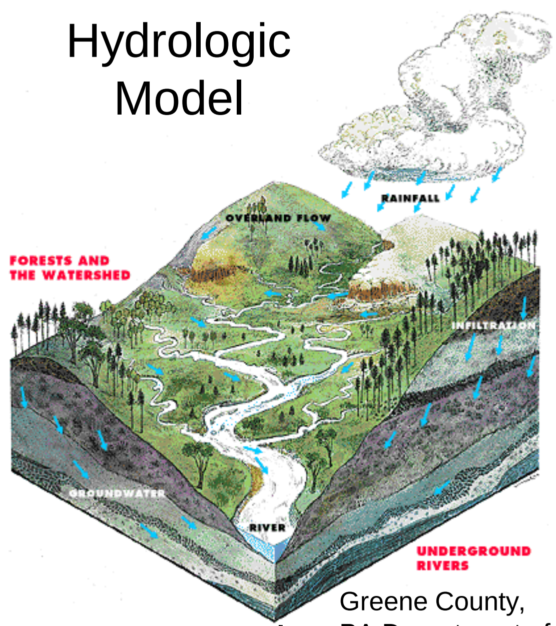






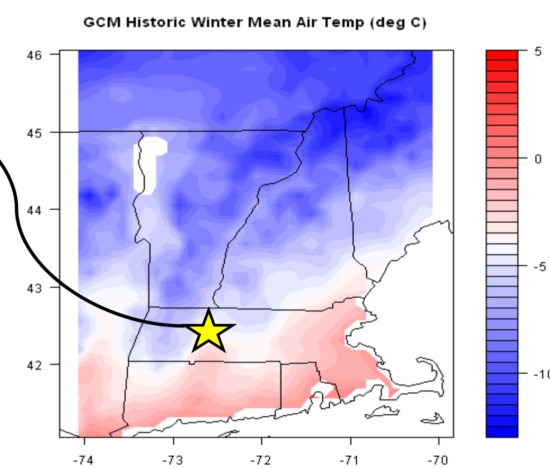
Water System Performance Under Future Climate Scenarios

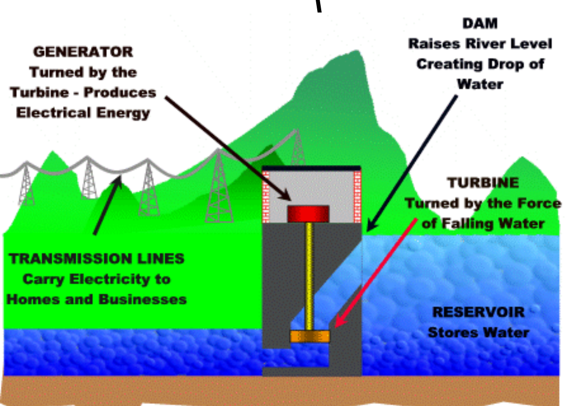
Hydrologic Model



Greene County, PA Department of Econ. Development

Downscaling





Wisconsin Valley Improvement Company

Water Resources System Model

The Decision Tree for Climate Risk

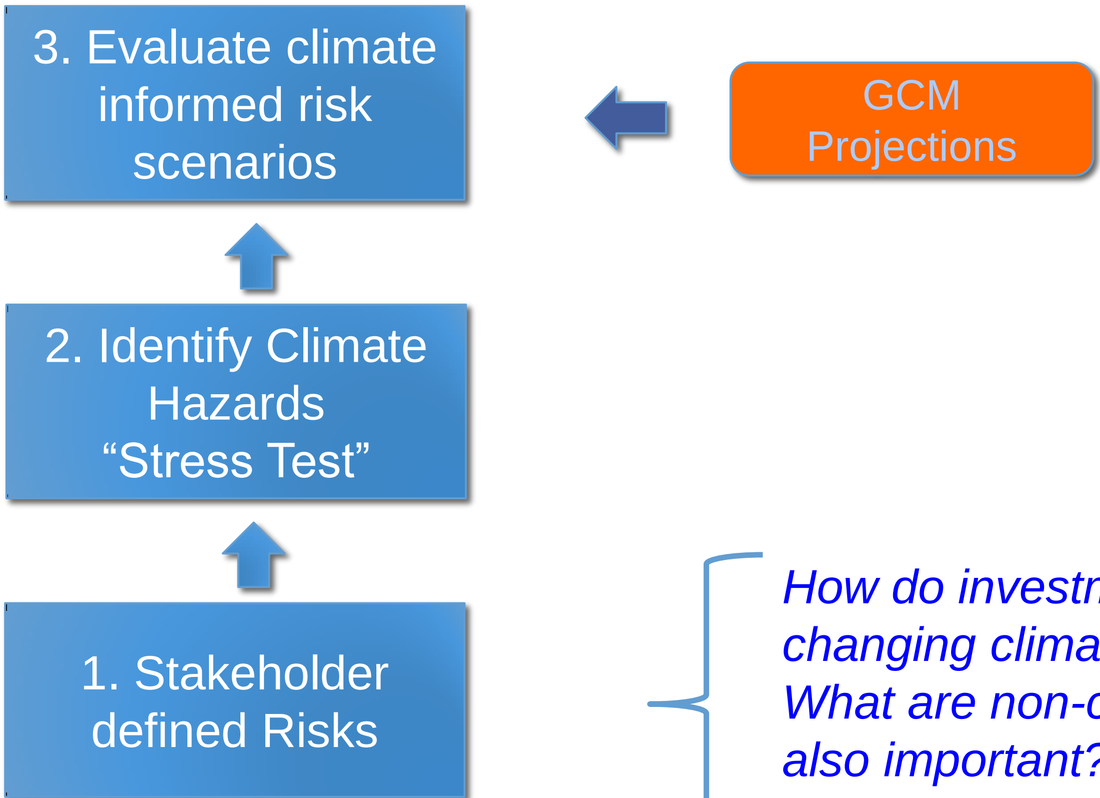
- Guidance for conducting Climate Risk Assessment for water infrastructure

