# Water Trading on the Colorado River: A History and Review of the Efficiency and Equity Considerations

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**Abstract**

With reduced supply due to climate change and increased stress due to growing populations, improved management of Colorado River resources becomes ever more important. Increased water trading is one management tool to increase flexibility, enhance economic well-being, and incentivize water-use efficiency. However, markets of Colorado River water remain thin. Beginning with background and history on interstate and intrastate water trading of Colorado River water, this paper reviews the Colorado River water trading literature. The paper summarizes the literature on the gains from optimal reallocation and water trading, and pays particular attention to third-party impacts, issues of equity, and barriers to trade. Identification of the barriers and negative externalities associated with water trading is important in this context because water trading remains an important management tool for Colorado River users facing increased water scarcity in the future.

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# 1 Introduction

The Colorado River is one of the most important water sources in the United States. It provides drinking water to nearly 40 million people, irrigation water to over 5 million acres of land, and habitat for numerous fishes and riparian ecosystems (U.S. Bureau of Reclamation, 2012). The Colorado River serves seven states in the U.S. and two in Mexico. Life as we know it today, with prosperous urban centers in Los Angeles, San Diego, Las Vegas, Denver, and Phoenix would not be possible without allocation, diversion, and management of Colorado River resources.

Management and appropriation of the Colorado River has been long and contentious (Hundley, 1986). Because of water's value to sustain life, produce energy, and grow crops, the allocation of its scarce supply has major economic implications. The 1922 Colorado River Compact agreement and subsequent legislation, collectively known as "The Law of the River," governs the allocation of the Colorado River among the Upper Basin and Lower Basin states. These water allocations, also referred to here as water rights, are fixed in time, despite changing economic and demographic factors across the basin states and over time.

Water rights regimes that are fixed in time, such as that established through the Colorado River Compact, are economically inefficient because water demands change over time due to urban growth, changes in agriculture, and changing climatic conditions (Howe, Schurmeier, and Shaw, 1986; Chong and Sunding, 2006). Environmental pressures and unsettled indigenous claims further induce scarcity and increase the value of this limited resource. Water trading, the voluntary exchange of quantifiable water allocations among willing buyers and sellers, is one mechanism to increase flexibility within a water allocation system, enhance economic well-being, equalize risk-sharing among users, and incentivize water-use efficiency (Burness and Quirk, 1980).

This paper reviews the water trading literature as it relates to the Colorado River Basin, with specific attention paid to issues of equity, the distribution of benefits from water trade, and other third-party impacts. This paper helps conceptualize the magnitude of water trading both within and across basin states, and what trading means for the economic well-being of the seven basin states.

Figure 1: Map of the Upper and Lower Colorado River Basins


Source: U.S. Geological Survey

# 2 History of Water Trading

Water trading of Colorado River resources consists of both intrastate transfers as well as limited interstate arrangements. Water trading takes many forms, and is referred to interchangeably in this paper as water leasing, water transfers, water markets, etc. In this section, I review the

background and history of water trading across and within the basin states.[1]

## 2.1 Intrastate Trading

Intrastate water trading regimes vary state-by-state according to individual state regulations and governing bodies. In some states, like Arizona, the water from the Colorado River is managed separately from all other surface water in the state (Arizona Water Banking Authority, 2016).

California's Colorado River allocation supports both Southern California urban populations and agricultural production in Imperial and Riverside counties. A 1988 agreement between the Metropolitan Water District of Southern California (MWD) and Imperial Irrigation District (IID) allowed MWD to buy approximately 100,000 acre-feet per year of IID's allocation. In 1998, IID entered into an agreement with the San Diego County Water Authority to trade roughly 200,000 acre-feet per year. Additional agreements developed with the 1992 California Water Bank (Summitt, 2011). Enabled by the Quantification Settlement Agreement of 2003, urban water agencies, namely MWD and the San Diego County Water Authority, executed long-term trades with the agricultural sector, primarily through Palo Verde Irrigation District and IID (Public Policy Institute of California, 2016). By enabling water transfers and other supply programs, the Quantification Settlement Agreement helps California operate within the state's 4.4 million acre-foot (MAY) annual apportionment of Colorado River water.

Nevada's Colorado River allocation of 0.3 MAF per year is managed by the Southern Nevada Water Authority, which was established in 1991. Although Nevada has banked resources in the Southern Nevada Water Bank, in the Arizona and California water banks, and in Lake Mead for its own future use, the state does not perform any water transfers between other basin states. The Southern Nevada Water Authority has stored 601,000 acre-feet in Arizona's aquifer and 330,000 acre-feet in California (Southern Nevada Water Authority, 2017).The Southern Nevada Water Authority's 2017 Water Resource Plan states that water transfers remain an important management tool for the future (Southern Nevada Water Authority, 2017).

Colorado's water market is administered by the Colorado River Water Conservation District, created in 1937. Colorado has the most active water market of the basin states and is often promoted as a model for other trading schemes (Michelson, 1994). The Colorado-Big Thompson project, a federal water diversion initiative, facilitated the water market. This market is one of the few where water price information is made available to ready buyers and sellers (Brown, 2006).

