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SUBJECT: Upgrading Agricultural Infrastructure & Operations for Climate Resilience in the Colorado River Basin

Background: The Colorado River Basin Water Crisis and Climate Change

The Colorado River Basin (CRB) is a critical source of water in the southwestern United States. The river provides water for over 40 million people, supports nearly 4 million acres of farmland, and generates more than 8 billion kWh of hydropower annually (Ficklin et al., 2013; Bass et al., 2023). Officially, the CRB is divided into three regulatory regions: the Upper Basin (Colorado, Wyoming, Utah, and New Mexico), the Lower Basin (Arizona, Nevada, and California), and Mexico (Ficklin et al., 2013). Water allocations for the CRB were established by the 1922 Colorado River Compact and the 1944 United States & Mexico Treaty. The allocations were based on the assumption that the river would yield 17 million acre-feet (maf) in streamflow without considering potential variability (McCoy et al., 2022). Today, average consumptive uses across the CRB exceed the natural supply, leading to an unprecedented water crisis. For instance, water consumption data from the Upper Basin reported that between 2000 and 2020, approximately 15 maf/yr of water was consumed from the CRB. This exceeded the actual supply by 1.5 maf/yr. Overconsumption throughout the CRB has been sustained by draining Lake Mead and Lake Powell. These reservoirs account for 80% of the CRB's storage, but over the past two decades, Lake Mead and Lake Powell have been depleted of 33.5 maf of water and are now at 30% capacity (Schmidt, 2023).

Climate change has exacerbated the water crisis throughout the CRB. In most years, no water reaches the Gulf of California because the natural runoff is entirely consumed before reaching Mexico (Schmidt, 2023). The General Circulation Model for climate has projected that temperatures throughout the CRB will increase by 2-6 °C by the end century with streamflow reducing between 10-30% (Ficklin et al., 2013). Water loss in the CRB is attributed to warming temperatures and drought, which decrease snowpack, rainfall, and soil moisture. The climatic conditions result in aridification, which cannot sustain the current water demands of the CRB (Bass et al., 2023).

The current management of the CRB does not adequately address growing concerns about the impending water crisis and associated impacts of climate change. These fundamental threats to the CRB can be mitigated using holistic climate resilience strategies. For instance, upgrading agricultural infrastructure and operations can successfully reduce the overall consumption of the largest water-use sector in the CRB—agriculture.

Strategy: Upgrading Agricultural Infrastructure & Operations

A holistic climate resilience strategy to address growing water concerns in the CRB is to upgrade agricultural infrastructure and operations. In the United States, the CRB irrigates 15% of American agriculture and sustains 90% of the nation's winter produce (*Colorado River is Critical to Utah's Water Security*, n.d.). This strategy focuses on low-cost innovations to infrastructure and management techniques, which include (Martin & McCoy, Culp & Kelly, 2022):

- **Canal Check Structures:** Upgrading check and precise measurement structures for canals is essential to improve the efficiency of water distribution and reduce waste. The check structures would help regulate water flows to ensure that fields receive adequate water while preventing water loss through runoff or seepage. The checks control the distribution of water in canals and reduce the risk of uncontrolled flow (Brouwer et al., 1985). Furthermore, precision monitoring of the structures could provide data for future management decisions.

For example, the Imperial Irrigation District in California effectively installed solar-powered Supervisory Control and Data Acquisition systems, flow measurement devices, and site controls for ten check structures in the Vail Canal Lateral. The project provides the Imperial Irrigation District with more accurate measurements and better coordination in flow management. Before the project, the Vail Canal system lost about 912.5 acre-feet per year due to infrastructural deficiencies, but water savings from the upgraded check structures are approximately 912.5 acre-feet per year. The project resulted in the offsetting of losses (*System automation upgrades to the Vail Canal Lateral in Imperial Irrigation District in California*, 2008).