- Designed to screen first and increase analysis *only if required*

- Bottom up = Project focused

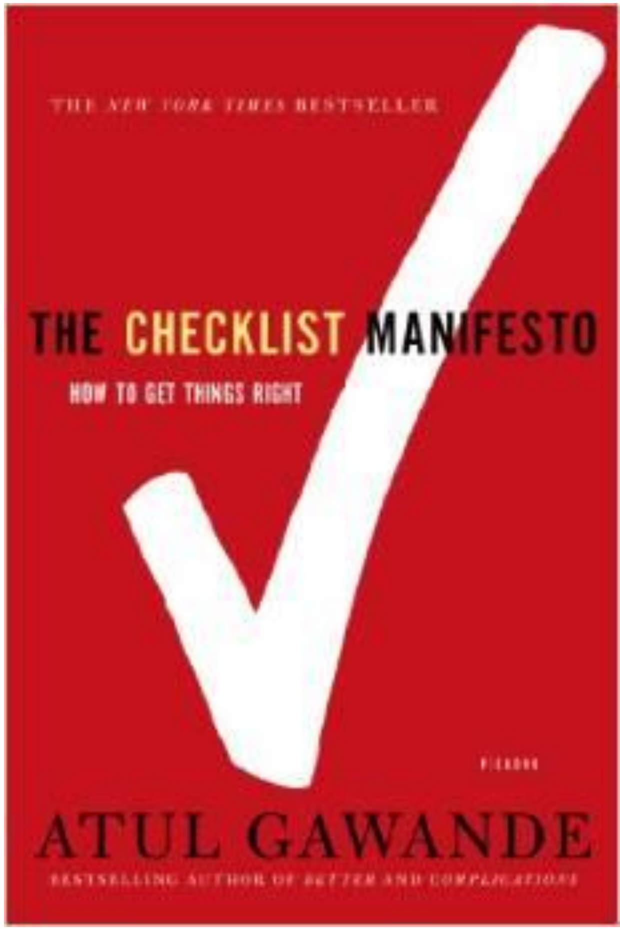
Decision-centric Climate Science

"Decision Scaling", Brown and Wilby, 2012
(EOS)



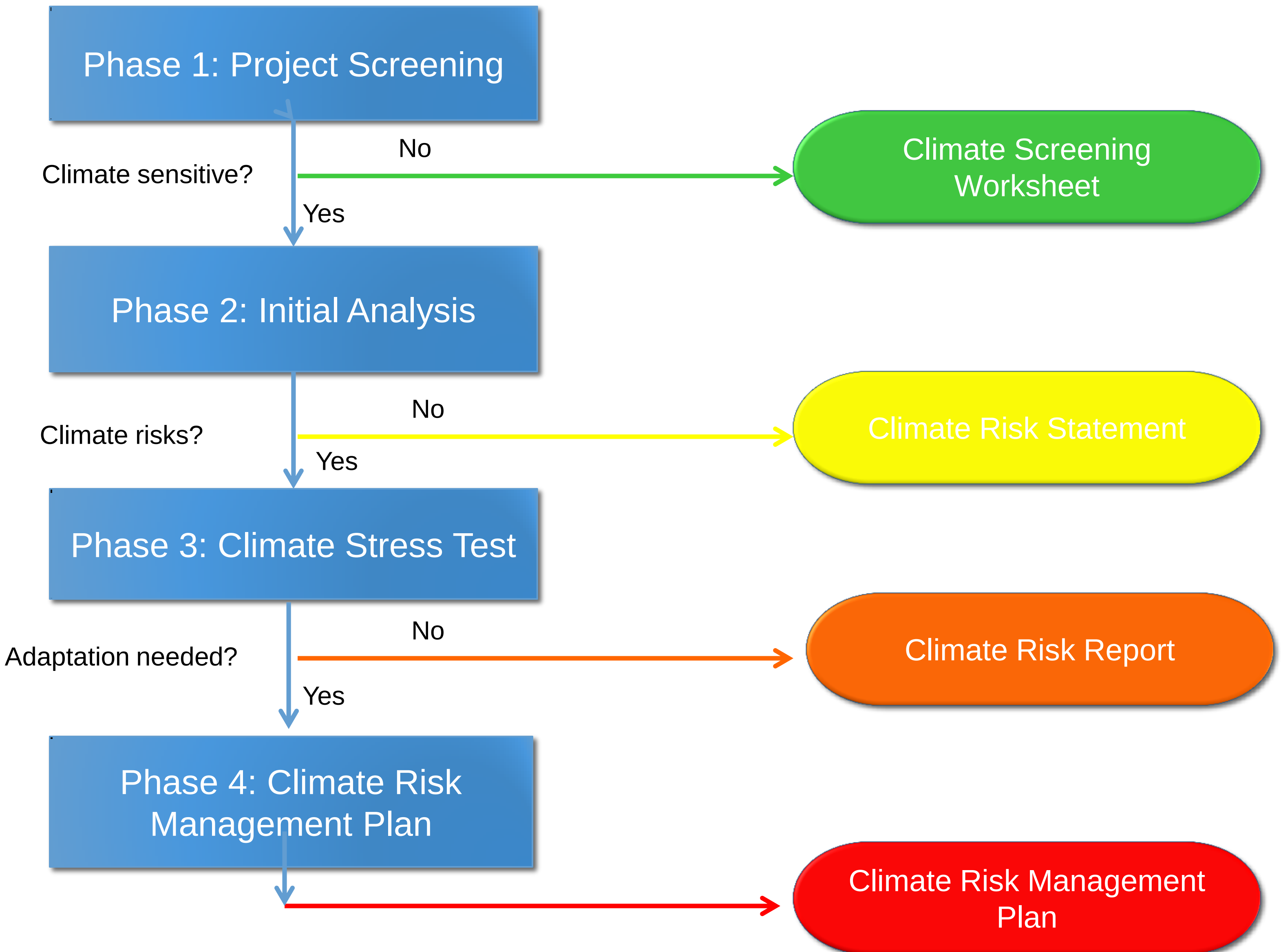
How do investments respond to changing climate conditions?
What are non-climate factors that are also important?
At what level of change makes an investment fail?