Arizona established a water bank in 1996 with the goal of fully utilizing Arizona's Colorado River allocation. The water bank has served a number of purposes for the state including groundwater management, mitigating the impacts of Colorado River shortages, enabling interstate storage and trades, and helping settle Native American claims to water (Megdal and Seasholes, 2016; Arizona Water Banking Authority, 2016). The Arizona Water Banking Authority has contracted with California and Nevada entities to allow these states to annually store some unused proportions of Colorado River allocations. These states pay Arizona to store water in the groundwater aquifer in order to extract a similar quantity of Colorado River water in the future.

[1]The author acknowledges that this compilation of water trading activity may not be comprehensive.

### 2.2 Interstate Trading

A fully flexible interstate water market, one which provides price information and enables buyers and sellers to voluntarily trade allocations across state boundaries, constitutes a policy instrument that would move us toward the economically efficient reallocation of Colorado River resources. Primarily due to legal and political barriers, interstate water trading agreements have been extremely limited in scope. However, pre-existing interstate water management programs show promise for increased interstate water trading in the future.

To my knowledge, interstate water trading agreements consist primarily of two programs. The first, the Pilot System Conservation Program, was coordinated between the Department of the Interior and several other Colorado River water agencies, including the Southern Nevada Water Authority and the Coachella Valley Water District (Southern Nevada Water Authority, 2017). In 2014, water agencies from both the Upper and Lower Basins and the Bureau of Reclamation agreed to jointly fund water conservation projects. Water conservation methods varied by agency, but included programs to pay farmers to reduce water consumption, which constitutes an incentive-based policy instrument that could function like a system for water transfers.

The second agreement was a program called the Drought Response Program, which among many other initiatives, encourages and implements systems to facilitate voluntary water transfers and exchanges. The Drought Response Program is a source of funding for water agencies to build long-term drought solutions, which may include water markets (U.S. Bureau of Reclamation, 2018). These two initiatives recognize the importance of water transfers as one tool among many to reduce water management challenges, and are reflective of movement in this direction going forward.

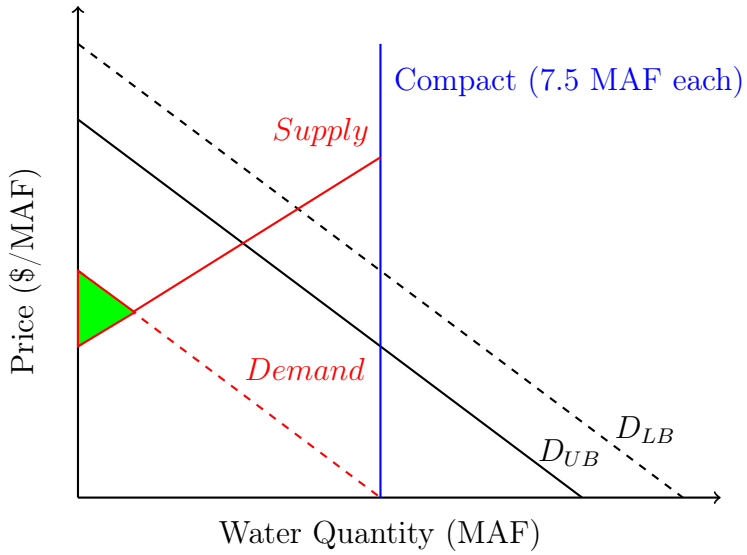
## 3 Efficiency Considerations

Water markets are espoused by economists as a policy instrument to manage water because of the market's ability to increase economic efficiency. Facilitating the transfer of water rights allows the resource to be allocated to those that value it the most, comprising a situation where aggregate economic welfare is increased.

Several inefficiencies result from a water appropriation scheme such as that governed by the Law of the River. The efficient allocation of water occurs where marginal net benefits are equated across users, meaning the economic benefit associated with an additional unit of water is equal across all (Olmstead and Keohane, 2006). Given that water demands across basin states vary, shortages due to drought increase scarcity, and urban growth changes demand over time, we know that the allocation of water resources determined by the Colorado River Compact and subsequent legislation is inefficient and inflexible. Trading can overcome these inefficiencies, generating greater economic benefits and providing proper incentives for water conservation technology investments (Chong and Sunding, 2006).

Figure 2 provides a simple illustration of the potential gains from interstate water trade. $D_{LB}$ and $D_{UB}$ represent the aggregate demand curves for the Lower Basin and Upper Basin, respectively. The vertical blue line represents the equal allocation of water between the two halves, from which supply and demand curves for a water market are derived. The area of

Figure 2: Water Trade Between Lower and Upper Basins




the shaded triangle shows the economic benefits from water trade, assuming linear, parallel demand curves and perfect competition.

Using hydroeconomic models, several papers examine the magnitude of economic benefits that would stem from optimal reallocation of water resources (Harou, 2009). This branch of literature employs optimization models to estimate and identify optimal allocations and prices which could emerge in hypothetical water markets. Relatively few papers in this body of literature have applications to the Colorado River.