- **Modernizing Farm Irrigation Systems:** The primary crop irrigated by the CRB is alfalfa, which requires immense moisture to grow, especially in arid conditions. The common method of irrigation for alfalfa is “flood irrigation,” where acres of alfalfa are watered by flooding fields, resulting in significant water loss (Shaw, 2024). Transitioning to efficient irrigation practices such as drip systems can prevent unnecessary losses from runoff and evaporation. Drip irrigation systems, which have a 70-80% efficiency rate, are installed in the ground by the root systems of plants (*Drip Irrigation* n.d.; Megersa & Abdulahi, 2015). They gradually emit water into the soil around the roots and maintain soil moisture levels that minimize water losses while improving plant productivity [10]. In addition, technological innovations in the precision monitoring of soil moisture can create more efficient channels for monitoring soil health and scheduling water deliveries (Martin & McCoy, Culp & Kelly, 2022).

The State of Israel has successfully implemented an agricultural system where 30% of its agricultural water is treated wastewater used in drip irrigation for non-food crops. The region faces many challenges due to water scarcity, arid conditions, and dense populations. Despite these major constraints, the nation’s technological advances in irrigation systems have innovated domestic food production. Since 1950, Israel's agricultural productivity has increased by 1600%, but due to their irrigation practices, the nation retains a low per capita level of water use (Megersa & Abdulahi, 2015).

The benefits of upgrading agricultural infrastructure and operations extend beyond the provided examples. However, improvements to these water-intensive systems will reduce and alleviate pressure on the CRB. Investing in this strategy may result in more resilient crops that are adaptable to climatic changes such as warming temperatures. Moreover, applying this strategy to the most productive agricultural regions could improve profit margins and allow marginal landscapes to transition back to their natural environments, in turn reducing additional water demands (Martin & McCoy, Culp & Kelly, 2022). Upgrading agricultural infrastructure and operations offers significant resilience benefits, but implementation depends on the inclusion of key stakeholders.

Key Stakeholder and Implementation

The successful implementation of upgrading agricultural infrastructure and operations will require the collaboration of stakeholders across multiple levels of regulation. The key stakeholders include:

- **Federal Agencies:** The U.S. Bureau of Reclamation accounts for water uses and facility operations in the Lower Basin, while the Upper Colorado River Commission accounts for water use in the Upper Basin. In addition, the Environmental Protection Agency is primarily responsible for implementing the Clean Water Act and ensuring water quality is maintained. Similarly, the United States Department of Agriculture and the Department of Interior are regulatory agents that assist with strategy enforcement to improve water quality throughout the CRB (*California River Board of California*, n.d.). These federal agencies are critical for providing oversight, funding, and technical support for agricultural water-efficiency projects.
- **State and Local Governments:** State governments have authority over water governance, including allocations, conservation initiatives, and policy development (*State water governance: Approaches from six western states*, 2022). Support and enforcement from State and localized agencies are essential to ensure upgraded agricultural infrastructure and operations are managed and performing adequately.
- **Agricultural Communities:** Agricultural cooperatives, farmers, and ranchers are the primary stakeholders in implementing agricultural water efficiency measures. Their inclusion is essential to the success of these efforts. Financial incentives must be considered to encourage application.
- **Tribal Communities:** Indigenous reservations in the CRB have property and sovereignty rights to divert about 20% of the annual streamflow. Tribal communities impacted by water-use mitigation initiatives must be included in the decision-making process. Collaborative efforts that include Indigenous Knowledge will result in more respectful and sustainable strategizing (*Tribes and water in the Colorado River Basin* 2016).

Timeline Considerations

Upgrading agricultural infrastructure and operations on the CRB is a long-term strategy that requires sustained investment and implementation. Achieving this resilience initiative would take between 5-7 years, but given the accelerating impacts of climate change, it is essential to consider it with urgency. Coordination between stakeholders would require 1-2 years of planning. Securing funding sources, equipment, and organizing a qualified workforce would take an additional 3 years. Finally, implementation would require 1-2 years, with sustained management for the foreseeable future.