A "Checklist" Approach

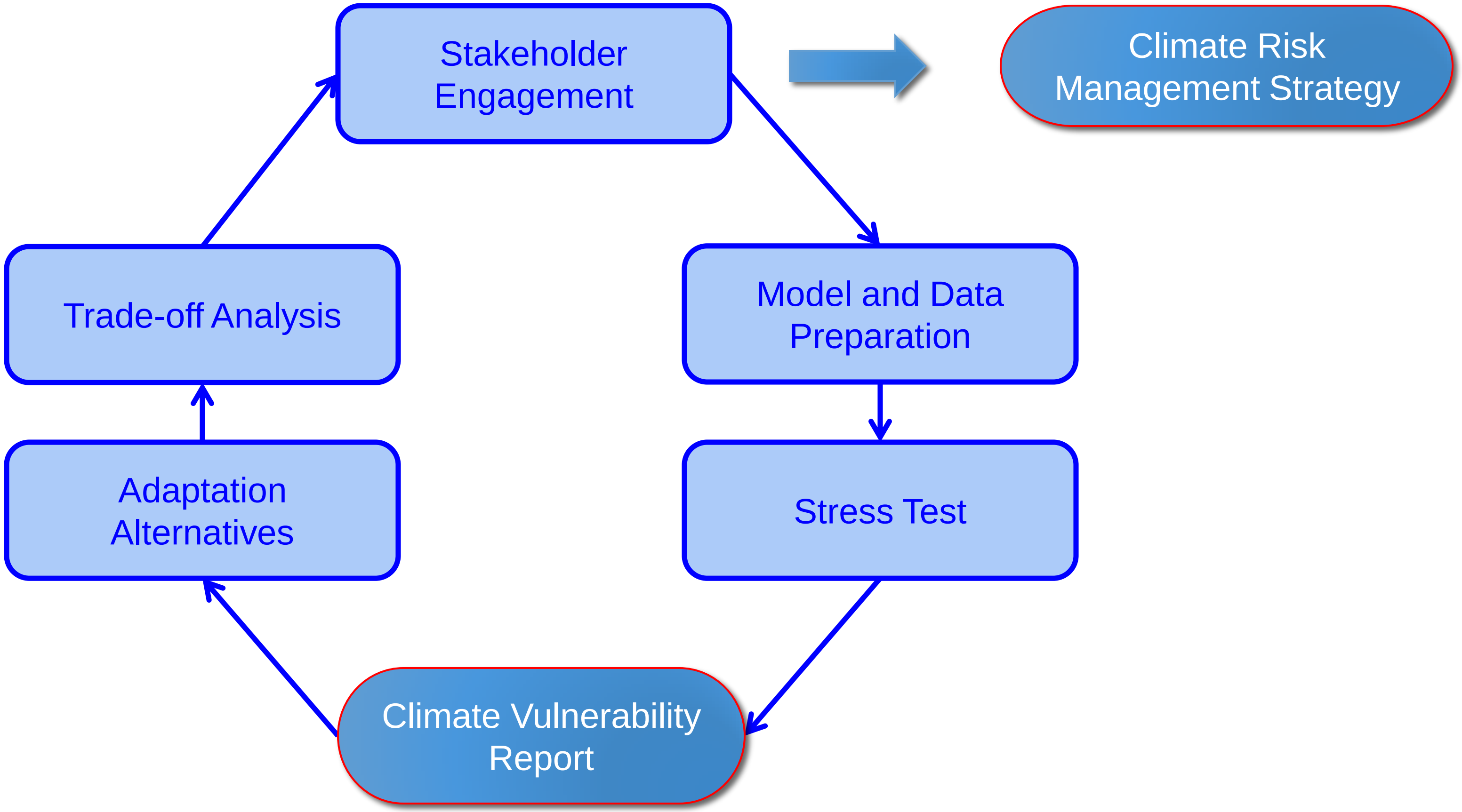


- Straightforward to implement
- Defensible process – passes the board
- Hierarchy of effort
  - Screening level vs detailed assessment
- Adds value to the process
  - More robust to uncertainty
  - Builds consensus among constituencies

Decision Tree for Climate Risk Assessment



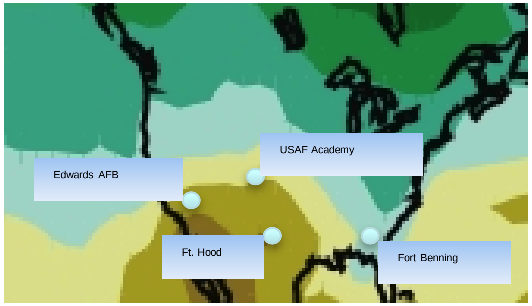
Decision Tree Step 4: Climate Risk Management

