Analyzing Water Supply Management and Governance Institutions Across Scales

by

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ABSTRACT

This dissertation provides a foundation for understanding how water governance has changed over time, how watershed positionality and governance level shape the goals and strategies as well as the coordination of organizations actively involved in water issues, and how local, rural stakeholders changed legacy groundwater management.

The first study examines the evolution of Colorado River Basin water management over the last century to understand how changing environmental conditions and path dependency have shaped past water management changes. Improved understanding can help inform policy responses to current challenges. The combined spatial, temporal, and network analyses show that Colorado River Basin water governance has been influenced by 100 years of rules that are layered and still in place. The rules have evolved water management strategies over time, shifted the emphasis of water management actions, and changed the distribution of authority across actions and rule levels.

The second study explores how water management coordination varies based on governance level and physical location in the watershed. Additionally, this study analyzes how the level of governance and hydrologic position of organizations shape goals, strategies, and beliefs about the risks and benefits of changes to Colorado River Basin water management factors. The content and cluster analysis found the level of governance more influential than the hydrologic position and that coalitions can rearrange in a short period of time based on how the issue is framed.

The last study unveils how local, rural residents were able to change legacy groundwater management through a process that began with a social movement to a

ballot initiative to public input on groundwater management via a management goal-setting policy process in the Douglas Groundwater Basin in Arizona. The framing analysis shows that the public can identify problems and solutions, including paired solutions, but residents do not know whom to identify as being responsible for addressing water management in the basin.

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TABLE OF CONTENTS

CHAPTER

APPENDIX

LIST OF TABLES

Table Page

LIST OF FIGURES

Figure Page

CHAPTER 1

INTRODUCTION

In the Colorado River Basin, demographic and climate changes along with the ongoing Megadrought in the American Southwest motivate the shift to sustainable water management but complex governance creates challenges for non-incremental change (Cook et al., 2010; Owen, 2018). The Megadrought is the most severe drought within the last 1,200 years and drought conditions are intensified by aridification due to climate change in the region (Williams et al., 2022). Along with climatic challenges, water resources have been a source of tension, contestation, and disagreement for more than 100 years in the Colorado River Basin (Mirumachi et al., 2021; Sullivan et al., 2019). The long history of formal water governance in the Colorado River Basin began with the 1922 Colorado River Compact. Today, reservoirs have dropped to formal shortage levels that impact the 40 million people who rely on the Colorado River water supply (Udall & Overpeck, 2017). Some communities located within the Colorado River Basin do not have Colorado River water allocations per the 1922 Compact and rely on other supplies such as groundwater. Water governance in the basin has been shaped by the institutional water governance structure across spatial and temporal scales.

In **Chapter 2**, I analyze institutions and governance related to large-scale water supplies to build an understanding of how past policy changes shape current challenges and identify factors enabling the adoption of sustainable water management policies. Informed by water governance literature, institutional theory, and path dependency theory (Larson, Wiek, et al., 2013; Ostrom, 2007; Peters, 2022; Schmidt, 2010), I conducted an institutional analysis of water governance in the Colorado River Basin from 1922 to 2022 using the Law of the River documents (Heikkila & Andersson, 2018). This research acknowledges the long history of formal water governance for the Colorado River Basin water system from open access to a highly regulated resource. Indigenous peoples' water management and use of the Colorado River Basin has an even longer history that is not covered in this dissertation but is a prominent piece of the larger story of water in the West.

In **Chapter 3**, I analyze Colorado River water management with a focus on governance level and upstream-downstream hydrologic positionality. Collaborative governance theory (Haller et al., 2016; Karambelkar & Gerlak, 2020) and the advocacy coalition theory and framework (Koebele, 2019a; Koebele, 2019b; Schlager, 2007) were engaged to conduct this study to understand how governance level and physical location in the watershed shape four themes: goals, strategies, and beliefs based on upstream-downstream positionality and level of governance. Additionally, governance level and hydrologic position were studied to analyze coalition formation and coordination between organizations with active roles in Colorado River water management.

In **Chapter 4**, I work to enhance understanding of how the public frames groundwater management problems and solutions, and if the problem frames are predictive of solution frames for implementing groundwater regulation. Framing and social movement theory were coupled to analyze how local, rural stakeholders were able to change legacy groundwater management (Benford & Snow, 2000). Informed by existing research on framing problems and solutions, social movements, and environmental policy processes (Benford & Snow, 2000; Caiani, 2023; Steinberg, 1998;

Walker et al., 2018), I analyze the framing of groundwater management in the Douglas Groundwater Basin through public comments on the AMA goal-setting process.

Finally, the findings in this dissertation and their theoretical, policy, and decision-making implications are synthesized and discussed in **Chapter 5**.

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CHAPTER 2

INSTITUTIONAL ANALYSIS OF WATER GOVERNANCE IN THE COLORADO RIVER BASIN, 1922-2022

Introduction

On June 14, 2022, the U.S. Bureau of Reclamation (USBR) instructed Colorado River Basin (CRB) states to develop a plan to reduce annual water use by 2-4 million acre-feet (MAF) within 60 days (James, 2022; Stern, 2023). The 60-day period has passed without a consensus and shortly after the USBR declared a Tier 2a shortage for the following year, resulting in reduced water availability for Arizona and Nevada (Schlageter, 2021; Stern, 2023). The shortage operation guidelines were produced via multiple negotiated agreements, illustrating long-term rule accumulation (Department of the Interior, 2007; USBR, 2019). USBR's instruction to the Basin States demonstrates the scale of the regional water security challenges. The states' delay illustrates the complexity of negotiation in the context of a century's worth of accumulated rules and agreements in the CRB. In addition to the current request to reduce water use in the short term, the Basin States are negotiating new long-term rules for coordinated operations of Lake Powell and Lake Mead. Insight into how we have arrived at the current water crisis can help inform the redesign of operating rules. Such insight requires a better understanding of the evolution of water governance institutions.

Water has been the source of tension, contestation, and disagreement for over a century in the CRB (Mirumachi et al., 2021; Sullivan et al., 2019). Before 1900, communities used water locally without basin-wide impact (Kuhn & Fleck, 2019). From the early 1900s, questions arose about equitable allocations of Colorado River water with the expansion of irrigation and other water diversion projects (National Research Council, 2007). Consequently, the 1922 Colorado River Compact (CRC) was created to clarify allocations. During the 1920s, the water management paradigm shifted from pre-modern to industrial modernization via federal investments in large, regional water diversions and storage projects, resulting in basin-wide changes to the spatial and temporal distribution of water (Allan, 2003; Mirumachi et al., 2021). Specifically, these changes led to altered streamflow variability, habitat degradation, and salinization (Barnett & Pierce, 2008; Furnish & Ladman, 1975; Glenn et al., 2001; Hwang et al., 2021).

While the physical infrastructure is critical to the sustainability of the CRB, so is the social infrastructure, or the institutions that govern water access and infrastructure operation. Institutions are norms and rules that influence and shape human-human and human-nature interactions, including the way people make decisions and manage water resources (Cave et al., 2013). Institutional analysis can provide insights into water governance as actors interact to make decisions about new or altered rules, governance strategies, and management regimes (McGinnis, 2011). Examining the institutional context in the CRB illuminates how institutions evolved under social and environmental change.

One century later, the 1922 CRC remains in place and is supplemented by new agreements, court decisions, and other rules. Despite a substantial body of water governance research, the long-term evolution of the institutional structure that shaped the CRB over the last century is not fully explained. We know that current management actions and our understanding of these actions have not kept pace with increasingly arid conditions and growing demand (York et al., 2019). Water scarcity in the American Southwest is exacerbated by increasing water demands and climate changes, particularly higher temperatures that increase evapotranspiration (MacDonald, 2010; Udall & Overpeck, 2017). Williams et al. (2022) found that from 2000 to 2021 the Southwest has been in the most severe drought in at least 1,200 years. This raises the question of why water management has not changed more significantly in response to increasing scarcity. Path dependency of institutions may play a role. Repetitive practices and patterns resulting from socially constructed rules and norms give rise to path dependency (Schmidt, 2010).

Understanding how the tension between changing environmental conditions and path dependency have shaped past changes in water management can inform policy responses to the current challenge. This motivates two research questions: 1) How has the emphasis on different water management actions and rule levels changed over time? 2) How has the distribution of authority changed across actors and institutional levels in the CRB over the last century? I examine path dependency by extracting and analyzing the incentives and constraints that guide water governance choices from formal water management rules. I anticipate that path dependency has shaped the emphasis on different water management actions and rule levels over time. Further, the distribution of authority is anticipated to change from a few central actors to a larger number of actors as the network increases. This is measured based on the actors involved and the alteration of responsibilities for water management actions to examine how authority is distributed across actors and institutional choice levels over the last century.

1. Theoretical Framing

1.1. Water Governance

Water governance is a set of interacting social, economic, and political systems that enable society to develop, plan, and manage water resources across time and space (Larson et al., 2013; Pahl-Wostl et al., 2010; Rogers & Hall, 2003; Wiek & Larson, 2012). Water governance challenges are distinctive because water has characteristics of both public (non-excludable, non-rival) and private (excludable, rival) goods (White, 2012). Common pool resources are rival, meaning usage diminishes others' ability to use the resource, and non-excludable, meaning excluding users is prohibitively difficult (Ostrom, 2005). The use of common pool resources often results in conflicts when resource supply does not align with demand. Governance of natural resources can alleviate this conflict with rules that are created to allocate and distribute resources, such as water (Ostrom, 2011).

Water systems are nested, dynamic, and layered, therefore institutional arrangements must be able to fit the characteristics of water (Lebel et al., 2013; Young, 2002). Nested systems include connections and networks within a larger analytical unit. For example, smaller spatial entities (e.g., sub-basin, state) are nested in larger systems, such as watersheds or river basins. Dynamics can persist over time, as is characteristic of water systems with water management regimes that last for decades or centuries (Elshafei et al., 2014; Garcia et al., 2016). The introduction of new dynamics and conflicting institutional arrangements can limit and direct water governance decision-making and actions (Olivier & Schlager, 2021). Layering can be conceptualized as concurrent system inputs, where impacts accumulate as each layer is considered (Green & Dzidic, 2014). Multi-level water governance responds to these system characteristics. Broadly, level pertains to institutional jurisdictions such as government at International, National, Sub-national, or Local levels (McGinnis, 2015). Between levels there is a hierarchy; the higher levels of organization are arranged in a formal way by law.

The field of multi-level governance offers relevant insights, as it is concerned with how actors operating at different institutional levels collaborate to solve shared problems (Cash et al., 2006; Heinen et al., 2021; Pahl-Wostl, 2009). Multi-level governance scholarship is characterized by strong descriptive elements that document changes in governance arrangements (Bisaro et al., 2020; Liu & Lo, 2021). While multi-level governance is concerned with common goals, it acknowledges that power and authority are split among governance levels (Harmes, 2006). Thus, it is important to note that multi-level governance processes and outcomes are influenced by relationships and power dynamics between actors and decision-makers (Ishtiaque et al., 2021; Nunan, 2018). Current multi-level governance research challenges include uncertainty and nested relationships stemming from actors' differing goals and agendas coupled with a changing climate (Jones & White, 2022; Sullivan & White, 2019). Prior multi-level governance research has established a strong theoretical base, and further empirical research is needed to test and refine theory.

1.2. Institutional Theory

Institutional theory has foundations in organizations and organizational theory (Barnard, 1968; Scott, 1987; Selznick, 1948), economics (Nee, 2005; Williamson, 1981), and sociology (Fligstein, 1997; Meyer, 2010; Zucker, 1987). North (1991) distinguishes institutions from organizations stating that organizations play the game per the rules and that institutions set the rules of the game and the players. Institutional theory is concerned with procedural rules and posits that certain aspects of government structure can empower or obstruct political interests (Kraft & Furlong, 2013; Peters, 2022; Peters et al., 2005). Sjöstedt (2019) calls for governance research that incorporates institutional theory to empirically contribute to governance knowledge and literature. According to Scott (2005), institutional theory combines components from historical and comparative research and focuses on deeper social structures such as norms and routines. Institution refers to the "rules used to structure patterns of interaction within and across organizations", thus the rules that govern behavior (Ostrom, 2007, pg. 22). Rules specify authority and constraints by creating or restricting authority via limits, timing, and how infrastructure can be used. Institutional change can be examined to understand how resource, water, in this case, governance has evolved (Olivier, 2019).

The Institutional Analysis and Development (IAD) Framework (Figure 1), aids in evaluating and understanding institutional arrangements (Heikkila & Andersson, 2018). The framework facilitates analysis of how governance unfolds, in this case, water use and management. The IAD framework provides a foundation for examining rules and is well-established through insights from hundreds of natural resource case studies (Ostrom, 2005; Sullivan et al., 2019). Rules each actor must abide by, their rights, obligations, and constraints based on official (i.e., written), legislatively specified rules, are called rules-in-form. Rules-in-form are formal rules within official and other written documents that provide clarity on governance arrangements (i.e., roles, responsibilities, incentivized and disincentivized actions, and goals) and help provide a picture of the rules-in-use (Brady et al., 2018; Cole, 2017; Ostrom, 2011). Rules-in-use are rules that are in action and include both rules-in-form and informal rules (i.e., norms and customs that are not explicitly stated or written) (Ostrom & Basurto, 2011; Schlager & Cox, 2018). The IAD Framework can be extended to consider the feedback loops from policy outcomes to rules-in-use (Figure 1) to aid in understanding the changes to the institutional structure as rules layer upon each other over time, enabling analysis of the evolution of governance regimes (Hardy & Koontz, 2009; Heikkila & Andersson, 2018; McGinnis, 2015; McGinnis & Ostrom, 2014; Ostrom, 2011; Ran et al., 2020). One IAD Framework strength is that it connects outcomes at different levels of analysis explicitly (Ostrom, 2005). Moreover, as policy decisions are made rules-in-use are added or revised, thus changing the structure and process for future rule change.

To sort linkages between specific rules and help assess the institutional structure, rules can be organized based on their rule level, also known as level of analysis. Rule level pertains to the range of actions that actors are allowed, required, and/or prohibited to take. The IAD Framework characterizes three rule levels where different types of choice processes occur: constitutional, collective-choice, and operational. Constitutional level rules define the scope and identify actors that can be involved in collective decisions; collective-choice level rules determine the strategies, norms, and rules available for policy making for actors with defined roles; and operational level rules describe how actors make choices amongst available options set by the collective choice processes (Cole, 2017; McGinnis & Ostrom, 2014; Ostrom, 2005).

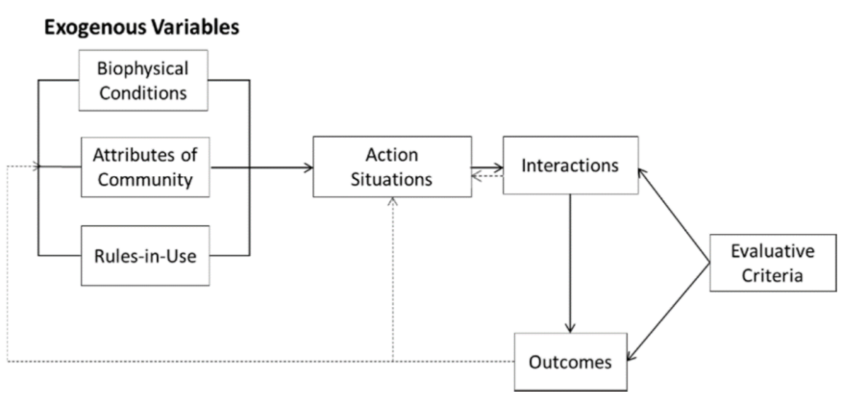

Figure 1. IAD Framework (Ran et al., 2020) adapted from Ostrom (2005).

1.3. Path Dependency Theory

Path dependency theory, stemming from historical institutionalism (Mahoney & Rueschemeyer, 2003; Peters et al., 2005; Thelen, 2003), is well-established in social science and institutional change literature (Gains et al., 2005; Kessy, 2018; Krasner, 1984; Peters et al., 2005). Path dependency refers to regularized patterns and routine practices that result from socially constructed and framed norms and rules (Schmidt, 2010). The theory argues that there is an inertial tendency for original choices to persist once an organization or governmental program instigates a particular policy or style of action (Krasner, 1984; Peters, 2019; Pierson, 2000). The causal structure of path dependency theory proposes that essential decisions at starting points result in outcomes whose self-reinforcing processes and lock-in of system features make the initial selection difficult to break from (Arthur, 1989; Katznelson et al., 2003; Kay, 2005; Newig et al., 2019). Path dependency can occur early on in policy-making processes when one strives to maintain their negotiating position as an exertion of power and is shaped by lock-in effects that direct decision-making into existing, often perpetuating, directions (Gillette, 1998; Mirumachi et al., 2021; Wilson, 2014). These choices are locked into the institutional structure and become apparent when institutions do not adjust to system changes (Gillette, 1998). Conversely, network structure changes can be evidence of changes in power dynamics. To investigate such network changes, social network analysis is commonly used.

Social network analysis is commonly used to assess the relationship between nodes (actors in this case) through their connections (Jones & White, 2021; Olivier et al., 2020; Prell et al., 2009). Such relational information helps identify institutional network structures. Network analyses can be used to examine multi-level networks, often found in natural resource governance (Friemel, 2017). Network metrics, betweenness, and degree centrality provide information on actor connectivity within the network. Betweenness centrality indicates how much control a node has via being a part of the connection between other nodes. Thus, high betweenness denotes entities that act as key bridges in the network, as they have more information flow control compared to other entities (Olivier, 2019). Degree centrality is comprised of the in-degree, the number of connections directed to a node, and out-degree, the number of the node's outgoing connections. High in-degree values indicate which nodes are the main rule targets, on the other hand, high out-degree values indicate which nodes are the main rule issuers. Identifying actors that issue rules and are the targets of rules can help improve the understanding of power dynamics within and across institutional levels. The institutional level refers to formal government jurisdictions (e.g., National, Basin, Sub-basin, State, Sub-state). Water governance rules have three types of power that interact: power dynamics within and across institutional levels, power as a theoretical understanding of how rules affect actors' empowerment to achieve their objectives, and power in the policy-making process (Kashwan et al., 2019).

