XYZ / 2023 / 4

GLASSNET Geospatial Data for Sustainability

The Value of Water in US Agriculture:
integrating spatially and temporally heterogeneous hydroclimatic and economic data

Iman Haqiqi*, Purdue University, United States, ihaqiqi@purdue.edu

Global-Local-Global Analysis of Systems Sustainability

GLASSNET

An International Network of Networks

First edition: June 2023

Please cite using the following references:

Haqiqi, I., Bowling, L. C., Jame, S. A., Baldos, U. L., & Liu, J. Hertel, T. W., (2023). Global Drivers of Local Water Stresses and Global Responses to Local Water Policies in the United States. *Environmental Research Letters*. *18*: 065007 https://doi.org/10.1088/1748-9326/acd269

Baldos, U.L.C., Haqiqi, I., Hertel, T.W., Horridge, M. and Liu, J., 2020. SIMPLE-G: A multiscale framework for integration of economic and biophysical determinants of sustainability. *Environmental Modelling & Software*, *133*, p.104805, https://doi.org/10.1016/j.envsoft.2020.104805

Center for Global Trade Analysis
Department of Agricultural Economics
Purdue University
West Lafayette, IN 47907
https://www.gtap.agecon.purdue.edu

The Value of Water in US Agriculture:

integrating spatially and temporally heterogeneous hydroclimatic and economic data

Iman Haqiqi, Department of Agricultural Economics, Purdue University, ihaqiqi@purdue.edu

Keywords

Agricultural economics; water resources; value of water; irrigation

Data Items

Data items are listed in Table 1. The main variable is the gridded estimate of the value of water for irrigated agriculture in the United States for 75,651 grid cells (at 5 arc-min resolution) given the technology, prices, and weather conditions around the year 2010. To enable future applications that can reflect the long-run average values, the estimated shares in total expenses are provided. All the variables are available in separate files in NetCDF and GeoTIFF and combined in the CSV format. Here, CONUS stands for the Contiguous United States.

Table 1. Data items and descriptions

Variables	Note	Resolution	Label	Units
Value of water	Annual long-run economic value of water in crop production averaged around 2010 (per grid cell)	5 arc-min	value_water_irr	$1000
Value of crops	Annual market value of irrigated crop production averaged around 2010 (per grid cell)	5 arc-min	value_crops_irr	$1000
Area of irrigated cropland	Annual physical area of irrigated cropland (per grid cell)	5 arc-min	areas_cland_irr	1000 ha
Cost share of irrigation water	Average share of payment to water and irrigation services in total production expenses	5 arc-min	share_water_irr	NA
Average value of water	Average economic value of water per hectare of irrigated cropland	5 arc-min	avgwatervalue_irr	$/ ha

Related literature

There have been numerous studies debating the value of water since Adam Smith's Paradox of Value. The paradox indicates that the "use value of water" is lower than the "exchange value of diamond". There are multiple alternative quantitative approaches to calculating the value of water in agriculture (Ward & Michelsen 2002; Griffin 2016). Current studies consider relative benefits, marginal utility, and opportunity costs in calculations. One common method is the average irrigation yield gap approach considering the increased crop yield due to irrigation (compared to rainfed) and the underlying prices (Haqiqi et al., 2016; D'Odorico et al., 2020). A more complicated method is the conditional and marginal values of water which consider specific weather (water stress and heat stress) and market prices (Haqiqi 2019; Haqiqi et al., 2021). In this document, the provided dataset follows the irrigation expenditure approach (Haqiqi et al., 2023).

This approach reflects the expectations of farmers about the value of water in the coming growing seasons. Also, the economic zero-profit condition implies that in the long run, the total costs are equal to total revenues. Thus, the estimated shares of water can be applied to total revenues to get the value of water in new economic circumstances providing rough estimates of the value of water in the future.

Methods

Here, the value of water is calculated and applied in the SIMPLE-G model (Baldos et al, 2020; Haqiqi et al, 2023). It is based on total explicit and implicit payments for water and other irrigation inputs including energy for pumping and transfer, labor, maintenance, and capital. The main assumption is that the value of water should be at least enough to cover the irrigation-specific expenses. The expenditures are based on county-level information from the United States Department of Agriculture (USDA) Census of Agriculture (USDA, 2014) and the United States Geological Survey (USGS) Water Data for the Nation. Regarding the data, the county-level expenses are obtained from the USDA for total costs and input costs including fuel, labor, fertilizer, seeds, chemicals, and other inputs for the 2002, 2007, 2012, and 2017 Census years. The information regarding physical areas and volume of water is obtained from USGS Estimated Use of Water in the United States (Maupin et al., 2014) county-level data for 2005, 2010, and 2015.

