

Winner Takes All or Win-Win: The Pros and Cons of Water Trading in Arizona

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Abstract

Water markets have been identified as one solution to addressing water scarcity in the Western United States. This paper examines how water transfers indicate water commoditization and the implications surrounding water markets' social, environmental, and economic aspects. A systematic review of the recent literature found a disparity highlighting substantially more research on the environmental and economic benefits of water markets than on the social impacts of water markets. This finding contrasts with survey responses that found Arizona residents prioritize social needs, revealing a disconnect between what academics discuss in the literature and what is important to people.

Keywords: water transfers, commoditization, social impacts, environmental impacts, economic impacts

Acknowledgment

I am deeply grateful to my husband for his unwavering encouragement, support, and patience throughout the writing of this capstone paper.

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Introduction

Over-allocation of water resources, prolonged drought, and rapid population growth increase water stress in Arizona. To help alleviate some of the pressures caused by these issues, the state, private individuals, and private companies buy, sell, and lease water rights. However, the commoditization of a vital resource is not without its hazards, and regulations must be enacted to avoid exploitation. The benefits of water transfers in the literature are plentiful, but the potential drawbacks of water trading have yet to be as thoroughly researched. Evaluating both is critical for the equitable and successful functioning of water markets.

According to climate Scientist Brad Udall, the West is no longer experiencing a drought but aridification (Loomis 2021). Drought is a temporary condition, whereas aridification is permanent. Reduced Colorado River flows are the new normal. Adapting to this new standard will require the resilience and cooperation of those who rely on the Colorado River for their livelihood. Transferring excess water from conservation measures to another use is one way Arizona residents can adapt to increasing water scarcity. Current regulations hinder water transfers by making them more time-consuming and costly, expenditures that large investment companies can more easily absorb than smaller groups or individuals. Market forces favor a winner takes all scenario. For water transfers to be sustainable, they must be presented as a win-win for everyone.

Water transfers can also encourage unsustainable growth by creating an illusion of more water availability than exists. Increased efficiency does not make a finite resource infinite. The city of Buckeye, Arizona, is an example of unsustainable growth with limited groundwater resources. For a city of its planned size, reliance on the Arizona Groundwater Replenishment District to provide the required assured 100-year water supply may result in an uncertain future.

Literature review

Regulations surrounding water use in Arizona were devised over a century ago. In the 1850s, the doctrine of Prior Appropriation was implemented which states first in time, first in right (Woods 2021). The first person to put surface water to beneficial use receives the oldest water right. As a result, senior water rights are prioritized when surface water is allocated. Any water that is not used is reallocated to the next in line, a use it or lose it arrangement.

Drought and overallocation of the Colorado River impact water availability to water rights holders. The Colorado River Compact was created in 1922 and its main purpose was to allocate the river water between the upper (Utah, Colorado, Wyoming, and New Mexico) and lower basins (Arizona, California, and Nevada) with the dividing line at Lees Ferry on the Arizona Utah border (Gelt 1997). Each basin was allocated 7.5-million-acre feet. An acre-foot is the amount of water needed to cover one acre to a depth of one foot or approximately 326,000 gallons. These allocations were based on the annual flow at Lees Ferry of 16.4-million-acre feet. However, based on three hundred years of data, actual average flows were 13.5-million-acre feet (Gelt 1997). Between the allocations for the upper and lower basins plus 1.5-million-acre feet allotted to Mexico, the total allocations equal 16.5-million-acre feet. According to Glennon (2016), the actual available water is around 11-million-acre feet. This discrepancy results from 1.6-million-acre feet lost each year from Lake Mead and Lake Powell due to evaporation in addition to nine percent of the annual flow estimated by the Bureau of Reclamation to be lost due to climate change. However, changing the way water was allocated is difficult because the infrastructure was planned and built around those water expectations (Regan 2022). Water transfers have been identified as a way to help alleviate the stress caused by over-allocation.

According to Glennon (2016), “A water transfer simply changes one current use to another. If new growth can’t secure water through transfers, it will get water the old-fashioned way: by making new diversions from rivers, building new dams, or drilling new wells.” Water transfers help alleviate water stress in the arid and drought-stricken Southwest by providing options to meet water demands for those who need them, such as municipal water managers or environmentalists. Water transfers can also offer significant economic benefits by transferring water from a lower value to a higher value. According to Brewer et al. (2008), “Groundwater for farming near Marana, Pima County, Arizona, costs approximately \$27 per acre-foot, whereas the same water supplied by Tucson Water, with an increasing block rate structure, will cost customers from \$479 to \$3,267 per acre-foot.” However, Eden & Murray (2019) state, “Gross economic benefit comparisons ... fail to account for important *non-market values* [emphasis added] such as food security, wildlife habitat, ecosystem services, and rural cultures dependent on agricultural water use.”

Water transfers can be used to restore in-stream flows, benefiting environmental causes as well. According to Richter et al., (2019) reducing river flows by just ten percent results in ecological damage. Richter et al., (2019) also state that Colorado was the first to allow purchasing water rights for in-stream purposes. However, by 1973 when this decision was made, any water right purchased would be a junior water right from a river that was already over-allocated. The result is a water right on paper but little chance of receiving any water due to prior appropriation.

Most water transfers in the Western United States are short-term leases usually lasting only one season or one year rather than permanently transferred as shown in Figure 1. This is mostly due to the flexibility of short-term leases (Eden & Murray 2019).



Figure 1. The volume of water leased and permanently transferred in the Western United States. Water Resources Research Center Arroyo 2019.

According to Culp et al. (2014), some of the prominent laws regarding water transfers in Arizona and other parts of the West that hinder water transactions by making them more time-consuming and costly are:

1. Appurtenancy doctrine which ties the water rights to the land; water rights must be legally transferred if used for another purpose.
2. No-harm-to-juniors rule requires proof the transfer will not infringe upon other water rights holders. This increases the cost and time it takes to complete transactions.
3. Anti-speculation doctrine requires precise details regarding the new location, purpose, and water use.
4. Beneficial use doctrine requires water to be used for some purpose. Water not fully utilized may be considered abandoned and therefore forfeited. This can result in inefficient water use just to hang onto the water.

