

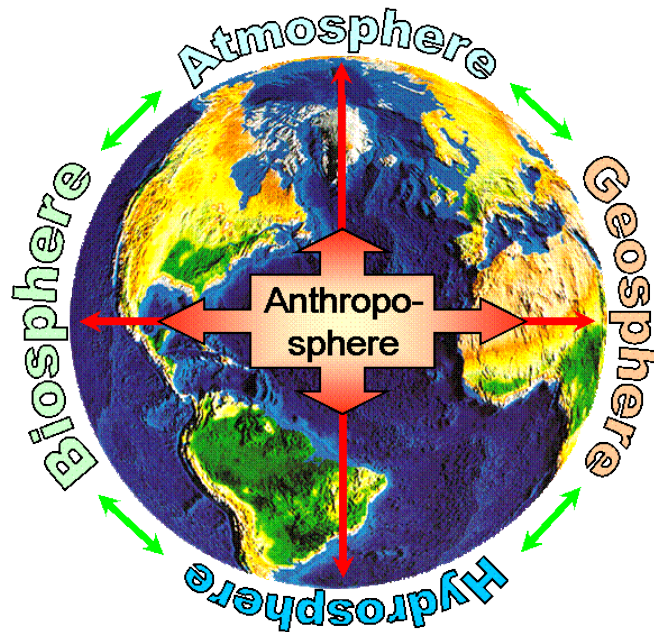
# Energy and Water in the Earth System: An Integrated Modelling Approach



**Patrick Breach, PhD Student**  
**Prof. Slobodan P. Simonovic, PhD, P.Eng**

# Introduction

- Human activity has the ability to influence global systems composing the *Earth system*
- Drive to understand interconnections to facilitate policy and decision making to adapt to global change



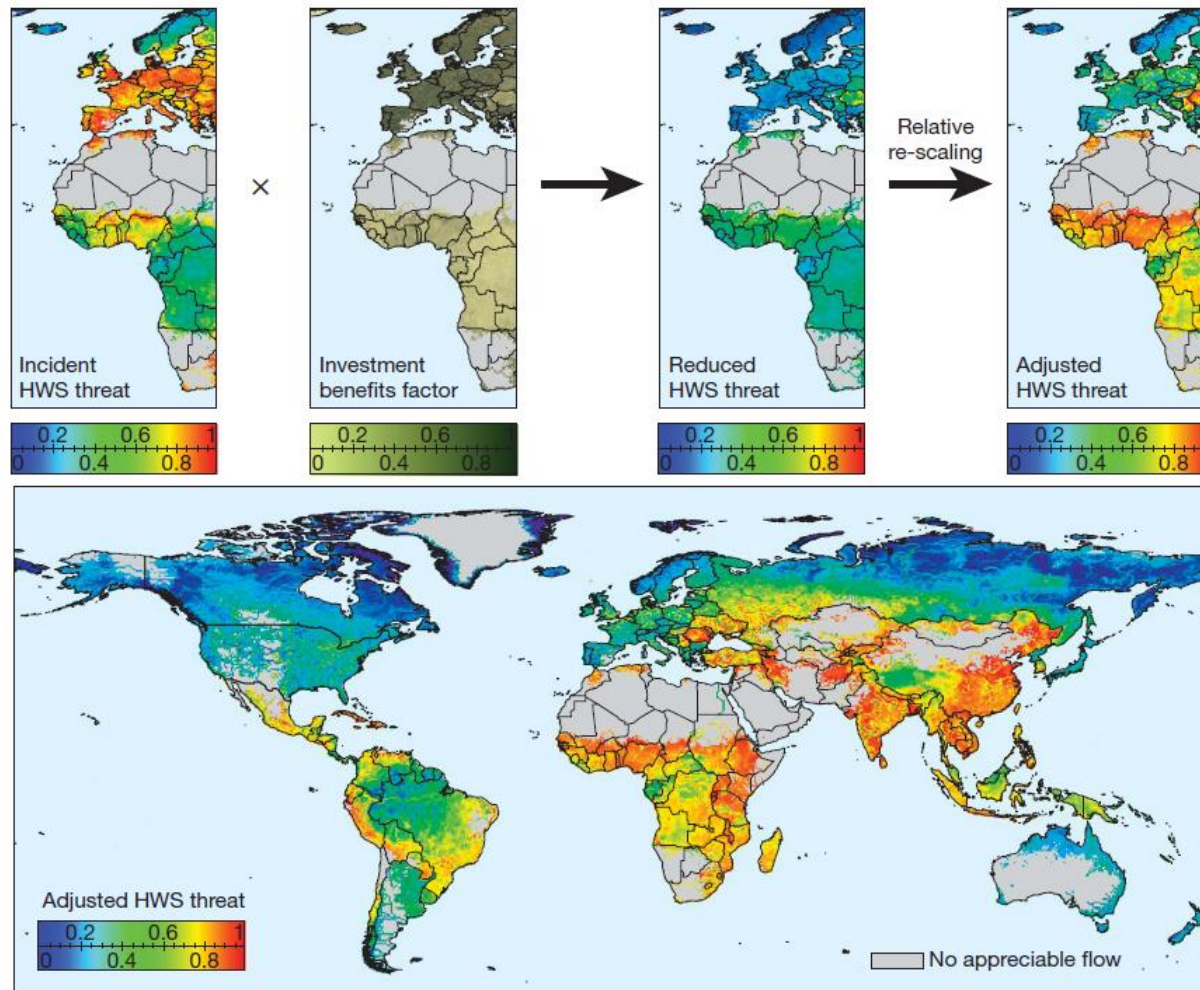
The earth system consists of positive and negative feedback loops.

