Sharing Colorado River Water: A View From Southern California

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The Colorado River Basin (CRB) supplies approximately one-third of the water used by Southern California's cities and suburbs while also supporting the region's large-scale agricultural operations, particularly in Imperial and Riverside counties. This article evaluates the economic value of water across urban and agricultural sectors using a hydro-economic model. The hydro-economic model highlights the potential impacts of water curtailment on various states and user groups and serves as a tool for evaluating various policy interventions to manage shortages.

The Colorado River Basin (CRB) and its tributaries provide water to nearly 40 million people and irrigate almost 4 million acres of agricultural land. The Colorado River Compact of 1922 (the compact) and its subsequent agreements and court decrees regulate the use and management of the CRB among the seven basin states, Native American tribes, and Mexico. Article III of the compact allocates 7.5 million acre-feet (MAF) annually to the Upper (Colorado, Utah, Wyoming, and New Mexico) Basin and Lower (Arizona, California, Nevada) Basin states. States within each sub-basin were responsible for allocating water shares among themselves. Mexico's share of 1.5 MAF needs to be satisfied first.

By 1948, the Upper Basin states entered the Upper Colorado River Compact—an agreement assigning percentage shares of the 7.5 MAF apportionment to the Upper Basin states (51.75% Colorado, 23% Utah, 14% Wyoming, and 11.25% New Mexico), rather than fixed amounts to each state. On the other hand, the Lower Basin states resorted to a judicial apportionment ordered by the Supreme Court in 1963, which allocated 4.4 MAF to California (with 3.4 MAF allocated to the Imperial irrigation district and Coachella Valley water district), 2.8 MAF to Arizona, and 0.3 MAF to Nevada. Until 1990, most of the basin states did not use their full allocations. Nonetheless, historical streamflow records show that the compact overpromised water allocations by overestimating the river's average annual flow at the time the contract was signed—an estimate rarely met in subsequent years. In addition, the impacts of climate change and population growth have exacerbated the imbalance between water supply and demand, intensifying pressure on the basin.

Decreased water supplies increase competition for water among states and users, potentially causing concern and conflicts. Notably, the basin states, federal government, and stakeholders are currently working to craft new agreements regarding the management of the basin's major reservoirs, which will go into effect when the current operating rules expire at the end of 2026. This new agreement will be significant, as it will set the course for Colorado River water management for the next few decades.

However, current negotiators rely almost exclusively on models that only account for hydrologic factors to craft their proposals, leaving important economic factors out of the picture. In other words, current proposals do not consider how new management rules may impact the economic well-being of different water users (e.g., agricultural producers and municipalities). This is essential information that, if made accessible through a hydro-economic model, can empower stakeholders across the basin to develop economically sound strategies for navigating future water shortages.

This article contributes to understanding the economic value of water use in the basin. By modeling a wide range of users, sectors, and regions, it identifies economically efficient water allocation options that can inform responses to potential curtailments and compensations. At the core of this contribution is introducing a hydro-economic model of the CRB (HEM-CRB), which provides insights into current water-use patterns and establishes a foundation for assessing future climate shocks and policy interventions. The model estimates the economic value of water across uses and regions, illuminating opportunities for reallocation and exchange to maximize the overall economic benefit of limited water supplies.

Policy Proposals and Negotiations

In the early 2000s, low river flows, increasing water demand, and dropping reservoir levels pushed the CRB states and the federal government to create a new framework to manage the system's two major reservoirs (Lake Powell and Lake Mead). The result was the 2007 Interim Guidelines, which established certain rules to prevent reservoir levels from falling to critically low elevations.

However, despite the 2007 guidelines, reservoir levels continued to decline as the 21st century progressed. In 2019, the basin states were once again pushed to find ways to halt (or at least slow) the decline. The resulting agreements were called the Drought Contingency Plans (DCP). The DCPs asked the Upper Basin to voluntarily reduce

water, but did not result in substantial reductions in reservoir decline.

