Integrated Modeling of Social and Biophysical Processes Influencing Water Availability in Southwest Idaho: Update on Irrigation and Climate Change Integration

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Treasure Valley

- Southwest Idaho: semi-arid, hot-dry summer, relatively wet winter
- Most populous area in Idaho
- Rapidly growing population
- Shifting urban-agriculture interface
- Complex water management
- Irrigation dominated agricultural activities & human influenced hydrological processes
- Many diverse stakeholders

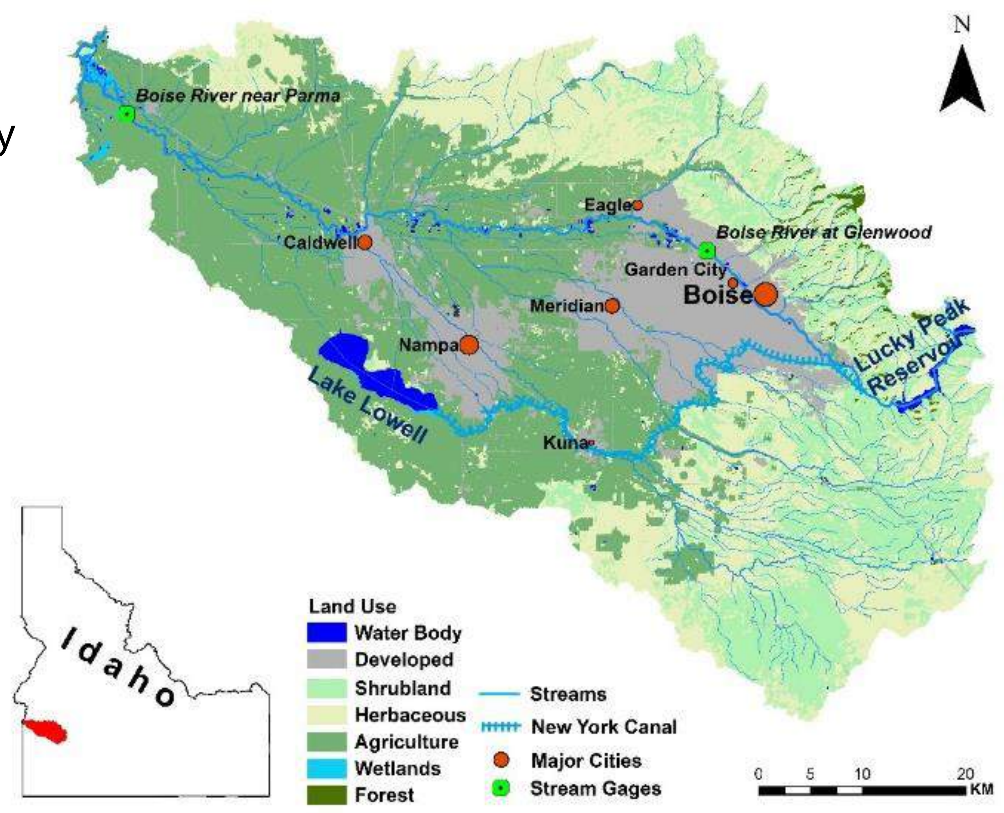


Fig. 1. Location of the Treasure Valley area and the included major cities, major highways, streams and the New York Canal.

Research Questions

- What will the Treasure Valley land use look like?
- How will the water availability change?
- How will human decision making influence the trajectory of change?

Modeling Framework

- Climate: Using historical weather observations and future downscaled GCM projections to drive Weather Generator
- Hydrology: Semi-conceptual HBV model
- Irrigation: Following local water rights constraints
- Population and Land Use: Dynamic regression models.