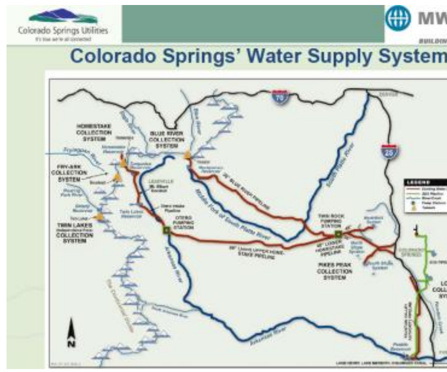


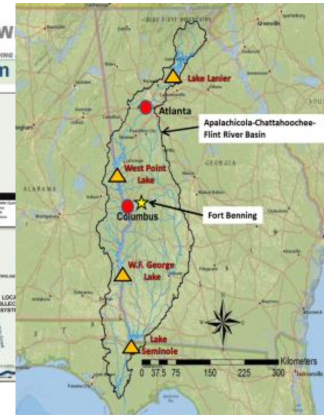
DECISION SCALING

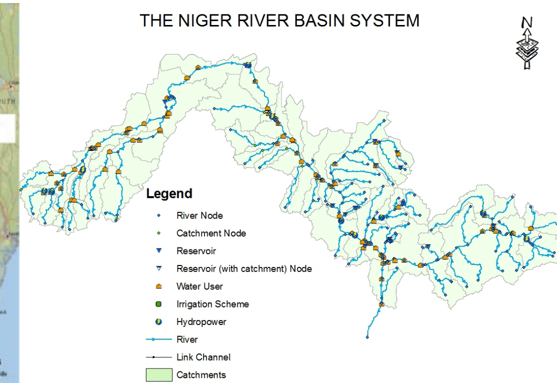
Stage 4 Examples

Decision Scaling Project Sites







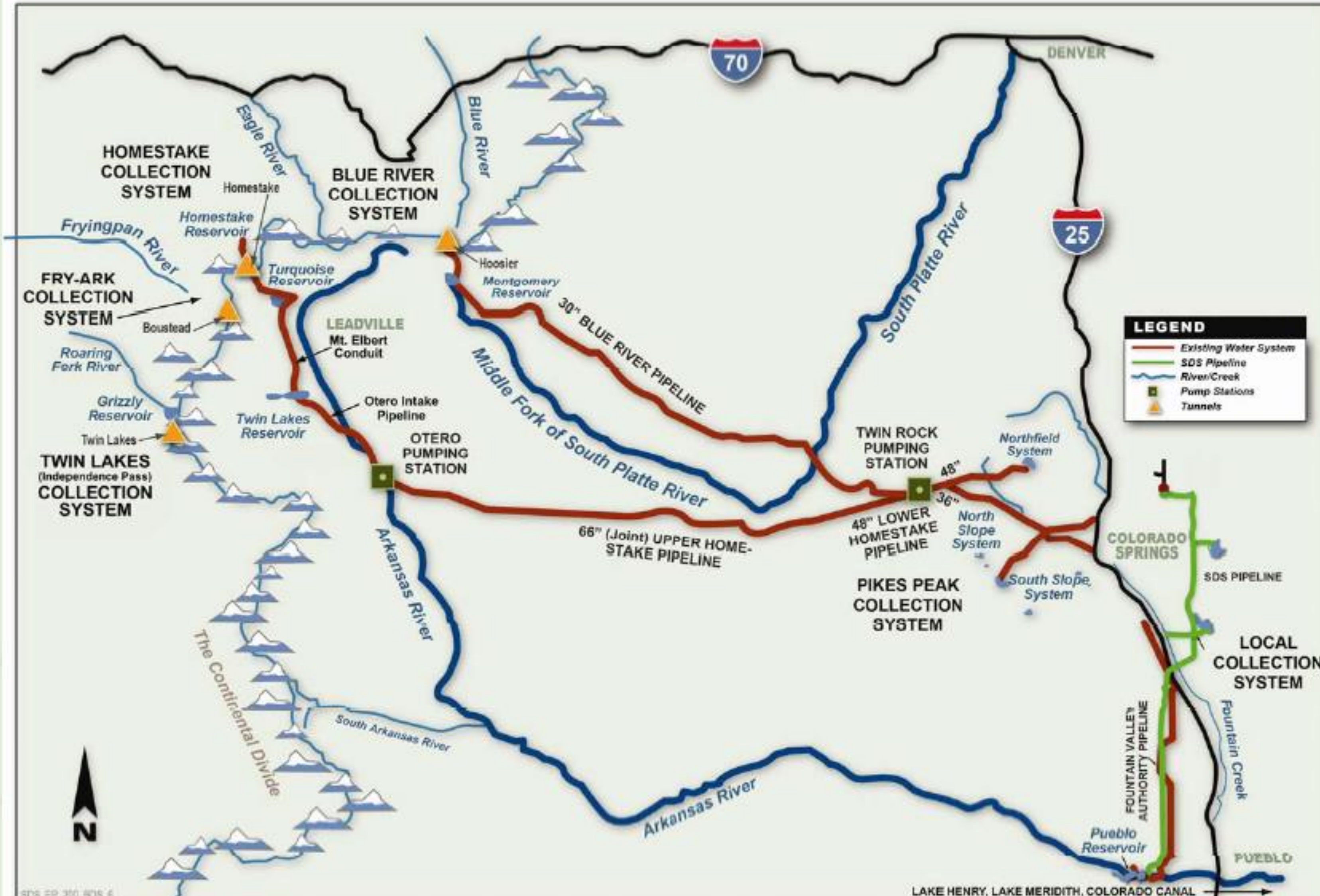


- Great Lakes of North America
- Kosi River Basin, Nepal
- Indus River Basin, Pakistan
- Niger River Basin
- Colorado Springs Water Supply
- Northeast US Water Supply (NYC, Boston, Providence, Hartford, Springfield)
- California Department of Water Resources
- Texas Water Supply (Fort Hood)
- Southeast US (Appalachicola-Chattahoochee-Flint

