Economics of Accounting for Groundwater Use Under Conditions of Climate Change

James "Jimmy" Palmer, University of Connecticut, and james.palmer_ii@uconn.edu

Selected Poster prepared for presentation at the 2024 Agricultural & Applied Economics Association Annual Meeting, New Orleans, LA: July 28-30, 2024

Economics of Accounting for Groundwater Use Under Conditions of Climate Change

James "Jimmy" Palmer[a], Christopher Bruno[b], Farhed Shah[a]
(a) University of Connecticut Agriculture and Resource Economics Department, (b) University of Pennsylvania Management Department

UCONN COLLEGE OF AGRICULTURE, HEALTH AND NATURAL RESOURCES

Introduction/Background

Agriculture relying on water withdrawals from Republican River Basin and underlying Ogallala reservoir is challenged by climate change. Predicting the region's water demand from these sources provides a tool for resource management.

The Republican River Basin is shared by the states of Colorado, Nebraska, and Kansas. Withdraws from the river basin are restricted by federal regulations on minimum river flows, an inter-regional compact, and surface water rights. As groundwater and river water resources are connected, overdraft of groundwater in the upstream state may result in reduction in downstream river flow. Compact restrictions have been disputed, with SCOTUS judgement placing liability on the upstream state(s).[1]

Prior economic analysis constructs steady-state constrained optimization models for simulating water allocations between the two states withdrawing the most water, Nebraska and Kansas.[2] Such simulations incorporates the above flow restrictions, steady state hydrology, and vary compact restrictions. Simulations limited two counties for each state. Data going into the simulations include a water rights analysis of farms withdrawing Republican River Basin water. Our research extends this work to show the change in benefit of withdrawing water under projected climate change.

Objectives

Estimate marginal benefit of each state's withdrawing Republican River Basin water dependent on amount withdrawn and climate variables.

Obtain optimal water allocation for individual state and social planner

Predict change in net benefits from climate change projections.

Data

Two counties chosen for each of two states overlapping the basin, with no other major river or basin in its borders and no complex hydrology of reservoir. Data spans 1997-2017.

USDA Agricultural Census (taken every five years)

PRISM temperature data by way of Schlenker and Robert.[3]
NOAA precipitation
NEMAC CMIP5 climate simulations projections.

Kansas Geological Survey and Nebraska Department of Natural Resources water well depth

Methodology

Marginal benefit is proxied by normalized price of water (bushel/acre-ft), NPW, calculated as pumping cost for volume of water ($/acre-ft), APC, per weighted average crop price ($/bushel). Weighted crop price is the average price between four crops, weighted by the percent of area harvested out of the total area harvested for all four crops. The pumping cost is calculated from the per distance cost multiplied by the average well depth plus a fixed cost.[4]

NPW for each state (i) is regressed on area weighted average annual county temperature, area weighted total annual county precipitation, and total volume of water irrigated between counties varied by the total area of irrigated land with county fixed effects.