2. Water Governance of the Colorado River Basin

Priority rights to water in the West are based upon the doctrine of prior appropriation; whoever first diverts river or stream water and puts it to beneficial use may claim priority rights to that amount of water. In 1922, the CRC was crafted by the seven Basin States and the Federal Government and established the Upper Basin (UB) and Lower Basin (LB) boundaries (Figure 2). The goal of the 1922 CRC was to equitably allocate water across the basin with an average of 7.5 MAF allotted annually to each sub-basin (Fleck, 2016). The LB was allotted an additional 1 MAF for treaty obligations to Mexico (Owen, 2018). AZ chose not to ratify the 1922 CRC, partially due to the treatment of its tributary rivers (Gila and Salt) (Hundley, 2009; Sullivan et al., 2017). In 1928, the Boulder Canyon Project Act (1928 BCPA) approved Hoover Dam construction so long as the 1922 CRC was ratified by six Basin States and authorized splitting the LB's 7.5 MAF of Colorado River water between the LB states: CA allotted 4.4 MAF, AZ allotted 2.8 MAF, and NV allotted 300,000 MAF annually. The ratification appointed the Secretary of Interior (SOI) as the authority for LB water use (Kuhn & Fleck, 2019). Arizona opposed this and filed Supreme Court cases from 1930-1936 to nullify the 1928 BCPA, but the Supreme Court declined to hear the cases and in 1936 the Hoover Dam was completed.

The 1940s to the early 1990s was a period of water allocation and infrastructure development in the CRB. The 1944 Mexican Water Treaty allocated 1.5 MAF of water to MX in normal flow years, marking the first time MX had a formally identified role in managing Colorado River water. In 1944, the AZ legislature ratified the 1922 CRC. Post-WWII, the population in the Southwest increased massively, driving a subsequent growth in water demand (Terrill, 2022). The Upper Colorado River Basin Compact of 1948 (1948 UCRB) addressed demand growth by creating the Upper Colorado River Commission (UCRC) for new water projects and apportionment of water. Under the 1948 UCRB of the Colorado River Storage Project Act of 1956 was created and approved two major UB water storage projects: Flaming Gorge Dam and Glen Canyon Dam. Plans for the Central Arizona Project (CAP), a system of canals and pumps to deliver water to

Phoenix, Tucson, AZ farmers, and Tribes, were introduced in the 1940s. Congressional approval was required to move the CAP forward and Congress would only approve if AZ and CA settled their differences. Ultimately, the Arizona v. California U.S. Supreme Court Decision of 1964 provided a resolution and upheld the 1928 BCPA water allotments. Later, the 1968 Colorado River Basin Project Act was passed, and Congress agreed to fund the CAP, which finished construction in 1993.

Since the mid-1990s Colorado River water governance has focused on demand management under variable hydrology. Initially, during this period, the basin had high flows and policy innovation to allocate and locally store surplus supplies. This is evident via the 1999 interstate banking rule allowing LB states to store water in AZ aquifers and the 2001 Surplus Sharing Agreement (Sullivan et al., 2017). Around 2000, the Millennium Drought began, shifting the basin to low flows, resulting in management aimed at stabilizing and decreasing demand. From 2005 to 2007, water scarcity and drought increased, and in 2005 Lake Powell storage dropped to 33% of capacity (Water Education Foundation, 2022). In 2007 the Colorado River Interim Guidelines for Lower Basin Shortages and the Coordinated Operations of Lake Powell and Lake Mead (2007 IG) were signed. These operations included guidelines to conserve water in Lake Mead and equalize storage between the main reservoirs (Lake Mead and Lake Powell).

Also, during this period, the criteria for decision-making expanded to include diverse human and natural uses of water supplies. The 1992 Grand Canyon Protection Act required Glen Canyon Dam water releases to meet tribal, environmental, cultural, and recreational needs. In 1992, the Ten Tribes CRB Partnership was established to strengthen tribal influence among the Basin States for supply use and management

(CRWUA, 2021). Further expansion of actors formally included as decision-makers took place from 2014 to 2018, expanding consideration of ecology and extending tribal rights. Regarding ecology, a pulse flow released in 2014 to a 24-mile stretch along the U.S.-Mexico border and Delta that historically was two million acres of riparian habitat and wetland (Owen, 2018). Furthermore, the U.S. and Mexico signed Minute 323 in 2017, supporting increased conservation and storage in Lake Mead to help offset drought, prevent triggering shortages, and dedicating 210,000 acre-feet over nine years for Colorado River Delta environmental restoration (Water Education Foundation, 2022). Regarding tribal rights, the USBR released a Tribal Water Study in 2018 that described how tribal water use fits into Colorado River management and ways future tribal water resource development could influence CRB operations.

The current water management period is focused on responding to drought, climate change, aridification, and increasing demand. The 2019 LB and UB Drought Contingency Plans encouraged the seven Basin States to consider all water users, beyond junior rights holders, as having a stake in keeping the system intact via voluntary water reductions. In 2021, the first-ever Tier 1 shortage was declared and required AZ, NV, and MX to reduce their Colorado River water delivery (Schlageter, 2021). In 2022, as water shortage conditions continued, a Tier 2a shortage was declared, which cut the 2023 Colorado River supply for AZ, NV, and MX. The USBR further demanded in 2023 that water use be cut an additional 2-4 MAF by the Basin States and tribes reliant on the Colorado River (Stern, 2023).

Presently, tensions are elevated about CRB's water governance amidst an uncertain climate and water supply (Gerlak et al., 2021; Karambelkar & Gerlak, 2020;

Sullivan et al., 2019). In part, some tensions result from differing goals between the UB and LB (e.g., separate drought contingency plans). Furthermore, the UB has not historically used its full allocation while the LB has, and at times, used more. Today, we have detailed records showing the average annual flow through the basin was 14.67 MAF from 1906 to 2021 and 12.3 MAF from 2000 to 2021 (Salehabadi et al., 2022), both less than the 17.5 MAF early western water decision-makers assumed (Kuhn & Fleck, 2019). While water governance management strategies and water action responsibilities have changed over time, we do not fully know how those changes have shaped water management actions and actors' roles. This research describes changes in rules-in-form over a one-hundred-year period and analyzes these changes in the context of the case history.

Figure 2. Case Study Location, Colorado River Basin, U.S.

3. Methods

For this analysis, written rules for governing the physical supply of water in the CRB were examined (Ostrom, 2011). To identify rules that guide governance decisions, a systematic approach to determine how water management actions are described in written formal governance documents to address concepts related to water governance at the basin and sub-basin scale was used. Then, content analysis was conducted to determine how internal decision-making processes are expressed in formal documents (Bernard et al., 2016; Bowen, 2009). Next, each rule was characterized based on spatial scale and whether the rule grants or constrains authority based on rule issuer and target. This information is used to map the institutional structure using social network analysis. Lastly, the results are interpreted in the context of the case history presented in Section 2.

3.1. Data and Rule Selection

To understand the evolution of the water governance structure, documented rules and agreements from 1922 to 2022 were analyzed. Only formal documents with legal or regulatory standing regarding CRB water governance were considered. The set of these documents is called the "Law of the River" documents (Sullivan et al., 2017; Wescoat, 2023). The scope of the document population was specified via the following document selection criteria: 1) address formal rules pertaining to at least one of the following: the Upper CRB, the Lower CRB (including Mexico), and the CRB (excluding water export areas); 2) fit within basin or sub-basin institutional level boundaries; 3) published between 1922 and 2022; and 4) directly address the Colorado River Basin, physical water availability, and/or water management activities. This search and screening process yielded 14 documents for further analysis (Table 1).

Table 1

Colorado River Water Governance Document Selection.

Documents	Abbreviation
Colorado River Compact of 1922	1922 CRC
Boulder Canyon Project Act of 1928	1928 BCPA
California Seven Party Agreement of 1931	1931 CSPA
Mexican Water Treaty of 1944	1944 MWT
Upper Colorado River Basin Compact of 1948	1948 UCRB
Colorado River Storage Project Act of 1956	1956 CRSP
The Arizona v. California U.S. Supreme Court Decision of 1964	1964 AZCA
The Colorado River Basin Project Act of 1968	1968 CRBP
The Criteria for Coordinated Long-Range Operation of Colorado River Reservoirs of 1970	1970 CLRO
Minute 242 of the U.S.-Mexico International Boundary and Water Commission of 1973	1973 M242
2001 Surplus Sharing Agreement	2001 SSA
2007 Colorado River Interim Guidelines for Lower Basin Shortages and the Coordinated Operations of Lake Powell and Lake Mead	2007 IG
2019 Lower Basin Drought Contingency Plan	2019 LDCP
2019 Upper Basin Drought Contingency Plan	2019 UDCP

Empirical and theoretical governance literature was drawn upon for the thematic rule selection. Existing natural resource governance case studies were used to ascertain broad categories with specific aims related to water systems (Larson et al., 2013; Wiek & Larson, 2012). From the literature, four main domains associated with water system management: water supply, storage, movement, and use activities were identified (Garcia et al., 2019; Mirumachi et al., 2021; Wiek & Larson, 2012). Next, keywords were defined and created based on theoretical water resource concepts (Kallis, 2010; York et al., 2019) and mapped to the four types of water management to create a water management type coding guide (Table 2). Rules were selected if the rule is within at least one of the institutional level boundaries of interest and addresses at least one CRB water management domain.

Table 2

Water Management Action Type Coding Guide.

Action	Definition	Keywords
Supply	Physical water amount	water right, water permit, physical availability, quantity, apportion*, allocat*, water source, allot*
Storage	Containment of the physical water amount	storage, reservoir, ICS, storage credit, surplus, stock, accumulat*, groundwater bank*, aquifer storage
Movement	Relocation of the physical water amount	deliver*, conveyance, interbasin transfer, releas*, interstate, withdraw*
Use	Consumption of the physical water amount	water use, water demand, demand management, water conservation

3.2. Content Analysis and Coding Scheme

Content analysis was conducted using codes derived from theory and prior knowledge of water governance and institutions (Akamani & Wilson, 2011; Mirumachi et al., 2021). To better understand and document the institutional arrangements, the rule level, spatial scale, issuer, and target of each rule without mutual exclusion were characterized. The three rule levels defined in the IAD Framework were utilized. To understand the network of actors, each rule's spatial scale based on politically defined boundaries, issuer(s) based on actor(s) that impose rules, and target(s) based on actor(s) that rules are imposed upon were coded. Dr. Garcia (Committee Co-Chair) and I used consensus coding to reach intercoder agreement (Cascio et al., 2019; Hill et al., 1997).

3.3. Network Analysis

I constructed a directed network based on the rule characterizations above using the igraph package (Gabor & Nepusz, 2006) in R. Directed networks indicate the flow of information, or in this case, rule direction from the issuer to the target. To test the hypothesis that the distribution of authority changes over time and is split as the network size increases, I looked at the degree (number of ties) and linkages (betweenness) within the network (Hermans et al., 2017; Kharanagh et al., 2020). As is commonplace to examine network linkages, also called bridging behavior, the measure of in- and out-degree centrality and betweenness centrality were calculated (Friemel, 2017; Jones & White, 2021; Olivier, 2019). To clarify, the rule issuer and target were counted separately by using both the in- and out-degree centrality measures.

4. Results

4.1. Evaluation of Rules

Constitutional, operational, and collective-choice rules related to water supply, storage, movement, and use were effectively modified by the addition and layering of new rules (Figure 3a). In total, 118 rules were extracted and examined from the 14 documents. The rules spread across the documents ranging from two in the 1956 Colorado River Storage Project Act to the highest amount of 40 in the 2007 Interim Guidelines (Figure 3b). While the Millenium Drought began in 2000, the significant increase in rules via the 2007 Interim Guidelines indicates a delayed, but robust policy response. Additionally, no formal rules have been rescinded and as a result, the rules are layered upon each other. This is an important finding because, while new rules have been added, the initial water management activities and responsibilities have been maintained over the long term. Through this analysis, rules were found to have stayed in place and shaped subsequent rules-in-form over time across the CRB, as anticipated (Bardach, 2006).

The number of rules by rule level and water management action type were calculated from the extracted and coded rules (Figure 3a). Of the extracted rules, operational rules are the most common and constitutional level rules are the least common. To further investigate rule levels, the occurrence of each rule level by document was examined (Figure 3b). As the documents were developed over time, this allowed for the parsing out of the timing and context of additions of rules by level. Operational level rules are most common and are found in each document. Collective choice rules are the second most prevalent and constitutional rules are least prevalent. Such findings demonstrate that policy change in the CRB has been at the operational level, signaling that the focus of change has been on further specifying how practical decisions are made. Further, the focus of change has not been on the way decisions are made although there have been some collective-choice level rule additions, indicating that the way policy is made is evolving but at a slower pace. There are only two constitutional level rules, one in the 1922 CRC and one in the 1948 UCBR (Figure 3b) which is surprising as both documents set up major governance structures. The lack of change is notable as many new actors are added over time and part of the job of constitutional level rules is to specify actor roles in lower-level rules. Constitutional level rules occurred least signaling that there are informal processes for selecting decision-makers or that these are out of scope given the selection criteria.

The occurrence of each water management type per document based on the extracted rules was analyzed. Since the rules in these documents have stayed in place since their implementation, I examined the cumulative count of rules over time based on the type of water management (Figure 3c). Use and movement rules follow similar increasing patterns while storage and supply rules follow similar, but slower, increasing patterns over time. Also, rules regarding water use and movement actions occurred most often in the documents. Water movement rules are tied for least prevalent in 1922 to the second most prevalent in 2019 (Figure 3c). This aligns with the period of water allocation and infrastructure development paved the way for moving water and aided in the expansion of rules regarding the physical dispersion of CRB water detailed in the case history. Notably, storage rules were the least prevalent until 2007 when the coordinated operations between Lake Mead and Lake Powell, as well as the use of storage by individual water users, became important strategies to cope with drought (Figure 3c). This increase in prevalence is in alignment with the water governance period of demand management under variable hydrology starting in the mid-1990s as well as the current water management period focused on drought. Water supply rules start as second most prevalent in 1922 and fall to least prevalent in 2007 although the 2007 Interim Guidelines were set for drought management (Figure 3c). Despite the 2019 DCPs, also established for drought management, currently, water supply rules are least prevalent even though the CRB has historically struggled with water supplies and overallocation. This may be due to the doctrine of prior appropriation driving priority water rights in the West and challenging changes to allocations of water supplies.

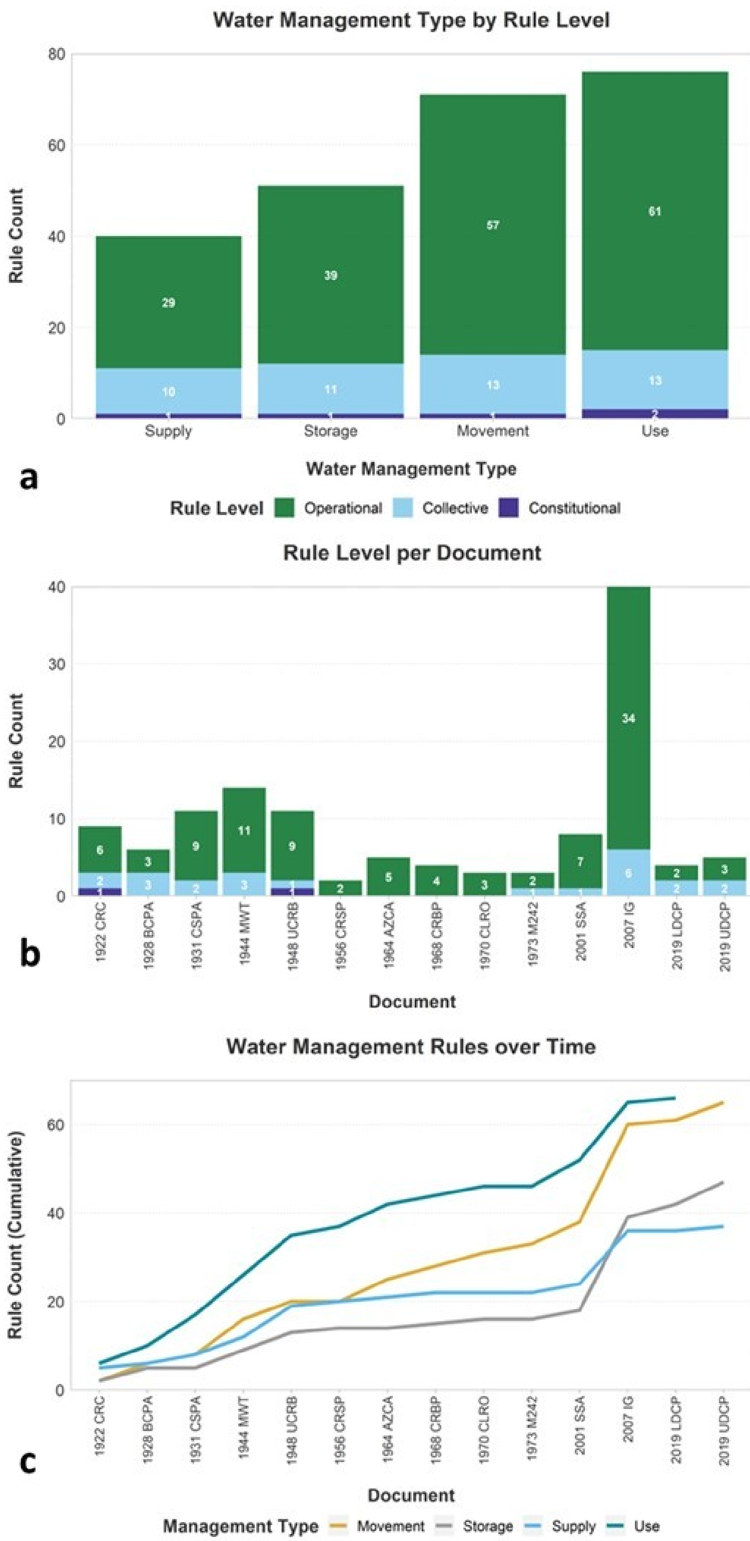

Figure 3. a. Rule Level per Water Management Type; b. Rule Level Count per Document; c. Cumulative Water Management Rules over Time.

4.2. Water Governance Network

Figures 4a-d illustrate the water governance network in 1922, 1948, 1973, and 2019, respectively. The circular nodes represent actors while the arrows represent and indicate the rule direction between the rule issuer and target. The color-coding in Figure 4a-d aligns with the governance level of the actors as listed in Table 3. When comparing the 1922 (Figure 4a) with the 1948 network diagram (Figure 4b) there is a significant increase in the number of actors in the network from 6 to 27 and the number of connections. This finding aligns with the addition of national, state, and sub-state actors to the water governance network, particularly via the 1944 MWT. The most notable finding is the increase in the number of actors involved and the total number of rules connecting the rule issuers and targets when comparing the 1922 (Figure 4a) and 2019 (Figure 4d) networks. These substantial differences demonstrate the network structure changed via a six-fold increase (from 6 to 35) in the number of actors involved and by one order of magnitude (from 10 to 178) in the number of connections between actors via the rules. Collectively, Figures 4a-d show changes in the distribution of authority over time as the network grows. The growth of the network in the number of actors and rules aligns with the governance period starting in the mid-1990s with a focus on expanding the criteria for decision-making and actors formally included as decision-makers.