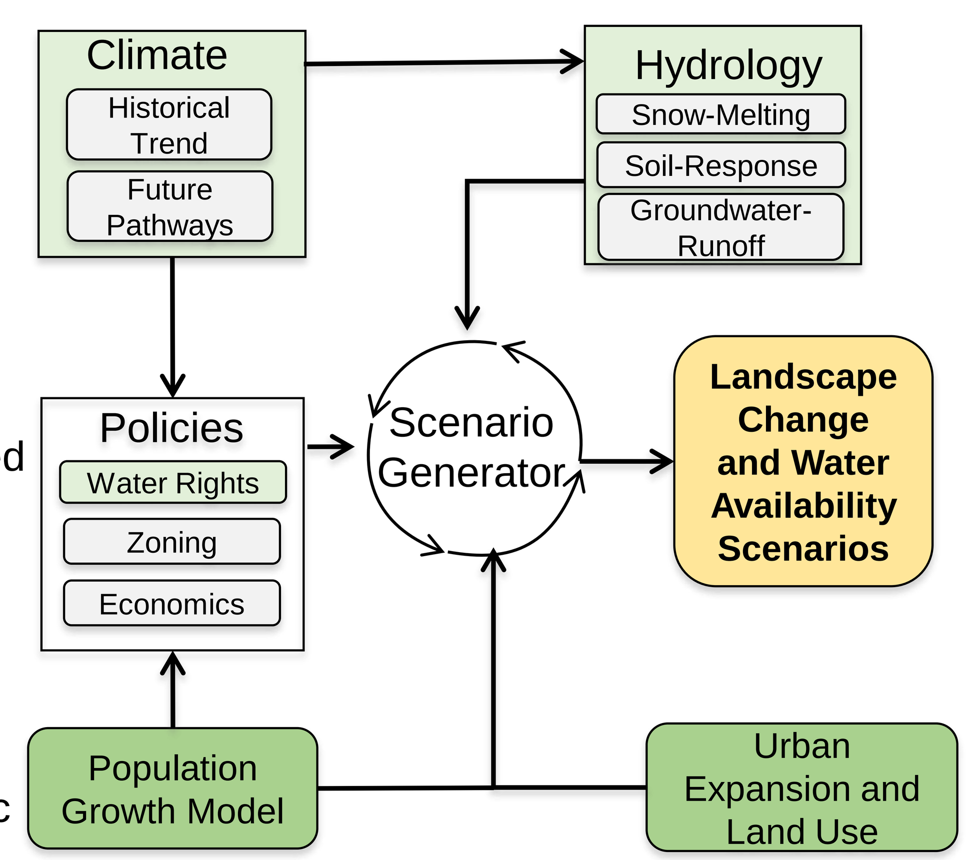


Fig. 2. Conceptual modeling framework for projections of future land use and water availability scenarios. Light green boxes represents the work that is mostly tackled. Green boxes represents the on-going work.