Colorado Springs Utilities
It's how we're all connected

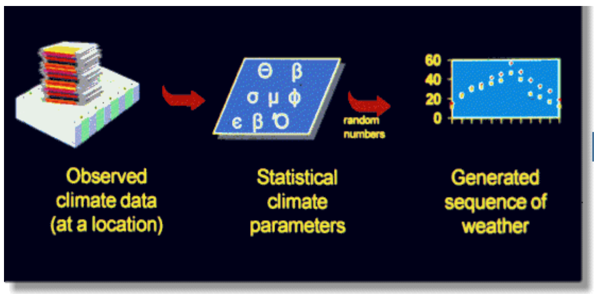
MWH
BUILDING A BET

Colorado Springs' Water Supply System

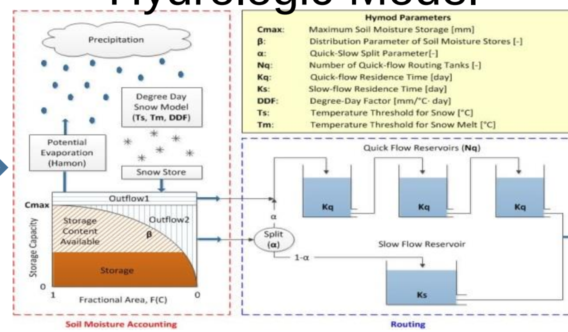


Climate Stress Test

Climate/Weather Generator

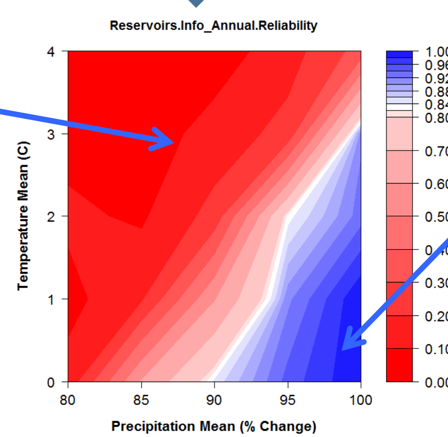


Hydrologic Model



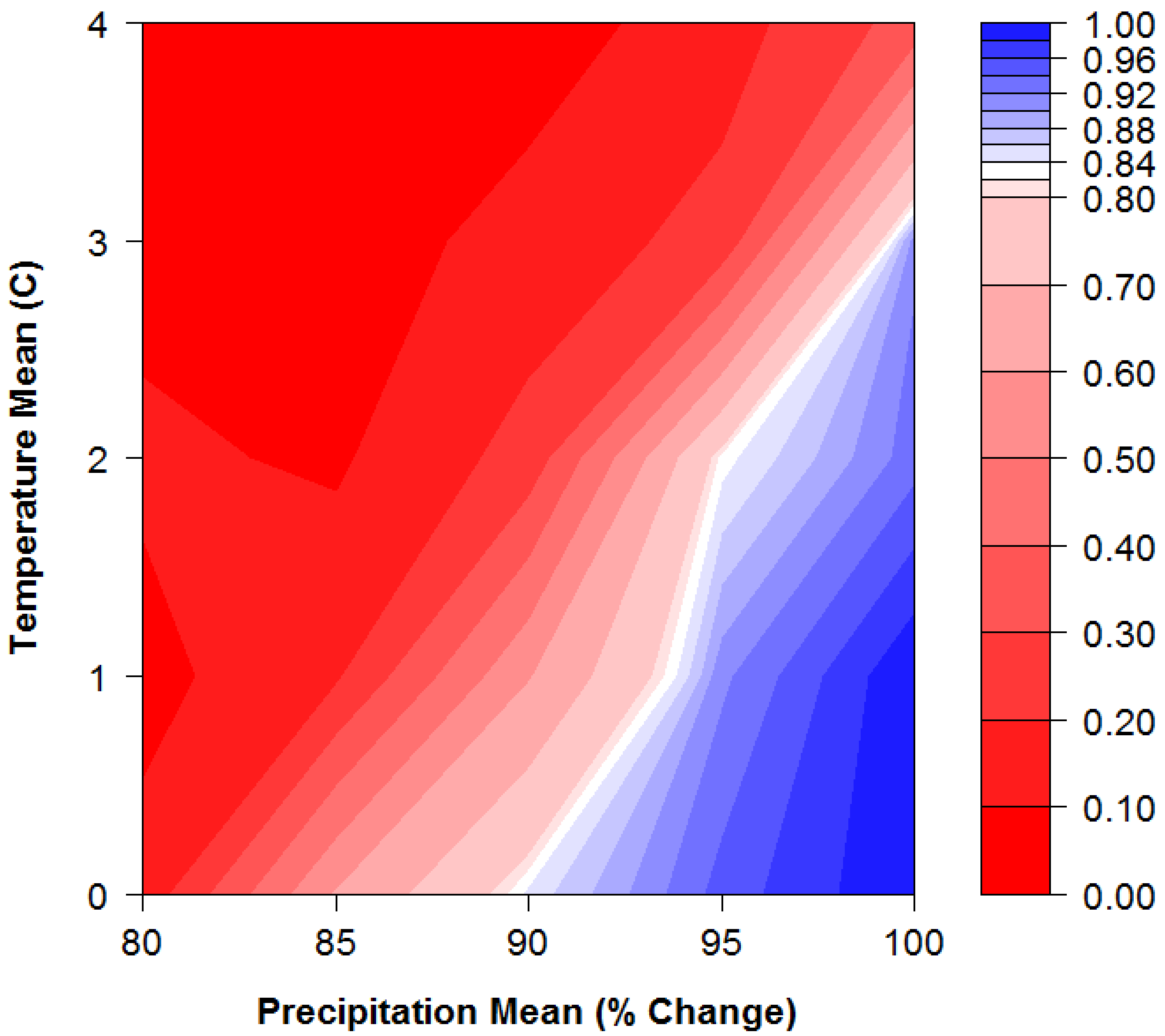