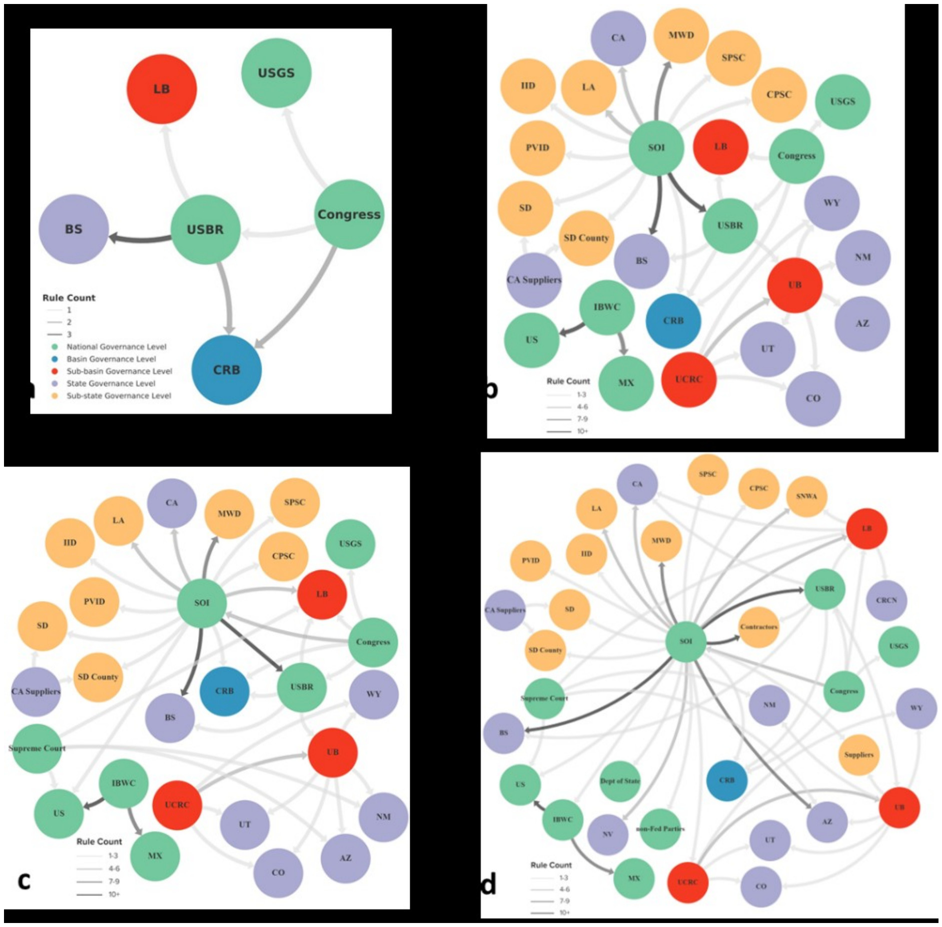

Figure 4. Network Diagram Snapshots: a. 1922; b. 1948; c. 1973; d. 2019.

Table 3

Rule Issuers and Targets by Governance Level with Rule Count Totals.

Governance Level	Actors	Rules Issued	Rules Targeted
National	US, MX, USBR, SOI, Congress, Supreme Court, Dept of State, non-Fed Parties, USGS, IBWC	153	48
Basin	CRB	0	9
Sub-basin	Upper and Lower Basin, UCRC	23	17
State	Basin States, AZ, CA, CA Suppliers, NV, CO, WY, NM, UT, CRCN	2	48
Sub-state	MWD, SNWA, PVID, IID, CPSC, LA, SPSC, Contractors, Suppliers, SD, SD County	0	51

Different processes, rule issuing and targeting, are dominant at different governance levels (Bodin & Crona, 2009). Table 3 shows the total amount of rules issued by and targeted at actors at the same governance level throughout all 14 documents analyzed. A significant portion of the rules are issued, and thus originate, at the national level (Table 3). Rule targets at the national level delegate rule implementation to lower levels of governance, most frequently (51) to the sub-state level. The second most rules are issued at the sub-basin level (Table 3). This makes sense because as actors, the UB and LB receive rules from actors at the national level and then make specific operational rules for states and sub-state actors. The distribution of rules in the sub-basins is possible via state members' voluntary agreement permitting both basins the power to issue rules. Sub-state actors are the most targeted by the rules (Table 3). As rules can grant or constrain authority, thus, even if an actor is the target of several rules, they are not necessarily heavily constrained or without authority for decision-making. Interestingly, the second most targeted levels are both the national and state, even though the national is the main rule issuer. These findings are consistent with a top-down structure of authority where actors with higher levels of governance (e.g., national) have more authority and use this authority to issue rules than actors with lower levels of governance (e.g., sub-state).

By looking at the top five actors for each metric, I found that the distribution of authority does not significantly change over time due to a lack of alteration to responsibilities for water management actions. Tables 4-6 are breakdowns of the top five actors' centrality measurements at each time snapshot. The U.S. is the main rule target, indicated via high in-degree values (Table 4), thus the U.S. plays a major role in responding to rules. The actors with high in-degree values are consistent to a point because while only the U.S. and BS remained in the top five from 1948 to 2019, the U.S. consistently has the highest in-degree from 1948 to 2019 (Table 4). The SOI dominates the network over time as the entity that issues the most rules, as indicated by high out-degree values from 1948 onward (Table 5). From 1948 on, there are a small number of actors, SOI, IBWC, USBR, and UCRC, who consistently have high out-degree metric values indicating they issue the most rules. Actors that act as intermediaries have high betweenness values. There is less consistency in the top five actors with the highest betweenness metric values. From 1948 to 2019 the UB and USBR are the only actors that remain in the top five. In the case of the highest betweenness value per time snapshot, the USBR, UB, and SOI are indicated as the top intermediaries (Table 6), but we know that multiple intermediaries receive rules and then make specific operational rules for other entities (i.e., states and water suppliers). Considering betweenness is a representation of actors that serve as links by receiving and issuing rules, it makes sense that when the network is smaller and simpler fewer actors have a linking role. Betweenness, in this case, may be a measure of the increasing complexity of the network and institutional structure over time. Actors who are rule issuers and targets do not vary widely. The same cohort of actors, the CRB, USBR, U.S., SOI, and UB (Tables 4-6), have the highest centrality values over time, indicating the bureaucratic hierarchy has remained because actors in positions of power in the water governance network have been maintained over the last 100 years.

Table 4

Top 5 Actors In-Degree Value per Snapshot Year.

1922		1948		1973		2019	
Actor	Value	Actor	Value	Actor	Value	Actor	Value
CRB	4	US	13	US	17	US	19
BS	3	MX	9	MX	9	Contractors	15
USBR	1	CRB	7	CRB	8	USBR	14
USGS	1	BS	4	BS	6	BS	13
LB	1	MWD	4	LB	5	AZ	10

Table 5

Top 5 Actors Out-Degree Value per Snapshot Year.

1922		1948		1973		2019	
Actor	Value	Actor	Value	Actor	Value	Actor	Value
USBR	6	SOI	24	SOI	29	SOI	103
Congress	4	IBWC	22	IBWC	24	IBWC	24
		UCRC	9	Congress	11	Congress	11
		USBR	7	UCRC	9	UCRC	11
		UB	7	USBR	7	USBR	10

Table 6

Top 5 Actors Betweenness Value per Snapshot Year.

1922		1948		1973		2019	
Actor	Value	Actor	Value	Actor	Value	Actor	Value
USBR	2	UB	17	UB	17	SOI	23
		USBR	14	USBR	12.2	UB	11.7
				SOI	10.8	LB	7.1
						UCRC	5.6
						USBR	4.5

5. Discussion and Conclusion

In the combined spatial, temporal, and network analyses covering the past century the way Colorado River Basin water governance has been influenced by the legacy of policy is observed. This study presents a 100-year temporal analysis, drawing on formal documents and rules that shape CRB water governance by integrating a case history, institutional analysis, and social network analysis. The results indicate that rules have evolved water management strategies over time, shifted the emphasis of various water management actions, and changed the distribution of authority across actors and levels. The rules span multiple scales from sub-state to national, indicating the multi-level governance system structure that is characteristic of Colorado River Basin water governance.

In the institutional analysis, water system dynamics were found to persist over time with the layering of rules (Figure 3c), consistent with other water management studies (Elshafei et al., 2014; Gleick, 2003; Pulwarty et al., 2005). The persistence of original decisions still in place today provides evidence that lock-in effects shape how water governance has changed. Over time, the layering of new rules has permitted CRB water governance to remain viable through new operating conditions and infrastructure integrations, as seen in the case history. However, there are limitations to what incremental adaptations can do to sustain systems over the long term (Kates et al., 2012; O'Brien et al., 2012). The layered incremental adaptation approach for the CRB has not kept pace with accelerating climate change, drought, aridification, and increasing demand. This is evident via the USBR's demand to reduce an additional 2-4 MAF of water for use in 2023. USBR's demand – and the BS's difficulty in meeting it – gives an example of the challenge of negotiating new rules in the context of 100 years of history and the evolution of water governance in the CRB. The findings that governance approaches used over the last century have not kept pace with water management challenges in terms of climatic and governance regime changes align with other water governance studies (Hileman & Lubell, 2018; Olivier et al., 2020; Vano et al., 2014; York et al., 2020).

Over the last century, change has occurred, but the path dependency of institutions has played a role in the magnitude of change to water management. The maintenance of the original rules via the addition of rules that have created layers within the water governance institutions and the actor network provides evidence that path dependency has shaped how water governance has changed (Lewis & Steinmo, 2012; Peters, 2019). Although the addition of operational and collective choice rules throughout the period was observed, operational rules are more prevalent (Figures 3a-b) indicating that rulemaking has focused on operations but that some shifts in the way decisions are made have been made throughout the past one hundred years. Only one additional constitutional level rule after the initial 1922 CRC was observed which indicates the processes for selecting decision-makers are informal, and/or constitutional level rules are not captured within the selection criteria scope. Other studies of path dependency and water policy have similar findings about water management changes amid original management decisions (Anderson et al., 2018; Ingram & Fraser, 2017; Marshall & Alexandra, 2016).

Despite struggles with water overallocation since the early 1920s (Hundley, 2009; Kuhn & Fleck, 2019), there are few supply rules (Figures 3a and 3c). The lack of supply rules demonstrates how early allocation agreements endure even with changes over time. Water use rules are present in every document (Figure 3b) potentially because the pre-1920s doctrine of prior appropriation and the 1922 CRC set rules in alignment with the doctrine for beneficial use. As a case in point, the overallocation since the inception of the 1922 CRC has not been addressed in the rules-in-form within the Law of the River documents. These findings are in agreement with other study findings that water management in the CRB is path dependent and that rules have been shaped by early rules, particularly ones set via the 1922 CRC (Heinmiller, 2009; Loos et al., 2022; Turley, 2021).

As the challenges facing the CRB have evolved over the last century, so too has water governance and the structure of the actor network. Over time, actors across institutional levels and types of water management were added (Figure 4a-d). Overall, the central network structure remained stable without actor replacement or removal, only additions. As the actor network grew, the distribution of authority changed from a few central actors to many actors in the current large and complex network. Network growth is due in part to the mid-1990s and 2014 to 2018 expansion of criteria for actors formally included in the decision-making for natural and human uses of Colorado River water. Changes in the network reflect changing values as more attention was paid to diversity, equity, and inclusion as evidenced by the addition of new actors (Mexico, IWBC, etc.). Such network additions support the hypothesis that over time authority has been distributed across a growing number of actors.

This analysis found that the key decision-making positions remained the same. The actors who issue and are targeted by the rules lack significant change over the last century (Tables 4 and 5). Original positions of power have been maintained over time, narrowing the space for problem-solving and renegotiation. Generally, in systems with centralized power, substantive changes are harder to make because powerful actors may use their power to maintain the status quo or exert their power over less powerful actors (Ishtiaque et al., 2021; Partzsch, 2017). Consistent with existing literature (Berggren, 2018), the findings support the hypothesis that path dependency has shaped how water governance evolves and who is able to influence decisions.

In contrast to Olivier & Schlager (2021), the addition of dynamics and institutional arrangements did not limit or change the direction of water governance decision-making and actions in this analysis. The governance system complexity increased and became highly institutionalized as more water management rules were created. Highly institutionalized governance systems are fragile and have limited opportunity for flexibility because there are tensions and constraints for change and limits on possible choices (Gillette, 1998; Ishtiaque et al., 2021). Actors in these types of governance systems are incentivized to maintain the system and there is less space for experimentation and innovation between the rules. Thus, the finding that water management responsibilities also remained stable over time aligns with and empirically contributes to the literature on institutions and path dependency (Kessy, 2018; Marshall & Alexandra, 2016; Wilson, 2014). These findings are in agreeance with other cases that have found that water resource governance does not significantly evolve, change, and shift over time as they are shaped by the path dependence set by the original governance structure (Möck et al., 2022; Pahl-Wostl, 2015; Thiel et al., 2019).

Although the network has evolved with the addition of rules and actors and an increase in the number of connections between actors (Table 3 and Figures 4a-d), issues recur as there has been no major structural change or reform of the institutional network. These findings are important as substantial differences in governance outcomes and processes cannot be expected without changes to the water governance network (Bodin & Crona, 2009; Das et al., 2019). Due to the lack of major alteration, the water governance structure has not kept pace with an increasingly changing climate in the Anthropocene and is unable to respond sufficiently. Further, the current system for water governance does not fully address the context in which the CRB is operating, and management rules have not kept pace with the changing water system. The case history details changing priorities and the increasing challenge of water scarcity. An improved understanding of current CRB governance and how it has evolved can help provide insight to inform the redesign of operating rules and fill the knowledge gap of how we have arrived at the critical water situation we are in today.

This study is novel because it surpasses existing descriptive studies and their critiques by taking an analytical approach to examine the content within the majority (14) of Law of the River Documents (Table 1) (Ingram et al., 1984; Wescoat, 2023). Additionally, this study goes beyond other institutional studies of the CRB that focus on water quality, hydropower operations, the state-level, reservoir operation, and the decision-making process by using an analytical lens including a 100-year time scale, five levels of governance, and management actions related to supply, storage, movement, and use (Berggren, 2018; Karambelkar, 2018; Sullivan et al., 2019; Turley et al., 2022).

It is important to note that other variables not examined in this study may influence the findings. For example, informal stakeholder groups referred to as shadow networks by Wutich et al. (2020) may influence decision-making via informal drivers and factors (e.g., unplanned interactions, social influence, social norms) and impact how decisions are made regarding resource management. This study is limited as I only cover changes to water management strategies and responsibilities based on formal rules across high institutional levels. Informal rules and norms are not included in the data set or analysis, as a result, this study could be missing changes to water management influenced by informal rules across lower institutional levels. Thus, the full story of the deficiency of past water management and incremental changes amidst rapid climatic change has not been captured. To fill this gap, other studies could be conducted to understand how path dependency, adaptations, and informal rules have and have not contributed to sustainable water management in the CRB. Identifying the shortcomings of historic and legacy water governance may help inform more effective strategies for future adaptations.

The long, but not full, history of the evolution of the CRB water system from open access to a highly regulated resource is acknowledged in this study. Indigenous peoples' water use and management of the basin has an even longer history that is not covered in this study but is recognized as an important piece of the larger story of water in the West. To improve the understanding of how the CRB water system evolved, future analysis should take the larger history into account, especially with our increased understanding of the importance of Tribal perspectives and input.

Taken together the institutional analysis, social network analysis, and case history indicate a tension between path dependency, a changing environment, and shifting values. Through examining the case history, I found that CRB water management has shifted from managing demand growth to managing conflict over time, marked by the evolution of water resource management to reservoir development, then to managing water scarcity. The institutional analysis empirically demonstrates the path dependency of institutions over the century-long, and ongoing, water governance regime. This study contributes to understanding the evolution of water governance in the CRB with this analysis where a layering of new rules without the removal of existing rules and an expanding network of actors over the last century was found. Expansion of the network demonstrates a shift in values to be more inclusive of actors within the water governance network. To build upon this scholarship, factors that may shape and influence decision-making, such as informal rules and norms as well as shadow networks, should be studied to help tell the larger story of how water governance has evolved in the CRB over time. Future research could apply this approach to other basins with histories of water policy and conduct cross-case comparisons with this study as well as existing studies to add to water governance knowledge and literature.

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CHAPTER 3

COORDINATING COLORADO RIVER WATER MANAGEMENT: GOVERNANCE AND UPSTREAM-DOWNSTREAM DYNAMICS

Introduction

Reservoirs in the Colorado River Basin (CRB) have dropped to formal shortage levels, impacting the 40 million people who rely on Colorado River (CR) water (Udall & Overpeck, 2017a). In 2022, an unprecedented Tier 2a shortage was declared with water reduction operations beginning January 1, 2023. In mid-June 2022, the United States Bureau of Reclamation (USBR) demanded the seven Basin States (BS) and Tribes dependent on the CR make a plan to cut 2023 use by an additional 2-4 million acre-feet (MAF) by mid-August 2022 (Stern, 2023). Since this deadline was not met, as California did not sign the January 2023, 6-State Consensus-Based Modeling Alternative (CBMA) agreement letter, the USBR published an operations draft outlining two use reduction cuts amongst the Lower Basin (LB) in April 2023. Neither strategy was desired by the LB states, so they ultimately compromised and agreed to their own "Lower Basin Plan" proposal in May 2023 to conserve at least 3 MAF by December 31, 2026. To date, there is no formal plan for how voluntary reductions to meet long-term water supply goals will occur.

The complexity of CRB water governance is compounded as new basin operation guidelines are due in 2026. Coordination for the CRB is complicated because the system is split between the sub-basins (Upper and Lower). "Modern-day management of the Colorado River Basin is marked by a decentralized and fragmented governance system: a complex web of disjointed and piecemeal authorities and institutions inform the allocation and use of water with no single venue to deal comprehensively with Colorado River Basin issues (Karambelkar & Gerlak, 2020, p. 4)". Furthermore, the Upper Basin (UB) has not historically grappled with supply challenges like the LB has due to water scarcity, demographic and climatic changes, and tensions based on historic water rights. Since there is not a singular venue for collaboration to address the ranging and fast-paced water challenges in the CRB, coordination among actors and decision-makers is at a crucial point in time.