In 2022, the commissioner of the Bureau of Reclamation told a congressional committee that the basin states needed to cut a one-time amount of 2 to 4 MAF of water to prevent reservoir collapse before 2026. The testimony sparked a new round of negotiations among the basin states. The process resulted in another update to the 2007 Interim Guidelines in the form of a supplemental environmental impact statement, where the Lower Basin agreed to cut 0.75 MAF of additional water each year from 2023 to 2026 with the hope of stabilizing the system through 2026. At the end of 2026, the 2007 guidelines and its companion agreements and modifications will expire, requiring a new set of agreements. State and federal government leaders are currently negotiating to create a new agreement to manage the major reservoirs in the CRB.

The new agreement will introduce a significant change, as it will set the course for CRB water management for the next few decades. As of this writing, the volume of water cuts being proposed, but not yet agreed to, by all parties may be enough to account for current losses of flows. Even if there is widespread agreement among all the CRB states and Mexico on specific water cuts proposed post-2026, these measures may not be enough to fully address future flow reductions caused by climate change in the CRB.

The Colorado River Basin and Southern California

The CRB supplies roughly a third of all water for Southern California cities and suburbs. It also supplies nearly all of the irrigation water used by the farming industry in Imperial County and approximately 60%–70% in Riverside County, primarily in the Coachella Valley. Southern California's farmers are the CRB's largest water users and hold the highest-priority water rights. In contrast, urban centers have lower-priority rights within the basin.

The Imperial Irrigation District (IID), Coachella Valley Water District (CVWD), Palo Verde Irrigation District (PVID), Metropolitan Water District of Southern California (MWD), and San Diego County Water Authority (SDCWA) are the major California water users of the CRB. The irrigation districts IID, CVWD, PVID, and Native American tribes hold senior water rights to 3.85 MAF. The urban centers MWD and SDCWA hold 0.55 MAF. The Quantification Settlement Agreement (QSA), signed in 2003 by the SDCWA, CVWD, IID, and MWD, enhanced urban water supply reliability through water transfers from agricultural irrigation districts. However, those water transfers threatened the sustainability of the Salton Sea, a vital but highly polluted habitat for fish and birds. The Salton Sea, primarily fed by IID drainage, suffers from reduced inflows due to water curtailments and advanced irrigation systems. This has led to increased nutrient concentrations and habitat degradation. The QSA addressed these concerns, but future water reductions may have catastrophic consequences for the already degraded ecosystem.

Southern California's irrigation districts grow field crops, tree crops, and vegetables. While alfalfa and other hays are less dominant here than in the broader CRB, they still cover about 50% of irrigated land—38% in IID and

Table 1. Summary of Cropland, Water Use, and Benefits of Urban and Agricultural Sectors by State

		AZ	CA	CO	NV	NM	UT	WY	Colorado River Basin Total
Agriculture	Crop acreage (Thousands of Acres)	803	529	470	3	42	190	166	2,199
	Water use (Thousands of Acre-Feet)	2,996	1,743	1,656	7	131	583	423	7,539
	Total Benefits (Millions of Dollars)	489	576	220	1	20	75	35	1,416
	Per Acre-Foot Benefits (Dollars/AF)	163	330	133	143	153	129	83	188
Domestic	Population (Thousands)	5,936	18,784	3,878	2,085	880	1,726	101	33,391
	Water use (Thousands of Acre-Feet)	1,176	2,837	503	316	146	268	24	5,253
	Total Benefits (Millions of Dollars)	2,358	13,384	861	747	742	180	57	18,328
	Per Acre-Foot Benefits (Dollars/AF)	2,005	4,718	1,712	2,364	5,082	672	2,375	3,489
Total	Water use (Thousands of Acre-Feet)	4,172	4,580	2,159	323	277	851	447	12,792
	Benefits (Millions of Dollars)	2,847	13,960	1,081	748	762	255	92	19,744
	Per Acre-Foot Benefits (Dollars/AF)	682	3,048	501	2,316	2,751	300	206	1,543

Source: Crespo et al. 2023.