5. Salvaged water doctrine does not allow water rights holders to benefit from conserving water. Any water not used will be given to the next in line.

These laws confirm the Arizona Municipal Water Users Association’s, (AMWUA 2018) statement, “Arizona policy leaders have historically rebuffed efforts to make it easier for the private sector to acquire and market water supplies.” However, the Arizona Department of Water Resources estimated that Arizona will need an additional 900,000 to 3.2 million-acre feet over the next 20-100 years (AMWUA 2018).

Water transfers can potentially play a pivotal role in meeting future water demands. The population of the Phoenix-Mesa-Chandler metro area is expected to grow by 67.3 % between 2022 and 2060, ranking 17th among all 384 metro areas in the United States (Stebbins 2022). Figure 2 shows 79% of water supplies in the western United States were used for agriculture and 63% of all water transfers were for municipal uses in 2015.

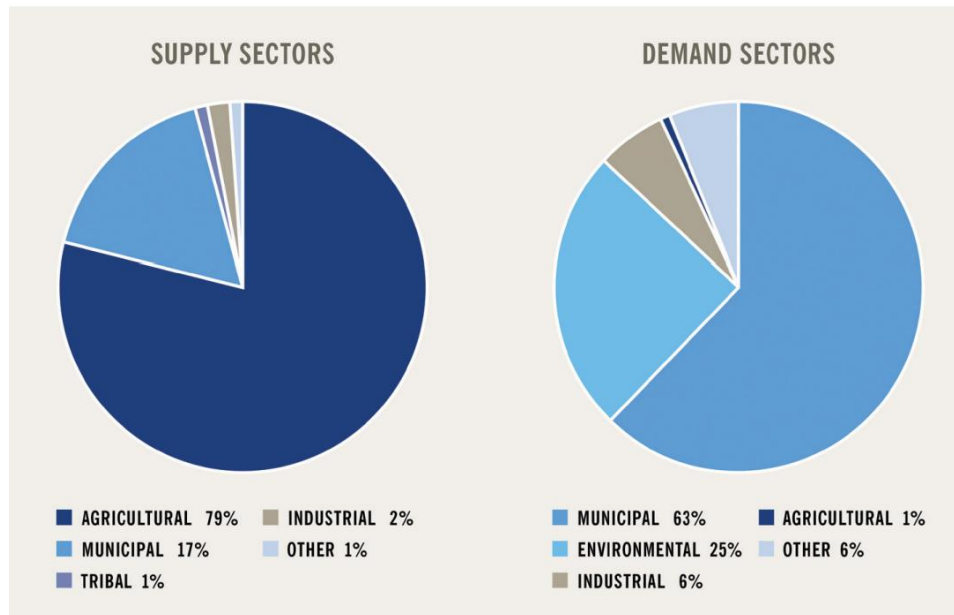


Figure 2. Percentage of water traded in the western states by sector in 2015. Water Resources Research Center Arroyo 2019.

Greenstone, one of several water investment companies, based in Phoenix has been buying farmland for its water rights in part to sell to cities. According to property records, limited liability corporations affiliated with Greenstone have bought farmland in three Arizona counties totaling 8,863 acres (James and Hing 2021). In 2019, Greenstone sought approval from the Arizona Department of Water Resources to sell 2,083 acre-feet of water rights to the city of Queen Creek, a fast-growing suburb of Phoenix, leaving 485 acres dry (James 2020). Glennon (2021) states, “As the West enters an era of water reallocation, most of the water will come from farmers, who consume more than 70% of the region’s water.”

Water transfers can potentially increase water efficiency, which can help alleviate water stress, but water transfers are not a panacea for unsustainable growth in Arizona. The Central Arizona Groundwater Replenishment District (CAGRDR) was created in response to a decision made in 1993 by Arizona policymakers allowing developers and municipalities access to groundwater to meet the 100 years of assured water supply required for housing developments in actively managed areas or AMAs. The CAGRDR aims to find renewable water sources to replace the pumped groundwater. However, due to drought and the over-allocation of the Colorado River, the CAGRDR increased its replenishment fee for those enrolled from \$154.00 per acre-foot in 2002 to \$742.00 per acre-foot in 2021 (Tory 2021). Most of the water for residents of Pinal County comes from groundwater through enrollment in the CAGRDR. In 2019, the Arizona Department of Water Resources stopped approving 100-year assured water supply certificates for Pinal County Arizona after it found insufficient groundwater to meet demands (Tory 2021).

Tribal water rights date back to when the reservations were established making Native water rights senior water rights. Eden & Murray (2019) state that “Indian water rights...are extensive and largely undeveloped, making their future use both a source of great uncertainty

and an opportunity for innovative market arrangements.” One market arrangement made between the Gila River Indian Community and the CAGR in 2018 was a 25-year lease. The CAGR will receive approximately 830,000 acre-feet (33,185 acre-feet per year) of the GRIC’s Colorado River allocation (Tory 2021). The Colorado River Indian Tribes’ water allocation is for reservation use only. In 2019, tribal members voted to seek federal approval that would allow the CRIT to lease their allotted water off the reservation (Eden & Murray 2019).