The purpose of this study is to understand how governance level and physical location in the watershed shape goals, strategies, and beliefs about risks and benefits related to water management changes. Secondly, this study asks if and how governance level and hydrologic position shape coalition formation and coordination between organizations via common goals, strategies, and beliefs. To address this, variations in contemporary water management goals, strategies, and beliefs based on governance level and upstream-downstream watershed positionality were analyzed. This study is guided by three research questions: 1) How do Colorado River management goals and strategies to achieve these goals differ upstream to downstream and across governance levels (Federal, State, and Local)?; 2) Are observed patterns of coordination consistent with commonalities in identified goals and strategies?; and 3) How do governance level and physical location influence Colorado River water governance coordination? Coordination is based on actors collaborating and organizing their actions to reach common goals (Satoh et al., 2021). First, I hypothesize that goals and strategies will be shaped by governance level and hydrologic position because these two attributes influence the organization's responsibilities and risks. I anticipate the beliefs about the risks and benefits of changes to water management are also influenced by the governance level and physical hydrologic position (e.g., upstream or downstream) as changes upstream impact downstream and because the history of development resulted in differences in water use between the sub-basins. Second, I hypothesize that coordination is more likely to be observed among organizations with similar goals and strategies because they work together or do related work via common strategies to achieve common goals. Further, I anticipate that actors with common goals and strategies form coalitions and coordinate water management regimes. Lastly, I anticipate that governance level and physical watershed position are factors that shape coalition formation because organizations at the same governance level have similar responsibilities (Lawless et al., n.d.), and watershed position influences which organizations coordinate based on proximity and existing working relationships.

To date, CRB scholarship is dominated by empirical studies of the LB (Huckleberry & Potts, 2019; Norton et al., 2021; Singer & Michaelides, 2017; Sullivan et al., 2017, 2019; Varady et al., 2001). To improve UB knowledge, this study includes both sub-basins via examining commonalities between them at the Federal, State, and Local governance level. Existing upstream-downstream dynamics research includes numerous empirical studies at the international and multi-country spatial scale (Kuenzer et al., 2013; McIntyre, 2015; Moellenkamp, 2007; Munia et al., 2016; Pandey et al., 2020), but lacks analysis at other spatial scales. To advance upstream-downstream dynamics scholarship, I conducted research at the sub-basin spatial scale, where the basin is mainly in the continental U.S. While many environmental governance studies analyze data across hierarchical levels of governance (Hammer et al., 2011; Hileman & Lubell, 2018;

Nykvist, 2017; Sullivan & White, 2020), there is an opportunity to contribute to governance knowledge through conducting analysis across the same governance level. This study helps bridge the gap by focusing analysis on the commonalities and differences of organizations at the same governance level.

1. Case Background

The American Southwest has experienced a megadrought since 2001 (Cook et al., 2010; Owen, 2018). This particular megadrought is referred to as the Millennium Drought and is the most severe drought within the last 1,200 years (Williams et al., 2022). Drought conditions are exacerbated by aridification due to climate change in the region (Figure 1). Recent research indicates that the CRB will not return to pre-Millennium Drought conditions due in part to aridification, increased temperatures, and drier soil conditions (Overpeck & Udall, 2020; Udall & Overpeck, 2017a). Water management negotiations for Colorado River water are grappling with the ongoing megadrought and climatic changes that impact CRB water supplies.

The CRB has a century-long history of formal water governance. Referred to as the Law of the River, a set of formal water governance documents guide how water in the CRB is managed (MacDonnell et al., 1995). The first of these documents, the 1922 Colorado River Compact, delineated the basin into two politically constructed sub-basins, UB located upstream, and the LB located downstream (Figure 5). Four states (Wyoming, Utah, Colorado, and New Mexico) are in the UB. The LB is more heterogeneous as it is composed of three states within the U.S. (Arizona, California, and Nevada) and Mexico. Mainly, the debate and negotiations for the CRB water supply are in the United States. The UB and LB have similar cultural and social characteristics but differ in terms of water use, infrastructure, and climate. Historically, the LB has used, and at times used more than, the yearly allotted 7.5 MAF of Colorado River water, whereas the UB has not despite having the same amount of allocated water. According to Schmidt et al. (2023), less than half of the total CRB water uses are in the UB. Due to hydrologic position, water activities in the LB do not have the same impact on the UB as water activities in the UB do on the LB.

Figure 5. Colorado River Basin, U.S. (Lawless et al., n.d.).

Over time, the Law of the River has defined water management roles and responsibilities at the Federal, State, and Local levels of governance (Lawless et al., n.d.). Each level has a vested interest in developing management regimes aligned with their goals. Institutions in the UB and LB are distinct. LB institutions are more diverse than UB institutions due to population growth and increased demand that sparked the development and evolution of the LB's institutional infrastructure (e.g., post-2007 robust institutional infrastructure and 1980 GWMA). The UB and LB have separate organizational entities and defined differences via compacts. For example, per the 1922 Colorado River Compact and 1944 Mexican Water Treaty, the UB is required to send a running total of 82.5 MAF over each 10-year period to the LB. This 10-year period helps the UB to grapple with natural variability in streamflow. Additionally, the LB is constrained via a legacy of policy-making that has created many layers of rules whereas the UB is not as constrained (Lawless et al., n.d.).

2. Theoretical Framing

Existing water governance literature and knowledge lacks strong "theoretical foundations for describing and explaining the dynamics and transformative change of water governance" (Pahl-Wostl, 2015, p. 159). To address this, my research examines water governance dynamics via water organizational management goals and strategies for water governance in the CRB and beliefs about the risks and benefits of changes to water management. Three coordination dynamics guide this study: management goals and strategies (organizational), upstream to downstream (hydrologic position), and levels of governance (institutional). In terms of organizational coordination, goals are defined as what an individual or group seeks to accomplish (Locke et al., 1981). Strategies are tactics that are motivated and purposive to maximize goal progression (Meina Liu & Wilson, 2011). Regarding the hydrologic position, upstream refers to the hydrological location that is near the water source and downstream refers to the hydrological location that is away from the source and the direction the water flows. Levels of governance refer to the formal, hierarchical, and lawfully arranged institutional jurisdictions of government (McGinnis, 2015). In order of hierarchy, Federal level is followed by State level, then Local level. Generally, in policy and decision-making literature, risk is defined as an outcome we are uncertain of (Loomis & Helfand, 2003). Risks are perceived as negative outcomes and benefits are perceived as positive outcomes (Siegrist et al., 2000). Benefits, within the decision-making literature, are typically defined as advantages that result from a particular decision or course of action (Saaty & Sodenkamp, 2010). Further, this study is grounded in collaborative governance theory (CGT) and the advocacy coalition theory (ACT) and framework (ACF) to describe and explain the institutional and upstream-downstream dynamics of water governance via analyzing organizational coordination.

2.1. Collaborative Governance Theory

Generally, collaborative governance is defined as "the processes and structures of public policy decision-making and management that engage people constructively across the boundaries of public agencies, levels of government, and/or the public, private and civic spheres in order to carry out a public purpose that could not otherwise be accomplished" (Emerson et al., 2012, p. 2). Collaborative governance theory identifies enabling factors for collaborative governance such as institutional flexibility, a sense of ownership and accountability among stakeholders, broad stakeholder inclusion, as well as a shared understanding of the joint resources, rules that govern resource use, and one another's resource needs (Fleck, 2016; Haller et al., 2016; Karambelkar & Gerlak, 2020). Some benefits of collaborative governance processes are trust building, buy-in, and knowledge system integration (Conrad et al., 2018; Ostrom, 1990; Pahl-Wostl, 2009). Differing social, ecological, legal, spatial, and temporal conditions can enable or block decision-making and coordination which impacts how and why collaborative governance takes place in certain times and particular issue spaces and not others (Guerrero et al., 2015). For example, often, environmental challenges, such as water scarcity, span large geographic areas and require long-term management regimes. Barriers to successful collaborative governance include understanding how trust and legitimacy can be maintained throughout the process and how coordination conflicts can be resolved, as well as decision-making that lacks the inclusion of diverse interests (Huitema et al., 2009; Sullivan et al., 2019). Batory & Svensson (2019) critique collaborative governance as a fuzzy concept and advocate for narrow definitions and conceptualizations of collaborative governance for the operationalization of collaborative governance for research and practice, and theory-building. Thus, this study focuses on a foundational pillar of collaborative governance called coordination.

Coordination focuses on the engagement of actors in joint, cooperative endeavors. These activities often are conducted to achieve desired outcomes and increase the capacity of oneself and others to reach a common goal (Emerson et al., 2012; Weible et al., 2011). According to social norm theory, coordination is based on norms and relationships (Schlüter et al., 2017; Schultz et al., 2007). Collaborative governance goes a step beyond social norm theory and can be useful in understanding the coordination patterns between actors. Relationships are important for coordination activities, specifically for how people come together and jointly plan how to manage resources. Opportunities to build relationships and trust in informal ways can advance collaboration (Fleck, 2016; Harrison, 2009). Non-binding communication, referred to as “cheap talk”, contributes to relationship building and has been found to influence the likelihood people cooperate successfully to manage common-pool resources (Berthomé & Thomas, 2017; Ostrom, 2006, 2010). Moreover, relationships that go beyond just water and water management can have an informal influence on water governance (Wutich, DeMyers, et al., 2020). To narrow in on coordination as a main collaborative governance component, the Advocacy Coalition Framework is a useful tool, which is used in this study.

2.2. Advocacy Coalition Theory and Framework

The Advocacy Coalition Framework (ACF) is a policy process framework designed to capture complicated policy structures and processes. The ACF is "a modern variant of interest group theory" (Kraft & Furlong, 2013, pg. 80). Within the ACF, the theoretical logic referred to as ACT by Koebele (2019a) following Schlager (2007) hypothesizes relationships between ACF variables to help explain phenomenon in the policy process. "At the core of ACT is the assumption that policymaking is driven by groups of actors (i.e. advocacy coalitions) who coalesce around shared beliefs and coordinate to promote policies that align with these beliefs before others do the same (Sabatier, 1988)" (Koebele, 2019b). In other words, the foundational expectations of the ACT are two-fold where coalition formation is belief-based and coalitions are adversarial so the policy process is a competition among advocacy coalitions (Koebele, 2019b; Satoh et al., 2021). The theoretical focus on advocacy coalitions within the ACT is useful for identifying coalitions by grouping actors with commonalities together based on two criteria: shared beliefs and purposeful coordination of actions (Jenkins-Smith et al., 2014). The ACT is critiqued as a weakly predictive theory about enabling conditions because several processes and factors contribute to coalition formation in their actions through coordination and because the hypothesized relationships may not be universal (Koebele, 2019b). To address the weaknesses, coalition formation can be teased out through comparative work or be partially teased out in single case studies to analyze to what degree the ACT predicts coalitions (Lubell et al., 2009). Additionally, the weakness of the ACT alone can be improved by pairing the theory with other theories, CGT in this case following Koebele (2019b), to improve the application of the ACF. As a tool, the ACF can help researchers explore questions of how and why certain actors form a particular group and not others. For example, California's rejection of the 6-state CBMA agreement discussed above. Existing studies use ACF at the organizational level of analysis and in a collaborative setting (Koebele, 2019b; Leach et al., 2013; Leach & Sabatier, 2005). Weible & Sabatier (2018) press that more researchers should apply the ACF to organizational-level studies to help gain in-depth understanding of how coalition actors negotiate agreements and learn from one another.

Figure 6 illustrates how CGT and ACT are combined in this study and illustrates the hypothesized relationships. Specifically, I hypothesize that the factors of governance level and hydrologic position shape common goals and that these common goals and beliefs form coordination and advocacy coalitions. The arrows indicate the direction of influence of constructs, variables, and factors on one another. The dashed lines are the hypothesized relationships, and the solid lines are established relationships in existing literature. The blue boxes identify variables associated with CGT, orange boxes with ACT, teal boxes with both CGT and ACT, and the pink boxes are the factors I theorize indirectly influence on coordination by shaping goals and beliefs (Figure 6).

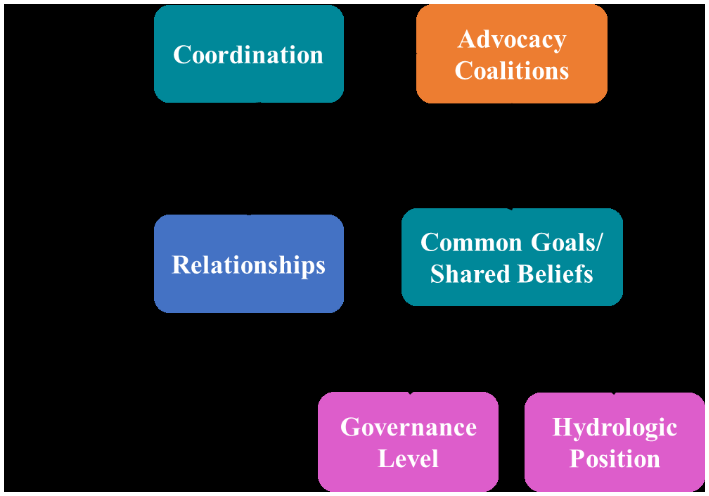

Figure 6. Theoretical Framing based on CGT and ACT.

3. Methodology

To examine goal and strategy, as well as risk and benefit variations across governance levels and hydrologic positions, this study uses primary data from interviews with CRB water experts. Organizations are the social unit of analysis; this research examines shared goals as expressed by organizations. Primary data was collected via semi-structured interviews with relevant actors and organizations across Federal, State, and Local levels of governance and in both sub-basins. Secondary data for coalition identification was collected via the 6-state CBMA agreement letter (CRB State Governors, 2023) and the Department of Interior's Record of Decision for the Lower Basin Plan (USBR & DOI, 2024) on publicly available websites.

3.1. Data Collection

The interview protocol was submitted for IRB review and followed data management best practices. Interviewees were selected based on free listing in which ten key informants composed of Arizona State University staff, faculty, and affiliates with expertise in water resources were asked to free list individuals and organizations actively involved in water issues in the CRB area (Brewer, 2002; Wutich et al., 2020). The key informant list was reviewed and edited by Dr. White (Committee Co-Chair) and Dr. Wutich (Committee Member), who have participatory and ethnographic research experience with CRB water experts. There was a set limit of two interviewees from each agency to limit repetitive responses and better penetrate the network. Interview questions were informed by CGT and the ACF to address the hypotheses regarding coordination based on governance level and location commonalities, and coalition formation based on common risks and benefits. Questions inquired about organizational goals and strategies for planning and coordinating water management and the risks and benefits related to changes in water management.

In total, there were 18 interviews (Table 7). When categorizing the organizations, I found the need to expand the governance level designations to include sub-basin and non-profit, as over half of the organizations did not fit within the three levels of governance (Federal, State, and Local) I initially started with, and reference in the research questions and hypotheses. Additionally, the reference to the hydrological position needed to be expanded to include the CRB, as 6 of the 18 organization's operations have an influence on the full basin, not just one sub-basin. Based on hydrologic positionality, there are six organizations in the CRB graphic scale, seven in the UB, and five in the LB position (Table 7). Based on governance level, there is one organization at the Federal and one at the Sub-Basin level of governance (Table 7). There are four organizations at the State governance level, three at the Local level, and nine at the Non-Profit governance level (Table 7).

Table 7

Characteristics of Interviews with Colorado River Basin Water Experts.

Organization	Abbreviation	Hydrologic Position	Governance Level
Arizona Department of Resources	ADWR	LB	State
National Audubon Society	Audubon	CRB	Non-Profit
National Audubon Society, Southwest	Audubon SW	LB	Non-Profit
Arizona Department of Agriculture	AZ Dept Ag	LB	State
The Babbitt Center for Land and Water Policy	Babbitt Center	CRB	Non-Profit
Central Arizona Water Conservation District	CAWCD	LB	State
Colorado River Research Group	CRRG	UB	Non-Profit
Central Utah Water Conservancy District	CUWCD	UB	Local
Environmental Defense Fund	EDF	CRB	Non-Profit
Getches-Wilkinson Center at the University of Colorado Law School	Getches-Wilkinson Center	UB	Non-Profit
The Glen Canyon Institute	Glen Canyon Institute	UB	Non-Profit
The International Boundary and Water Commission	IBWC	CRB	Federal
Navajo Nation Department of Justice	NN DOJ	CRB	Local
Southern Ute Indian Tribe	Southern Ute	UB	Local
The Nature Conservancy	TNC	CRB	Non-Profit
Upper Colorado River Commission	UCRC	UB	Sub-Basin
Water Resources Research Center	WRRC	LB	Non-Profit
Wyoming Attorney General's Office	WY AG Office	UB	State

3.2. Analysis Approach

3.2.1. Coding and Coalition Identification

Interview transcripts and organizational documents were thematically coded and analyzed based on *a priori* codes informed by CGT and ACT. The intercoder agreement was checked between Dr. Garcia (Committee Co-Chair) and I, then revised as needed to establish coder agreement (Geisler & Swarts, 2019). Interviewee's characteristics (hydrologic position, governance level, and organization they are representing and their position) were documented to analyze coalitions.

The theoretical focus on advocacy coalitions within the ACF guided two approaches of sorting organizations into coalitions (Koebele, 2019b; Lubell et al., 2009). First, organizations were grouped into coalitions based on goals and strategies, then based on risks and benefits. Secondly, organizations were grouped based on commonalities in their stated coordination with other organizations and in two formal policy letters; the 6-state CBMA agreement letter (CRB State Governors, 2023) and the Department of Interior's Record of Decision for the Lower Basin Plan (USBR & DOI, 2024).

3.2.2. Cluster Analysis

To find groupings of actors that emerged from the coded interview data, hierarchical clustering analysis was utilized. Hierarchical clustering is useful because it does not require the pre-specification of the number of clusters (Wilks, 2019). The distance was computed using the jaccard distance metric which is the recommended method for binary variables (Pandit & Gupta, 2011). Then, the Ward method for comparing clusters was used because it minimizes the within cluster variance and is, therefore, the method most consistent with the hypothesis that coalitions consist of actors with highly similar goals and beliefs (Murtagh & Contreras, 2012). The results of the cluster analysis are visualized via dendrograms. Dendrograms are used to determine the appropriate number of clusters by identifying where the distance between clusters jumps rapidly (Wilks, 2019).

4. Results

4.1. Predictors of Coalitions

Through the content analysis of the interviews, nine goals, seven strategies, 12 risks, and eight benefits were identified regarding changes to Colorado River water management. This study includes representative quotes for and the count of organizations that identified each goal (Table 8), strategy (Table 11), risk (Table 14), and benefit (Table 17) in the interviews.