Wat. Res. Model

Climate Vulnerability

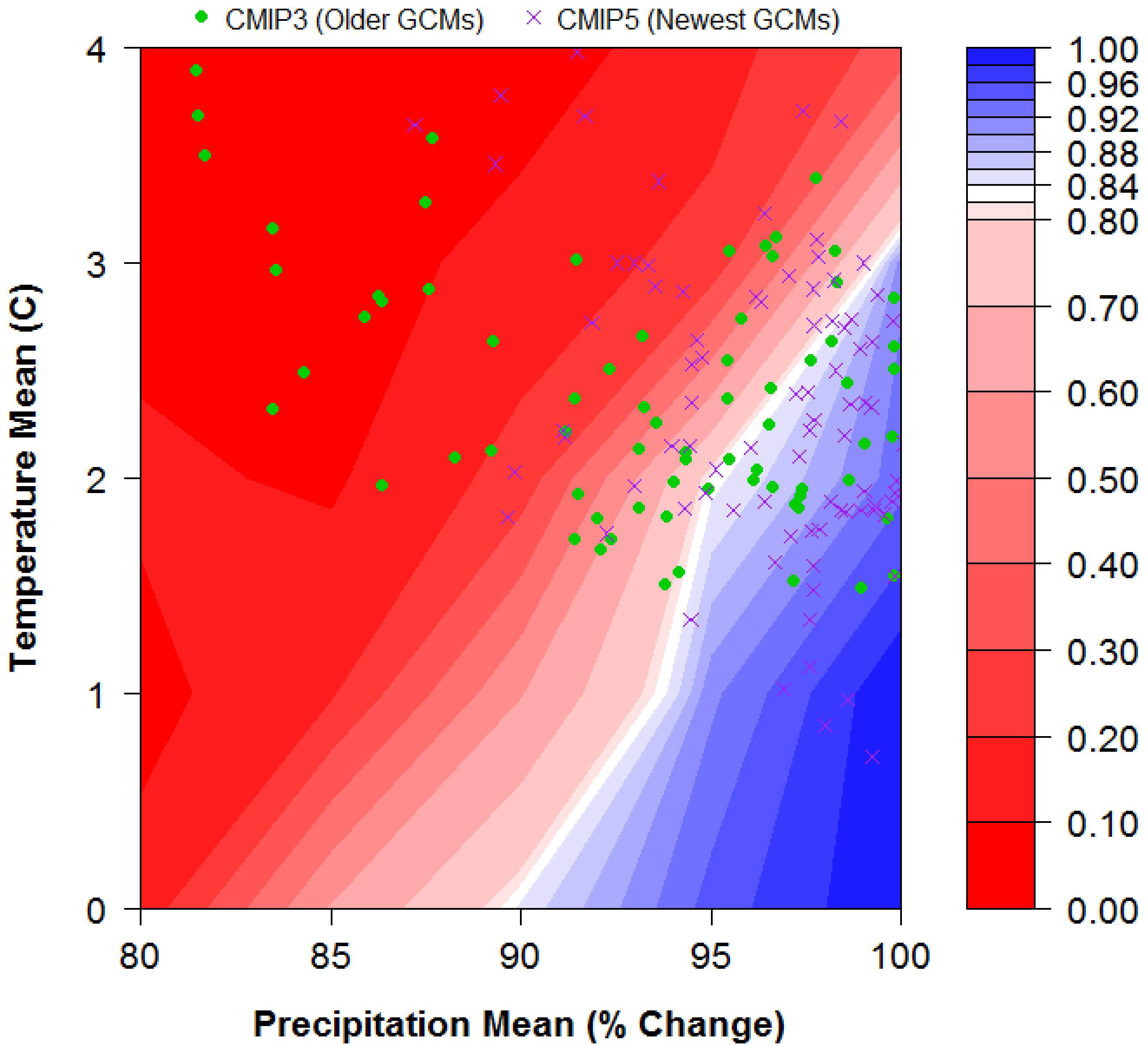


Robust

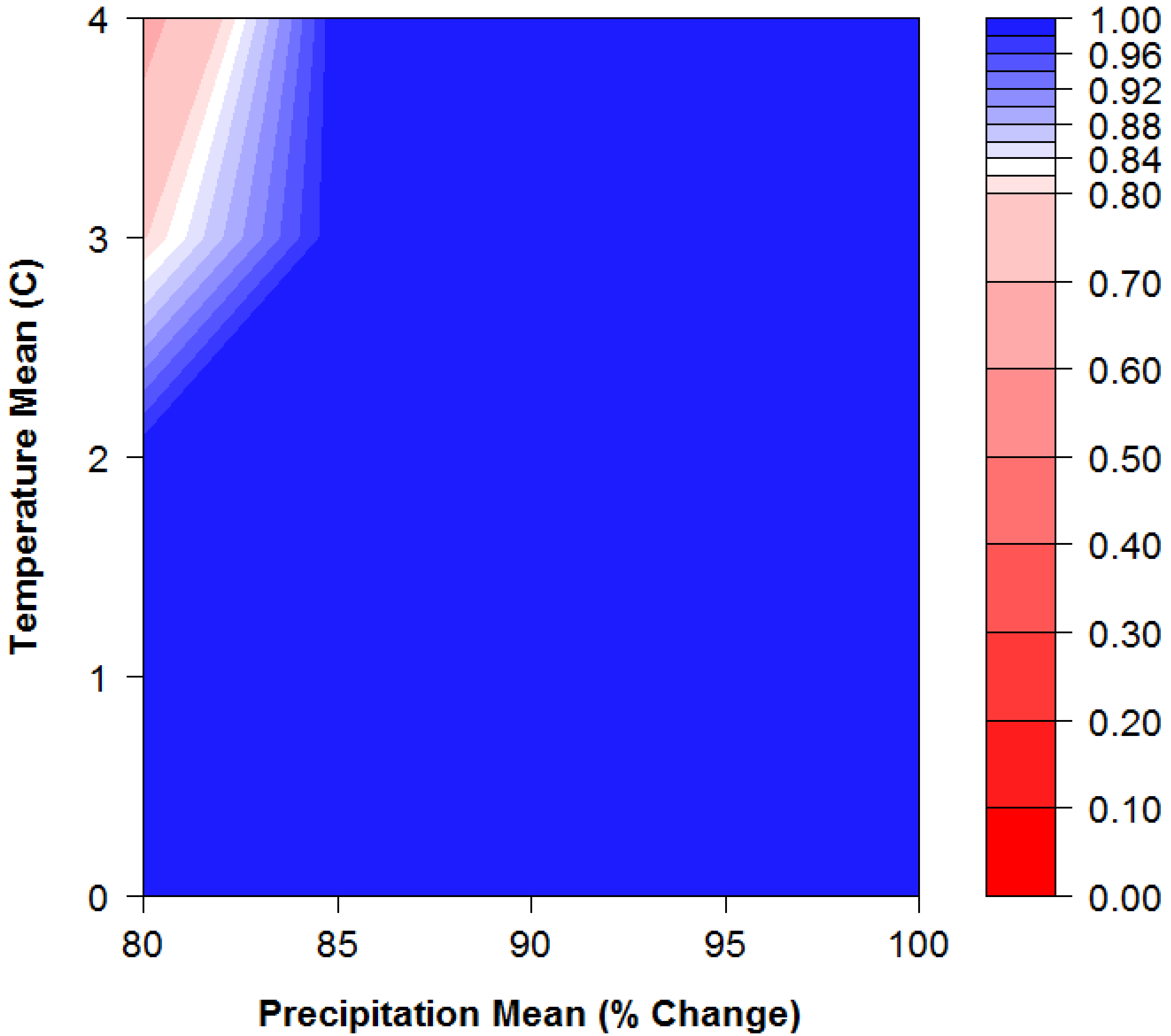
Colorado Springs (USAFA): Future Conditions



Colorado Springs (USAFA) Water Assessment



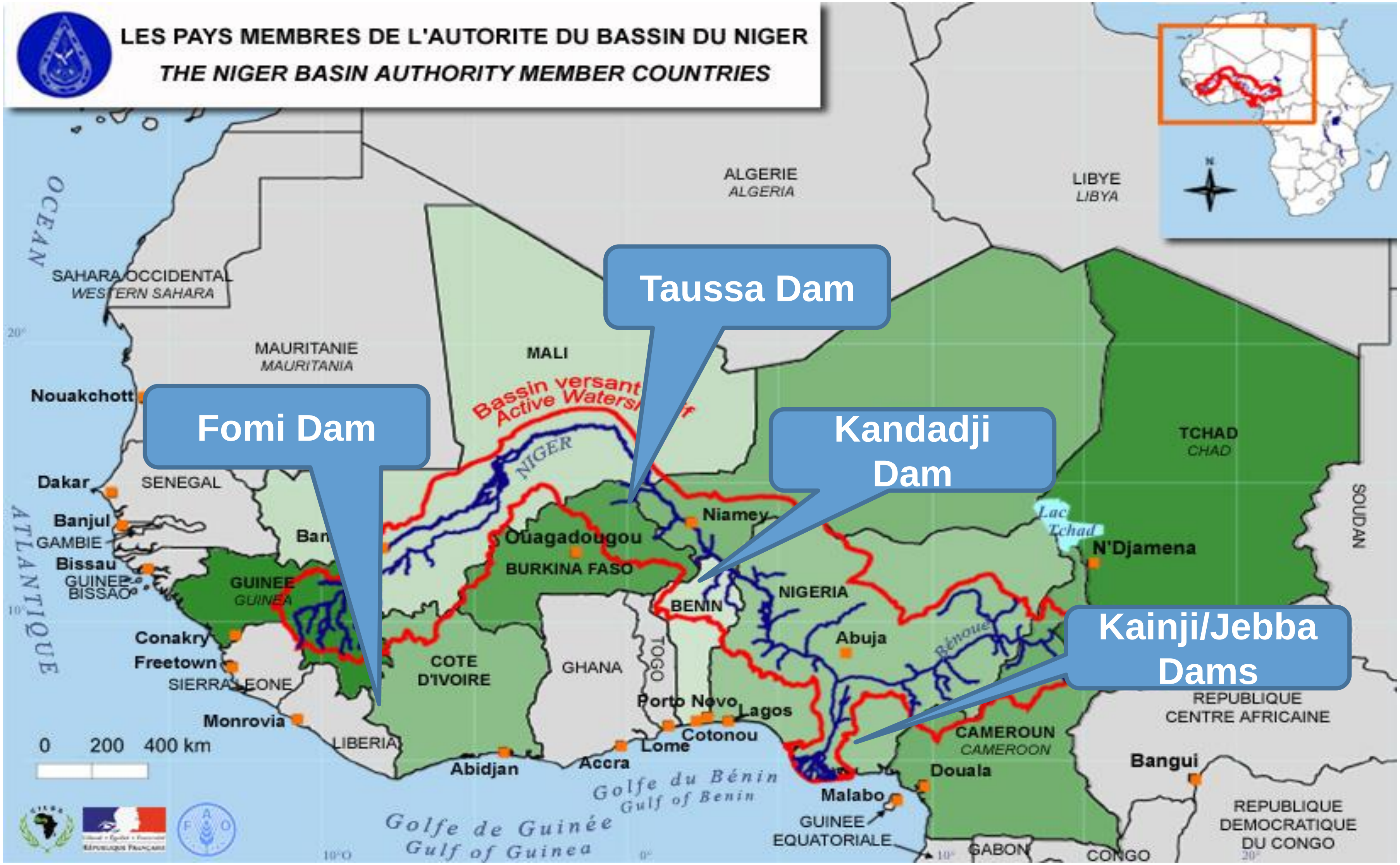
Colorado Springs (USAFA): Demand Reduction Scenario