Small changes caused by man such as CO<sub>2</sub> and other climate forcing as well as pollution impact right across all interconnected systems throughout the global commons

# Introduction

- Energy and water supply are important components as they are limiting factors for human development
- Sources of energy and water should be sustainably managed
- Alternative forms of water supply and energy production will likely play a vital role in the future
- How will the development of alternate supplies affect the dynamics of global change?

# Introduction



Vorösmarty et al. (2010)



# Introduction

- Alternative energy sources:
  - Recovered heat and bioenergy from wastewater treatment



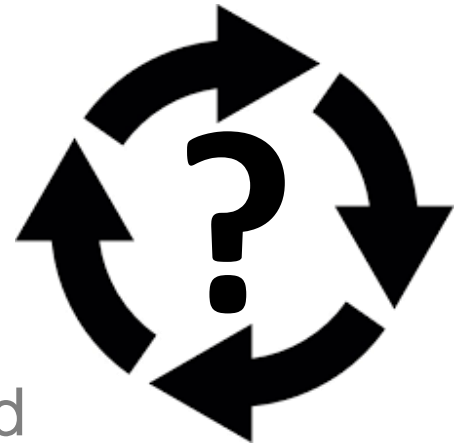
# Introduction

- Alternative water sources:
  - Desalination
  - Wastewater reuse
  - Groundwater mining



# Research Questions

- How will the development of alternate supplies affect the dynamics of global change?
- Will capital resources be sufficient to adapt to:
  - Water stress as a result of population growth and climate change?
  - Depleting fossil fuel resources and increased energy demand?
- What feedbacks exist between water and energy supply development?

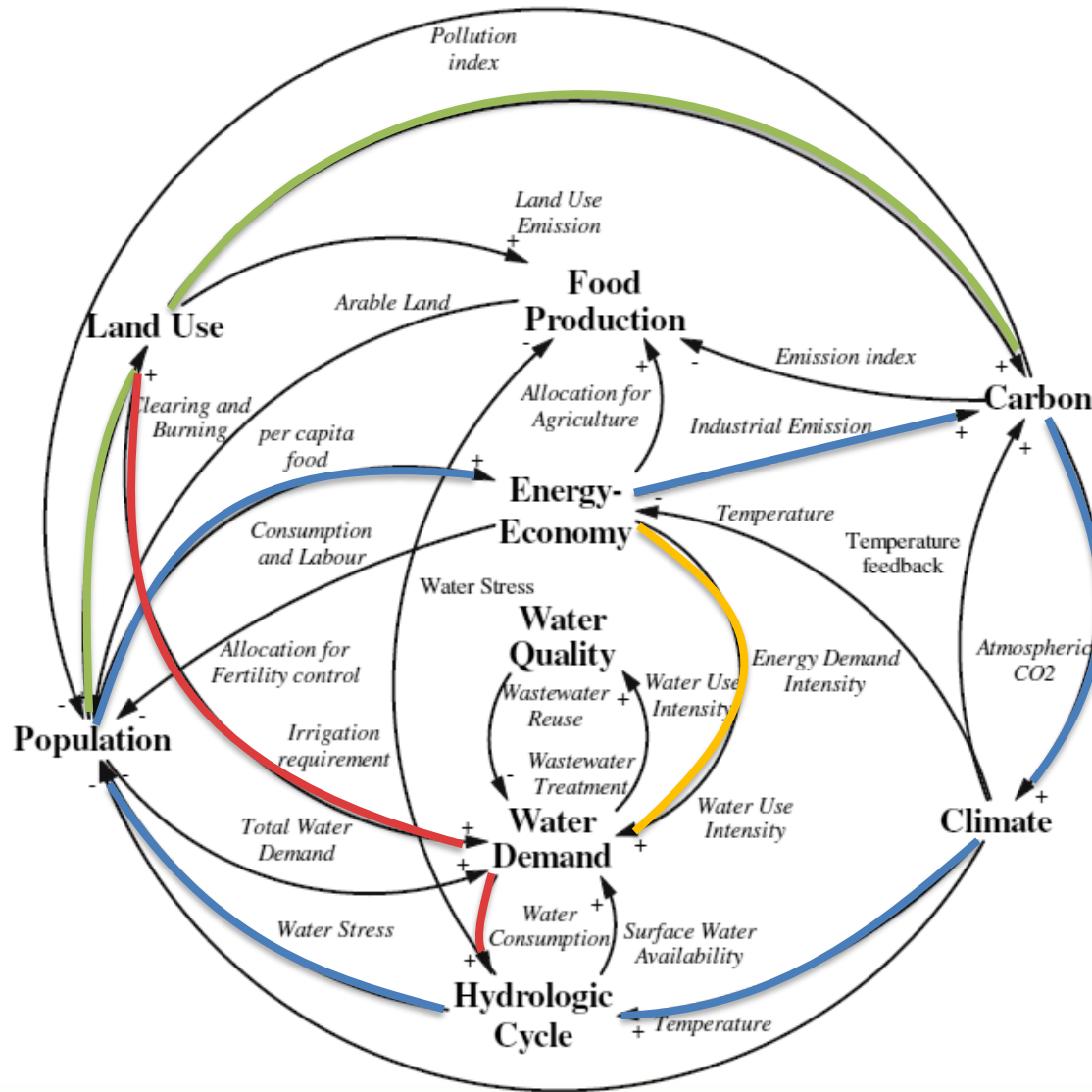


# Modelling Approach

- Build onto ANEMI Integrated Assessment Model
- Break out capital stocks for energy and water supply infrastructures
- Determine the effect of increased energy demand and water stress on the distribution of capital
- Assess the ability to adapt in future time period