Connections, Integration and Synergies

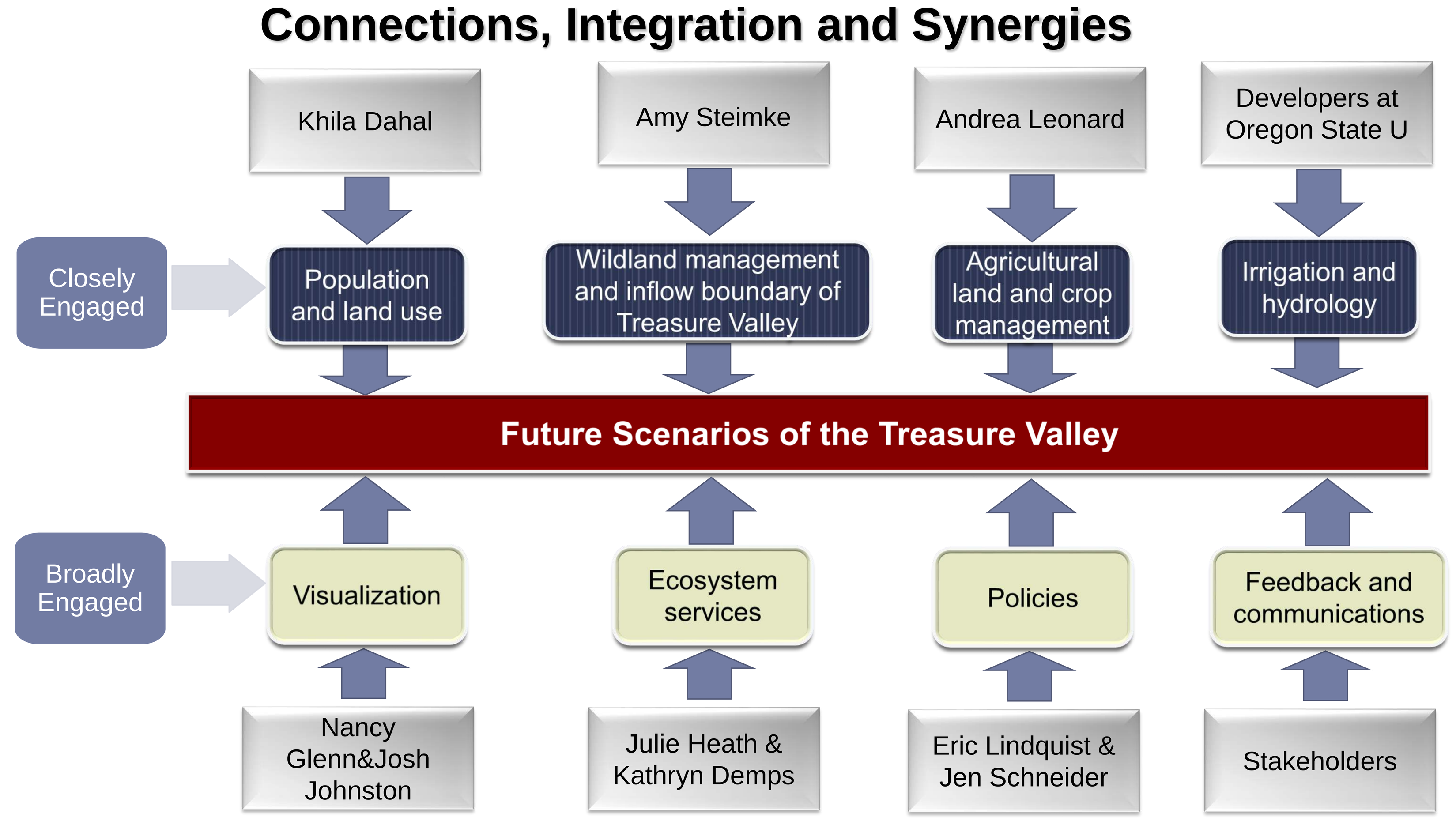


Fig. 3. The work is focusing on future scenarios of the Treasure Valley. A team of scientists, engineers and stakeholders are contributing to the integration of knowledge.

Progress Update 1: Irrigation

- Local water rights dataset are integrated into a semi-conceptual hydrologic model
- 4,838 Points of Diversions (PODs) and 3,859 Places of Use (POUs) are appropriated for irrigation use
- 78% of the PODs use groundwater as water source, and only 22% use surface water as water source
- Surface water is the main water source on the diverted water volume.

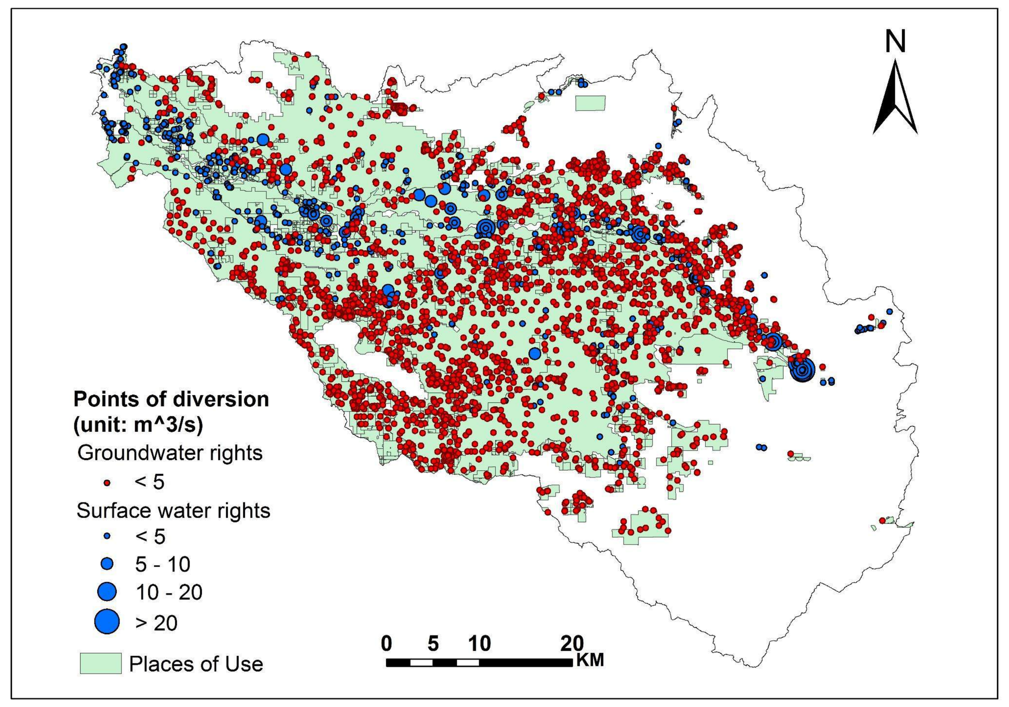


Fig .4. . Local water rights data (PODs and POUs) from Idaho Department of Water Resources (Irrigation water use only).