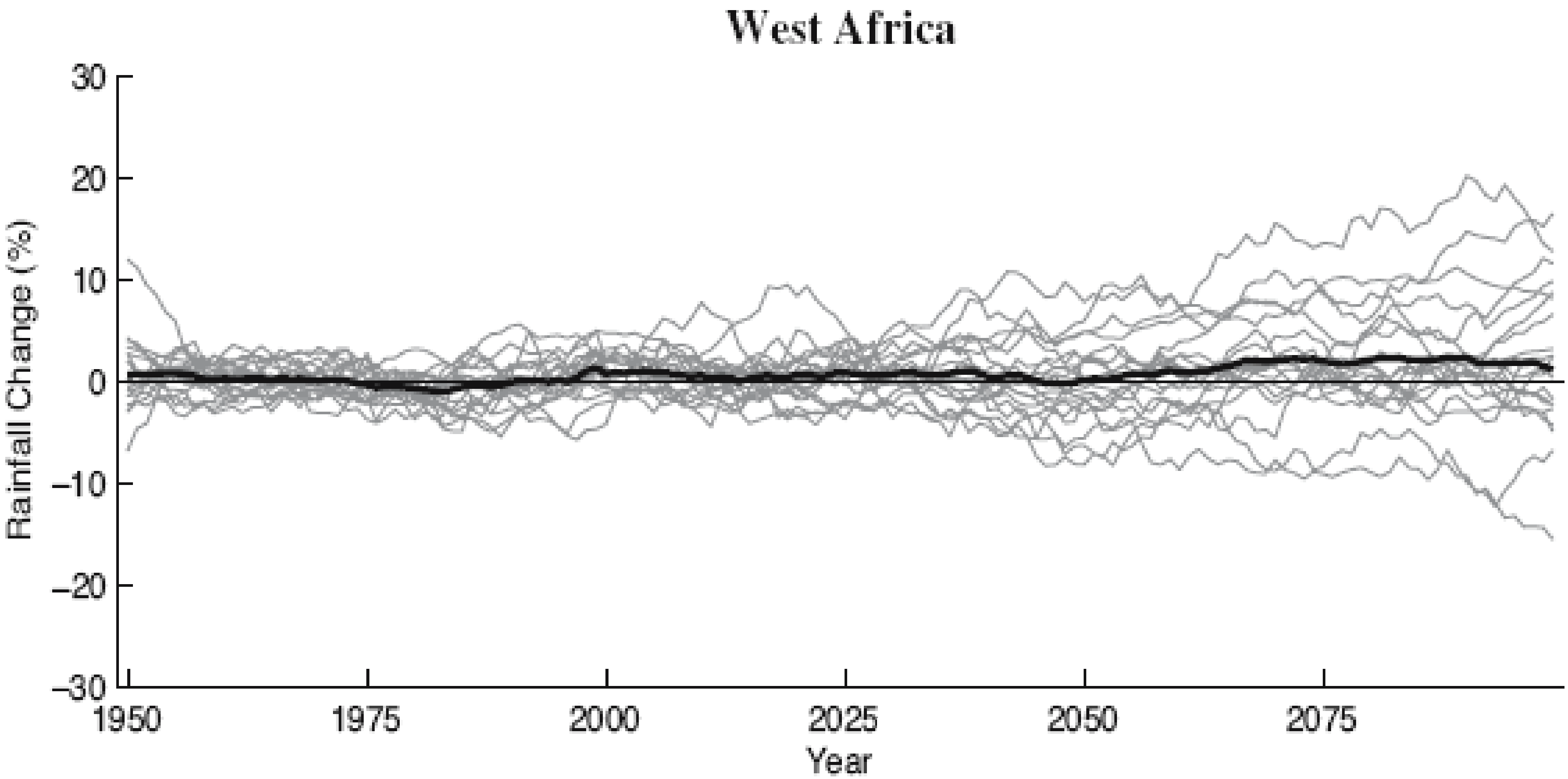
Assessment of Climate Risks to the Niger Basin Investment Program

- **Investment plan of $8 billion over next 20 years**
- **Team: Brown, Yonas Ghile, Ken Hunu, Amal Talbi, N. Harshadeep, Tony Garvey, Johan Grijsen, Aondover Tarhule, Hrishi Patel**

