Undergraduate Thesis Prospectus

# Creating Resilient Communities by Mitigating Aquifer Depletion

(technical research project in Environmental Engineering)

# The Competition for Groundwater in the American Southwest

(sociotechnical research project)

by

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October 27, 2023

On my honor as a University of Virginia student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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## General Research Problem

*How has aquifer depletion in the American Southwest impacted urban communities and big farming?*

Across the Southwest USA, aquifers are hitting all time lows. A New York Times study revealed that four out of ten wells across the U.S. recorded their shallowest water levels to date. On this matter, the Southwest does not have time on its side. "'From an objective standpoint, this is a crisis,' said Warigia Bowman, a law professor and water expert at the University of Tulsa. "There will be parts of the U.S. that run out of drinking water" (Rojanasakul et al., 2023). This is largely the result of overdraft, when groundwater pumping and diversions deplete the water table faster than it can replenish itself. The overdraft crisis began across the Southwest in the early 20th century and has placed immense strain on river valleys (Zektser, Loaiciga, & Wolf, 2004). The uncertainty and fragility of these sources has drastically impacted urban environments and agriculture. Not only has technology adapted to meet the changing environment, but so have social groups as they vie for access to water resources.

## Creating Resilient Communities by Mitigating Aquifer Depletion

*How may water scarcity in the American Southwest best be managed?*

This is an independent project within the Department of Civil and Environmental Engineering advised by Professor Jonathan L. Goodall.

Since the mid-20th century, rapid population growth in the Southwestern United States has driven increased domestic, agricultural, and industrial water demand. Extraction of surface and ground water has increased by more than 50% in the Southwest since 1950, with 80% attributed to crop irrigation (Heilman and Konieczki, 2004). Urban overuse, coupled with

climate change and droughts, has led to an overdraft crisis that prevents aquifers from recharging at necessary rates. Examining paths that address this crisis is vital for urban resilience and agricultural sustainability in the Southwest.

In 2013, the United Nations Convention to Combat Desertification predicted that 168 countries could face water shortages for irrigation by 2030 (Khan et al., 2021). Access to freshwater hinges on individual countries' adoption of water resources management practices. Traditional irrigation falls short, as the field flooding technique reduces soil nutrients and crop yield. With the need to double food production by 2050 to accommodate a growing global population, alternative irrigation approaches and aquifer management techniques must be explored.

Agroforestry, which involves planting trees in agricultural systems, can increase captured rainfall and reduce the reliance on irrigation and groundwater extraction. It also stabilizes the banks of water bodies on farms, preventing erosion and maintaining ecological health (USDA, n.d.).

General watershed management approaches include managed aquifer recharge which temporarily pumps surplus surface water into an aquifer. The conjunctive use approach exchanges groundwater for surface water to meet demand. These techniques act as catalysts for natural processes like infiltration and seepage, fulfill immediate water needs, and ready the watershed for periods of drought. However, there are increased costs and energy consumption associated with them (Scanlon et al., 2012). Without further review of innovative water management approaches and adoption of these practices, the United States may very well be one of the countries facing water shortages by 2030.

*Methods*

To answer this research question comprehensively, an extensive review of published literature about existing technologies and management policies will be conducted. The Biden Administration recently reached an agreement among Southwest irrigation districts, cities, and Native American Tribes to make a 13% reduction in their consumption of Colorado River water (Flavelle, 2023). Therefore, it is logical to evaluate the effectiveness of identified irrigation techniques and management strategies in achieving that reduction objective. For example, World Agroforestry reports that agroforestry can utilize 70% of annual rainfall compared to 6-40% with traditional methods, depending on the crop (World Agroforestry, n.d.). The potential water-savings can be calculated and compared to the Colorado River reduction goals. This assessment will provide insight into the suitability of each technology and policy for the arid Southwest region of the United States.

**The Competition for Groundwater in the American Southwest**

*In the southwestern US, how have agricultural interest groups, commercial enterprises, and residents competed to promote the water management policies they favor?*

The desert landscapes of California, Utah, Nevada, Arizona, and New Mexico have long incited competition over water resources. Population growth in the mid-20th century has driven increased domestic, agricultural, and industrial water demand. Irrigation accounts for 80% of the 50% increase in water extraction since 1950 (Heilman and Konieczki, 2004).