The goals include access to Colorado River water, balancing the reservoir level, equitable allocation, habitat/environmental protection, long-term policy, protecting water rights, storage, sustainability, and Tribal inclusion (Table 8). Sustainability was the most identified goal (14) followed by Tribal inclusion (8). Habitat/environmental protection and storage were each identified by only three organizations.

Table 8

Representative Interview Quotes of Goals.

Goal	Representative Quote	N
Access	*"… ensure…water is protected and that the policy will remain effective for years to come and for future generations for more secure access to the water."*	5
Balance	*"…having the water uses balanced with the annual available supply, and, in fact, rebuild and restore resiliency in the Colorado River."*	7
Equitable Allocation	*"…create an equitable allocation of water for the nation that is respectful of our senior water rights within the basin as well as our ancestral homes and communities that live within our region." "The goal is to ensure Tribal water is allocated equitably, equitably among all users."*	5
Habitat/ Environmental Protection	*"Enduring health of the Colorado River system as a foundational goal and that includes planning for embedding specific environmental outcomes in agreements and management water management plans."*	3
Long-term Policy	*"…big picture we want to develop new management rules that require consideration of the hydrologic extremes that may be generated by a changing climate, and that these extremes are likely to evolve over time."*	6
Protect Water Rights	*"…secure and protect the water rights claims, and our where our boundaries are…"*	7
Storage	*"We need to intentionally manage uses to rebuild an appropriate, healthy storage account and live within the annual variations of supply."*	3
Sustainability	*"… another goal for the new rules is to have a sustainable management framework that puts supply and demand into balance and reduces the risk over time of those imbalances."*	14
Tribal Inclusion	*"Another goal…is at minimum to see Colorado River Tribes have a seat at the table in terms of governance or decisions about management."*	8

First, the goal presence and absence based on hydrologic position was compared. The goals based on hydrologic position have little difference. All three hydrologic positions do not identify storage as a goal (Table 9). The goals for the CRB and UB are the same. The only variation for the LB is the additional absence of habitat/environmental protection (Table 9). This could point to CRB and UB having different habitat or environmental responsibilities or obligations than the LB.

Table 9

Goal Presence and Absence Based on Hydrological Position.

Goals		
Position	**Present**	**Absent**
CRB	Access Balance Equitable Allocation Habitat/Environmental Protection Long-term Policy Protect Water Rights Sustainability Tribal Inclusion	Storage
UB	Access Balance Equitable Allocation Habitat/Environmental Protection Long-term Policy Protect Water Rights Sustainability Tribal Inclusion	Storage
LB	Access Balance Equitable Allocation Long-term Policy Protect Water Rights Sustainability Tribal Inclusion	Habitat/Environmental Protection Storage

Second, goal presence and absence based on governance level was compared and I found that the goals differ across levels (Table 10). Federal is the only governance level missing sustainability. Only organizations at the Non-Profit governance level listed all the identified goals. This finding aligns with the operations of Non-Profit organizations, as they tend to have a more holistic view and approach to challenges, and typically have broad mission objectives for projects and initiatives. Non-Profit is the only governance level that lists habitat/environmental protection as a goal (Table 10). Sub-Basin is the only governance level missing protecting water rights and Tribal inclusion as goals. This may be the result as the majority of the 30 Federally recognized Tribes in the CRB have parts of their Nations located in the LB (e.g., Arizona is home to 22 of the 30 Tribes) (Indian Affairs Bureau, 2020). Only organizations at the Sub-Basin and Non-Profit list Storage, which is interesting because these are the two non-traditional governance levels and storage rules and requirements are required for Federal, State, and Local level organizations within the Law of the River documents (Lawless et al., n.d.). Local and Non-Profit list access as a goal, which aligns with the "boots on the ground" approach Non-Profits often utilize to aid Local groups and communities.

Table 10

Goal Presence and Absence Based on Governance Level.

Goals		
Level	**Present**	**Absent**
Federal	Protect Water Rights Tribal Inclusion	Access Balance Equitable Allocation Habitat/Environmental Protection Long-term Policy Storage Sustainability
State	Balance Equitable Allocation Long-term Policy Protect Water Rights Sustainability	Access Habitat/Environmental Protection Storage Tribal Inclusion
Local	Access Equitable Allocation Long-term Policy Protect Water Rights Sustainability Tribal Inclusion	Balance Habitat/Environmental Protection Storage
Sub-Basin	Balance Storage Sustainability	Access Equitable Allocation Habitat/Environmental Protection Long-term Policy Protect Water Rights Tribal Inclusion
Non-Profit	All	None

Next, the presence and absence of strategies based on hydrologic position and governance level were compared. The strategies include agricultural partnership, collaboration with Tribes, conservation & investments in conservation, education, flexible planning and policy, inclusive policy and decision-making, and modeling the water system (Table 11). The most often identified strategies were inclusive policy and decision-making (12), collaboration with Tribes (7), and flexible planning and policy (7). Agricultural partnerships were identified least (3).

Table 11

Representative Interview Quotes of Strategies.

Strategy	Representative Quote	N
Ag Partnership	*"So, looking for and testing what's possible, we work with Ag districts to test ideas."* *"…develop these solutions where Ag is a partner instead of a target."*	3
Collaborate with Tribes	*"I do come back to the issue of Tribal engagement and coordination because we need to be sure that the current level of coordination is agreeable to all the parties."*	7
Conservation & Investments	*"We are investing heavily in conservation measures."* *"…actually reducing existing uses, especially on a long-term or permanent basis."*	5
Education	*"We are involved in public thought, leadership, and communications."* *"…public funding, private funding, bringing resources to the table, and …talking about it publicly…speaking at conferences, talking to the public."*	6
Flexible Planning & Policy	*"We really believe that the post-2026 operating policy should be adaptable and accommodate whatever potential future hydrology we might face."*	7
Inclusive Policy & Decision-Making	*"…being ready and willing partners to negotiate and settle water rights claims within the basin."* *"…figure out what they will and won't do to participate in shortage sharing in the basin so that there's a solution."*	12
Modeling System	*"We're trying to influence the modeling, making sure the environmental metrics are built in so there's kind of a technical side of that work there."*	5

There was no difference found the in strategies based on hydrological position, as each position listed all the identified strategies (Table 12). Conversely, strategies were found to differ based on governance level (Table 13). Organizations at the three traditional governance levels (Federal, State, and Local) list collaborating with Tribes as a strategy while the two non-traditional (Sub-Basin and Non-Profit) governance levels do not (Table 13). This may be attributed to the more recent focus on the inclusion of Tribes and Tribal perspectives and input as important to the CRB water system. Along this vein, organizations across all levels of governance mention inclusive policy and decision-making. Such findings indicate that water management that includes historically excluded perspectives is a strategy across all governance levels for CRB water governance.

Surprisingly, organizations at the Federal, Sub-Basin, and Non-Profit governance levels do not list conservation and investments (Table 13). This may be influenced by the fact that the Federal organization interviewed does not have a role in funding. Further, this finding may indicate that organizations at the Sub-Basin and Non-Profit governance levels do not provide conservation and investments or that they do not need to use strategies regarding conservation and investments. On the other hand, organizations at the State and Local levels list conservation and investments (Table 13). This finding could reflect that they provide conservation and investments to each other or that they work closely together which could also reflect similar hydrological locations.

Table 12

Strategy Presence and Absence Based on Hydrologic Position.

Strategies		
Position	**Present**	**Absent**
CRB	All	None
UB	All	None
LB	All	None

Table 13

Strategy Presence and Absence Based on Governance Level.

Strategies		
Level	**Present**	**Absent**
Federal	Collaborate with Tribes Inclusive Policy & Decision-Making	Ag Partnership Conservation & Investments Education Flexible Planning & Policy Modeling System
State	All	None
Local	All	None
Sub-Basin	Flexible Planning & Policy Inclusive Policy & Decision-Making Modeling System	Ag Partnership Collaborate with Tribes Conservation & Investments Education
Non-Profit	Ag Partnership Flexible Planning & Policy Inclusive Policy & Decision-Making Modeling System	Collaborate with Tribes Conservation & Investments Education

Subsequently, the presence and absence of risks and benefits to changes in water management based on hydrologic position (Table 15) then by governance level (Table 16) were compared. The risks include climate change, imposed solutions, inefficient planning/policy, litigation, no consensus, overuse/misuse of incentives, short-term focus, maintaining the status quo, supply quality issues, system collapse, uncertainty/instability, and uncompensated organizations that do not use their full amount of allocated water (Table 14). Maintaining the status quo (12) and inefficient planning and policy (11) were the most identified risks and supply quality was listed only once. One interviewee explained their beliefs about the risks regarding inefficient planning and policy by stating: *"I'm concerned that we're not having enough of the creative conversations and hard conversations based on the hydrologic reality and the future projections."*

Table 14

Representative Interview Quotes of Risks.

Risk	Representative Quote	N
Climate Change	*"…the potential for climate change gets more and more severe."*	7
Imposed Solution	*"…the Bureau of Reclamation made a pretty serious effort to expose what would happen if we were to call for some kind of across-the-board reduction in water use. The Lower Basin did not like that particularly and the Imperial Irrigation District did not like that."*	3
Inefficient Planning/Policy	*"…risk that we don't adequately anticipate the extremes of hydrology that we are likely to experience, particularly on the dry side…we are at risk of managing a system that is perpetually in crisis which results in less measured decision-making…".*	11
Litigation	*"The risks are possibly not achieving a favorable outcome that's usually characterized as failure such as litigation."*	7
No Consensus	*"If one or more of the Basin States end up in lawsuits or bringing cases to the Supreme Court, a lot of the collaboration and cooperation has to stop and nobody wants that to happen."*	9
Overuse/Misuse Incentives	*"…we need an operating policy that is sustainable and does not incentivize improper use of water."*	5
Short-term Focus	*"…spending all this money that we have before us on short-term, one-year fixes versus investment and durable and long-term solutions."*	3
Status Quo	*"…there's risk keeping the status quo. We're not only trying to manage water with central laws in a time when climate change is rapidly changing and what our environment and ecosystem looks like."*	12
Supply Quality	*"…if algae or something got into that raw water pond, we would have been devastated…it would impact the town and other water users…"*	1
System Collapse	*"We are now explicitly looking at the possibility the Colorado River might not flow year-round in the Grand Canyon which a few years ago that would have sounded a little armistice… environmental alarmism or a scare tactic. Today it is an acknowledged fact and risk factor that the major public agencies and water management agencies are identifying…".*	8
Uncertainty/ Instability	*"Risk is absolute uncertainty about climate and what the hydrology will actually look like."*	9
Uncompensated	*"Tribes are the only users that are not being compensated for unused water that goes downstream."*	3

Each hydrologic position differs by only one risk of changes to Colorado River water management (Table 15). Organizations in the CRB watershed position may be deterred from agreeing to a new management strategy because they list all the risks except imposed solutions, which are typically issued by organizations with high governance levels. Likewise, UB organizations could potentially be deterred from management strategy changes as they list all but the risk of having strategies focused on the short-term. LB organizations list all risks except for not being compensated for not using their full water allocation. Not being concerned with compensation aligns with the case history as the LB has historically used all, and sometimes, more than their full Colorado River water allocation, while the UB has not.

Table 15

Risk Presence and Absence Based on Hydrologic Position.

Risks		
Position	**Present**	**Absent**
CRB	Climate Change Inefficient Planning/Policy Litigation No Consensus Overuse/Misuse Incentives Short-term Focus Status Quo Supply Quality System Collapse Uncertainty/Instability Uncompensated	Imposed Solution
UB	Climate Change Imposed Solution Inefficient Planning/Policy Litigation No Consensus Overuse/Misuse Incentives Status Quo Supply Quality System Collapse Uncertainty/Instability Uncompensated	Short-term Focus
LB	Climate Change Imposed Solution Inefficient Planning/Policy Litigation No Consensus Overuse/Misuse Incentives Short-term Focus Status Quo Supply Quality System Collapse Uncertainty/Instability	Uncompensated

Risks based on governance level differ (Table 16). The Federal level lists the fewest risks (2) followed by the Sub-Basin level (4). All levels, aside from the Sub-Basin, list the risk of overusing/misusing incentives meant to promote water conservation. The Non-Profit level has all but one risk, supply quality (Table 16), this may speak to views Non-Profit organizations have that there are several risks associated with not changing Colorado River water management.

Table 16

Risk Presence and Absence Based on Governance Level.

Risks		
Level	**Present**	**Absent**
Federal	Inefficient Planning/Policy Overuse/Misuse Incentives	Climate Change Imposed Solution Litigation No Consensus Short-term Focus Status Quo Supply Quality System Collapse Uncertainty/Instability Uncompensated
State	Climate Change Imposed Solution Inefficient Planning/Policy Litigation No Consensus Overuse/Misuse Incentives Status Quo System Collapse Uncertainty/Instability	Short-term Focus Supply Quality Uncompensated
Local	Climate Change Inefficient Planning/Policy Litigation No Consensus Overuse/Misuse Incentives Status Quo Supply Quality System Collapse Uncertainty/Instability Uncompensated	Imposed Solution Short-term Focus
Sub-Basin	No Consensus Status Quo System Collapse Uncertainty/Instability	Climate Change Imposed Solution Inefficient Planning/Policy Litigation Overuse/Misuse Incentives Short-term Focus Supply Quality Uncompensated
Non-Profit	Climate Change Imposed Solution Inefficient Planning/Policy Litigation No Consensus Overuse/Misuse Incentives Short-term Focus Status Quo System Collapse Uncertainty/Instability Uncompensated	Supply Quality

The benefits include certainty/stability in water supplies, compensation for not using allocated water, development for community improvement, equity in water management, funding opportunities, innovation for different water management approaches, resilience to water system changes, and Tribal water protection (Table 17). The most identified benefits were certainty/stability (6) and Innovation (6), whereas compensation and equity were each listed only once.

Table 17

Representative Interview Quotes of Benefits.

Benefit	Representative Quote	N
Certainty/ Stability	*"...increased reliability and less variability in water deliveries."* *"...movement toward a greater assurance that we'll manage, based on the fundamental health of the river, that sends a signal that's meaningful not only for environmental and community values that relate to the river but also for economic values."* *"...everybody being able to move forward, having some certainty with regard to what their future looks like..."*	6
Compensation	*"Another benefit of change would be to help Tribes be compensated."*	1
Development	*"...allow for greater development and funding opportunities."*	2
Equity	*"...benefits include some steps forward towards more equitable management for vulnerable communities, Tribes in particular, and for environmental resources."*	1
Funding Opportunities	*"...the recreational economy of the States, and frankly the identity of these Western States, will get a benefit. There'll be a shoring up of the recreational economy and the identity of these States."*	2
Innovation	*"I mean, I'm not looking forward to shortages, but given that, I expect shortages to become more a regular part of the space, and I'm looking forward to seeing what things people can do with their creativity and with the incentive support from federal, state and other sources."*	6
Resilience	*"...benefits that give us water management that results in a more resilient basin, more resilient economies to the extent that all of our economies from this city down to the most rural areas that have some dependency on water supply."*	3
Tribal Water Protection	*"...one of the benefits of change is changing the water management to ensure that Tribal water Tribal water is protected."*	2

The benefits were found to differ based on hydrologic position (Table 18). All three levels list certainty/stability, innovation, and resilience as benefits to changes in water management. The LB differs most as it lists three benefits compared to the UB (6) and CRB (7) (Table 18). This is surprising regarding the case history because the LB is more restricted via legacy policy and layered rules than the UB. Due to the existing restrictions, changes in water management could potentially change the restrictions on the LB.

Table 18

Benefit Presence and Absence Based on Hydrologic Position.

Benefits		
Position	**Present**	**Absent**
CRB	Certainty/Stability Development Equity Funding Opportunities Innovation Resilience Tribal Water Protection	Compensation
UB	Certainty/Stability Compensation Development Funding Opportunities Innovation Tribal Water Protection	Equity Resilience
LB	Certainty/Stability Innovation Resilience	Compensation Development Equity Funding Opportunities Tribal Water Protection

Based on the governance level the beliefs differ (Table 19). At the Federal and Sub-Basin levels the benefits of changes to water management are absent. Compensation is not identified as a benefit only at the Non-Profit level, this may be the case as Non-Profits often secure their own funding and do not get compensated for not using an allotted amount of water. Likewise, compensation is listed as a benefit at every governance level but Non-Profit, pointing to other governance levels benefitting for not using their full water allocation. Moreover, since all but one benefit was mentioned by organizations at the Non-Profit level, this may speak to views Non-Profit organizations have that there are several benefits to changing the ways water management for the Colorado River currently operates. Organizations with the most benefits identified in common are at the Non-Profit (7) and Local (5) governance levels (Table 19). Neither Federal nor Sub-Basin governance level organizations list any benefits to changes in water management and only two benefits, certainty/stability and resilience, are listed by organizations at the State level of governance. This may reflect that changes to how Colorado River water is managed have little to no impact on organizations at higher levels of governance.

Table 19

Benefit Presence and Absence Based on Governance Level.

Benefits		
Level	**Present**	**Absent**
Federal	None	All
State	Certainty/Stability Resilience	Compensation Development Equity Funding Opportunities Innovation Tribal Water Protection
Local	Compensation Development Funding Opportunities Innovation Tribal Water Protection	Certainty/Stability Equity Resilience
Sub-Basin	None	All
Non-Profit	Certainty/Stability Development Equity Funding Opportunities Innovation Resilience Tribal Water Protection	Compensation

Organizations at the Local and Non-Profit levels of governance had the most goals (6) and beliefs about the risks (9) in common. These similarities are reflected in an interview from an organization at the Non-Profit level of governance referring to organizations with lower levels of governance:

> ***"****We stay aware of what's going on, we monitor, and we track because the outcomes of those decisions will have effects that filter down to the smaller communities that we care about in terms of water allocations.****"***

4.2. Direct Evidence of Coalitions

Through the content analysis of the interviews, I found that several of the organizations (13) identified other organizations in the sample (18). Two organization pairs mention each other as partners 1) ADWR and CAWCD; and 2) Southern Ute Indian Tribe and UCRC as denoted by the red arrows in Figure 7. All 18 organizations mentioned partners that are not included in this study. There were 105 organizations identified, including half of the organizations in the sample, ranging across all three hydrologic positions including the USBR to the UB Dialogue Group, and across governance levels, including the U.S. Department of Fish and Wildlife to County Extension Offices. As this study analyzes coalitions based on the conducted interviews, only organizations within the sample set for this study were included (Figure 7).