- Prior Appropriation Doctrine (first in time is first in right)
- Flow time step: available water and IDU water demand
- Calculation unit: Hydrologic response unit (HRU);
- Surface water: stream reach
- Groundwater: assumed to be unlimited
- Irrigation: allocated in water right loop

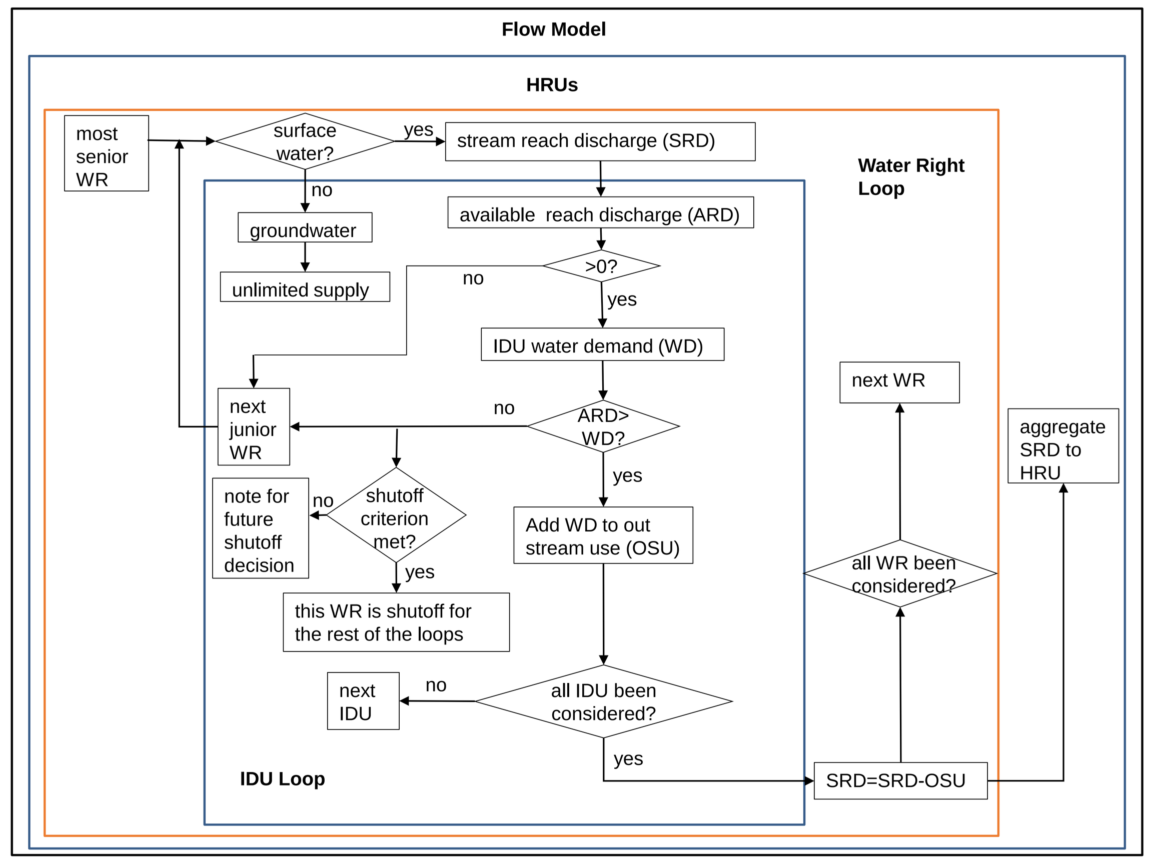
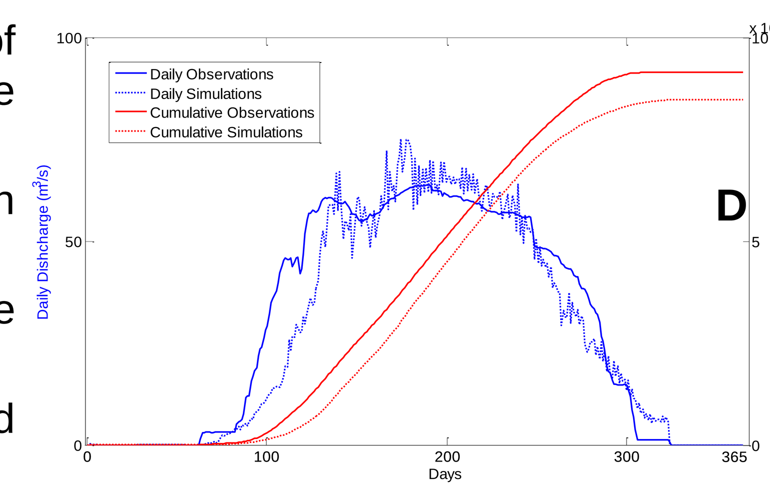