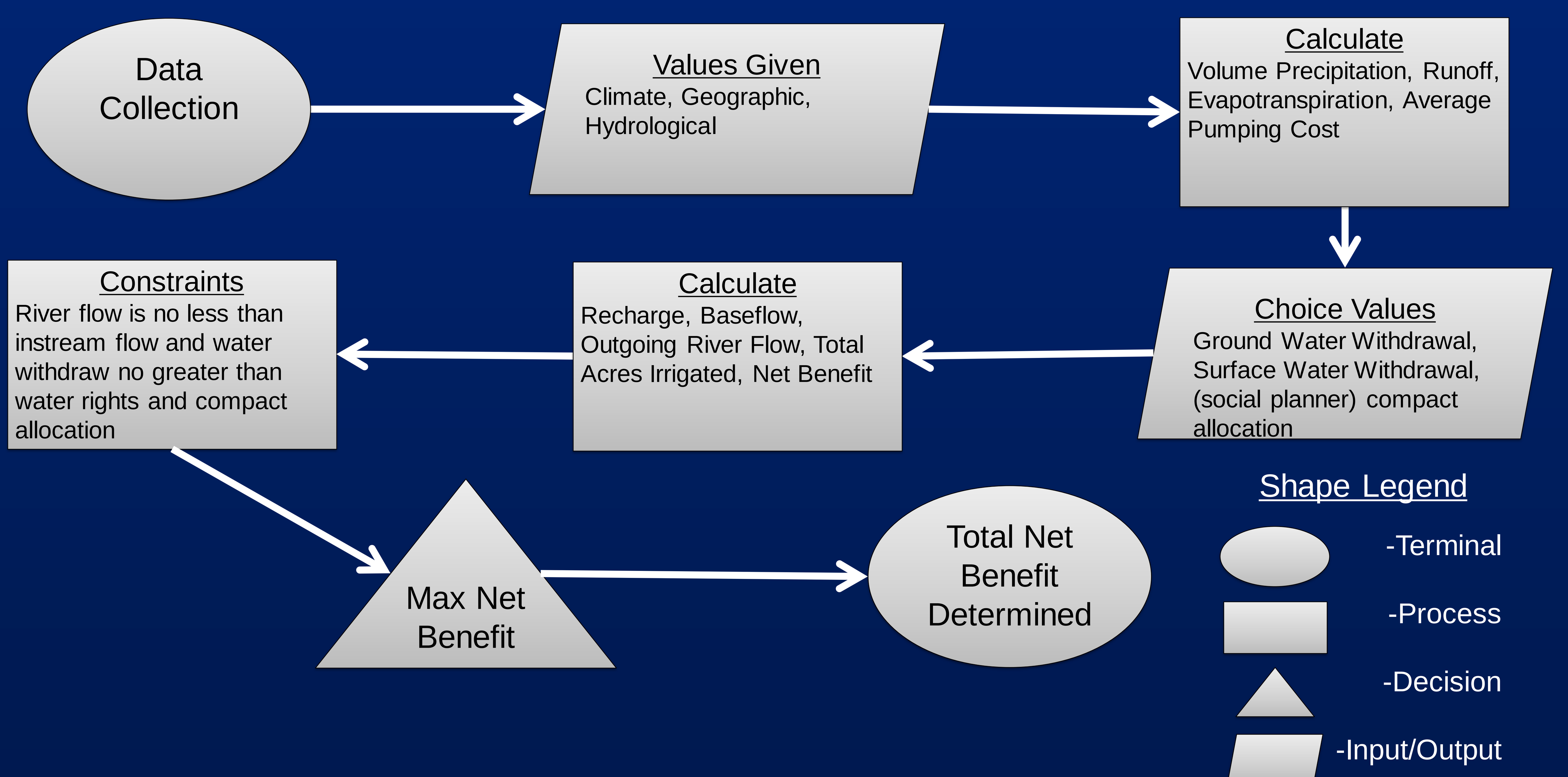
$$NPW_{i,y,c} = \beta_0 + \beta_1 Precip_{i,y,c} - \beta_2 Precip^2_{i,y,c} + \beta_3 Temp_{i,y,c} + \beta_4 Temp^2_{i,y,c} + \beta_5 TotIrrAcre_{i,y} + \alpha_c$$

$$NetBen_i = \int NPW_i(Precip_i, Temp_i, TotIrrAcre_i)\, dTotIrrAcre_i - APC_i GroundWithdraw_i$$

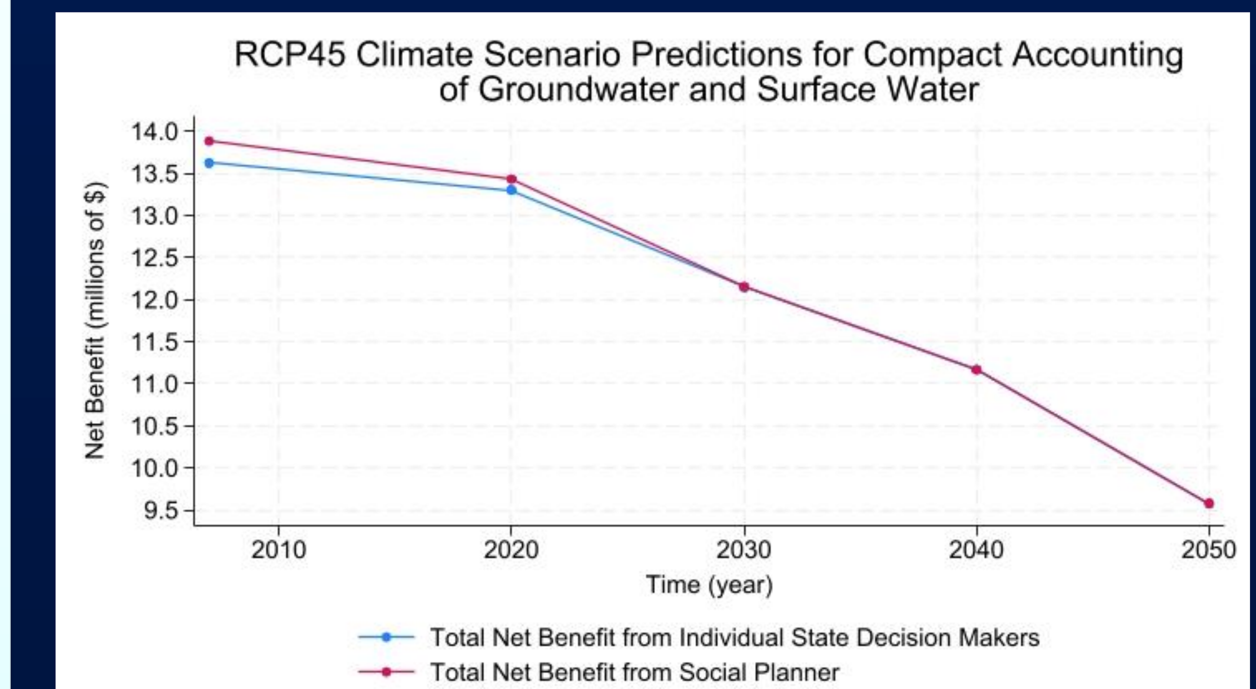
Simulations of compacts with and without groundwater accounting include two scenarios:

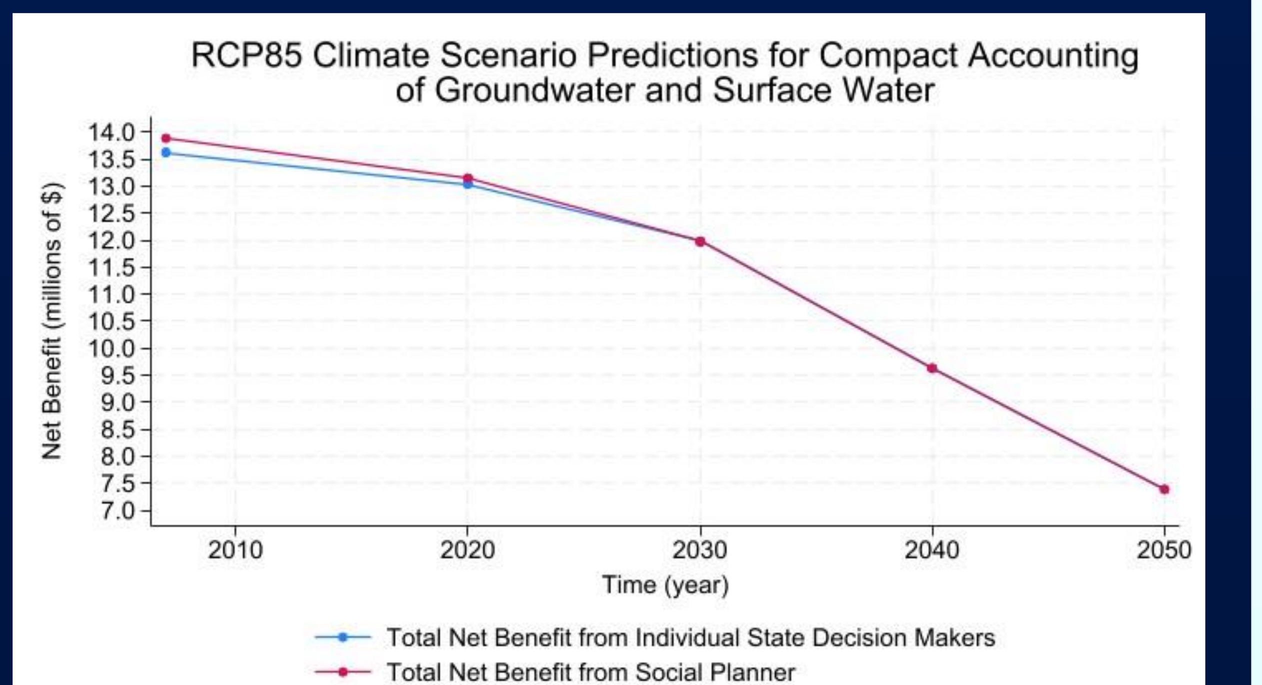
Both states act independently $Max\ NetBen_1$ & $Max\ NetBen_2$ **versus** a social planner Max $\sum_{i=1}^{2} NetBen_i$