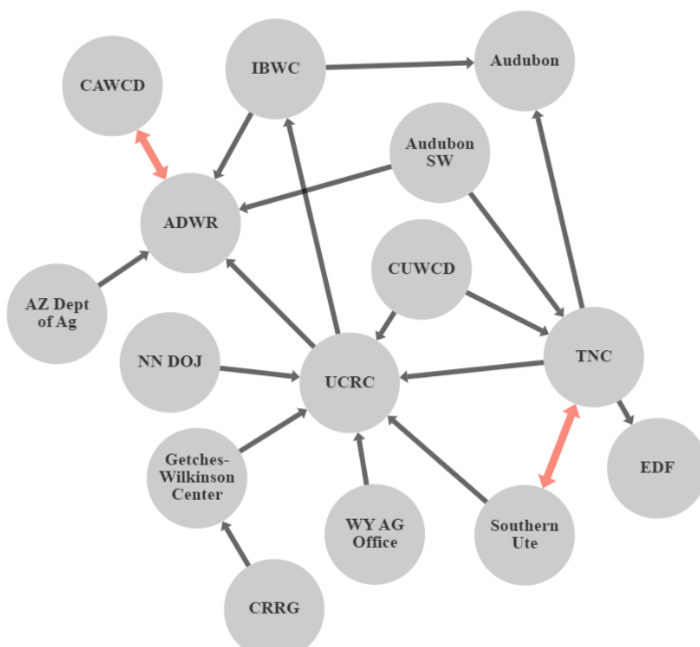

*Figure 7***.** Stated Coalitions in Interviews.

Figure 7 helps visualize CRB water governance behind the scenes. In practice, coalitions are linked via a complex web. Patterns of coalitions are connected by common organizations they partner with. Although there is not a direct partnership between organizations, non-state partners provide linkages between shared partnerships and information channels. For example, CRRG does not directly partner with the UCRC but does partner with the Getches-Wilkinson Center who partners with the UCRC.

There is a clearer separation of coalitions in practice compared to formally observed coalitions as identified in the 6-state CBMA letter signed in January 2023 composed of AZ, CO, NM, NV, UT, and WY (CRB State Governors, 2023), and the Department of Interior's Record of Decision for the Lower Basin Plan signed May 2024 composed of all 7 CRB states (USBR & DOI, 2024). Only certain types of organizations were eligible to sign these formal documents. Thus, the lack of identifying other organizations does not indicate a lack of coalition arrangements, such as those in practice, but does reflect the rearrangement of coalitions in a short time based on the framing of the issue at hand.

4.3. Cluster Analysis

The cluster analysis results are presented via dendrograms. Dendrograms aid in understanding how similar or dissimilar organizations are within clusters based on the distance between links. These visualizations of the clusters help convey the findings with detail and nuance by breaking down the clusters to show the grouping of the sample of 18 organizations.

Through the cluster analysis based on all themes (both common goals and strategies, and common beliefs about risks and benefits) four clusters were identified. For all themes, the cluster shown in green is the most internally heterogenous and the cluster shown in red is internally the most homogenous (Figure 8). The Glen Canyon Institute and UCRC are the most similar organizations followed by Audubon SW and TNC (Figure 8). One surprising finding is that CAWCD and CUWCD don't have more in common, as noted by their distance from each other within the coalition, because they are both conservation districts (Figure 8).

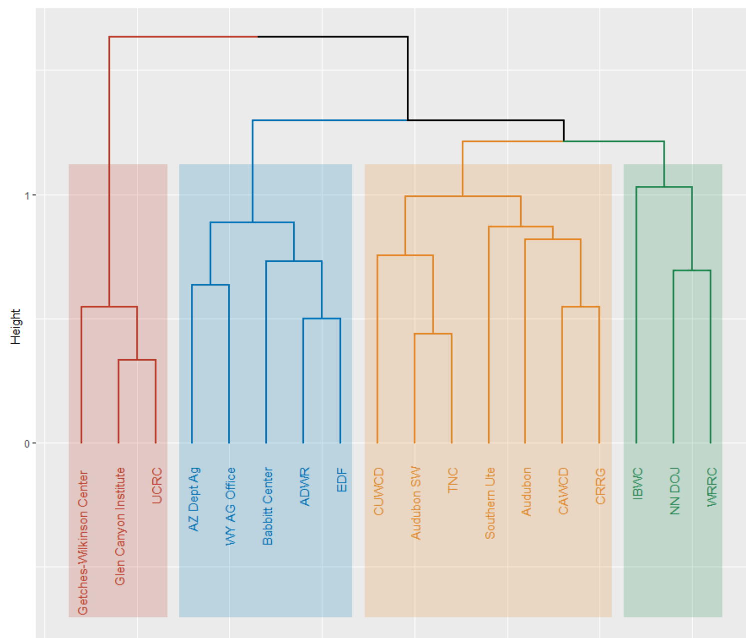

*Figure 8***.** Dendrogram of All Themes.

To further unpack the clusters, clusters were analyzed based on common goals and strategies (Figure 9) and common risks and benefits (Figure 10). Based on goals and strategies, the cluster shown in orange is the most internally heterogenous group and the cluster shown in red is the most internally homogenous. Within the red cluster, the Glen Canyon Institute and UCRC have the same goals and strategies, and the Getches-Wilkinson Center is also included in the grouping (Figure 9). It is not surprising that these three organizations are in the same cluster because they are all located in the UB. The second most similar organizations regarding goals and strategies are the Audubon SW and TNC in the cluster shown in orange (Figure 9).

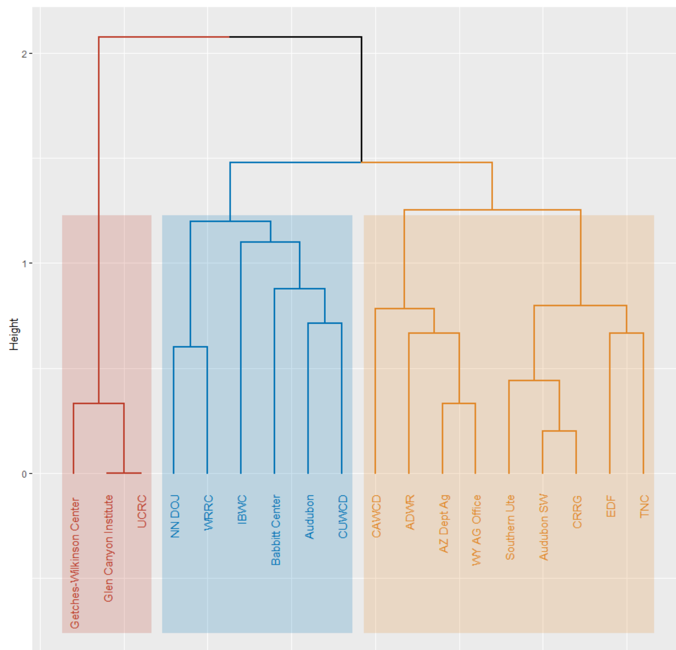

*Figure 9***.** Dendrogram of Goals and Strategies.

Next, clusters were analyzed based on common beliefs. For risks and benefits, the cluster shown in orange is the most internally heterogenous and the cluster shown in blue is internally the most homogenous (Figure 10). The risks and benefits of changes to water management have geographical clusters (Figure 10). Half of the organizations in the cluster shown in red are in the LB hydrologic position. The majority (5 out of 7) of the organizations in the cluster shown in orange are in the UB hydrologic position. Also, within the orange cluster, all three organizations at the Local level of governance are clustered (CUWCD, NN DOJ, and Southern Ute Tribe).

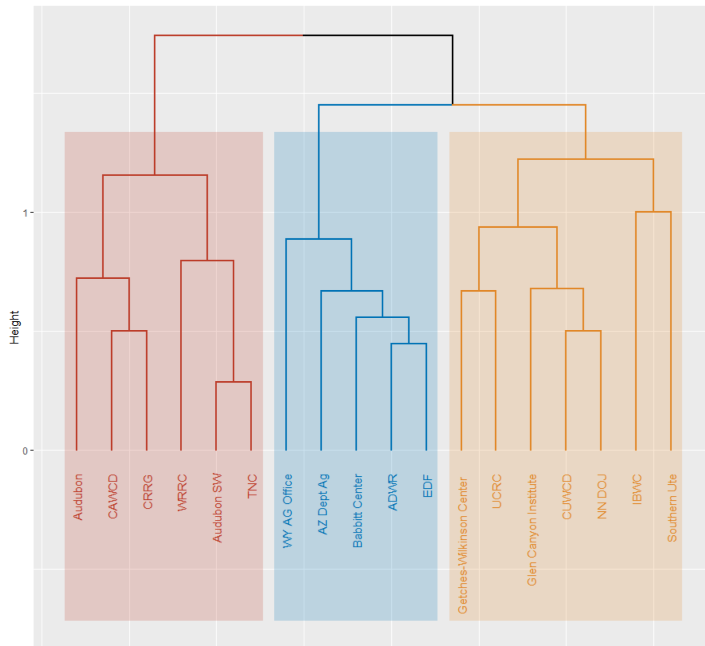

*Figure 10***.** Dendrogram of Risks and Benefits.

5. Discussion and Conclusion

Drawing upon collaborative governance theory and the advocacy coalition theory and framework this study was conducted to understand how governance level and physical location in the watershed shape four themes: goals, strategies, and beliefs based on upstream-downstream positionality and level of governance. Variations in contemporary Colorado River Basin water management goals, strategies, and beliefs based on upstream-downstream positionality and level of governance were analyzed. The analysis found that the governance level was overall more influential than the hydrologic position across the four analyzed themes. Another goal of this research was to study how and if governance level and hydrologic position shape coalition formation and coordination between organizations through common goals, strategies, and beliefs. To address this, primary and secondary data about coordination and coalition arrangements was analyzed and the themes of the organizations were compared to better understand the cluster analysis results. The findings make a unique contribution to advocacy coalition theory and literature (Jenkins-Smith et al., 2014; Koebele, 2019b; Sabatier, 1988) by demonstrating that coalitions can rearrange in a short period of time as an organization's alignments shift based on how the situation is framed.

Through the content analysis, the level of governance was found to be more influential than the hydrologic position on goals (Table 12), strategies (Table 13), and beliefs about the risks (Table 16) of changes to CRB water management. The governance level also influences beliefs about the benefits of changes to CRB water management (Table 19), but not significantly more than the hydrologic position (Table 18). The governance level may be more influential on the themes because several formal and informal variables (e.g., laws, norms, and mandates) influence organizations' operations and responsibilities based on their level of governance (Lawless et al., n.d.). An alternative explanation for these results could be that grouping based on three hydrologic positions is too broad to capture variations in the themes and there is more variation captured based on the five governance levels because there were more groups to be organized into.

One notable finding based on the hydrological position is that there does not appear to be a UB-LB split as the hydrologic position was not as influential as the level of governance. Observing that there was no difference in strategies across the hydrologic positions (Table 12) was an unexpected result because the sub-basins have different formal operation guidelines including separate 2019 Drought Contingency Plans and the

LB additionally has the 2024 Department of Interior's Record of Decision for the Lower Basin Plan.

Risks (12) were found to be more salient to organizations than benefits (8), consistent with other natural resource studies (Bell, 2024; Jin et al., 2020). As risks are typically viewed as negative outcomes, there is a tendency for people to have risk preferences, such as loss aversion or risk aversion, that seek to avoid experiencing an unwanted outcome (Brick & Visser, 2015; Tom et al., 2007; Yesuf & Bluffstone, 2009).

Through the cluster analysis, I found that the beliefs about the risks and benefits of water management changes are geographically clustered (Figure 10). In particular, the hydrologic positionality was found to be notably influential on the beliefs about the benefits (Table 18) and aligns with the context of this case. For example, compensation for not using an allotted amount of water has a different impact on the UB than the LB. As noted in the case history, the UB historically has not used all of the yearly allotted 7.5 MAF of Colorado River water, as formally allocated via the 1922 CRC, and is responsible for less than half of the total CRB uses (Schmidt et al., 2023), whereas the LB has historically used, and at times more than, the yearly allotment. Thus, the UB benefits via compensation for not using the full allocation and using significantly less than the LB, but the LB does not benefit because there is no unused water for the LB to be compensated for. As an interviewee in the UB explained:

> *"…downstream users need to understand that we're making severe cuts to provide water to them but we don't have to, we don't really need to."*.

Together, these findings support the hypothesis that goals and strategies are shaped by governance level and hydrologic position and that the beliefs about the risks and benefits of changes to water management are also influenced by the governance level and physical hydrologic position.

Commonalities in coordination were found, but the coordination between organizations for contemporary CRB water management is a complex web (Figure 7). Other cases have similar findings regarding the decentralized structure and patterns of collaboration of the CRB water management system (Fleck, 2016; Gerlak et al., 2013; Karambelkar & Gerlak, 2020). However, linkages between the identified organizations through commonalities as theorized within the ACT and ACF logic and predictions of partnerships were found (Jenkins-Smith et al., 2014; Koebele, 2019b; Lubell et al., 2009; Sabatier, 1988; E Schlager, 2007) based on stated coalitions (Jenkins-Smith et al., 2014). Two direct, mutually identified partnerships were found through the analysis. First, ADWR and CAWCD (Figure 7) identified each other as partners. These organizations have several commonalities via one goal and all strategies, hydrologically positioned in the LB, State level of governance, and are in the same goal and strategy cluster (Figure 9). Second, Southern Ute and TNC (Figure 7) identified each other as partners. These organizations have commonalities via two goals, five strategies, and are in the same goal and strategy cluster (Figure 10). These two mutual partnerships provide evidence to support the hypothesis that coordination is more likely to be observed among organizations with similar goals and strategies. Further, evidence to support the hypotheses was found as organizations have coordination commonalities with other organizations through indirect partnerships and linkages via non-state partners (Figure 7).

Coalitions split and alignments shift based on how the current or pressing issues are framed. At points in time, certain goals and strategies along with beliefs about risks and benefits are more salient based on the issue at hand (e.g., megadrought, legislative pressure, etc.). Further, depending on how an issue or situation is perceived, different groups have commonalities that can rearrange coalitions in a short period of time. Commonalities can help structure negotiated processes, as observed via formal coalition configuration evidence identified in the 6-state CBMA letter. Other opportunities to shift coalition arrangements could, for example, include framing policy solutions in such a way that coalitions may broaden. These findings contribute to the ongoing conversation in water governance literature to aid in filling gaps in describing and explaining water governance dynamics and transformative changes highlighted by Pahl-Wostl (2015).

This study offers contributions to existing knowledge, theory, and literature. This research builds upon existing applications of ACF to collaborative governance theory to deepen coordination and policy process understanding (Bodin et al., 2020; Koebele, 2019b, 2019a). Further, this research advances these previous studies and adds to collaborative governance knowledge and scholarship through the novel inclusion of governance level and physical location as factors that shape the identification of advocacy coalitions within the ACF. By integrating CGT and ACT with the ACF, this study contributes to collaborative governance literature, provides empirical evidence, and offers more insight into collaborative governance practice and study. Further, this research contributes to the gap in organizational-level case studies by using organizations as the social unit of analysis in the ACF, as Weible & Sabatier (2018) identified. Results from this study could help provide evidence-based information for the Federal

Government, USBR, and other coordinating actors (e.g. IWBC between the United States and Canada, Boundary Organizations, NGOs) in the CRB and other transboundary watersheds grappling with water supply challenges and changing rules.

Some limitations should be considered when interpreting the findings. First, the number and types of organizations I was able to interview were limited. Although standard procedures were followed to contact and interview a broad range of organizations across hydrological positions and governance levels, the sample only includes perspectives from 18 of the many organizations involved in CRB water management. Second, the interviews reflect organization perspectives based on one to two individuals at a point in time, thus the perspectives captured may not be as consistent over time as new information unfolds in the ongoing water management process. Longitudinal or repeated studies may help add value to this study, but researchers should be aware of the burden on stakeholders in an intense process, they may not have the bandwidth to be frequently interviewed. Additionally, the interviews were conducted at an active time of deliberation so responses may be reflective of an organization highlighting or holding information they view as useful in negotiations and want to maintain anonymity. One final caution is that the interviewees may have been limited in their responses based on how they were permitted to speak in their professional positions.

Findings from this inquiry may provide decision-makers with information about how governance level and watershed position influence water governance coordination and aid in identifying spaces for opportunities for better collaboration. It is important to study commonalities because multiple actors are often working towards the same goal with divided efforts. To address this disjoint, efforts to combine resources and approaches to coordinate strategies could be an efficient approach to achieving management goals and benefit multiple actors. Water management policy insights from this detailed upstream-downstream perspective and coordination lens may help inform the decision-making processes for the CRB that are moving forward. Future research could build upon this study by interviewing a larger sample size and repeating the study to capture additional snapshots of the ongoing negotiation and water management process.

Taken together, the case history, content analysis, and cluster analysis indicate that coalitions of organizations actively involved in water issues in the CRB area do not clearly break as UB vs. LB. Although the commonalities in goals, strategies, and beliefs are mainly shaped by the governance level of organizations, the hydrologic position is important to consider when analyzing how coalitions are arranged and split. Commonalities span across hydrologic positions and governance levels for sustainable and inclusive water management for the Colorado River system. Understanding dimensions of variability for coordination processes in the basin is beneficial as millions of people depend on Colorado River water and other basins that face similar challenges related to water supply, climatic change, and rule change.

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CHAPTER 4

POLICY ANALYSIS OF RURAL GROUNDWATER MANAGEMENT IN ARIZONA: VOTER-DRIVEN POLICY CHANGE

Introduction

On December 1, 2022, the Douglas Groundwater Basin (DGB) was designated as an Active Management Area (AMA) by voters in Cochise County, Arizona (AZ) via local election (AZDWR, 2024a; Mitchell & Mast, 2023). An AMA designation can be assigned to an area that utilizes groundwater supplies making it subject to rules that monitor, regulate, and preserve groundwater in AZ. In the DGB, groundwater dependent farming and ranching are major sources of livelihood, underpinning the importance of sustainable management. Groundwater is a critical resource across AZ (41% of the state's water supply, (Governor Hobbs' Office, 2023)) and globally (Margat & Van der Gun, 2013; R. Taylor et al., 2013). Yet many basins in AZ and globally are not actively monitored and managed, and many are in decline (Jasechko & Perrone, 2021). While scholarship offers state-centered and community-led governance models, sociopolitical factors often block these approaches in practice (Closas & Villholth, 2019; Molle et al., 2018). The case of the DGB as a voter-initiated but state-administered groundwater management approach under implementation offers a compelling case to investigate how sociopolitical factors shape implementation. Specifically, investigating problem and solution framing in the DGB offers insight into the diversity of public perspectives on the groundwater management problem and how this problem framing influences support for various solutions. It is important to study stakeholder perspectives as they offer contextual insight into sociopolitical factors that may block (or drive) groundwater management in practice (Isendahl et al., 2009).