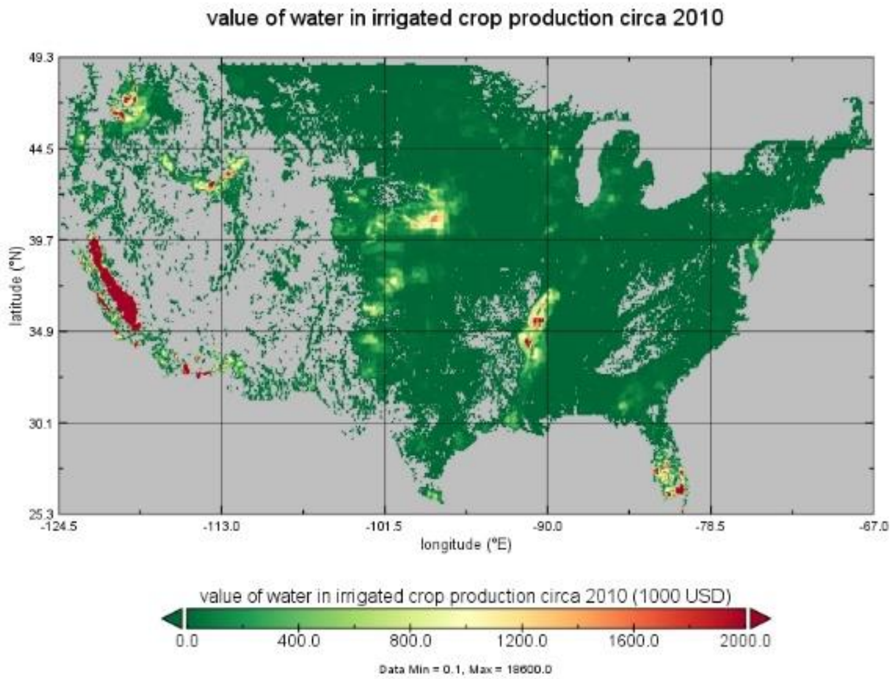
Summary statistics

The estimated value of water is summarized in Table 1 for USDA Farm Resource Regions. In 2010, the value of water in US irrigated cropland is estimated to be around $10 billion. Considering an average irrigation withdrawal of 115 billion gallons per day in 2010 (Maupin et al., 2014), the average value of water is 0.063 $/m3. This value varies by grid cell and by water source. The value is reported for all the cultivated grid cells, demonstrating low values on currently non-irrigated locations (Figure 1).

Table 2. The aggregate value of water for irrigated production by USDA Farm Resource Region around 2010

	USDA Farm Resource Regions	Value of water in 2010 (million USD)	Water share in irrigated production expenses/revenues
1	Heartland	449	9.1%
2	Northern Crescent	231	7.7%
3	Northern Great Plains	182	9.5%
4	Prairie Gateway	952	9.9%
5	Eastern Uplands	28	6.8%
6	Southern Seaboard	109	7.7%
7	Fruitful Rim	7,272	17.1%
8	Basin Range	180	9.8%
9	Mississippi Portal	595	12.9%
	United States	9,997	14.3%