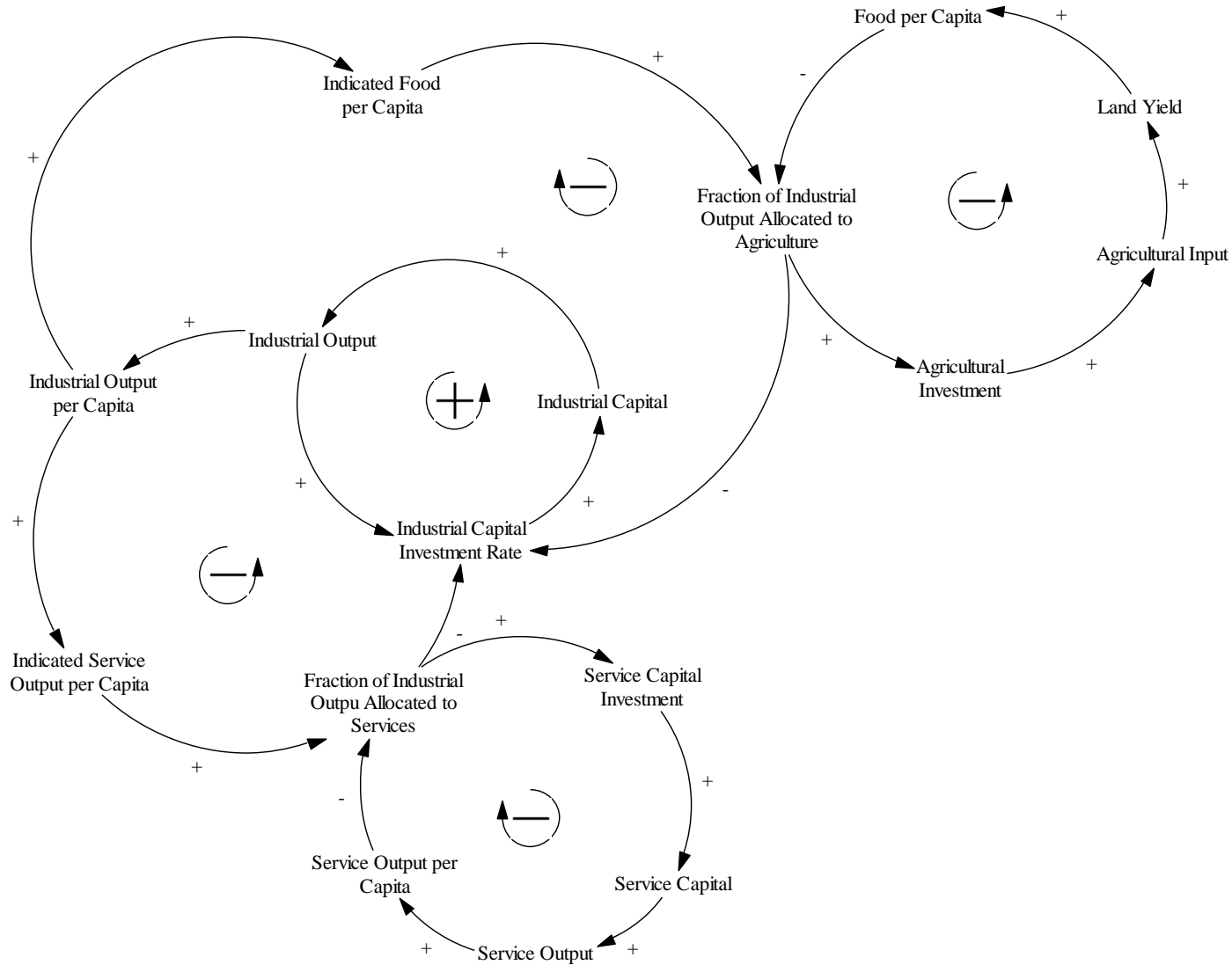
# ANEMI2 Integrated Assessment Model



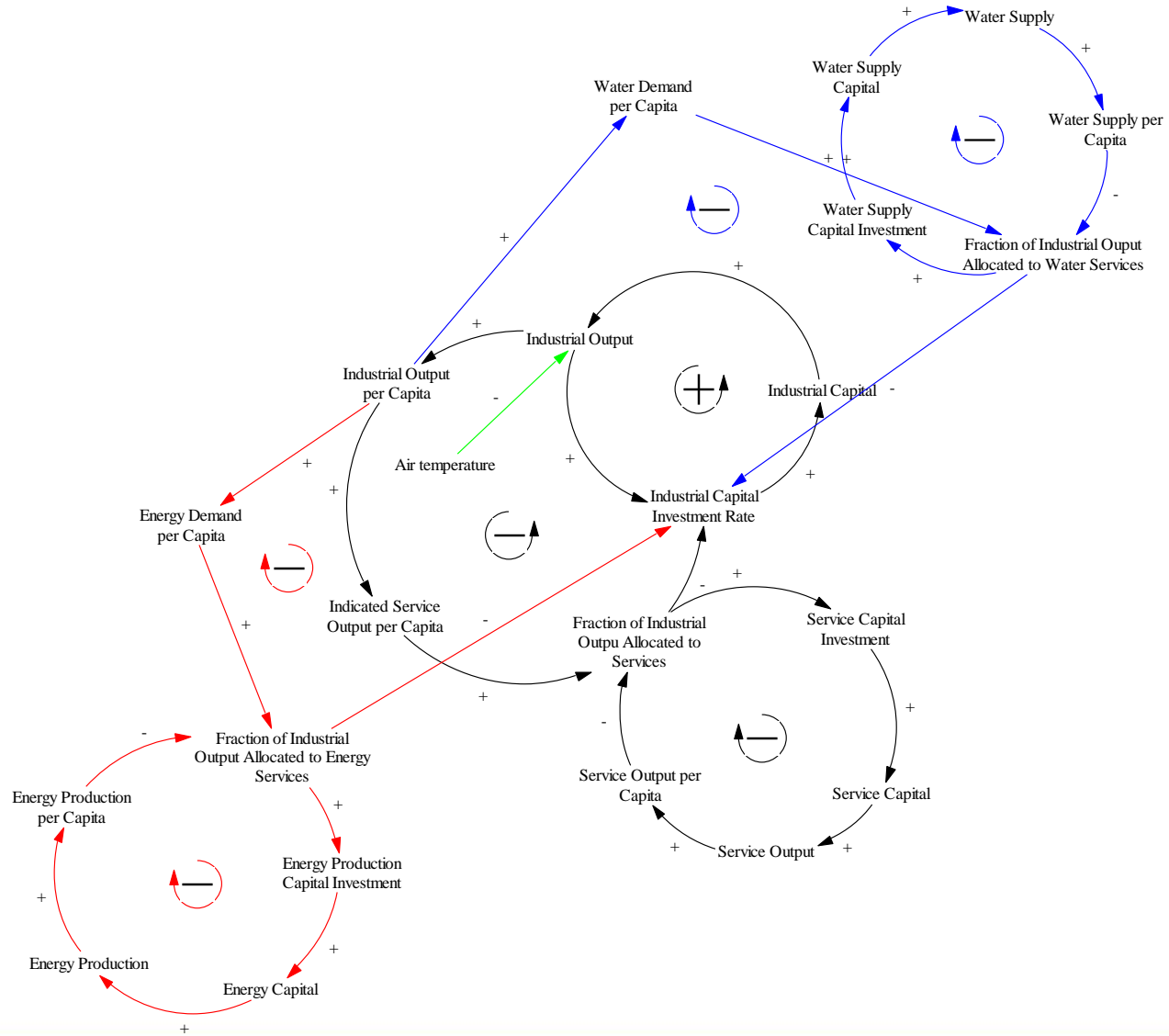
# ANEMI Integrated Assessment Model

- Used in the past to assess:
  - Global change from an integrated system dynamics simulation based perspective
  - Dynamics of global water stress with the inclusion of pollution effects
  - Impact of carbon taxation on global energy-economy, CO<sub>2</sub> emissions, and climate