Brooker and Young (2004) estimate the economic benefits achievable from optimal allocation of Colorado River water, and find that trading can recover 64% of the total benefits from optimal reallocation. The authors estimate the economic benefits from expanded intrastate and interstate consumptive use markets. They find evidence of benefits from intrastate trading, but see negligible differences in efficiency improvements from interstate trading over intrastate transfers.

Other water trading studies which focus on the Colorado River have examined the features of existing markets, without utilizing an optimization model or formally testing for market efficiency. Brookshire et al. (2004) study the prices paid for water in three intrastate water markets covering areas in Arizona (Lower Colorado), Colorado (Upper Colorado), and New Mexico (Rio Grande). They look at the price history in order to examine the efficiency of these three separate markets, but their analysis does not constitute a formal test of market efficiency. Summary statistics from trades within each of these markets reveals significant differences in water market activity, including prices and quantities. They attempt to sketch out an aggregate demand curve for water rights using a two-staged least squares method (Brookshire et a. 2004).

Howe and Goemans (2003) evaluate the functioning of water markets in terms of types, size, and frequency of transfers and how they are determined by different institutional arrangements and economic conditions. They compare two different institutional arrangements for markets in Colorado to show how the nature of rights and oversight not only affects market thickness, but also third-party impacts. Results show that more severe economic impacts are likely in

specialized, marginal agricultural regions. The indirect effects of lost agricultural production are higher than those in a thriving area (Howe and Goemans, 2003).

### 3.1 Barriers to Colorado River Water Markets

The barriers to water markets are high; impediments include costs due to information gathering, negotiation, and enforcement, legal barriers, and political and social resistance. These high transactions costs, some of which are unique to water as a non-standard commodity, reduce and inhibit water trading activity.

Wildman and Forde (2012) identify barriers specific to interstate water marketing on the Colorado River. Regulations on water trading vary widely across basin states, making a merge of the intrastate markets challenging. Furthermore, an interstate market requires management by an authority with interstate jurisdiction, meaning either the U.S. Bureau of Reclamation must step into a more substantive role setting basin-wide conservation policies or a new authority needs to be created. Lastly, a concern for Colorado River basin users is the fear of a Lower Basin "water grab". Distrust and uncertainty of a market arrangement, particularly on behalf of Upper Basin states that are worried about losing their water rights, are major impediments to future water transfers between Upper Basin and Lower Basin states (Wildman and Forde, 2012).

## 4 Third-Party Impacts and Equity Considerations

Given the unique features of water as a commodity and the externalities associated with trading, water markets generally require additional regulation to minimize third-party impacts. Third-party impacts refer to impacts that are unintended and external to the trade. These may include impacts on the environment and instream flows, impacts on other rights holders and downstream use, and groundwater-surface water interactions. Furthermore, third-party impacts may involve a social equity component and include disproportional impacts on low-income groups and socioeconomic area-of-origin effects (Chong and Sunding, 2006).

Water trading regimes can have significant equity or distributional consequences. Water trading sometimes results in land fallowing. Decreased farm activity leads to less farm employment and other negative effects on the local economy. The negative local effects of water exports are an important concern. However, if the new income from a trade is being reinvested into the local community, then the net effect can be positive (Chong and Sunding, 2006). Negative socioeconomic area-of-origin impacts can be accommodated and compensated.

Government agencies can establish funds to mitigate negative, third-party impacts. Local, regional, or federal governments can improve equity in water distribution by providing subsidies or making water available to those that cannot pay the market price for water. Chong and Sunding (2006) suggest a cap on the amount of trading or additional payments on water purchases to go to the local government to account for water trade effects. Additionally, Howe and Goemans (2003) suggest an additional transfer fee per acre-foot be imposed on the buyer and transferred to the government in the area of origin to support social services and facilitate transition. The efficiency-equity tradeoff is well-known among economists, but seldom addressed

formally. However, the equity dimension is important because it both dictates outcomes in the real-world and determines the relative well-being of different areas and groups of people.

# 5 Conclusion

Economists promote market-based instruments to manage water by showing that there are large economic benefits from the reallocation of water from low-value to high-value uses. A fixed water allocation scheme, such as that dictated by the Law of the River, reduces economic surplus relative to a scheme that flexibly reallocates water across users during times of drought, and over time as demographic and economic factors shift demands in different areas. With reduced supply due to climate change and increased stress due to growing populations, improved management of Colorado River resources becomes even more important.

Although Colorado River water markets have remained thin, we can expect to see an increase in water trading in the future. The Bureau of Reclamation's 2012 study on water supply and demand in the Colorado River Basin acknowledges future water supply and demand imbalances, which are exacerbated in part by reduced supplies due to climate change (U.S. Bureau of Reclamation, 2012). Several strategies are proposed to resolve these imbalances, of which water transfers, exchanges, and banking make up an important component of the suite of management tools required to meet the needs in the Basin going forward. Understanding the barriers to trade and finding ways to remedy third-party impacts will be vital for the successful implementation and development of water markets in the future.

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