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Distortive Incentives and Resource Misallocation

Unveiling the Paradox of California's Water Crisis

By Robert Huang, University of Southern California

> *Though the water running in the fountain be everyone's, yet who can doubt, but that in the pitcher is his only who drew it out?*
>
> *—John Locke, Second Treatise of Government (1690)*

John Locke's statement encapsulates the economic dynamics underlying California's current water shortages. For decades, the heavily subsidized agriculture sector used surface water at nominal costs and pumped groundwater without restrictions. What incentive would farmers have to conserve when they could so easily obtain water and knew that their neighbors' water extraction diminished the water available to themselves? Distortive prices and incomplete property rights have led to a misallocation of resources. While California is notorious for its recurrent droughts, paradoxically, it produces 80 percent of the world's almonds, one of the most water-intensive crops.[1]

Is California Running Out of Water?

In four of the last twelve years, more than 80 percent of California underwent severe droughts year-round.[2] Before 2010, this number never surpassed 50 percent in any single year. California appears to be deviating from its natural cycle of wet and dry periods, facing more droughts with fewer wet years.[3] Such extreme weather depletes reservoir-held surface water and is thus often depicted as the culprit of water scarcities. However, is this a fair statement?

In a typical year, 60 percent of California's total water supply comes from surface water sources, while the remaining 40 percent is provided by groundwater.[4] California's reservoir capacity totals over 41 million acre-feet, or 1.05 acre-feet per person. In contrast, its neighbor Arizona has a total capacity of 1.5 million acre-feet, equivalent to only 0.21 acre-feet per capita.[5] Despite the historical filling rate of 20 percent, California's reservoirs still hold a comparable amount of water per individual as Arizona's reservoirs do when completely full.

California also features an abundant groundwater supply. Its 515 groundwater basins can store up to 1 billion acre-feet of water, or 25.5 acre-feet per person. In comparison, the groundwater reserve per capita is 1.6 acre-feet in Arizona.

Indeed, California's water supply is dwindling compared to its past. However, even in a dry year, it has more water per capita than many states, such as Arizona, do in a normal year. Since water shortages are less acute in other Western states, this implies that the major drive behind the crisis is California's excessive water demand.[6]

In California, the daily water usage is 133 gallons per capita, the highest in the West and several times higher than the national average.[7] Since groundwater is essentially a free-for-all, Californians have rushed to extract it whenever heat waves depleted surface water. Due to such overconsumption, 93 million acre-feet of groundwater can no longer be replenished in the Central Valley alone, equivalent to 3.4 times the volume of Lake Mead.[8] While a wet winter may temporarily alleviate the supply stress by refilling the reservoirs, the water problem can only get worse if the demand remains high.

Failed Regulations and Missing Markets

To address the water crisis, the key is to understand why the demand is high. In California, half of the water is allocated to support the ecosystem, and the other half is used for human needs. The agriculture sector accounts for 80 percent of the human-use water, and urban households use the remaining 20 percent.[9] Given this disproportional ratio, current water regulations clearly target the wrong sector.

In the past decade, government officials have imposed several water use restrictions on urban residents, which lasted from months to over a year and mandated 25 percent to 35 percent reductions of usage.[10] Some Southern California households were rationed to 80 gallons of water per day, only enough for four eight-minute showers.[11] Given that agriculture utilizes four times the water of residences, equivalent savings can result from a reduction in farming water consumption of slightly over 5 percent. Unfortunately, agricultural water use has faced limited restrictions.

Farming water prices are astoundingly low. Urban households pay $6.50 per thousand gallons, but farming water is only priced at $0.34 per thousand gallons.[12] This translates into the sector's lavish use of water. Since 2005, water use per acre of farmland has increased by more than 20 percent as residential water use per capita dropped by 15 percent.[13] Today, each acre of California farmland consumes 2.9 acre-feet of water, while the national average is 1.5 acre-feet.[14]

One rationale for low agricultural water prices is to prevent the overdraft of groundwater. In most of California, anyone owning a parcel of land can pump groundwater.[15] Farmers may extract groundwater instead of purchasing from the market if the price exceeds the energy and capital cost of extraction.

In reality, keeping prices low fails to work. As a result, 73 percent of the farm water in California is pumped from the ground, the highest in the West and much higher than the second-highest rate at 46 percent in Nevada.[16]

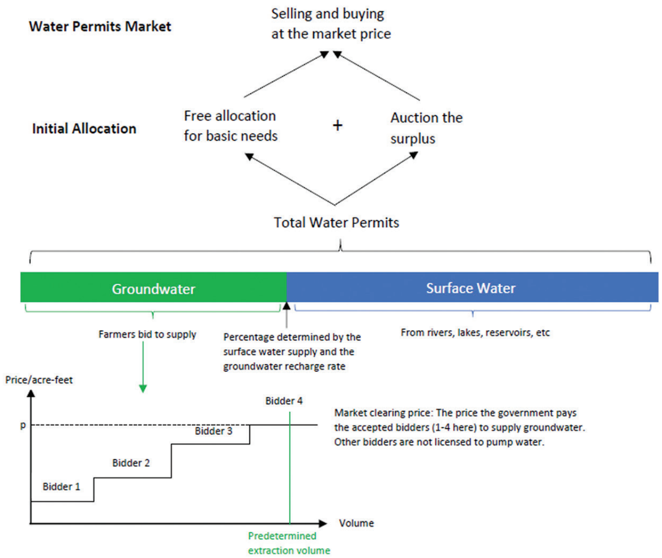
Government officials have been ignoring the fact that groundwater is non-exclusive (for owners of land overlaying the aquifers) and rivalrous. When a farmer pumps water, this increases the pumping cost and reduces the water stock for other farmers sharing the same aquifer.[17] Under this circumstance, the Nash equilibrium is that farmers extract all water immediately rather than conserve for future use. This is when no farmers can increase their payoffs by changing their water consumption levels.