(a) Total value



(b) Share

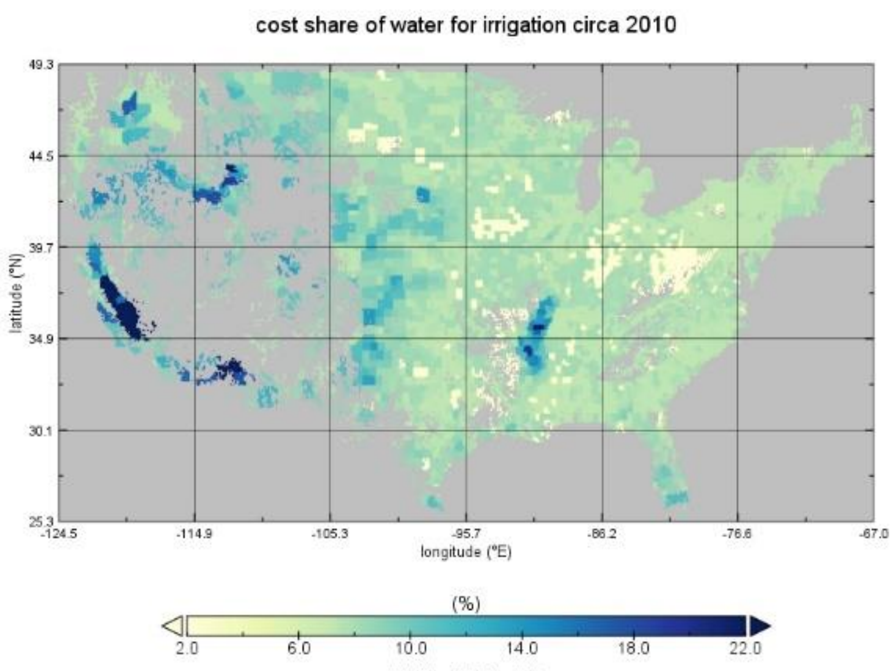


Figure 1. Estimated gridded value of water in terms of (a) total value per 5-arc min grid cell in 2010 prices; (b) share in total expenses/revenues of crop production for irrigated practices

How to read the files

The CSV file includes 75,651 rows of data and one top row for labels. The columns x and y are the coordinates of the center of the grid cell in 5-arcmin, considering "+proj=longlat +datum=WGS84". The FIPS column shows the US county codes. The sub-region column is the code for Farm Resource Regions as described in Table 1.

References

Baldos, U.L.C., Haqiqi, I., Hertel, T.W., Horridge, M. and Liu, J., 2020. SIMPLE-G: A multiscale framework for integration of economic and biophysical determinants of sustainability. *Environmental Modelling & Software*, *133*, p.104805, https://doi.org/10.1016/j.envsoft.2020.104805.

D'Odorico, P., Chiarelli, D. D., Rosa, L., Bini, A., Zilberman, D., & Rulli, M. C. (2020). The global value of water in agriculture. *Proceedings of the national academy of sciences*, *117*(36), 21985-21993. https://doi.org/10.1073/pnas.20058351

Griffin, R. C. (2016). *Water resource economics: The analysis of scarcity, policies, and projects*. MIT press.

Haqiqi, I. (2019). *Irrigation, adaptation, and water scarcity* (Doctoral dissertation, Purdue University Graduate School). https://doi.org/10.25394/PGS.9971558.v1

Haqiqi, I., Bowling, L. C., Jame, S. A., Baldos, U. L., & Liu, J. Hertel, T. W., (2023). Global Drivers of Local Water Stresses and Global Responses to Local Water Policies in the United States. *Environmental Research Letters*. https://doi.org/10.1088/1748-9326/acd269

Haqiqi, I., D. S. Grogan, T. W. Hertel, and W. Schlenker. (2021). "Quantifying the impacts of compound extremes on agriculture." *Hydrology and Earth System Sciences* 25, no. 2: 551-564. https://doi.org/10.5194/hess-25-551-2021

Haqiqi, I., Taheripour, F., Liu, J., & van der Mensbrugghe, D. (2016). Introducing irrigation water into GTAP Data Base version 9. *Journal of Global Economic Analysis*, *1*(2), 116-155. https://doi.org/10.21642/JGEA.010203AF

Maupin, Molly A., Joan F. Kenny, Susan S. Hutson, John K. Lovelace, Nancy L. Barber, and Kristin S. Linsey. (2014). "*Estimated Use of Water in the United States in 2010*." U.S. Geological Survey Circular 1405, 56 p., https://dx.doi.org/10.3133/cir1405

USDA. (2014). *2012 Census of Agriculture*. National Agricultural Statistics Service, United States Department of Agriculture. https://www.nass.usda.gov/Publications/AgCensus/2012/index.php

Ward, F. A., & Michelsen, A. (2002). The economic value of water in agriculture: concepts and policy applications. *Water policy*, *4*(5), 423-446. https://doi.org/10.1016/S1366-7017(02)00039-9