Frames define the problem and solution space of a given issue. By defining this space, frames have implications for policy outcomes, including how closely outcomes coincide with the stakeholders' desired outcomes. The way problems and solutions are framed reflects how stakeholders view issues in the situational context (Bardwell, 1991; Steinberg, 1998). Problem frames influence behaviors, behavioral intentions, and the solution space for addressing problems (Horstmann, 2008; Sullivan & White, 2020). Solution frames provide a window on how stakeholders interpret what action should be taken to address the defined problems. Often, people have conceptions of environmental issues that can hinder identifying solutions and approaches in terms of what actions are appropriate and should be taken. Differing views of the severity of problems, such as groundwater levels and supplies, can impact how problems and solutions are framed. Some people do not view problems as real and pressing while others view problems as so large that little can be done to address them (Bardwell, 1991). Improved understanding of how problems and solutions are framed and the linkages between frames can provide insight into public perceptions of environmental problem-solving and policy.

Drawing on existing research on framing problems and solutions, social movements, and environmental policy processes (Benford & Snow, 2000; Caiani, 2023; Steinberg, 1998; Sullivan & White, 2020; Walker et al., 2018), I analyze the framing of groundwater management in the DGB through public comments on the AMA goal-setting process. This work adds to prior work in Cochise County, AZ, and studies in rural regions that include the public's, including farmers', views. Farmer perspectives have been overlooked and limited despite farmers' notable roles in local groundwater governance processes, particularly in agricultural landscapes (Eaton et al., 2022; Koontz, 2003; Méndez-Barrientos et al., 2020). It is important to understand resource-dependent community's perspectives of resources, groundwater in this case, because their livelihoods and well-being are often inextricably tied to natural resources (Méndez-Barrientos et al., 2020; Thomas & Twyman, 2005; R. A. Turner et al., 2014).

Through a voter-led initiative, the community got the designation of the DGB as an AMA on the ballot and ultimately got it approved. Local resource-dependent communities like Cochise County often self-organize to manage shared resources as well as lead and participate in social movements to reclaim or defend their resources in response to perceived challenges (Villamayor-Tomás & García-López, 2021a, 2021b). Although processes for local action were envisioned for decades, this type of citizen ballot initiative for groundwater policy, regulation, and monitoring in AZ is unprecedented. The DGB AMA designation is a new phenomenon in AZ groundwater management and the process for this type of change has not yet been examined. Problem and solution framing applied to public input comments on policy change as part of the policy process for the new DGB AMA is one way to address gaps in knowledge and process understanding.

This research is a case study to understand how local, rural stakeholders were able to change legacy groundwater management via a social movement turned formal policy within the DGB. The following questions and hypotheses guide this research inquiry: 1) How does the public frame the problems and solutions of groundwater management in the Douglas Groundwater Basin? 2) Is the problem frame predictive of the solution frame for implementing groundwater regulation? Based on existing collective action framing literature, I hypothesize diagnostic and prognostic frames will be correlated because identified diagnostic frames can constrain prognostic options (Benford & Snow, 2000).

1. Theoretical Frame

This study seeks to address gaps in groundwater management understanding and contribute knowledge regarding the recent, first-of-its-kind in AZ, voter-driven creation of an AMA in AZ's DGB. To understand processes, discussions, and input about policy situations other researchers have used theories such as institutional theory (Brodnik et al., 2017; Fuenfschilling & Truffer, 2014; Peters, 2022), collaborative governance theory (Gash, 2022; Koebele, 2019), and collective action theory (Holahan & Lubell, 2022; Ostrom, 2005). While these theories could be useful in similar case studies, framing and social movement theory was applied because the AMA initiative began as an environmental social movement. Specifically, an approach to frame analysis theoretically grounded in social movement theory was used (Benford & Snow, 2000; Polletta & Ho, 2006; Šimunović et al., 2018).

1.1. Framing Theory

Framing has been used to investigate numerous policy and environmental situations, including environmental social movements (Barthel et al., 2015; Maier, 2020; Pellow, 1999). Other studies that ask similar questions about natural resource management and how people identify issues and possible solutions utilize framing (Dewulf et al., 2011; Jones et al., 2022; Ojeda-Matos et al., 2024; Šimunović et al., 2018). Framing is the "process by which people develop a particular conceptualization of an issue or reorient their thinking about an issue" (Chong & Druckman, 2007, pg. 104).

In framing theory, frames are the key unit of analysis and are schemas of interpretation used to identify or perceive life occurrences and events (Goffman, 1974; Snow et al., 1986). Frames are useful in improving understanding of a situation as explained by Nisbet (2009) who states, “Frames are interpretive storylines that set a specific train of thought in motion, communicating why an issue might be a problem, who or what might be responsible for it, and what should be done about it”. Hall (2016) sums up Nisbet’s quote stating “by highlighting certain aspects of a situation and leaving other elements out of the storyline, frames convey an analysis of a problem and its solution in a condensed format” (pg. 594).

Frames can be used as devices for defining problems and possible solutions (Horstmann, 2008). Problem frames are problem-solving schemata that help individuals interpret experience (Dennis & Brondizio, 2020; Johnston, 1995). Collective action frames are sets of action-oriented beliefs that inspire participation in collective action, such as social movements, that appear meaningful and often relate to group conflicts (Entman, 1993; Gamson, 1992; Klandermans, 2022). “Frames can be investigated in relation to their underlying action-oriented function, the core framing tasks” (Maier, 2020, pg. 18). The three core framing tasks are diagnostic framing, prognostic framing, and motivational framing (Benford & Snow, 2000; Pellow, 1999). Established in collective action literature, problem and solution framing is an approach to investigate collective action frames as diagnostic, prognostic, and motivational (Benford & Snow, 2000). Diagnostic framing refers to problem identification and the ascription of responsibility or blame for the issues. Prognostic framing refers to the articulation of a suggested solution, plan of attack, and strategies for implementing the plan. Motivational framing refers to a “call to arms” or rallying of people, including the identification of who is responsible for taking action.

Frames can play a substantial role in the transition from issue diagnosis to collective action, including in social movements (Caiani, 2023). To aid in the understanding of social movement dynamics, framing in the context of environmental social movements can be useful. “Through prognostic framing, social movements articulate proposed solutions, strategies, or remedies” (Hall & White, 2008, pg. 33). The coupling of framing and social movement theory is well-established in the literature and is a common approach to analyze policy phenomena (Benford & Snow, 2000; Caiani, 2023; Hall & White, 2008; Šimunović et al., 2018).

1.2. Social Movement Theory

Social movement theory has been developed by numerous scholars over time and is rooted in collective behavior literature (Blumer, 1939; Marx & Wood, 1975; Smelser, 1962). Social movement theory seeks to understand how collective action initiatives, particularly social movements, form, operate, and reach the intended objectives (Van Stekelenburg & Klandermans, 2009; Villamayor-Tomás & García-López, 2021b). Social movement literature notably increased in the 1960s, particularly in the US, in response to increased social conflict (e.g., civil-rights movement, the student movement, the women’s movement, and the environmental movement) and citizen participation in political life (della Porta & Diani, 2015; Kwok-leung, 2020; Van Stekelenburg & Klandermans, 2009). More recently, social movement theory has been applied to and is well-established in the fields of environmental politics and environmental justice (Bosi et al., 2016; Sicotte & Brulle, 2018), and politics (Gamson, 1990; McAdam et al., 1996; Tarrow, 1996).

Social movements are characterized as social processes of actors that have some continuity where actors are linked by dense and informal networks and share a collective identity that stands in opposition to their identified opponents (Diani, 1992; Killian, 1964; Maier, 2020; R. H. Turner & Killian, 1957). Tarrow (1995) defines a social movement as a “collective challenge by groups with purposes and solidarity in sustained and mainly contentious interaction with elites, opponents and authorities” (pg. 229). Often, social movements are formed to express dissatisfaction with existing, or lack thereof, policies in a certain area (della Porta & Zamponi, 2022; Madrigal et al., 2024). Social movements are frequently effective in the early phases of mobilization regarding agenda setting and getting positive outcomes to specific demands (Bosi et al., 2016; della Porta & Zamponi, 2022; King et al., 2005; Soule & King, 2006). Social movements can aid in bringing about political change and achieving policy goals (Bosi et al., 2016; Chambers & Kopstein, 2006). One pathway is to tap into existing political structures which have been found to help shape and provide opportunities for social movements to achieve policy objectives (Gahan & Pekarek, 2013; Polletta & Ho, 2006). Further, research on social movements can be used to study ongoing events (Bosi et al., 2016).

2. Case Description

2.1. Setting the Stage

The DGB is located in the Sonoran Desert with an arid, hot desert climate (Peel et al., 2007) and spans Cochise County, Arizona, USA, and Sonora, Mexico. The DGB is mainly rural with approximately 38,000 people in Arizona and 80,000 in Mexico

(AZDWR, 2009). The aquifer is in an isolated fault-block system characterized by the steep mountains that rise from the alluvial, sediment-filled DGB (White & Childers, 1967). Precipitation in Cochise County is highly variable, annually ranging from 11 to 41 inches (WRRC, 2024).

Groundwater is the main water source within the DGB. Groundwater use for irrigation began in the 1940s and now accounts for about 92% of water use in Cochise County and municipal use accounts for the remaining 8% (6.7% for domestic and 1.3% for commercial) (WRRC, 2024). Agricultural water use has continued to grow, increasing from 37,000 acre-feet in 1991 to 50,000 acre-feet in 2014. Today, there are 108,237 acres of irrigated agriculture including crops such as fruits, tree nuts, berries, and vegetables as well as livestock and poultry (USDA, 2022). Large-scale animal farms and nut orchards have developed within the DGB although most are not from the basin (Frederico, 2022b). Additionally, use has exceeded recharge leading to a decline in storage of an estimated 8.9 million acre-feet in 1990 to 7.8 million acre-feet in 2022 (AZDWR, 2023a).

2.2. Pre-Active Management Area Formation

Historically, there have been different forms of regulation in the DGB. In 1965, the State Land Commission declared the DGB as a Critical Groundwater Area because large withdrawals for irrigation resulted in substantial water-level decreases (Konieczki, 2006). This designation outlawed drilling new irrigation wells and established a halt on new agricultural land that remains today (Migoya, 2023). In 1980, the Critical Groundwater Area became an Irrigation Non-Expansion Area (INA) (Figure 11) via the 1980 Groundwater Management Act (GWMA) (Mitchell & Mast, 2023). An INA designation prevents new land from being cultivated but the areas that were irrigated before 1980 can continue with irrigation, dig wells, and deepen existing wells. Additionally, the INA designation required non-exempt annual well reporting, "Intent to Drill" notices, and introduced the Reasonable Use Doctrine. The doctrine stated that water needed to be used for beneficial use (i.e., watering livestock, drinking water, gardening).

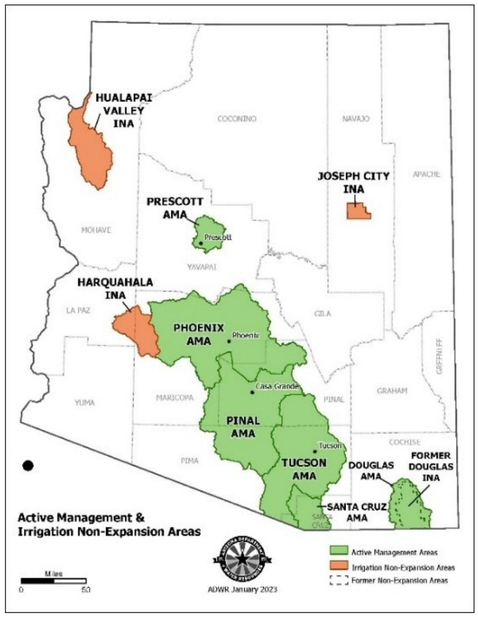

Figure 11. *Active Management & Irrigation Non-Expansion Areas (AZDWR, 2023b).*

The 1980 GWMA was created to preserve irrigation for existing cultivated lands and established four AMAs (Prescott, Phoenix, Pinal, and Tucson) in areas where aquifer levels were declining the fastest in 1980 (Apel et al., 2023; Recchia, 2022). The original four AMAs are subject to a set of groundwater use and withdrawal regulations. For example, the expansion of irrigated acres is prohibited, groundwater reporting and metering is required, wells must meet certain criteria, there are groundwater rights and withdrawal authorities, and a 100-year assured water supply is required to develop

(6+units) in the AMA (AZDWR, 2024b; Klein & Kenney, 2009; Megdal, 2012). An AMA designation intends to change groundwater consumption patterns and limit the growth of groundwater use in the given basin. Outside of the AMAs, there are limited restrictions and regulations on pumping groundwater supplies in rural Arizona, resulting in a lack of well and aquifer monitoring and measurement. Further, the main water management goal of the 1980 GWMA AMAs is safe-yield by 2025. Safe-yield refers to when groundwater withdrawn is equal to or less than the amount that is annually replaced (Ferris & Porter, 2021). Safe-yield may not be a goal for managing the DGB since the region does not have an allocated Colorado River Supply or water distribution canal to receive water to augment the groundwater supply. Likewise, groundwater in the basin is not consistently recharged and can be considered a finite resource.

Over the last decade, residents have raised concerns regarding groundwater regulation and management. There have been several failed attempts to introduce groundwater management in Cochise County (Frederico, 2022b; Holmes, 2022). In 2007, Cochise County elected to have a mandatory adequacy jurisdiction, thus requiring developers to prove water adequacy as determined by the Arizona Department of Water Resources (ADWR) (WRRC, 2022). Despite the INA status, no explicit pumping limits or groundwater use reporting was required. Further, in 2012, agriculture permitting regulation was relaxed and made setting up cattle farms easier (Tracey, 2022). Since monitoring is not required there is limited groundwater data available for the DGB. Nonetheless, available data shows a decline in groundwater levels from 2000 to 2020 during which all 14 measured wells in the DGB decreased at a median rate of 1.2 feet per year (AZDWR, 2023a; Kyl Center, 2024). According to ADWR, groundwater levels have declined more than 200 feet since 1965, the year the first DGB protection was established (Mitchell & Mast, 2023). Ongoing groundwater level decline has resulted in wells going dry and increasing public concern (Frederico, 2022a; Holmes, 2022).

2.3. Social Movement and Voter-Driven Active Management Area Designation

In March 2021, a resident-based grassroots organization called *The Arizona Water Defenders* was formed and began to collect signatures to help get Proposition 420 for an AMA designation onto the November 2022 ballot (Arizona Water Defenders, 2022; Frederico, 2022b; Tracey, 2022). The proposition leveraged the 1980 GWMA to enact management of groundwater over-pumping and the speedy expansion of large-scale, intensive commercial farms that are now commonplace in the basin. Several large-scale animal farms and nut growers from outside of AZ have operations in the area (Frederico, 2022b). These large-scale operations have made use of the minimal groundwater regulation of local aquifers, despite the strain on western water supplies from the ongoing, multi-decadal megadrought and increased aridification (Overpeck & Udall, 2020; Wescoat, 2023). The group shared information via door-knocking, social and news media, word-of-mouth, and signage. Groups also mobilized to oppose the initiative such as the *Rural Water Assurance* that unsuccessfully challenged the ballot initiative in court (Bittle, 2022; Shar, 2023). Voters approved the DGB AMA, and it was formally established on December 1, 2022 (Figure 12). Notably, the adjacent Willcox Groundwater Basin, located in both Cochise and Graham County, did not get approved, despite being on the same ballot. Arizona law dictates that there are two ways an AMA can be created: 1) citizen ballot initiative, and 2) ADWR director. The DGB is the first to be designated as an AMA since the 1980 GWMA and the first resulting from a citizen-driven initiative.

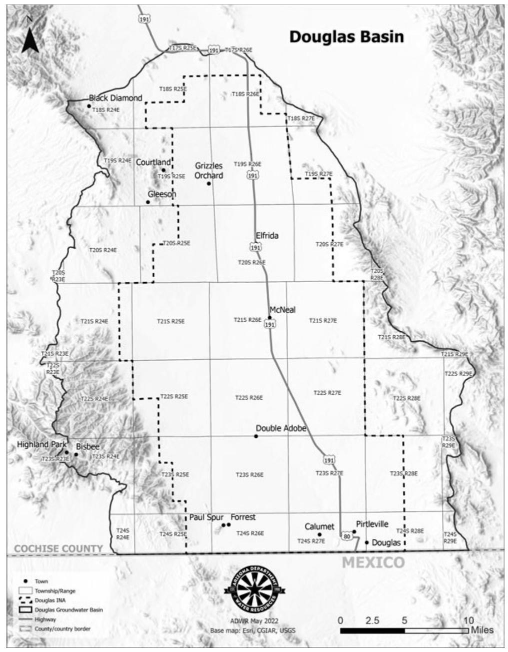

Figure 12. *Douglas Groundwater Basin (solid line), INA Boundaries (dashed outline), and AMA Boundaries are the same as the Douglas Groundwater Basin (solid outline) (AZDWR, 2023b).*

2.4. Post-Active Management Area Designation to Present

The ADWR is tasked with setting the Douglas Basin AMA goal and goal timeline. The AMA designation requirements must be implemented and take effect by January 2027. To this end and per the 1980 GWMA, the ADWR is required to set a management goal and establish a five-member, Governor-appointed Groundwater Users Advisory Council to represent the DGB users and serve a six-year term (Governor Hobbs' Office, 2024). The advisory committee then has two years to draft a management plan for the AMA (Tracey, 2022). AMA management plans include mandatory conservation requirements designed to help move the AMA to its management goal, including a 100-year assured water supply for new subdivisions of six or more lots, monitoring and reporting withdrawals, and conservation plans for large water users (Apel et al., 2023; AZDWR, 2024b; Megdal, 2012).

ADWR solicited public input on developing a draft management goal via public comments submitted by email, mail, and in-person to ADWR and collected during public meetings in January and April 2023. Based on public input, ADWR released a draft of the management goal on May 24, 2024. Public comments on the draft goal were collected and incorporated into the final goal. On July 28, 2023, ADWR director Tom Buschatzke signed an Order of Adoption for the finalized Douglas AMA management goal (Buschatzke, 2023).

3. Methods and Data

For this study, three public comment periods held by the ADWR in 2023 on the DGB management goal-setting process were analyzed. The comments are publicly available on the ADWR website. These comments are used as the data set because they are an accessible part of the policy process and include local input and perspectives on this DGB case study. I employ a case-centric method to detail how the groundwater policy change process advanced by analyzing contributing factors including the social movement, ballot initiative, and public input process (Beach & Pedersen, 2013; Punton & Welle, 2015). To understand the situation and context of the social movement turned policy change initiative, I first conducted a detailed case history of groundwater management and regulation in the DGB over time (Section 2).