# WORLD 3 Capital Sector Feedbacks

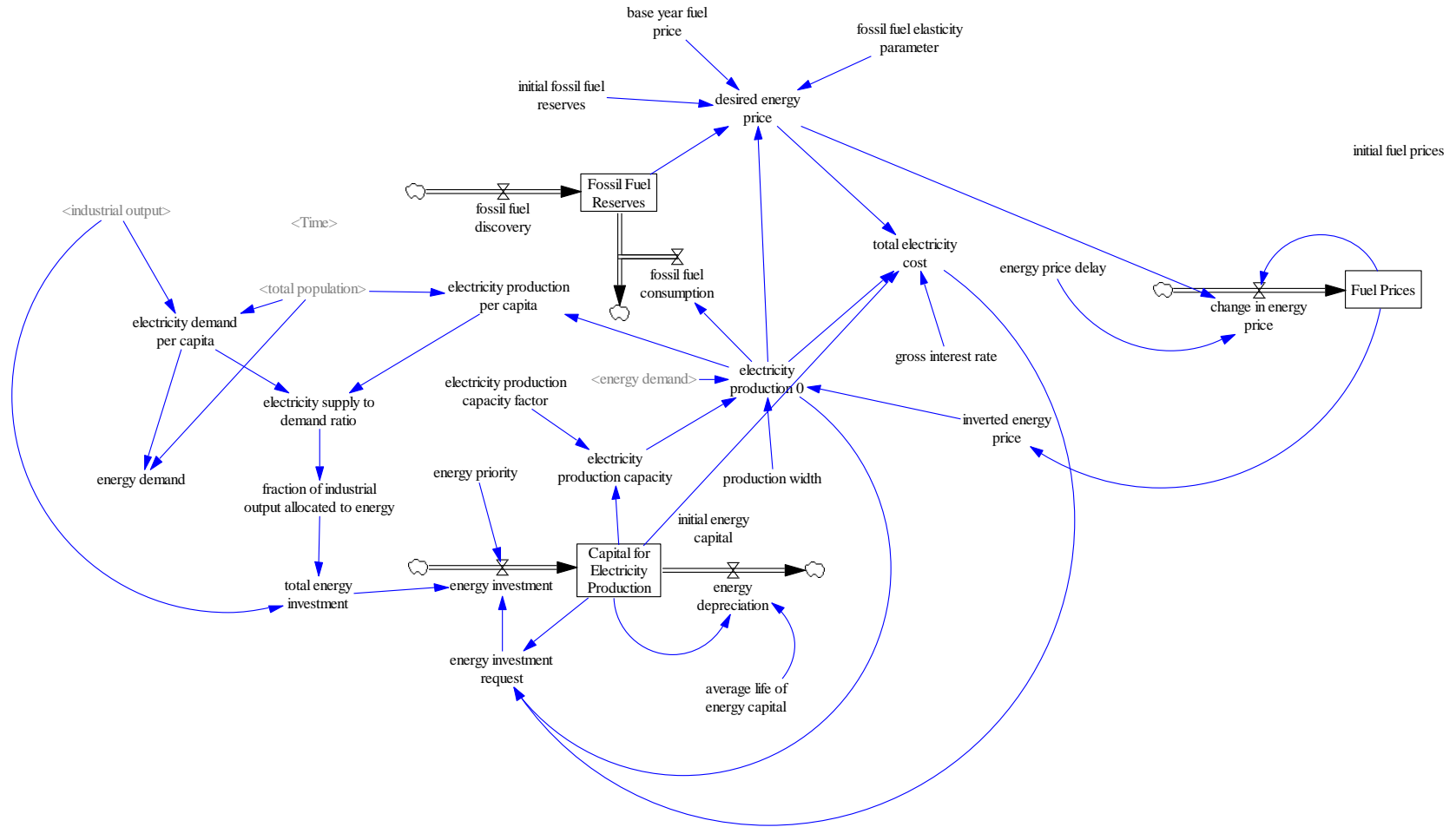


# ANEMI3 Capital Sector Feedbacks

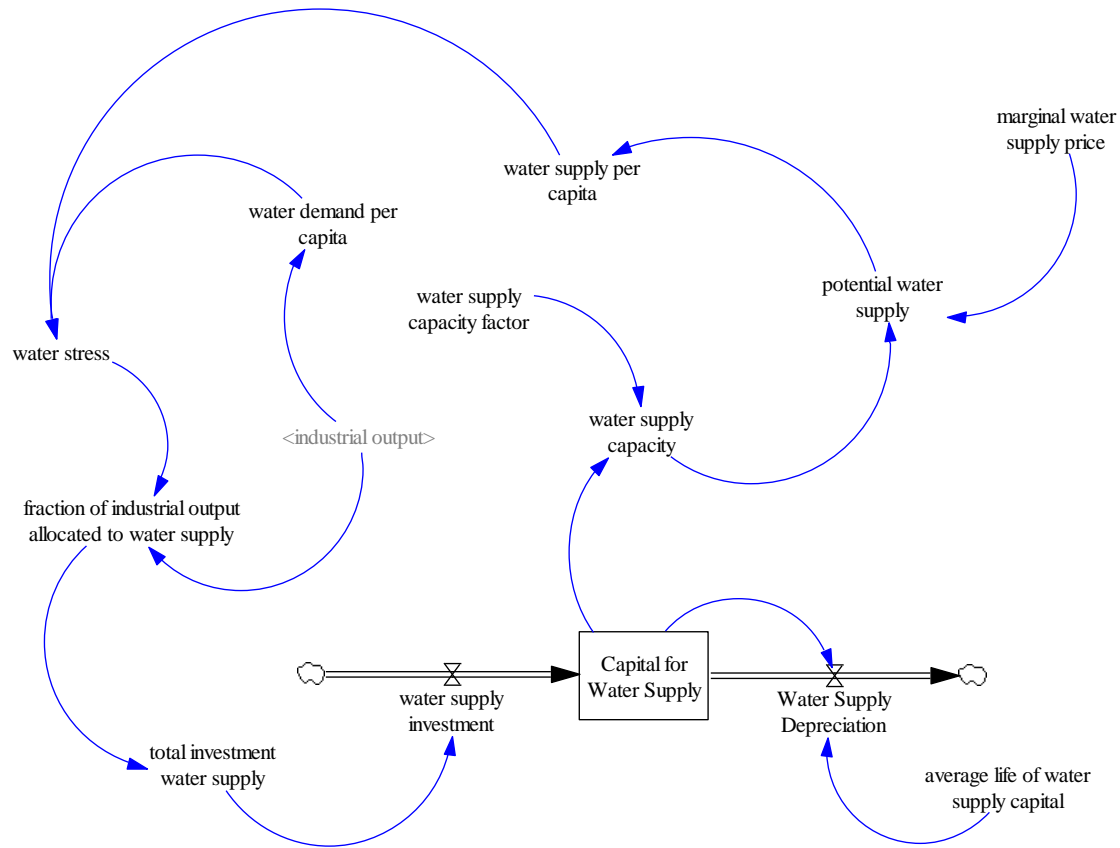




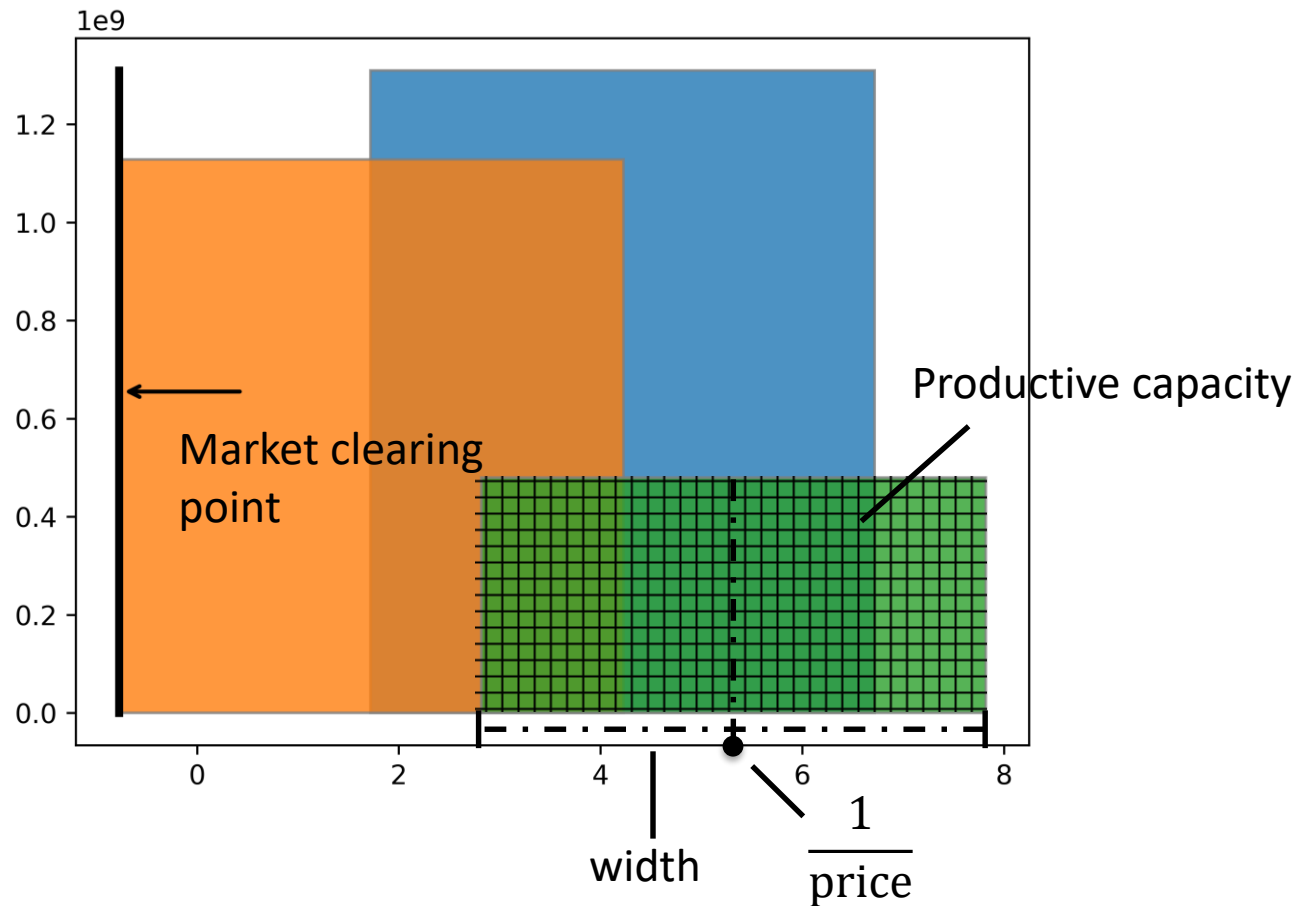
# Model Structure – Energy Production



# Model Structure – Water Supply

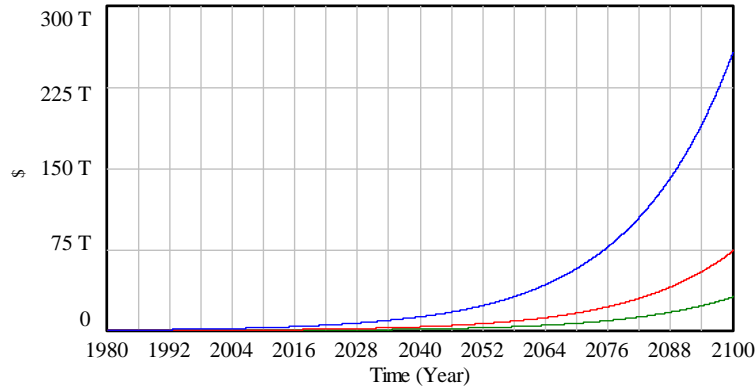