Note: This analysis focuses solely on irrigated areas within the Colorado River Basin, excluding trans-basin diversions for irrigation, except for the irrigated area served by the All-American Canal in California. Consequently, the reported irrigation area, water use, and economic benefits for agricultural use are underestimated. Arizona includes water from the Gila River and other tributaries, which are outside of the compact; urban water use in California also includes water from other sources, contributing to higher actual figures in both cases.

65% in PVID. Grapes, citrus, and vegetables are also key, with CVWD focusing on citrus and vegetables. Crop production brings up to $576 million annually to the region's farmers. The Southern California urban sector is home to over 18 million people and heavily depends on inter-basin water transfers from the CRB.

Comparing the economic value of water used by farmers and urban centers identifies potential opportunities for reallocation within and between sectors. This article presents the results of the hydro-economic model of the Colorado River Basin (HEM-CRB) to explore these dynamics. The HEM-CRB is an integrated framework representing the water system's complex interactions—essential for developing basin-level solutions.

The Economic Value of CRB Water

The HEM-CRB model estimates the economic value of water use across seven states, encompassing 40 irrigation districts and 379 urban centers. Agricultural water use is modeled for each of the 40 irrigation districts (across the seven states) to maximize the benefits of cultivating 39 different crops using three types of irrigation technologies. Please refer to our working paper, listed in the references at the end of the article, for a detailed description of the model framework, its assumptions, and the full set of results.

Table 1 summarizes the results of the HEM-CRB model by state and sector. As noted, CRB water generates a total of $19.7 billion in benefits at the basin level, including approximately $1.4 billion from agricultural production and $18.3 billion from urban water use. The share of benefits by state is as follows: California accounts for approximately 71% of the total, followed by Arizona with 14%, Colorado with 5%, Nevada and New Mexico each with 4%, Utah with 1%, and Wyoming with less than 1%. California's large urban population drives this, though benefits are partly from non-CRB sources. Comparing CRB water values across states and sectors using total benefit values is misleading due to significant variations in user size and water sources.

As indicated in the last row of Table 1, a more appropriate measure is to compare benefits generated per acre-foot of water used, also known as the dollar per drop. The large differences in the estimated benefits per acre-foot stem from high-value crop specialization and higher urban water prices in Southern California. While these results suggest the potential for efficiency improvements in water use across the rest of the basin, they do not justify allocating water curtailments based solely on average values. Instead, the marginal value—the shadow price of water—captures the benefit gained from the last unit of water used, reflecting how value changes with incremental water use. Under water scarcity conditions, efficient water allocation occurs when the marginal value of water is equal across all water uses. Ideal water markets produce efficient water allocation, as sectors will exchange water until the marginal value is uniform across all uses.

Table 2 presents economic indicators for the irrigation districts in California. The Coachella district (CVID) exhibits the highest per-acre benefit per acre-foot, with 75% of its land exceeding $2,000/acre-foot, due to its specialization in citrus and vegetables. The Yuma Project (YP) has approximately 30% of its land above this threshold. This highlights a division between districts specializing in high-value versus low-value crops. Irrigation districts with a greater concentration of high-value crops are vulnerable to significant benefit losses due to potential water curtailments. These results are valuable for designing programs for water transfers within the agricultural sector in California.

The Marginal Value of CRB Water in California

The marginal value of water with the optimal water allocation (shown as points in Figure 1 on page 8) represents the maximum additional benefit derived from one additional acre-foot of water. It reflects the value of water when allocated to its most beneficial use. Under optimal conditions (efficient use), the first acre-foot is allocated to the use yielding the highest benefits, with each subsequent acre-foot allocated in descending order of benefit. Thus, the marginal value decreases as water allocation increases, reaching zero when an additional acre-foot provides no further benefits. Aligning with the principle of optimal water allocation, the lines in Figure 1 depict the cumulative share of benefits. Under optimal allocation, the

Table 2. Benefits of Water Use by California Irrigation Districts

	Crop Acreage (Thousand Acres)	Water Applied (Thousand AF*)	Benefits (Million Dollars)	Per AF Benefits (Dollars/AF*)
IID	397.34	1,292.63	360.35	279
PVID	75.29	321.48	55.42	172
CVID	37.41	84.66	135.14	1,596
YP	14.60	28.85	22.52	781
SCW-CR	3.68	15.76	2.38	151
California	**528.36**	**1,743.38**	**575.81**	**330**

Source: Crespo et al. 2023.