Concluding Remarks

Upgrading agricultural infrastructure and operations is a critical strategy for addressing the water crisis in the CRB. By prioritizing the primary water-use sector of the CRB, populations will benefit from a water source with greater resilience to unprecedented climatic change and streamflow variability. This strategy is essential for the long-term sustainability of the Colorado River Basin and the benefits it provides as a resource.

References

- Bass, B., Goldenson, N., Rahimi, S., & Hall, A. (2023, July 20). *Aridification of Colorado River Basin's snowpack regions ...* Advancing Earth and Space Sciences.
<https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2022WR033454>
- Brouwer, C., Goffeau, A., & Heibloem, M. (1985). *Chapter 5- Irrigation Systems*. Chapter 5 - Irrigation System. <https://www.fao.org/4/r4082e/r4082e06.htm>
- Colorado River Board of California. (n.d.). *Programs*. crb.ca.gov.
<https://crb.ca.gov/programs/#:~:text=The%20Bureau%20of%20Reclamation%20plays,Lake%20Powel%20and%20Lake%20Mead>
- Ficklin, D. L., Stewart, I. T., & Maurer, E. P. (2013, August 19). *Climate change impacts on streamflow and subbasin-scale hydrology in the upper Colorado River basin*. PLOS ONE.
<https://journals.plos.org/plosone/article?id=10.1371%2Fjournal.pone.0071297>
- Martin & McCoy, & Culp & Kelly. (2022). *Colorado River Basin: Ten strategies for climate resilience*. Ten Strategies. <https://www.tenstrategies.net/>
- Megersa, G., & Abdulahi, J. (2015, March 31). *Academic Journals - International Journal of Water Resources and Environmental Engineering - irrigation system in Israel: A Review*. Academic Journals . <https://academicjournals.org/journal/IJWREE/article-full-text/A557E9051547>
- McCoy, A. L., Jacobs, K. L., Vano, J. A., Wilson, J. K., Martin, S., Pendergrass, A. G., & Cifelli, R. (2022, June 21). *The press and Pulse of Climate Change: Extreme events ...* Wiley Online Library.
<https://onlinelibrary.wiley.com/doi/full/10.1111/1752-1688.13021>
- North American Development Bank. (2008, July 16). *System automation upgrades to the Vail Canal Lateral in Imperial Irrigation District in California*. NADB.
<https://www.nadb.org/our-projects/infrastructure-projects/imperial-california---automation-system-for-the-imperial-irrigation-district>
- Shaw, S. (2024, January 24). *Hay – yes, hay – is sucking the colorado river dry*. High Country News.
<https://www.hcn.org/articles/south-colorado-river-hay-yes-hay-is-sucking-the-colorado-river-dry/>
- Schmidt, J. C. (2023, June 17). *The Colorado River Water Crisis: Its origin and the future - schmidt - 2023 - wires water - wiley online library*. Wiley Interdisciplinary Reviews.
<https://wires.onlinelibrary.wiley.com/doi/full/10.1002/wat2.1672>
- State water governance: Approaches from six western states*. National Conference of State Legislatures. (2022, November). <https://www.ncsl.org/environment-and-natural-resources/state-water-governance>

University of Colorado Law School Getches-Wilkinson Center for Natural Resources, Energy, and the Environment. (2016, June). *Tribes and water in the Colorado River Basin*. Colorado River Research Group.

https://scholar.law.colorado.edu/cgi/viewcontent.cgi?article=1177&context=books_reports_studies

University of Rhode Island. (n.d.). *Drip Irrigation*. URI HomeASyst.

<https://web.uri.edu/safewater/protecting-water-quality-at-home/sustainable-landscaping/drip-irrigation/#:~:text=Drip%20irrigation%20involves%20placing%20tubing,plant%20productivity%20and%20quality%20improve>

Utah Department of Natural Resources. (n.d.). *Colorado River is Critical to Utah's Water Security*. Utah Division of Water Resources.

<https://water.utah.gov/interstate-streams/colorado-river-story/#:~:text=The%20mighty%20Colorado%20River%20serves,of%20the%20nation%27s%20winter%20vegetables>