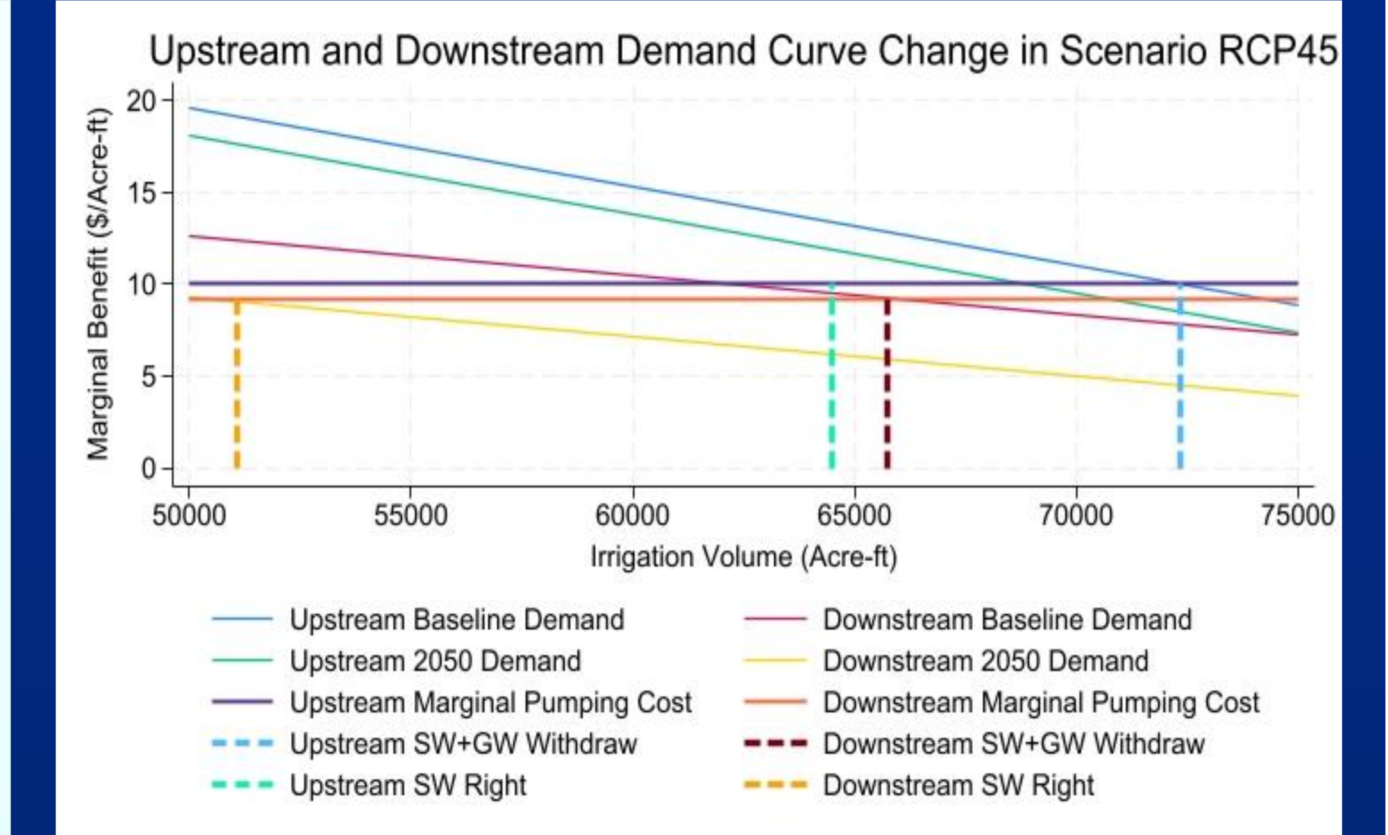
Optimization Procedure



Results







Result and Policy Discussion

There is a decline in productivity over time when adaption strategies (e.g. changing crop species or breed) are not part of the accounting. Water demand decreases with increasing temperature and near constant precipitation in both climate scenarios.

The larger net benefit from social planner solutions lead one to emphasize the need for reallocation of water shares. Decline in water benefit lends to monitoring usage and coordination of moving labor from unproductive farms.

Future Work

Expand dataset of normalized price of water, climate variables, and water usage to include majority of counties from each state that encompass Republican River Basin.

Improve model by providing dynamic description of water exchange and pricing for the Republican River Basin.

Citations

1. Kansas v. Nebraska, 574 U.S. 445 (2015)

2. Bruno, C. (2020). *Economics of Inter-Regional Water Compacts with Consideration of Groundwater and Surface Water Interaction: A Case Study from the Republican River Basin*. MS Thesis, Department of Agricultural and Resource Economics, University of Connecticut.

3. Schlenker, W., & Roberts, M. J. (2009). Nonlinear temperature effects indicate severe damages to U.S. crop yields under climate change. Proceedings of the National Academy of Sciences of the United States of America, 106(37), 15594–15598.

4. Williams, R. B., Al-Hmoud, R., Segarra, E., & Mitchell, D. (2017). An estimate of the shadow price of water in the southern Ogallala Aquifer. *Journal of Water Resource and Protection*, *9*(3), 289–304.