SDAP development of the Niger River Basin

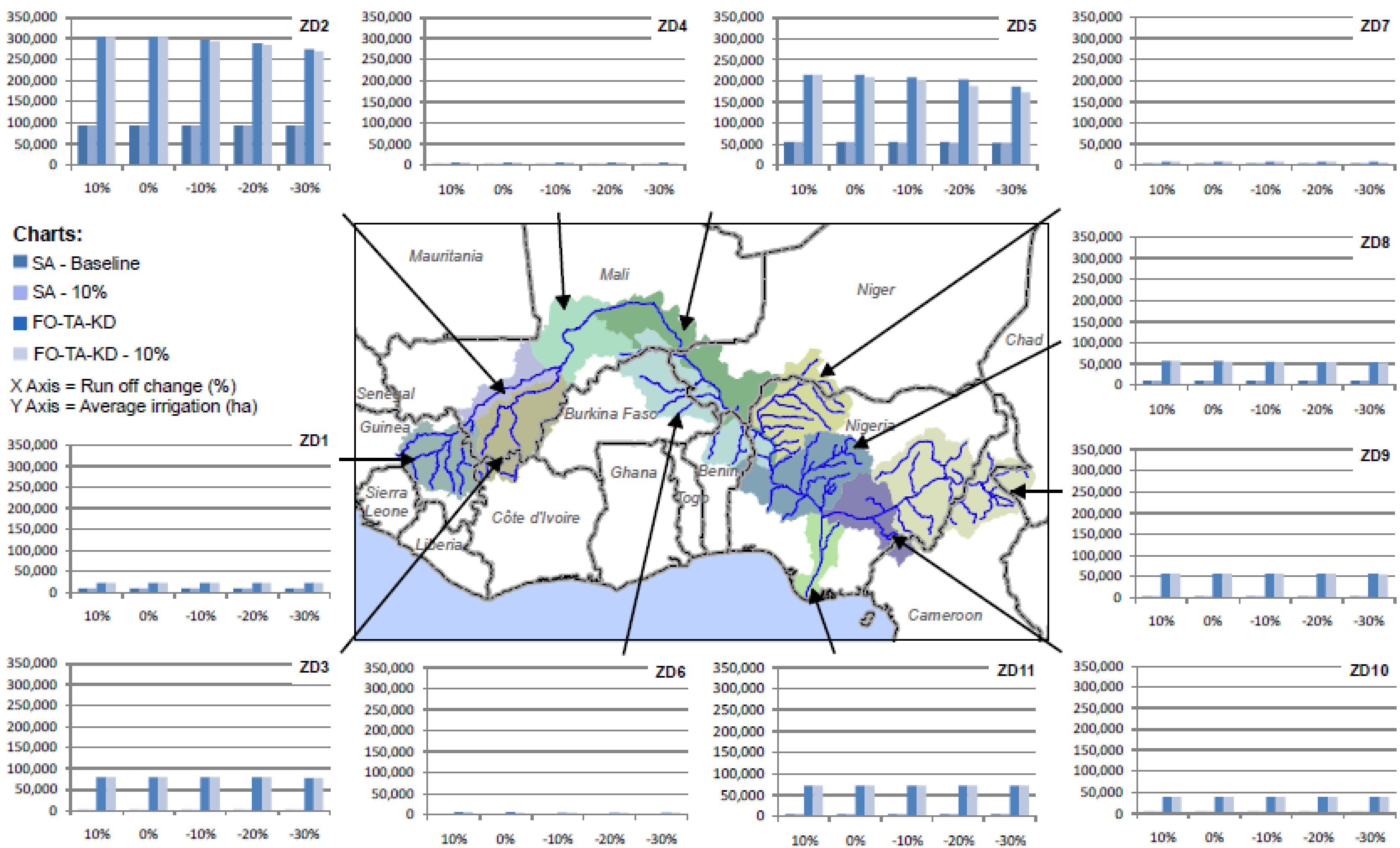


The future is uncertain …

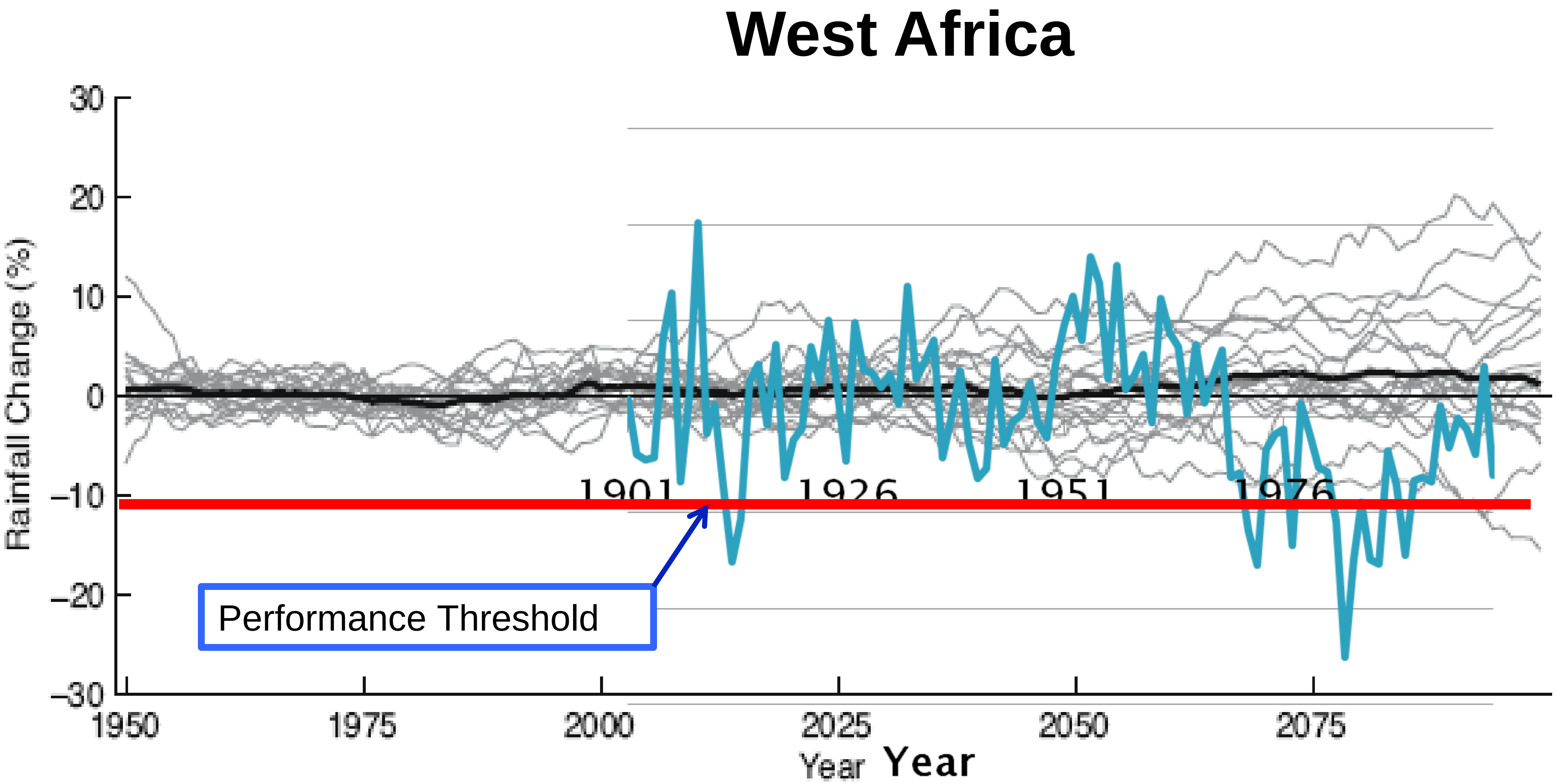


Wet Season Rice

Irrigation Sensitivity - Wet Season Rice



Models agree on low risk!



Conclusion

- Planners need guidance on how to plan for the uncertainties associated with climate change
- Decision Tree designed as straightforward and defensible process for assessing climate risks
- Informed by but not driven by climate model projections
- Climate Informed Decision Analysis can leads to plans that are robust to climate (and other) uncertainties

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Further Reading

- Brown, C. and R. L. Wilby (2012), An alternate approach to assessing climate risks, *Eos Trans. AGU*, 93(41), 401, doi:10.1029/2012EO410001.
- Moody, P. and C. Brown (2012), Modeling stakeholder-defined climate risk on the Upper Great Lakes, *Water Resources Research*, 48, W10524, doi:10.1029/2012WR012497.
- Brown, C., Y. Ghile, M. A. Laverty, and K. Li (2012), Decision scaling: Linking bottom-up vulnerability analysis with climate projections in the water sector, *Water Resour. Res.*, doi:10.1029/2011WR011212.
- Brown, C., Werick, W., Fay, D., and Leger, W. (2011) "A Decision Analytic Approach to Managing Climate Risks - Application to the Upper Great Lakes" Journal of the American Water Resources Association, 47, 3, doi/10.1111/j.1752-1688.2011.00552.x.
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- Brown, C. (2011) "Decision-scaling for robust planning and policy under climate uncertainty." World Resources Report, Washington DC. Available online at http://www.worldresourcesreport.org