Fig. 5. Water right loop showing how irrigated water is allocated based on available water from the stream, water demand at each integrated decision unit (IDU) and water rights information (e.g. Water rights priority dates, water use code). Currently, groundwater from wells are considered to be unlimited.

- Irrigation simulated within the constraints of water rights, water demand, and available water
- Model captures annual and monthly irrigation water use patterns (Fig. 6. A and B)
- Model reveals spatial irrigation water use patterns (Fig. 6. C)
- Model calibrated and partially validated based on historical discharge (Fig. 6. D)



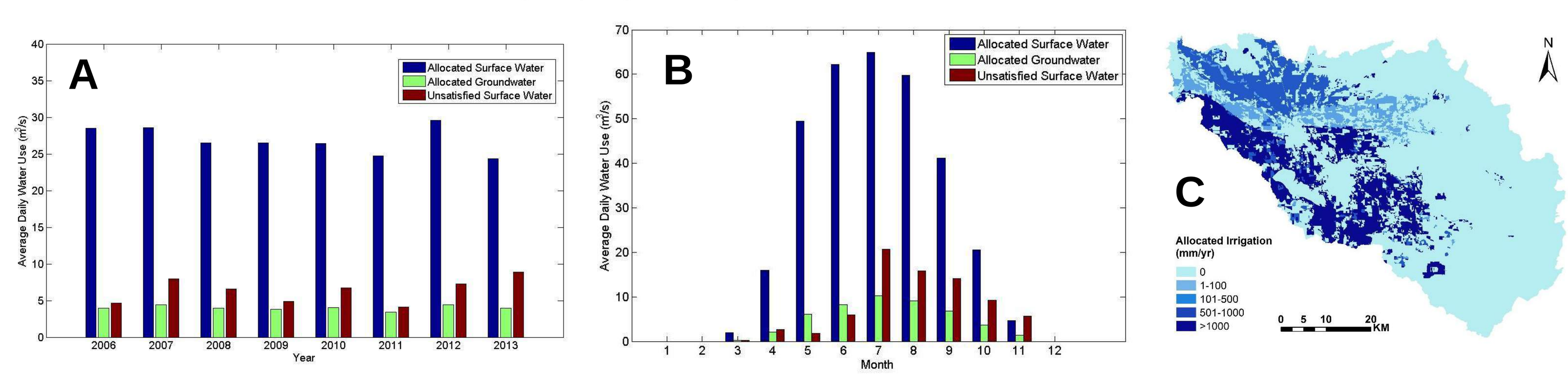


Fig. 6. Annual allocated and unsatisfied irrigation water (Panel A); Monthly allocated and unsatisfied irrigation water (Panel B); Spatial explicit map of water allocation, taking year 2013 as an example (Panel C); Observed New York Canal Discharge and the simulation diversion rate (Panel D).