The Arizona Municipal Water Users Association (AMWUA 2018) stated, “Market forces may have negative impacts on certain industries and smaller communities that may not have the resources to compete for limited water supplies.” The Harquahala Valley is a rural area about 60 miles west of Phoenix and the Harquahala basin is one of the few basins where the state can pump and transfer groundwater to urban areas. Residents of nearby La Paz County are concerned that the proposed Arizona House Bill 2609, which will open groundwater transfer out of the Harquahala basin by private companies, will exacerbate diminishing aquifer levels. Residents are already experiencing problems with their wells failing and redoing wells to pump deeper can cost between \$25,000 and \$30,000 (Whitman 2019). In Active Management Areas and Irrigation Non-expansion Areas around the state, groundwater is regulated. However, outside of these boundaries, the lack of regulation harms rural communities. Consistent regulation is needed for all of Arizona’s water resources.

Rapid urbanization is occurring although water availability may be less than estimated. According to the U.S. Bureau of Reclamation, climate change is expected to reduce Colorado River lows by nine percent. However, Brad Udall, senior water and climate research scientist at the Colorado Water Institute, believes climate change’s impact on the Colorado River will

reduce flows by closer to twenty percent (Glennon 2016). Rising temperatures due to climate change also impact the water needed to continue growing the same number of crops. The U.S. Bureau of Reclamation found that a 5% increase in water is required for each one-degree increase in temperature (Glennon 2016).

Buckeye, Arizona is an example of unsustainable growth in an area with a finite water supply; the city relies mostly on groundwater. The planned area for Buckeye is 642 square miles; Phoenix in comparison is 517 square miles. The city is growing and has planned 27 housing developments expected to bring 800,000 additional people by 2040 (Tory 2021). If the city must enroll in the CAGR to supply water for these developments, the CAGR will have to find 127,000 additional acre-feet of water annually. According to Tory (2021), “That’s more than four times the current replenishment obligations for the entire CAGR.”

Statement of Sustainability +Problem Statement

This study examines the pros and cons of water trading in Arizona and their impact on sustainability's social, economic, and environmental aspects by revealing what has been published compared to governmental agencies’ documents and public voices. Ideally, regulations supporting water transfers are implemented in an economic, social, and environmentally responsible way. If so, water transfers will play a role in meeting Arizona’s water demands sustainably.

Methodology

This study focuses on water trading in the Western United States, specifically in Arizona, and follows a sequential design featuring qualitative and quantitative secondary data from the

literature review. Statistics from county records, the Arizona Department of Water Resources, and the United States Department of Agricultural National Statistics provide quantitative data. Newspapers such as Az Central and Phoenix New Times containing interviews with residents provide qualitative data.

Research Question

How does the transfer of water rights indicate its commoditization and what are social, environmental, and economic perceptions and impacts surrounding water markets?

Methods

1. Systematic Literature Review with key phrase analysis.
2. Two-step sequential survey with quantitative and qualitative questions.
3. Analysis of secondary data from the USDA.

A systematic literature review with key phrase analysis will provide insight into what aspects of water transfers are being discussed in the literature. A two-step sequential survey will provide insight into how residents perceive water and sustainability in the Southwest. Lastly, Analysis of Arizona farm statistics from the USDA will help provide insight into the link between agricultural to municipal water transfers.

Results

1. Systematic Literature Review with key phrase analysis.

The result of a systematic review of the literature using Google Scholar and the Scopus database through the University of Arizona library, returned more results for the search phrase, “water transfers” + “environmental impacts” than the phrase “water transfers” + “social impacts” and the phrase “water transfers” + “economic impacts”. The search phrase, “water transfers” + “social impacts” returned the fewest results for both databases. According to these search parameters, there are more discussions on the environmental and economic aspects of water transfers than the social aspect in the recent literature. Across both databases, the search phrase “water transfers” + “social impacts” comprised 13% of 1,175 returned results.

Table 1. Google Scholar database search results

Google Scholar Database Search Results from 2022-2023	
“water transfers” + “economic impacts”	148
“water transfers” + “environmental impacts”	394
“water transfers + “social impacts”	66

Table 2. Scopus database search results

Scopus Database Search Results from 2022-2023	
“water transfers” + “economic impacts”	102
“water transfers” + “environmental impacts”	438
“water transfers + “social impacts”	27

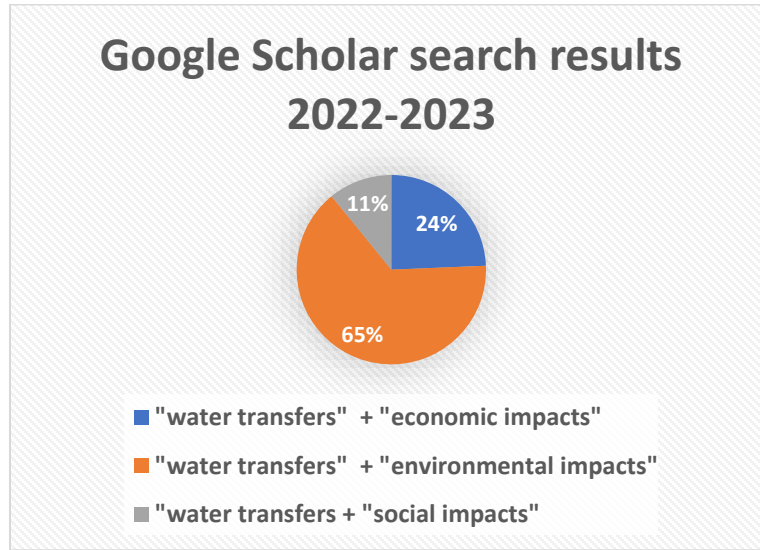


Figure 3. Google Scholar search results 2022-2023.