In 2014, the state government introduced the Sustainable Groundwater Management Act (SGMA) to regulate groundwater use, but local water agencies do not need to comply with it until 2040.[18] Although with benevolent intentions, the SGMA backfires because it incentivizes farmers to pump as much water as possible before the law takes effect. Since 2014, the total number of wells in California has increased by 16 percent, and the median well depth has more than doubled from 130 feet to 296 feet today.[19] Ironically, to limit new well drillings, the government ended up paying $2.9 billion to farmers as compensation for leaving their farmland idle.[20]

Policy Recommendations

As discussed, water allocative inefficiencies stem from low faming water prices and the incomplete property rights of groundwater. Market-based instruments can offer cost-effective remedies to these problems. Specifically, the state should replace the current pricing mechanisms with a cap-and-trade market that allows farmers to trade water with urban dwellers and set up a groundwater extraction auction.

Figure 1. Graphical Illustration of the Proposed Market Design



The first step for policymakers is to cap the aggregate water use across all sectors and determine the percentage of water to be supplied from ground sources. This cap should shrink during droughts to signal scarcity and over time to encourage long-run conservation efforts. The groundwater percentage should be set to ensure that the extraction rate remains below the natural recharge rate, with the possibility of temporary increases amid droughts.

Policymakers should allocate water use permits in a manner such that every farm and household can fulfill its basic needs and auction the surplus permits. One critique of cap-and-trade systems is the price volatility of permits.[21] The free allocation protects low-income households from potential price spikes. Once the initial allocation is completed, people can only obtain additional permits from the market.

This water trading system can reduce the aggregate water use to the capped level, and farmers are predicted to contribute the most to the reductions. Instead of facing extremely low water prices, farmers now need to purchase permits at market prices should they use more water than permitted. This incentivizes them to opt into water-efficient irrigation practices (e.g., drip and sprinkler) and cultivate fewer water-thirsty crops. To reduce statewide water use by 25 percent, a cap-and-trade system is projected to be 19 percent cheaper than water usage mandates.[22]

To overcome the tragedy of the commons in groundwater extraction practices, farmers should bid for the rights to pump water. The volume of extraction (green in figure 1) equals the water cap multiplied by the predefined percentage of supply that should come from groundwater. The lowest bidders will get pumping licenses and receive government payments at the market clearing price. After extracting water from underground, farmers cannot use it unless they hold or obtain unused water permits.

Farmers are willing to accept low compensation to supply groundwater only if their extraction expenses are even lower. This discourages the extraction from overdrawn aquifers that tend to feature higher pumping costs.[23] This auction can thus minimize the cost of supplying water and meanwhile protect the most vulnerable groundwater basins. A similar price intervention in Colorado reduced agricultural groundwater usage by 33 percent.[24]

Of course, establishing the cap-and-trade market requires substantial investments in infrastructure, such as constructing water transmission pipelines and installing volumetric meters to monitor extraction. All consumers should pay an annual fee proportional to their water consumption. The government should use revenues from this service charge, along with proceeds from the water permits auction, to fund the infrastructure projects without levying new taxes.

Evaluating the New Market Design

A few key metrics can be used to benchmark the efficiency of the cap-and-trade market with groundwater auctioning. The first is the correlation between water supply and permit prices. When the government reduces the water cap amid droughts, permit prices go up if the market is competitive. In the presence of a monopoly (e.g., a large farm holding all permits), the correlation could be close to zero because the farm can be a price setter. A correlation closer to −1 indicates that the prices can better signal the scarcity of water.

Since the policy primarily aims to correct farmers' incentives to conserve, water use per acre or per unit of production is an alternative metric. Water use will shrink if farmers take up water-saving irrigation methods and crops under the new rules.

To evaluate the effects on groundwater preservation, policymakers can compare the trajectory of total groundwater reserves before and after implementing the proposed design. Under the original scenario, reserves have been steadily dropping. If the market-based policy worked, reserves would increase over time as the policy promised a lower withdrawal rate than the natural replenishment rate.

Policymakers should deploy the new market design across different water districts in a randomized order. By introducing time variations in policy rollout, untreated water districts can serve as control groups for the treated ones. This could enable the interpretation of the changes in outcome variables as causal effects of the policy. If the entire state adopted the policy at the same time, the observed statewide changes could simply result from confounding factors such as a simultaneous climate shock leading farmers to permanently adjust their crop mix.

Endnotes

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Hoover Institution, Stanford University
434 Galvez Mall
Stanford, CA 94305-6003
650-723-1754

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