# Model Structure – Wood's Algorithm



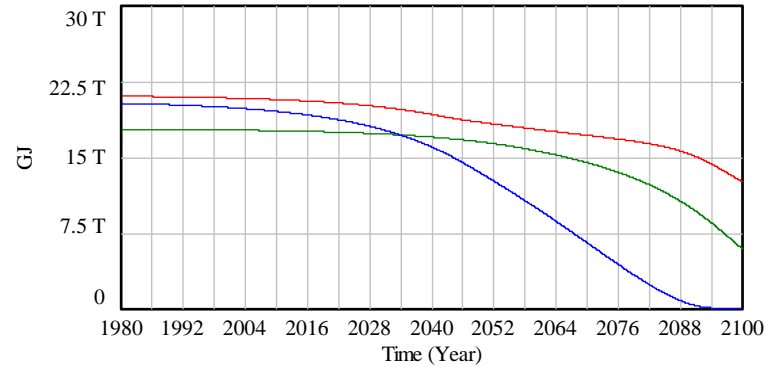
# Sample Results

Capital for Electricity Production



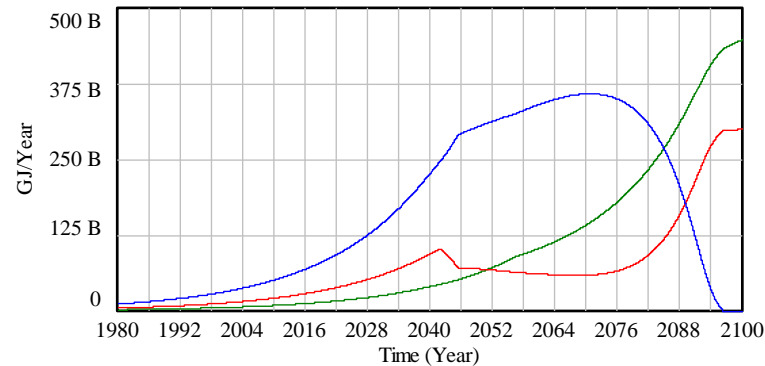
Capital for Electricity Production[Co] : anemi\_test  
 Capital for Electricity Production[Oi] : anemi\_test  
 Capital for Electricity Production[Na] : anemi\_test

Fossil Fuel Reserves