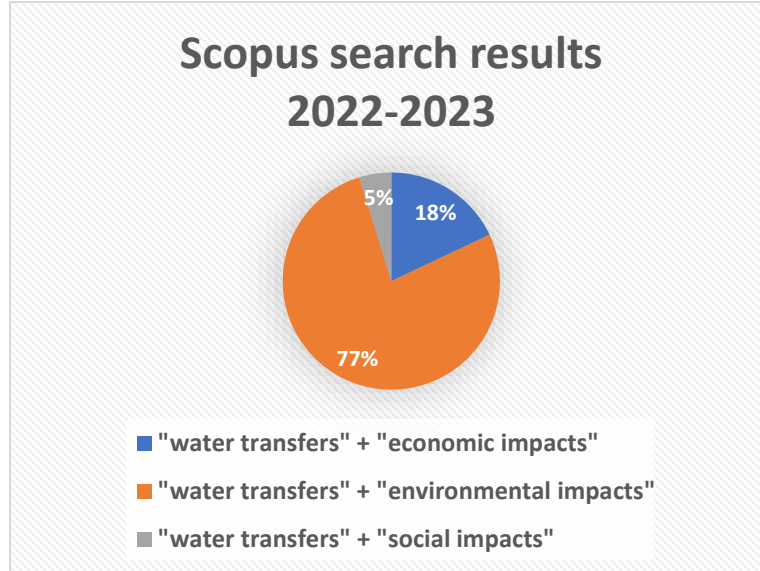


Figure 4. Scopus search result 2022-2023

2. Two-step sequential survey with quantitative and qualitative questions

The purpose of the preliminary survey was to gauge the water interest and awareness of Arizona residents. Concerning water interest, 87% of 24 survey participants responded either strongly agree or somewhat agree to the question, *I am interested in knowing how water is used in Arizona*. Additional questions surrounding water interest were, *I am interested in knowing where my tap water comes from*, *I often think about water security in Arizona*, and *I often review my monthly water bill*. Participants responded either strongly agree or somewhat agree 92%, 75% and 58%, respectively. Concerning water awareness, 46% responded either strongly disagree or somewhat disagree, and 21% responded neither agree or disagree to the question, *I am knowledgeable about Arizona water rights*. For the question, *I have heard of water markets*, 51% responded either strongly disagree or somewhat disagree, and 21% responded neither agree or disagree. Regarding the question, *I have heard of water investment companies*, 34% responded either strongly or somewhat agree, and 17% responded neither agree or disagree. The preliminary survey results show that 67% of respondents either strongly or somewhat agree with the statement, *water is a commodity, not a utility*. This result does not correspond with the follow-up survey question, *I think of water as either a commodity or utility*. This could be a result of how the first question was phrased as well as the difference in the number of respondents affecting the percentages. Additionally, participants in the first and second surveys were not necessarily the same people.

The purpose of the follow-up survey was to understand further why participants consider water to be either a commodity or utility and what sustainability means to lay people in Arizona. Out of 19 responses, 53% of respondents think of water as a utility, and 47% think of water as a

commodity. When asked to share why they chose either commodity or utility, most of those who chose commodity stated that water is a finite resource that can be bought or sold. Most of those who selected utility stated that water is a necessity, and everyone should have equal access to it. Two participants selected commodity and, when asked to share why stated that water is both a commodity and a utility. When asked, *when you think of sustainability, what comes to mind?* 48% of the responses were socially minded, 36% were environmentally minded, and 16% were economically minded. Three participants responded to the first question, *I think of water as a: utility or commodity* but did not elaborate when asked to share why they chose their answer. These same participants also did not respond to the open-ended question about sustainability. This action could be that open-ended survey questions are less likely to be answered because they are more taxing on the respondent or because the respondent did not know how to answer.

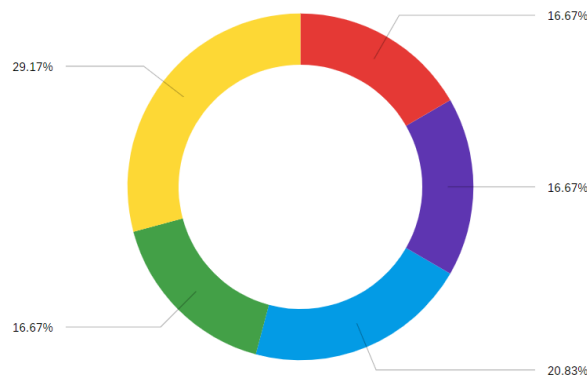


Figure 5. I am knowledgeable about Arizona water rights

■ Strongly agree
 ■ Somewhat agree
 ■ Neither agree nor disagree
 ■ Somewhat disagree
 ■ Strongly disagree

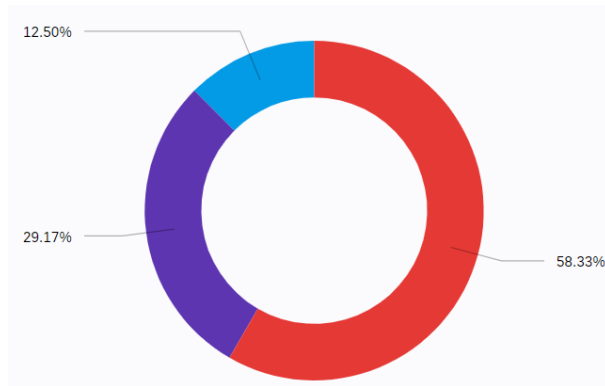


Figure 6. I am interested in knowing how water is used in Arizona

■ Strongly agree
 ■ Somewhat agree
 ■ Neither agree nor disagree
 ■ Somewhat disagree
 ■ Strongly disagree

