Modeling and Visualizing Food-Energy-Water Interactions at the Metropolitan Scale

D.A. Sampson[1,2,4], G. Mascaro[3], R. Maciejewski[4], R. M. Aggarwal[1,2], D. D. White[1], H. Sarjoughian[4], F. Lei[4], M. Mudara[4], X. Guan[3], A. Mounir[3], M. Roy Choudhury[2]

(1) Global Futures Laboratory, (2) School of Sustainability, (3) School of Sustainable Engineering and the Built Environment, (4) School of Computing and Augmented Intelligence Engineering, Arizona State University, Tempe, AZ 85287 USA

Central Arizona-Phoenix Long-Term Ecological Research
CAP LTER

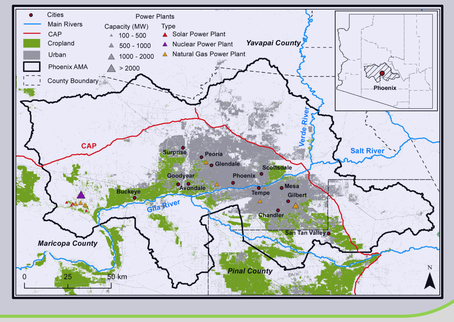
24th All Scientists Meeting & Poster Symposium, 25 March 2022.

ASU Skysong, 1365 N. Scottsdale Rd, Scottsdale, AZ

Arizona State University

Project Design

- The food-energy-water (FEW) sectors (as networked material and energy flows) co-occur in the urban metabolism system (UM) along with 1) Governance networks, 2) Urban infrastructure and form, and 3) Socio-economic drivers. In AZ irrigated agriculture must also be considered.
- We focused on the FEW nexus as influenced by climate change, agricultural cropping choice, energy policy, population growth, and the role of governance in the Phoenix Active Management Area (AMA)
- Developed a FEW framework: a user interface & visualization tool coupled to a water-energy-food model:
  - WEAP:MABIA (water & agriculture)
  - LEAP (energy)
  - Statistical Crop Model (SCM) (proportion of crops planted)
- Scenarios:
  - Δ urban water use efficiency
  - Δ energy sectors over time
  - Δ cropping patterns
  - Climate change/ influence on all sectors



Research Directions

(1) We coupled two off-the-shelf programs and one statistical model to create a credible, integrated model that captures the metropolitan-scale FEW interactions of the AMA

(2) We are exploring the notion that integrative modeling can improve governance across food, energy, and water sectors

(3) Human-computer-interactions along with alternative visualizations will assess what technologies can best support "sense making" when analyzing the FEW nexus

(4) The potential role of climate change impacts on water & energy use, and cropping patterns and crop yields in the Phoenix metropolitan region are being examined

Software Design

Software

- ✓ API coupling
- ✓ Back end: User interface for scenario generation
- ✓ Front end: Visual display of outputs (see below):

Python.org

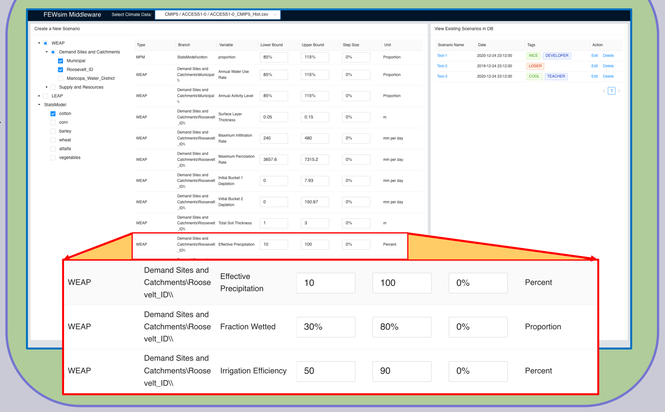
Data Granularity

- ✓ Available data across the UM system
  - Calibration (2008 to 2018)
  - Simulations (2015 to 2050)
- ✓ Synchronous spatial/ temporal data