Progress Update 2: Climate Change

- Three scenarios: Historical trend, and 2 future Representative Concentration Pathways (RCP 4.5 and RCP 8.5)
- 11 downscaled General Circulation Models (GCMs) in each future scenario
- 12 climate variables are analyzed and summarized to generate representative monthly ranges of each variable
- Latin Hypercube method to randomly sample 10 sets of monthly climate statistics within representative ranges of the variables
- Statistical weather generator (WXGN) to generate 10 ensembles of daily climate for each climate set under each RCP

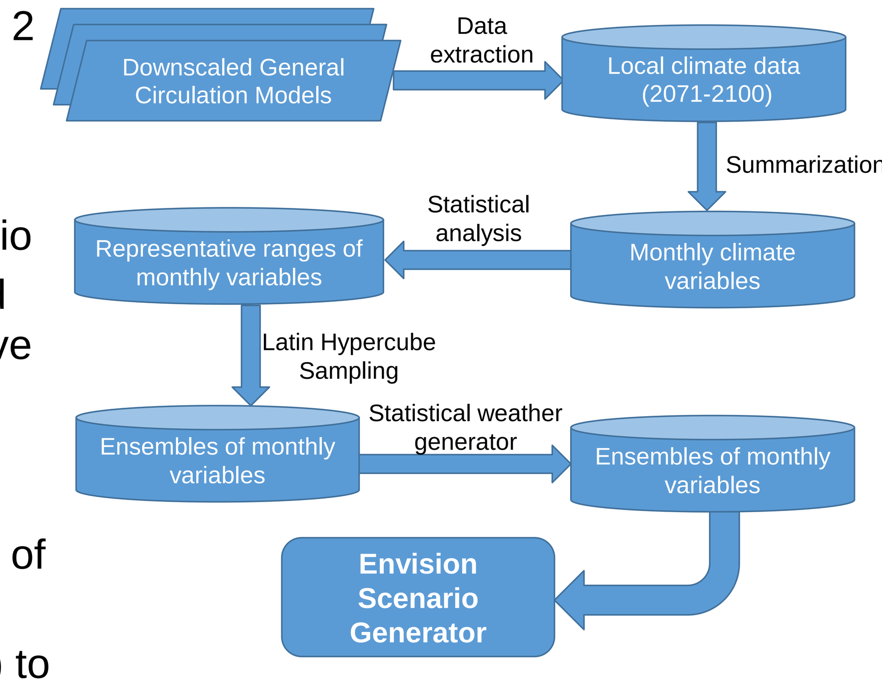


Fig. 7. Workflow of climate change scenarios

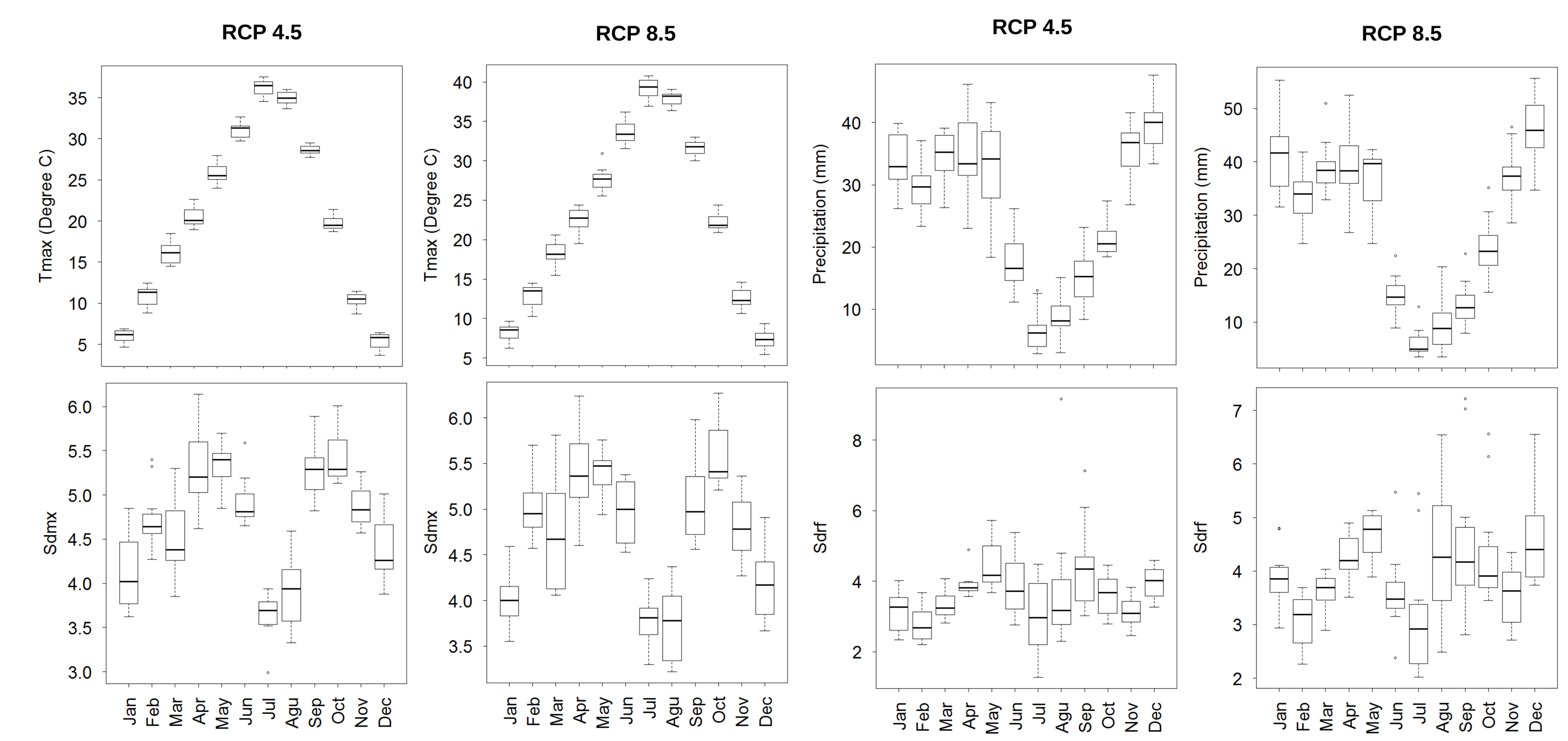


Fig. 8. Boxplot of monthly climate variables over 11 GCMs (taking maximum temperature (Tmax), standard deviation of maximum temperature (Sdmx), precipitation, standard deviation of precipitation (Sdrf) as examples). Both higher temperature and higher precipitation rates in RCP 8.5. Precipitation has larger variance between GCMs than temperature. The large variance indicates that an ensemble of climate realizations are necessary to capture the variations of climate change.