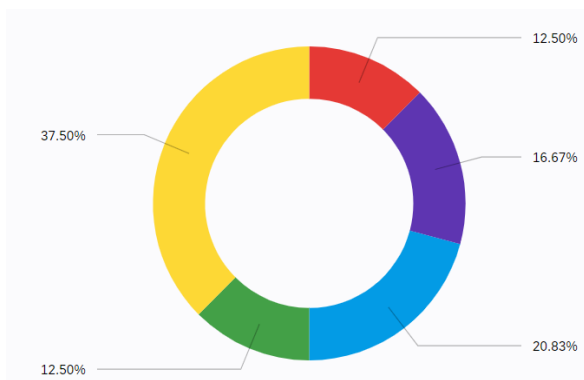


Figure 7. I have heard of water markets

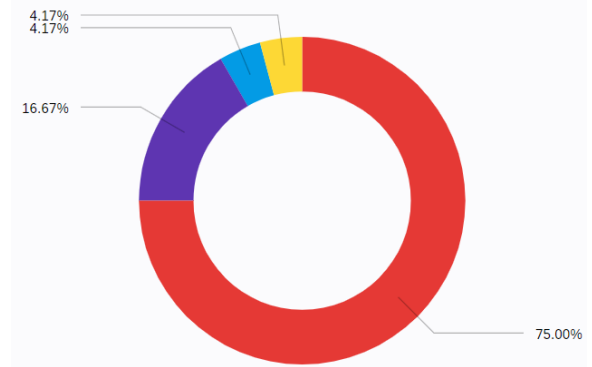


Figure 8. I am interested in knowing where my tap water comes from

■ Strongly agree
 ■ Somewhat agree
 ■ Neither agree nor disagree
 ■ Somewhat disagree
 ■ Strongly disagree

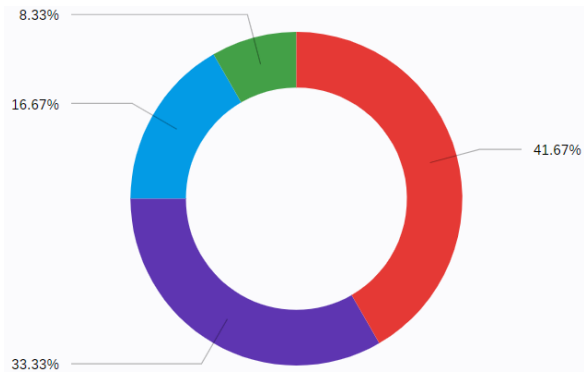


Figure 9. I often think about water security in Arizona

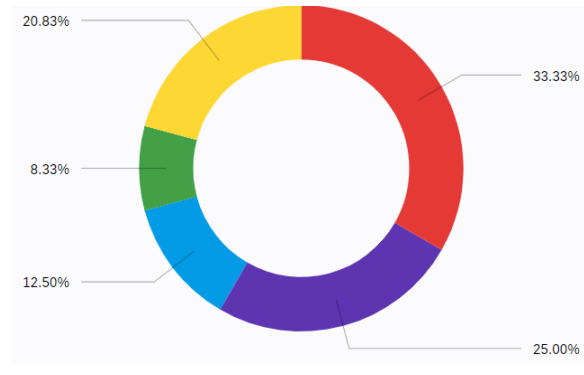


Figure 10. I often review my monthly water bill

■ Strongly agree
 ■ Somewhat agree
 ■ Neither agree nor disagree
 ■ Somewhat disagree
 ■ Strongly disagree

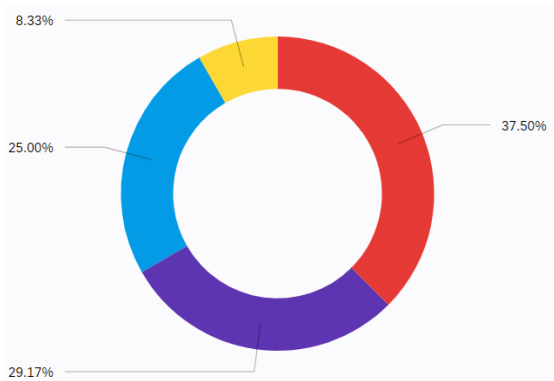


Figure 11. Water is a commodity, not a utility

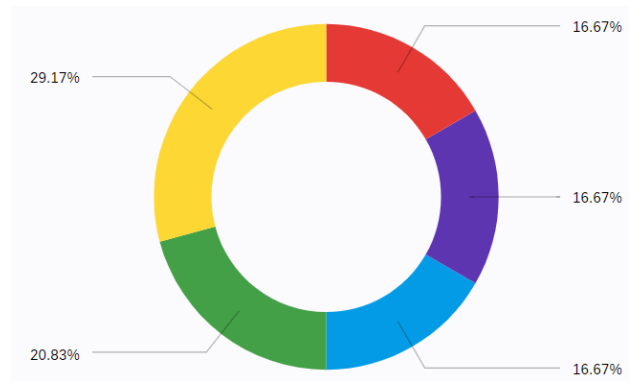


Figure 12. I have heard of water investment companies

■ Strongly agree
 ■ Somewhat agree
 ■ Neither agree nor disagree
 ■ Somewhat disagree
 ■ Strongly disagree

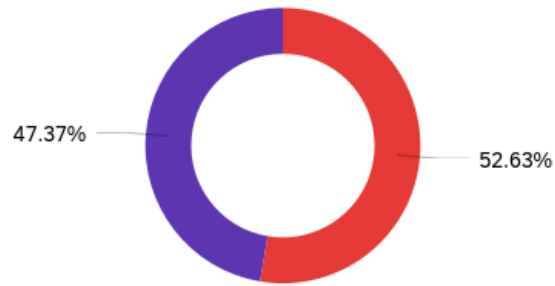


Figure 13. I think of water as a

Utility Commodity

Table 3. Survey participants share why they think of water as a utility.

Please share why you chose utility
I think water should be treated like a utility to ensure everyone has equal access
I choose utility because water is a necessity and very valuable resource especially since I live in an arid sunny climate.
I chose Utility because water is not an option it is a necessity for life It is something that is a necessity for survival.
It is a need, and everyone should have access to it. It is a need for everything. People can't survive without it.
We need water and should be used sparingly or with consideration.
Water is necessary to sustain human life- it is a necessity for every human being.
It's used for everything

Table 4. Survey participants share why they think of water as a commodity.