Note: IID stands for Imperial Irrigation District; PVID stands for Palo Verde Irrigation District; CVID stands for Coachella Valley Irrigation District; YP stands for Yuma Project; and SCW-CR stands for Silver Creek Wash-Colorado River. *AF = acre-foot.

marginal value is equal across sectors and regions. Points in the figure indicate the water share at which marginal value equalizes, providing insights into optimal allocation, water reduction shares during curtailments, and benefit distribution by sector.

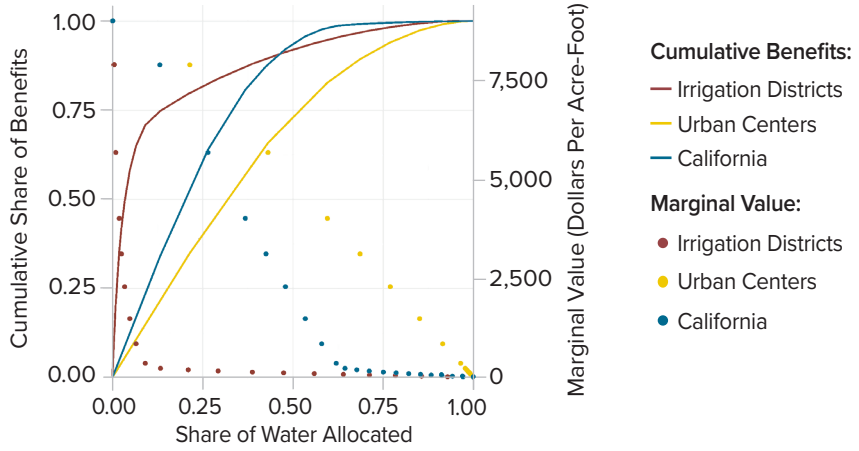
As indicated in Figure 1, irrigation benefits (red line) concentrate heavily; 20% of the water yields 80% of the benefits. Urban benefits (yellow line) show a sharp response to reductions, indicating higher sensitivity and larger losses than curtailments to the irrigation sector. Figure 1 illustrates that an optimal water allocation when water is scarce necessitates the agricultural sector (represented by the irrigation districts) bearing the majority of curtailments to avoid substantial benefit losses. However, because irrigation districts hold priority water rights, minimizing the impacts of water curtailments in Southern California requires compensated water transactions between irrigation districts and urban centers. This could benefit both irrigation districts and urban centers, as farmers can maintain their benefits and urban centers can sustain their water use.

Concluding Remarks

Declining water supplies will heighten competition for water across states and among diverse user groups—spanning sectors, within sectors, and across various administrative levels, including counties, subbasins, and states. Addressing the current and future challenges in the CRB requires informed decision making that accounts for the complex interdependencies among these groups at the basin-wide scale. Currently, many policy proposals rely almost exclusively on hydrologic models, often neglecting critical economic considerations. Incorporating economic efficiency into water management is essential, as it provides a sound basis for allocating water shortages. Estimating the economic value of different water uses enables the design of win-win solutions through compensation mechanisms both within and across sectors and regions.

The hydro-economic model presented in this paper offers a robust framework for evaluating policy interventions by estimating the value of water across regions and sectors. It also enables the calculation of marginal water values, providing key insights for designing compensation-based policies and supporting the development of efficient water trading systems. Our results reveal significant variation in the estimated value of water (in dollars per acre-foot) across states and sectors, suggesting a strong foundation for tailoring water policies to regional and sector-specific needs. The findings point to the agricultural sector as a critical policy target for addressing water scarcity, highlighting the model's potential to inform targeted, cost-effective strategies for managing current and future shortages across the basin.

Figure 1. The Total and by Sector Cumulative Share of Benefits and the Marginal Value of Water in California



Source: Authors' calculations.

Note: The X-axis indicates the water allocation proportion and is ordered from highest to lowest water value (dollars/drop).

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For additional information, the authors recommend:

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