Fossil Fuel Reserves[Co] : anemi\_test  
 Fossil Fuel Reserves[Oi] : anemi\_test  
 Fossil Fuel Reserves[Na] : anemi\_test

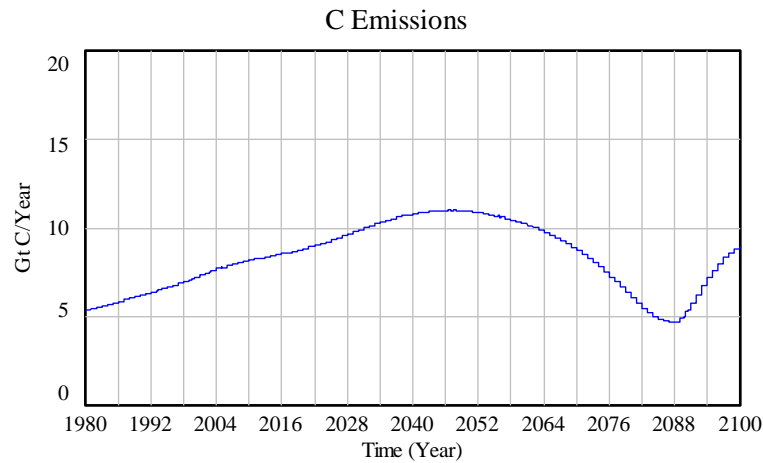
electricity production 0



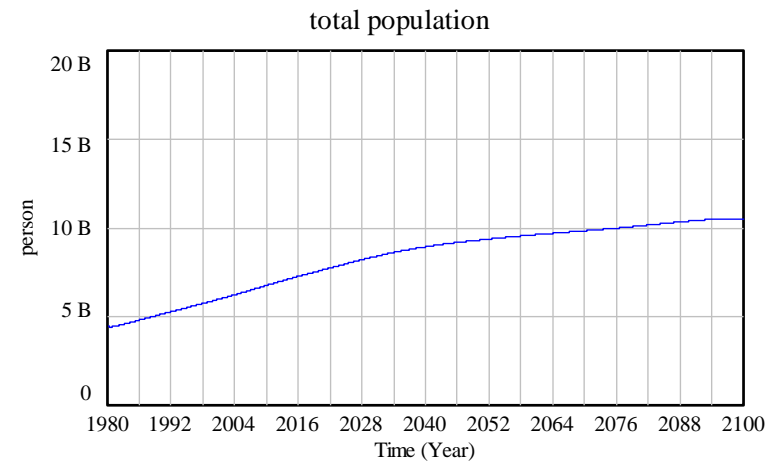
electricity production 0[Co] : anemi\_test  
 electricity production 0[Oi] : anemi\_test  
 electricity production 0[Na] : anemi\_test