Please share why you chose commodity
I wanted to choose both because it is a utility, a service paid for and provided for by the city however, it's more than that.. it's a commodity also because it's a life sustaining need. We need water more than food. Don't we?
Is under regulated, not easily accessible across the globe. I would have chosen to refer to it as a limited resource.
A commodity is something useful that can be bought or sold.
I think of it as a resource or good.
Water shortages have created future investment opportunities which therefore make water a commodity.
It's a finite resource
Water is a precious commodity, although it might be thought of as a utility.
I chose commodity because water is a natural resource that can run out.

Table 5. Survey participants share what sustainability means to them.

When you think of sustainability, what comes to mind?	Code
Building a society that works with and for the Earth, rather than around and despite it. Being caretakers and stewards of the Earth and making sure that our society operates in a way that cares for the planet as well as its inhabitants.	People, environment
Earth eco-friendly, produced by earth, used from earth	Environment
Finding a way to efficiently and intelligently conserve resources so that human life is sustainable.	People
Green energy	Economy, environment
Having something that can be sustained, that can be around for many generations to come.	People
I think of a way of maintaining the resources I have in order to last for the time I need it to last	People
It's using the resources with a conscious mind and understanding that it must be replenished.	People, environment
Long lasting lifesaving endeavors	People
Recycling	Environment, economy, people
Something long term, to live on after someone is gone or something is over.	People
Something that is self-sustaining. Useful. Not harmful. Gives back in a measure perhaps equal to what is taken or used. Long lasting. Natural vs manmade.	People, environment
Sustainability is being more mindful about using our resources wisely and carefully for instance, turn the water off when you are taking a shower or brushing your teeth.	People, environment
The ability to do something, or in the case of water to provide something in a way that can last indefinitely.	People, environment
The responsible use of resources where an efficient use of the resource is priority over other concerns.	economy
The source & quality of water is an essential part of a life.	people
Using renewable energy and water conservation.	Environment, economy



Figure 14. Coded responses to the open-ended survey question about sustainability.

3. Analysis of USDA Arizona farm statistics.

In 2017, most Arizona farmers were between the ages of 55-64 years old and 66% of farmers were 55 or more years old. The 45-54 age group represented 17% of farmers. Almost half of farms in Arizona, 49% composed of 1-9 acres and 16% composed of 500 or more acres. Farms consisting of 10-49 acres comprise 20% of all farms in Arizona. Farming as the primary occupation of Arizona producers represents 55% of farmers and 45% of farmers' primary occupation was something other than farming. Of all Arizona counties, Apache county had the most farmers in 2017 and Navajo county had the second most farmers. Of all Arizona counties, Apache, Coconino, and Navajo had more Native American farmers than other any other race.