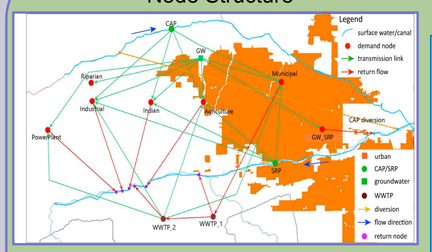
Sustainability Indices (SI):

- ✓ Pre-defined:
  - SI_{food} = f(nutrition adequacy, ecosystem & economic stability)
  - SI_{energy} = f(energy sector use/ dominance)
  - Si_{water} = f(water source/ use dominance)
- ✓ FEW Index = $\sqrt[3]{SI_{food} \times SI_{energy} \times SI_{water}}$

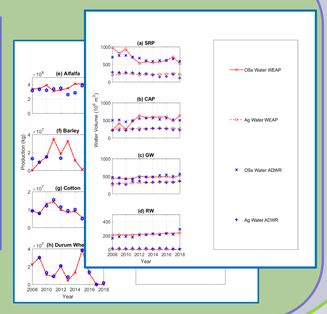
Interactive Scenario Generation



Node Structure



Calibration



Visualization

A

FEW nexus overview:
Energy → Water → Food

A=Visual flow

B=SI indices

C=Node details

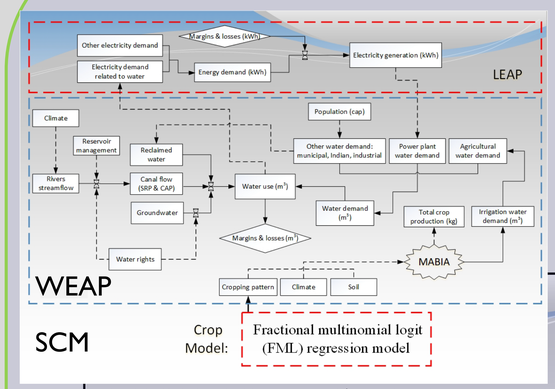
B

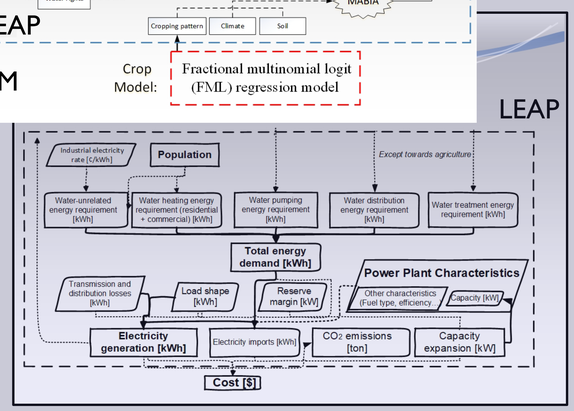
Sustainability Indices

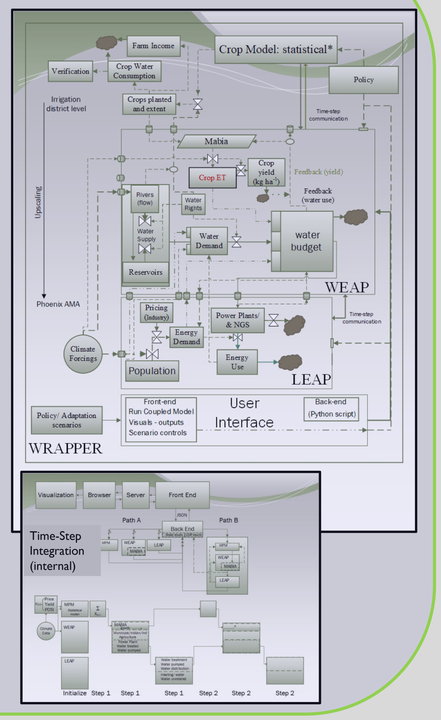
C

Node details & comparison to baseline

Conceptual Models







Acknowledgment

This material is based upon work supported by the National Science Foundation (NSF) under Grant No. 1639227: Innovations at the Nexus of Food, Energy, and Water Systems (INFEWS). Any opinions, findings and conclusions or recommendation expressed in this material are those of the author(s) and do not necessarily reflect the views of the NSF.

RIP Faith