Future Work

- Run the model for the ensemble of scenarios of climate change, and project the water use and water scarcity problems by 2100
- Integrate the crop choice model results into Envision
- Integrate urban water use in the model

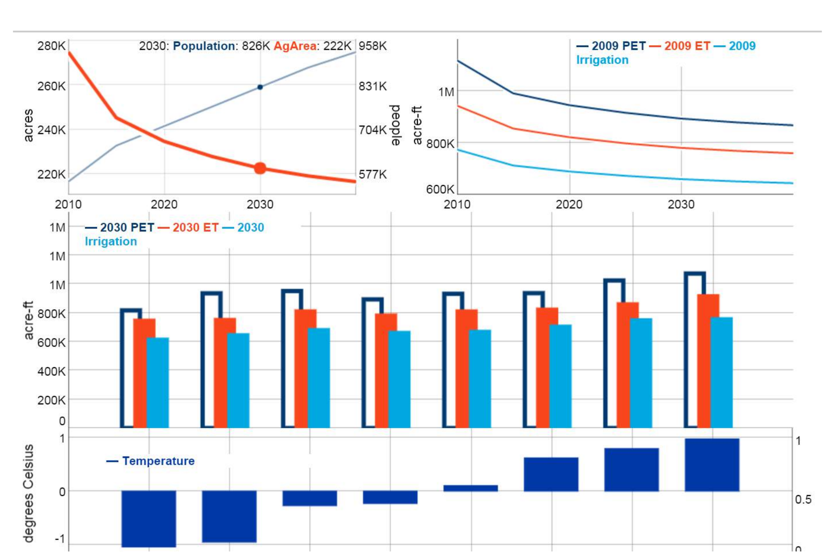


Fig. 9. An example showing fully integrated population growth, land use change, climate change, evapotranspiration and irrigation rates in the Treasure Valley.

Broader Impacts

- Advances the science by building a framework for water use projections that is applicable to semi-arid regions with limited water source
- The modeling outcome can inform stakeholders with better decision-making.

Outcomes

Han, B. et al. Spatially distributed simulation of intensively managed hydrologic systems: coupling biophysical and social systems to evaluate potential water scarcity (manuscript).

Han, B. et al. Integrated Modeling of Social and Biophysical Processes Influencing Water Availability in Southwest Idaho: Preliminary Results. *Agricultural Water Management* (in review) .