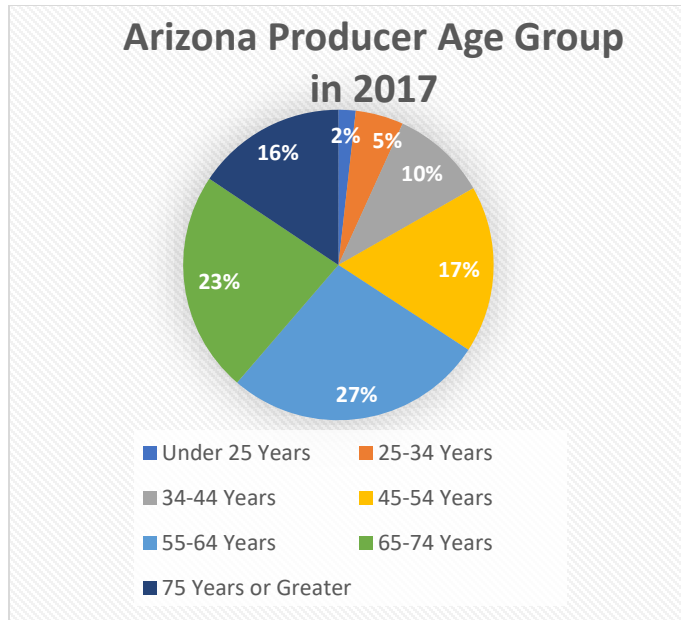


Figure 15. USDA Arizona Producer age

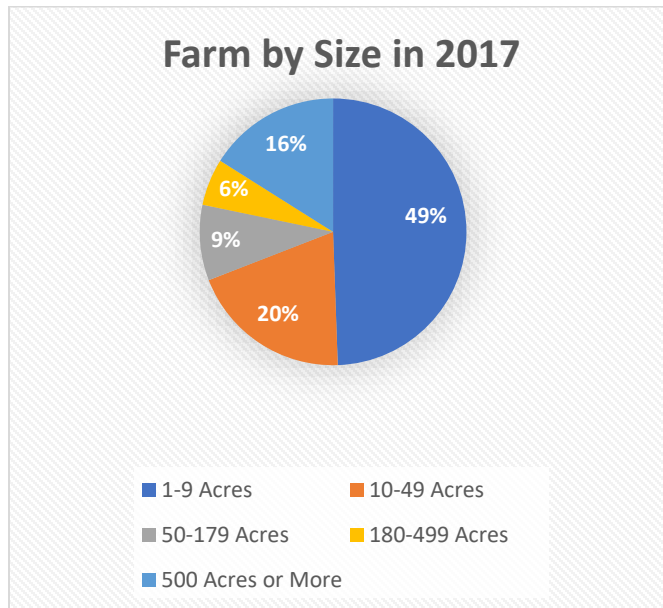


Figure 16. USDA Arizona farm size

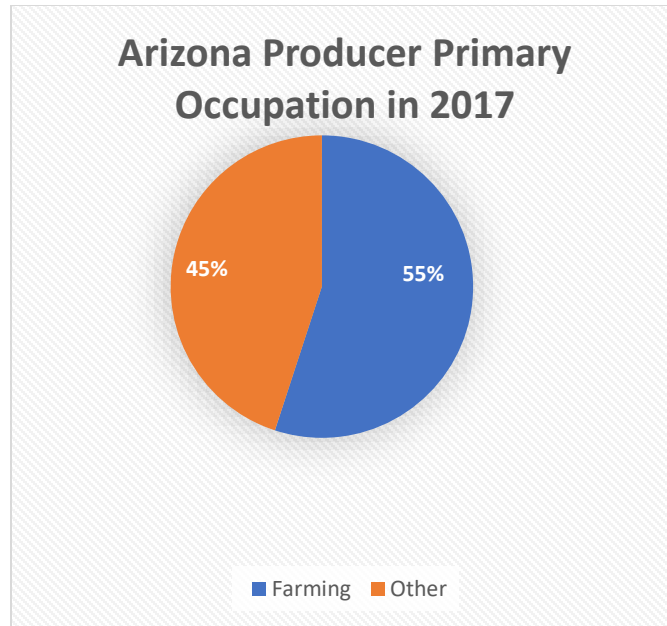


Figure 17. Arizona producer primary occupation.

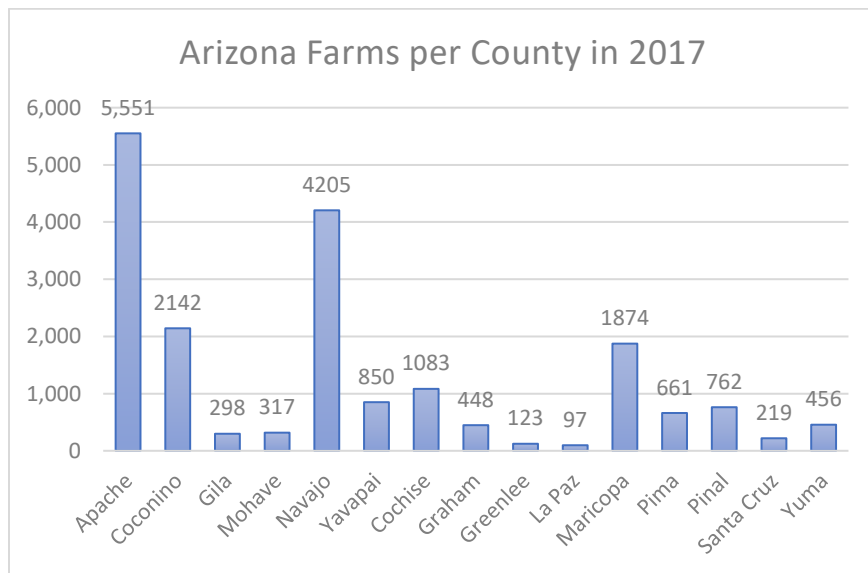


Figure 18. USDA Arizona farms per county.

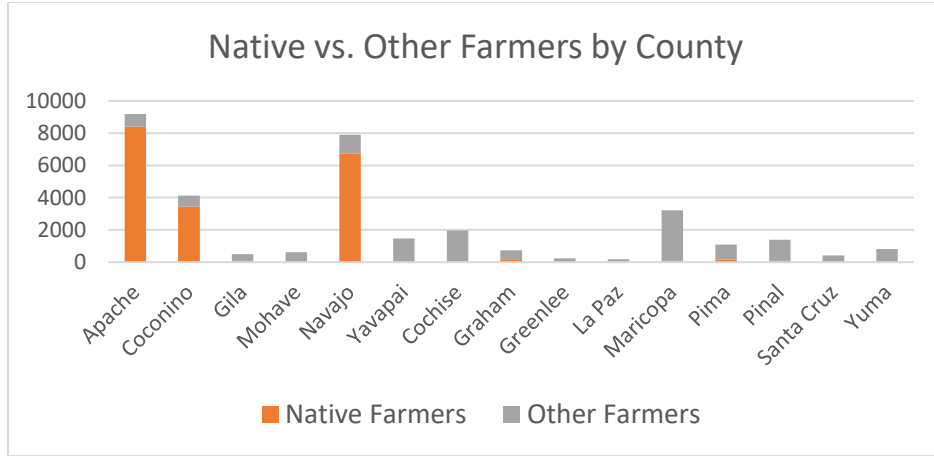


Figure 19. Native farmers vs. other farmers by Arizona county.

Discussion

The equitable functioning of water markets begins with awareness for all stakeholders. The preliminary survey results show 87% of participants either strongly or somewhat agree with the question, *I am interested in knowing how water is used in Arizona*. Yet, 46% responded either strongly disagree or somewhat disagree to the question, *I am knowledgeable about Arizona water rights*. Given 92% of participants responded either strongly agree or somewhat agree with the question, *I am interested in where my tap water comes from* as well as 75% having responded strongly agree or somewhat agree to the question, *I often think about water security in Arizona* indicates respondents overwhelmingly care about the social aspects of sustainability regarding water. This preliminary survey finding corresponds to the follow-up survey. When coding the opened ended sustainability question for themes, the survey responses were found to be favoring social needs. This finding reveals a disconnect between what the academics are discussing in the literature and what is important to people.

Water is a human right but what happens when it is priced according to its value as a scarce and necessary resource? One solution to encourage water conservation is increasing the cost of water. However, increasing prices disproportionately affect lower-income residents and municipalities with smaller budgets. Higher-income residents and wealthier cities may continue to consume the same amount of water or increase their water usage because the cost may not be a factor in their water use decision-making. In conversation with a Southside Tucson local, he shared if the cost of water increases, he would stop watering the pine trees he planted on his property. His trees provide shade in an area of Tucson disproportionately affected by increased temperatures due to the lack of trees. A thirty-year-old pine tree shades the east-facing bedroom reducing cooling costs for this local on a fixed income. If the increasing water costs resulted in the trees dying, this

low-income family would experience increased heat stress. This is one example of how treating water as a commodity has negative social implications.