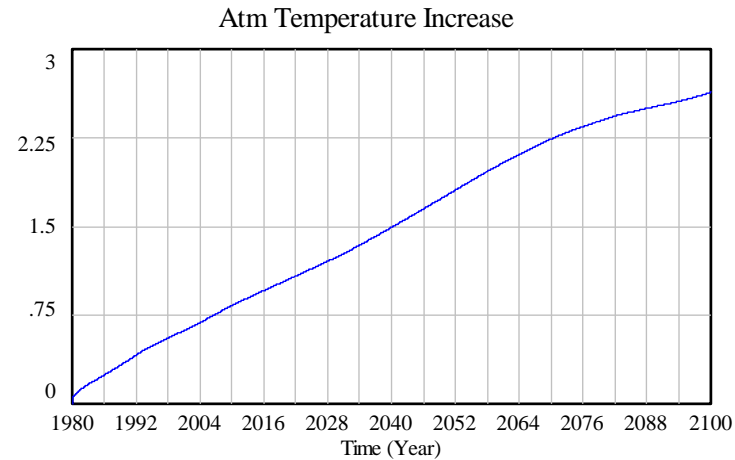
# Preliminary Results



C Emissions : anemi\_test



total population : anemi\_test



Atm Temperature Increase : anemi\_test

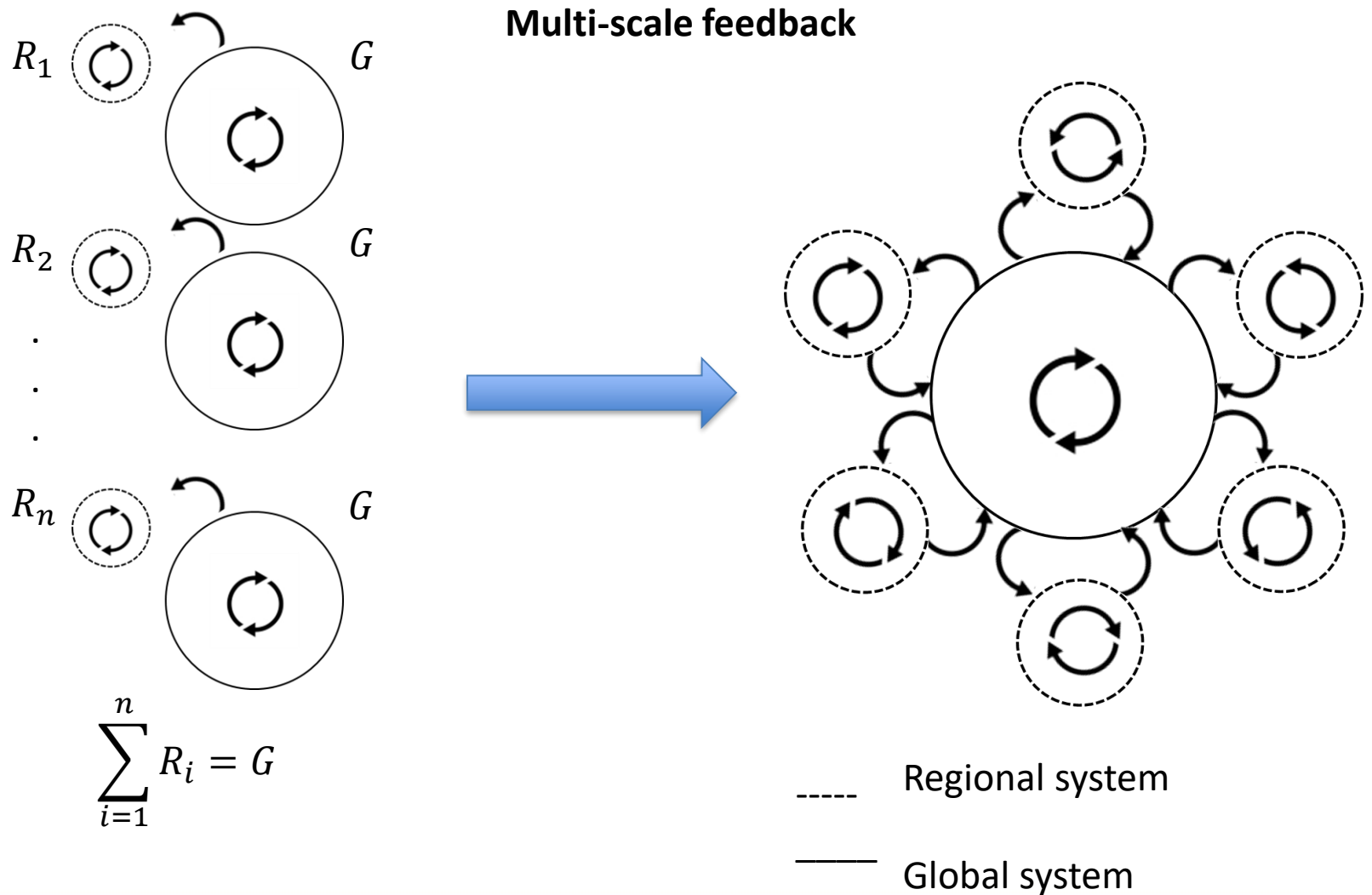
# Spatial Disaggregation

- Modelling takes place on a globally aggregated scale to highlight feedbacks
- Spatial disaggregation could provide more meaningful results and model behaviors

# Spatial Disaggregation

- Other approaches to disaggregation in IAMs:
  - Longitudinal slicing (MIT's IGSM model)
  - Defining homogeneous economic 'zones' (IMAGE)
  - Grid based approaches

# Spatial Disaggregation





# Closing Remarks

- Integrated assessment of energy and water supplies can help identify the need for alternative supplies
- More work needs to be done to implement system feedbacks for energy production and water supply
- Spatial disaggregation can provide more actionable regional results



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