These states face water allocation conflicts between agricultural organizations, industry interests, and social groups. For example, in Cochise County AZ, the absence of regulations for landowners with four acres or more enabled Riverview LLP, a Minnesota-based dairy company,

to expand their operations into the Willcox Basin in 2014. They now own one-third of the basin's farmland, leading to a steady decline in the water table (Bittle, 2022). Riverview's spokesperson, Kevin Wulf, maintains that they have reduced overall groundwater extraction through efficient irrigation systems and hydrologist consultation. With that said, the company refuses to disclose their actual water consumption. Retired hydrologist Kristin Uhlman supports the argument that unregulated pumping is causing the water table decline (Davis and Weingarten, 2021).

The Sacramento River Valley of California faces similar water scarcity issues. Farmers rely on groundwater from the banks of the Cosumnes River, endangering its flow volume and Chinook salmon survival (Zekster, Loaiciga, & Wolf, 2004). Conservation groups like the Sacramento Valley Conservancy and Sacramento County Flood Control Agency have acquired land to protect habitats, recharge groundwater, and enhance surface water flow (Sacramento Valley Conservancy, 2021). By acquiring this land, the greater Sacramento River Basin, in which the city of Sacramento lies, is made more resilient in the face of drought and floods. If environmental protection must be associated with human well-being, then there is an undeniable argument for the preservation of natural areas. However, respecting the land, prioritizing ecological health, and recognizing water as sacred, not just a consumable resource, hold intrinsic value too.

No group understands that sense of stewardship better than Indigenous peoples across the globe. In Aotearoa New Zealand, the Māori people successfully advocated for the Whanganui River to be recognized as a person in the eyes of the law (Hollingsworth, 2020). In 2004, the Gila River Indian Community (GRIC) earned 650,000 acre-feet of water rights to the Colorado River. With that responsibility, the community began to store some of the water underground, allowing it to seep into the depleted Gila Bend Groundwater Basin. According to GRIC

Governor Stephen Roe Lewis, the community "brought the water back. The plants that were literally asleep, started to germinate, started to grow again. It was almost like the land was healing itself on the banks of the river" (Monroe, 2023). GRIC has consistently placed the well-being of the land on an equal footing with that of their people.

Tribal communities, historically marginalized, have long struggled for water rights. The Winters Doctrine of 1908 set precedent for the water rights of North American Tribal reservations. In this case, the Gros Ventre and Assiniboine people regained sufficient annual water rights to the Milk River, ensuring their reservation's suitability as a homeland for irrigation and drinking water. However, the Colorado River Compact of 1922 excluded Indigenous peoples in the allocation of its water. As a result, Navajo Nation, which shares a border with the Colorado River and depends on its tributaries, faces the same water scarcity problem as many other citizens of these states. The difference is that historical injustices have resulted in Tribal members who "don't have piped water coming into their home, or safe water to even consume. They're economically depressed", said Heather Tanana, a professor at the University of Utah and citizen of the Navajo Nation (Kestler-D'Amours and O'Toole, 2023). Navajo Nation filed a lawsuit against the State of Arizona, citing the precedent of the Navajo Treaty of 1868 and Winters Doctrine. Their goal was to obtain federal support in securing critical water resources and the construction of adequate treatment and distribution infrastructure. In 2023, the Supreme Court concluded that there is no federal duty to meet these demands (Arizona v. Navajo Nation, 2023).

Beyond inadequate drinking water provision is disregard in policy for Indigenous peoples' sacred relationship with water and the land. The Hopi people's cultural site, the *sipapuni*, a geologic dome created by mineral deposits along the Little Colorado River, is

impacted by water use from the coal industry. The *sipapuni* is believed to be the Hopi's place of emergence. Executive Director of the Black Mesa Trust, Vernon Masayesva, has said that the *sipapuni* is seen as "the umbilical cord to the Colorado Plateau and the heartbeat of Mother Earth" (Chief, 2020). However, this significance remains unacknowledged in policy, as industrial interests take precedence in Arizona.

Across the arid Southwest, various groups vie for precious water resources. Big farming operations reap the rewards of lenient regulations, leaving local farmers and residents to bear the brunt of depleted aquifers' adverse effects. Farming operations utilize land acquisition to advance their business, as do conservancy groups but in the name of environmental protection. Legal battles and regulations define the region's response to drought and climate change. In 2026, the expiring governing statutes for Colorado River usage create an invaluable opportunity to rectify injustices and ensure the resilience of aquifers in the region. Comprehensive research into the backgrounds, values, and priorities of stakeholders, presented in a well-compiled research paper, will provide key guidance to policymakers as they determine the allocation of water rights across the Southwest.

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