Rapid growth also has social implications. The Central Arizona Groundwater Replenishment District functions as a groundwater credit card for developers. However, borrowing on a credit card without money in the bank to pay off the borrowed sum is usually not advised. This borrow-from-Peter to-pay-Paul mentality is facilitating unsustainable growth. While water markets present clear environmental benefits such as encouraging water conservation, unchecked sprawl represents the negative environmental impacts of water transfers. Rapid urbanization as a result of water transfers exacerbates water stress in Arizona instead of helping to alleviate it. As the challenge of finding renewable water sources increases, the CAGRDR will contribute to the competitive free market and the commoditization of water resources. As demands increase and supplies decrease, water in the southwest will become more of a commodity and less of a utility. Those who do not have the resources to compete with the highest bidder will be left without an essential resource.

The Arizona farm statistics may help explain Figure 2 which shows the transfer of water in the western United States from agriculture to municipal purposes in 2015. Figure 17. Arizona producer primary occupation depicts the primary occupation of Arizona farmers in 2017 which shows 45% of farmers' primary occupation is something other than farming. If farmers lease their water rights, allowing their fields to go fallow, would grant the flexibility for a second occupation. Additionally, farmers whose primary occupation is something other than farming may be more likely to either sell or lease their water rights. Figure 15 depicts 66% of farmers are 55 years or older. Farmers nearing retirement may consider selling their water rights to bolster their retirement savings. According to James & Hing 2021, a 77-year-old farmer near Cibola, Arizona has been farming for forty years mostly to hang on to the water rights which he is now

hoping to sell. Figure 16 shows 49% of farms range between 1-9 acres. Smaller farms may be more willing to sell or lease their water rights if the water rights are more profitable than farming. However, for large or commercial farms, the opportunity costs of leasing or selling water rights may not be more profitable than farming due to economies of scale. Figure 16 shows 16% of farms consist of 500 or more acres. The quantity of Native American farms and farmers in Apache County exceeds the number of farms or farmers in any other county. In Apache County, 77% of the land is used for farming. Out of 5,551 farms in 2017, 4,235 had less than \$1,000.00 in sales and 94% of the farms are family or individually held farms (University of Arizona Agricultural and Resource Economics, 2020).

Figure 18 and Figure 19 depicting Arizona farms per county and Native vs. other farmers by county respectively demonstrate the extent of Native American farming in Arizona. Arizona has the highest concentration of Native American farms in the United States and is the only state where more than half of all the ranchers and farmers are Native American (Murphree 2017). Native Americans living in Arizona and other parts of the West have been growing crops for thousands of years. Historical senior water rights belonging to these tribes will play a significant role in Arizona's water markets and help to meet Arizona's future water demands. According to Krol (2022a), "Without the tribes' water, state and federal water managers faced shortages they almost certainly couldn't solve on their own." Together, the Gila River Indian Community and the Colorado River Indian Tribes agreed to leave 674,000 acre-feet in Lake Mead to help with the diminishing water levels. When Arizona was facing water cuts after a tier 1 shortage was triggered in 2021, both tribes agreed to leave an additional 180 acre-feet of water in Lake Mead (Krol 2022a). Over two years, the GRIC will contribute 129,000 acre-feet per year and the CRIT will add an additional 50,000 acre-feet per year (Loomis 2021).

Long Term Storage Credits are another way Native American water rights will help meet Arizona's water demands. LTSCs are achieved when water is stored underground for more than one year. One credit equals one acre-foot of water. After one year, the water can be retrieved to be used anywhere in the active management area where it was stored if the groundwater levels in these areas are not dropping by more than four feet per year. Once the groundwater is pumped out, the regulations for use are subjected to surface water regulations; the same regulations applied to the water before it was stored underground. The Gila River Indian Community which does not use all its Colorado River allotment has been selling LTSCs mostly to developers. The GRIC created its own water storage company with plans to market 500 million acre-feet of water (Silber-Coats & Eden 2017). The Colorado River Indian Tribe has been converting traditional flood irrigation to much more efficient drip irrigation methods to conserve water. Leasing the conserved water is currently not allowed but if approved by the federal government, would improve both the CRIT's economic outlook and "sovereignty over its land and waters" (Krol 2022b quoted Amelia Flores CRIT Chairwoman).

Conclusion

The transfer of water from agricultural to municipal is an indicator of how water is becoming commoditized. As demand increases and supplies decrease for water resources, the value of farming is transferred from the produce to the water rights tied to the land. This phenomenon has implications for Arizona's social, environmental, and economic landscape. With most farmers in Arizona being Native American, tribal senior water rights will be a major player in Arizona water markets.

Water markets offer environmental and economic benefits that can help address Arizona's water scarcity. However, the social impacts of water markets must be included when regulations are being considered. A systematic literature review revealed academics have published significantly more on the environmental and economic benefits of water trading than on the social impacts of water markets. These findings suggest academics are focusing more on the commoditization of this resource and less so on how market forces may impact those who cannot compete in a free market. For water markets to function equitably, more research is needed on the social implications of water trading.

Limitations

Without the following limitations, this study would reflect more accurate findings. First is the lack of survey participants. Second, the search parameters for both Google Scholar and Scopus databases returned results that contained both “water transfers” and either “economic impacts”, “social impacts”, or “environmental impacts”. Resources using other phrases to discuss the same concepts would have been excluded from the search. Finally, coding the open-ended survey questions into themes is subject to the interpretation of the coder.

Future work

After going through the research process for this study, opportunities for future research appeared. For instance, increasing the social equity of water markets in research and application.

Additionally, conducting research into the implications of less agriculture due to water transfers to other higher value uses seems timely as well as research on sprawl's environmental and social impacts. The connection between water transfers and rapid urbanization is another opportunity for further research. Lastly, a follow-up idea would be to conduct a survey with questions about the effects of water commoditization on residents that includes participant demographics.

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