Second, to study how local, rural stakeholders frame problems and solutions by providing input on changing legacy groundwater management within the Douglas

Groundwater Basin, content analysis was employed to conduct a frame analysis of the public comments on the DGB AMA goal-setting process (Bernard et al., 2016; Bowen, 2009). Frame analysis is an interpretive research method to study various understandings of a concept (Beland Lindahl et al., 2016; Perri, 2005; Šimunović et al., 2018). Frames can be identified in text via open coding, where the text is carefully read to identify statements concerning the aims and theoretical approach of the research (Chong & Druckman, 2007; Rein & Schon, 1996). Framing was utilized in two ways: 1) frame-coded the public comments on the management goal-setting process; 2) record the public's diagnostic framing of declining groundwater levels that sparked the social movement and prognostic framing of groundwater solutions via the progression of the social movement itself.

Codes were assigned to the public comments based on existing collective action framing literature and developed codes as diagnostic, prognostic, and/or motivational (Benford & Snow, 2000; Goffman, 1974). The first two authors reviewed and revised the codes within the context of the data and water management concepts to establish reliability, then revisited the literature on framing to confirm the reliability collectively (DeCuir-Gunby et al., 2011). The data was coded based on how the public framed the groundwater problem, what they saw as solutions, and who is, or should, be responsible for taking action as laid out in collective action framing as a method to analyze qualitative data (Benford & Snow, 2000; Caiani, 2023; Goffman, 1974; Snow et al., 1986; Steinberg, 1998). Subsequentially, the coded segments were thematically categorized based on prior literature to identify types of problems and solutions identified for groundwater resource management and sustainability (Castle et al., 2014; Mays, 2013; Molle et al., 2018; Roberts et al., 2021). The codes were not coded as mutually exclusive, as several comments identified more than one problem and solution. Then, I analyzed the connections between the identified frames to understand how they are or are not linked.

4. Results

Through analyzing public comments on the DGB AMA goal-setting process, I found that comments included both diagnostic and prognostic frames but no motivational frames. Three main diagnostic frames were identified based on an insufficient groundwater supply in the Douglas Groundwater Basin: financial limitations, limits local and existing users, and water for livelihood (Table 20 and Figure 13). Financial limits framed as a problem align with the case history as there has been continued growth of large farms and increased amounts of groundwater use to sustain the farm growth since the 1940s. As water levels drop, wells need to be dug deeper to reach the water, but it is expensive, often too expensive for local operations to do so (Apel et al., 2023; WRRC, 2022). In Table 20, the representative comment for the financial limits frame describes this situation. Limits local and existing users framed as a problem is consistent with the case context because as wells go dry, the access to groundwater becomes more restrictive physically and financially, as described by the corresponding representative comment in Table 20.

Table 20

Representative Commenter Quotes of Diagnostic Frames.

Diagnostic Frame	Representative Comment
Financial Limits	*"As things stand, the profit motive to maximize returns leads directly to the tragedy of the Commons, where less deep pocketed interests are out competed for a finite water resource and are forced out of business and forced to leave for greener pastures."*
Limits Local/ Existing Users	*"The ADWR needs to work with, not encumber with paperwork and out of the park fees, the small to medium size agriculture and commercial ventures that add significantly to the economic and general well-being of our communities."*
Water for Livelihood	*"It's self-evident to say that water is absolutely essential to life in the Douglas Basin, as it is all over this world. This AMA was established to maintain that essential resource. Please ensure that we take this opportunity seriously as we move forward in protecting our essential water resources, as well as our local community and livelihoods."*

Eight possible solution frames were identified, including some solutions which were commonly mentioned together, to address identified issues (Table 21 and Figure 13). Solutions identified by the commenters include replenishing the aquifer, economic stability, maintaining a viable aquifer, protecting existing uses, prioritizing local access to groundwater supplies, including local representatives and stakeholders, modeling, and reducing use (Figure 13). There are 3 identified pairs where two solutions are commonly mentioned together: 1) Economic Stability & Maintain Viable Aquifer; 2) Protect Existing Uses & Prioritize Local Access; and 3) Prioritize Local Access & Local Reps/Stakeholders. The framing of aquifer replenishment as a solution mirrors solutions other basins have employed (Seasholes & Megdal, 2021) but as the aquifer is primarily a fossil aquifer that is recharged via rainfall and lacks water imports (e.g., a Colorado River apportionment) there are currently limited opportunities for groundwater recharge. In Table 21, the representative comment for replenishing the aquifer reflects the decline in groundwater storage and that use has exceeded recharge over the last three decades. Modeling framed as a solution is in alignment with the limited groundwater data collection over time because monitoring has not been required in the DGB.

Table 21

Representative Commenter Quotes of Prognostic Frames, with paired frames.

Prognostic Frame	Representative Comment
Replenish Aquifer	*"...maximizing efforts to enhance recharge and replenishment."*
Economic Stability & Maintain Viable Aquifer	*"...promote economically viable communities through safeguarding the scarce water resources in a desert climate."*
Protect Existing Uses	*"...protect long-term access to adequate supplies of groundwater for irrigation and other agricultural uses."*
Protect Existing Uses & Prioritize Local Access	*"...stabilize the water tables without hurting or eliminating the local farmers."*
Prioritize Local Access & Local Reps/Stakeholders	*"What you need to do is stop right now and, if you are truly concerned with the economy of the valley and the well being of those of us who live here, listen to us. Let us, we who live here, those of us who have commercial interests and those of us who simply have our homes and lives here, let us come together and find an AMA that honestly works and preserves the Douglas Basin and its economy."*
Modeling	*"There are models that reasonably predict the effects of climate change over time, and those can certainly be placed into consideration as policies are developed."*
Use Reduction	*"This plan should address the careless use of water and explore ways to recharge the aquifer aggressively."*

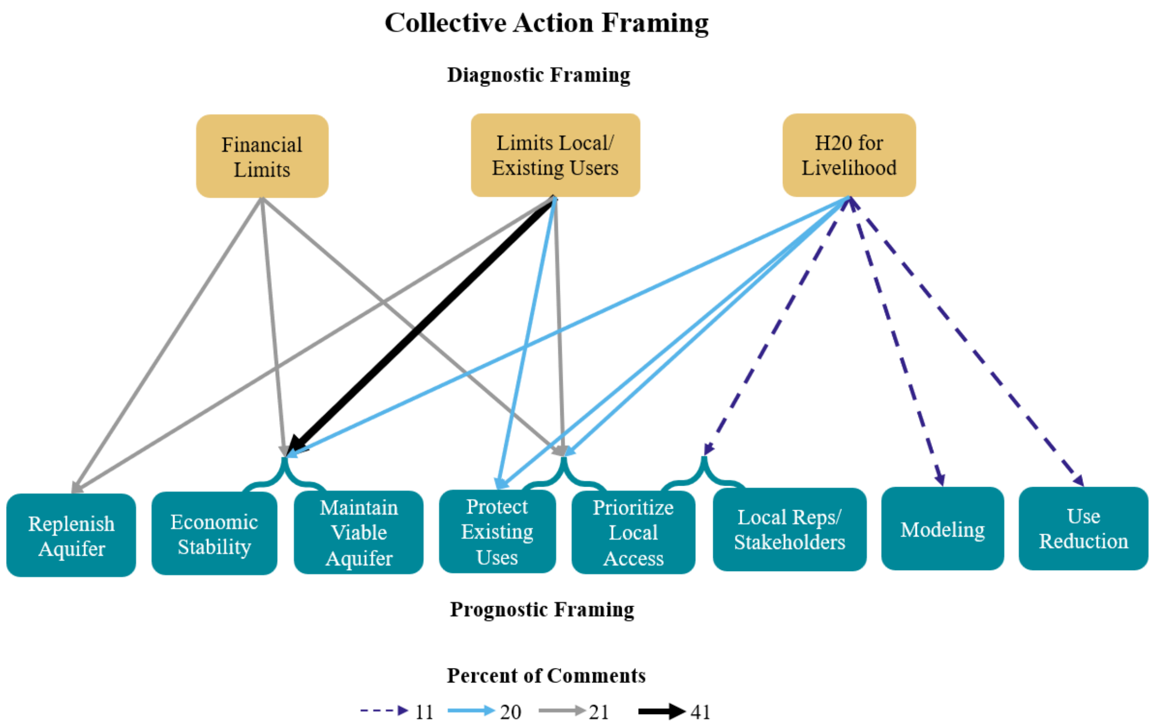

Figure 13. *Diagnostic and Prognostic Frames and Linkages. The brackets indicate commonly paired solutions.*

Figure 13 illustrates the relationships between diagnostic and prognostic frames. Note that comments were not coded as mutually exclusive; thus, the percentages equal more than 100% because some commenters identified multiple problems and solutions. As seen in Figure 13, some combinations of problem and solution framings are more common than others. For example, 41% of commenters linked the problem of limitations on local and existing users and the solution promoting both economic stability and maintaining a viable aquifer. Alternatively, 21% of commenters linked the problem framing of financial limitations to solutions and the solution as both combinations of 1) economic stability paired with maintaining a viable aquifer and 2) protecting existing users paired with prioritizing local access to groundwater supplies. Lastly, 21% of commenters linked the issue of limitations on local and existing users to solutions for replenishing the aquifer and the combination of protecting existing users and prioritizing local access to groundwater supplies. The remaining combinations of problem and solution framing were associated with a small percentage of commenters.

5. Discussion and Conclusion

Through the analysis of the groundwater management history and AMA goal-setting process in the DGB, I studied how local, rural stakeholders changed legacy groundwater management through a process that began with a social movement to a ballot initiative to public input on groundwater management via a management goal-setting policy process. This case study on the three comment periods contributes to the larger discussion regarding public input for political change via environmental social movements (Rootes & Nulman, 2015). The empirical study of the DGB resident's approach to change groundwater policy helps to contribute to knowledge and understanding of how local-level stakeholders can drive change to manage natural resources. Further, an improved understanding of how voters can drive environmental policy change could help provide more insight for future natural resource governance regimes that reflect local perspectives.

Rural, local-level stakeholders can drive change to manage natural resources by self-organizing and leading as well as participating in social movements. The DGB grass-roots social movement occurred early on when residents self-organized and formed *The Arizona Water Defenders* organization to achieve their groundwater management policy objective to shape the voting ballot and change to groundwater policy, as detailed in the case description (Gahan & Pekarek, 2013; Polletta & Ho, 2006). The community's gumption and involvement in these processes demonstrate the water situation is taken seriously, and residents are willing to participate in collective action initiatives to change groundwater policy and protection. Further, the AMA designation for the DGB demonstrates that social movements can assist in bringing about political change and achieving policy goals (Bosi et al., 2016; Chambers & Kopstein, 2006). This grass-roots, bottom-up social movement turned policy initiative and change aligns with social movement theory and literature notions that local, grass-roots types of public-initiated movements are often successful, as demonstrated by the AMA being approved by voters and designation (Chambers & Kopstein, 2006; Villamayor-Tomás & García-López, 2021b). Other studies have similar findings that social movements are frequently effective in the early phases of mobilization regarding agenda setting and obtaining positive outcomes to specific demands, such as changes to water management and policy (Bosi et al., 2016; della Porta & Zamponi, 2022; King et al., 2005; Soule & King, 2006).

Within the public comments, local-level stakeholders identify problems and solutions but do not identify who is responsible for taking action to implement solutions. In the frame analysis, I found that public commenters framed three problems and eight solutions (Tables 20-21). The problems identified are compatible with each other as they relate to the well-being of the community members and feed into each other. Two of the three diagnostic frames in the comments focused on limitations regarding finances and local and existing users' access and use of groundwater. Financial limitations are a problem that locals face in keeping pace with large-scale operations, which typically have disposable income to pay for deepening wells unlike smaller-scale and local operations, to reach the declining groundwater level (Table 20). These limitations correspond with the problem of limiting local and existing users' access and use of groundwater via different regulation requirements, such as new paperwork and fees that can be a hindrance to smaller-scale operations (Table 20). Further, these problems and limitations are compatible with the problem of not having enough water to use for and maintain livelihoods in the DGB. These problems impact community members' daily lives, tasks, and occupations because agriculture is a major industry for the DGB workforce. Commenters identified almost three times more solutions (8) than problems (3), suggesting that they perceive several options for groundwater management and groundwater issues in the DGB as both real and pressing, but not so large that little can be done to address them (Bardwell, 1991). The absence of motivational framing in the public comments speaks to a disconnect between the community and those responsible for groundwater management. Additionally, the lack of motivational framing suggests the lack of a community mandate for ADWR since the agency was not identified as being responsible for implementing solutions, despite their administration of the implementation phase for the policy change via asking for public input comments. Notably, the absence of motivational framing contrasts with existing literature and studies that find motivational frames are the least used but are not missing as the case in this study (Jones et al., 2022; Ojeda-Matos et al., 2024).

Public framings of groundwater management problems are linked to solution frames for implementing groundwater regulation. Through the analysis, I found that the public has similar views on singular and paired groundwater solutions. Each diagnostic frame was linked to at least one solution pair which speaks to the public's perception that more than one solution is needed to address the identified problems (Figure 13). All three diagnostic frames link to the paired solutions of economic stability and maintaining a viable aquifer as well as protecting existing uses and prioritizing local access. Commenters who frame problems as limitations on local and existing users tend to frame solutions as a combination of economic stability and maintaining a viable aquifer, as this linkage was identified by 41% of commenters followed by the protecting existing uses and prioritizing local access solution pair identified by 21% of commenters (Figure 13). The diagnostic frame of having enough water for livelihood includes the most linkages to the solution frames including all the solution pairs and three singular solutions, suggesting there the issue can be solved. Surprisingly, the water for livelihood problem frame was not linked to the aquifer replenishment solution frame as the amount of groundwater available for livelihood use would likely increase with aquifer replenishment. Protecting existing uses is a salient solution for problems centered around use and access to groundwater in the DGB. Both diagnostic frames of limits local and existing users and water for livelihood are linked to protecting existing uses as a singular and paired solution with prioritizing local access (Figure 13). These results agree with existing framing literature that posits problem frames predict solution frames as the feasible solutions are constrained by the problem frame (i.e., problems are linked to solutions relevant to that particular problem) (Benford & Snow, 2000; Gahan & Pekarek, 2013; Parks, 2022).

This study helps contribute to case study gaps related to farmer perspectives that have been overlooked and limited in existing studies. Within the public comments, 48% of commenters self-identified as farmers. Therefore, the study includes farmer perspectives on local groundwater governance, which have been acknowledged as limited in rural region studies and knowledge (Eaton et al., 2022; Koontz, 2003; Méndez-

Barrientos et al., 2020). Often, farming communities are not welcoming of government intervention and more restrictive regulations (de Loë et al., 2015; Méndez-Barrientos et al., 2020; B. M. Taylor & Van Grieken, 2015). This is demonstrated by a commenter who stated: "*And ranchers didn't trust big government*" and another who said, "*We value local control of our water resources*". Therefore, this is a unique case as the DGB community, reliant on groundwater resources, voted to have increased restrictions on themselves to limit outsiders, meaning people and organizations not from the DGB viewed as exploiting and over-using the groundwater, and promote their rural way of life in the region. Further, some comments reflected an us-versus-them view of outsiders, as one commenter explained: "*It's imperative that water rights for local residents over non-local corporate interests be held to the highest degree*". Another explained:

> *"Prioritize water rights for locally residing water users. The goal was for local family farms to have cattle in the area not corporate farming from out of the country/area."*

The importance of understanding resource-dependent community's perspectives of resources (Méndez-Barrientos et al., 2020; Thomas & Twyman, 2005; Turner et al., 2014) is reflected in comments that express that livelihoods and well-being depend on having a sufficient groundwater supply, as demonstrated by the quote representing the public's water for livelihood diagnostic frame in Table 20.

Detailed case studies can help capture the nuance and characteristics specific to the community. Communities are unique with no two exactly alike, but there are commonalities between communities grappling with similar challenges such as water management and public involvement in political life. This single-case research approach aligns with other studies on policy processes (te Lintelo et al., 2020; Ulriksen & Dadalauri, 2016) and the findings have broader implications than solely generating knowledge relevant to the DGB case. Single cases can provide tests for process-based theory that would be difficult to implement in large-n analyses, help refine hypotheses, and provide supporting evidence. Such studies enable the identification of conditions not captured in current theory or caveats to current theory (i.e. cases outside of existing theory). Understanding how voters can drive environmental policy change has implications for future natural resource governance that is reflective of local perspectives. The empirical study of this successful bottom-up approach to enact environmental policy change is anticipated to contribute to knowledge and understanding of how local-level stakeholders can drive change to manage natural resources.

There are several limitations in this research that should be noted. The data source for the public's comments only includes the views of those who submitted comments. Public participation in the comment periods could be limited due to barriers related to the people's level of access to the modes of participation that are not considered in this study. Many of the comments were the same but submitted by different commenters. Due to this, some commenters may have left out other perspectives they hold that were not mentioned in the pre-drafted comment. Despite these limitations, the findings contribute to a nuanced and important discussion on rural resource management that is affected by the Active Management Area designation and the ongoing management process.

One year after the adoption of the AMA management goal, residents are asking what the next steps are and who is responsible for ensuring the management goals are reached, as a plan has not yet been revealed. In March 2024, AZ Governor Katie Hobbs appointed five local leaders to volunteer as members of the Groundwater Users Advisory Council (Governor Hobbs' Office, 2024). Currently, the development of conservation programs is planned to be completed on July 15, 2024, with plan adoption on December 1, 2024 (AZDWR, 2024a). The first informal AMA plan draft, including water conservation programs, is anticipated to be released in August 2024 (Migoya, 2024). By the end of 2024, ADWR is required to have an approved and adopted AMA plan. This ongoing process includes steps important to transitioning to more sustainable groundwater management with collaboration from local- and state-level stakeholders. The approach and findings of this study could help inform related resource governance policy processes, including those that are shaped by community input and involvement in the collaborative governance of natural resources.

This research carefully reviewed the water management case history of the Douglas Groundwater Basin and applied frame analysis to the ongoing policy change process. Studying the case history helped provide context to the framing analysis. Water management regulations in the basin have changed over time, including a halt on new agricultural land that has remained in place since 1965. This single-case study empirically contributes to framing literature and social movement scholarship by applying frame analysis to understand the groundwater policy change process that began as a social movement. The framing analysis results demonstrate that the public can identify problems and solutions, including paired solutions, but residents do not identify who is or should be responsible for addressing water management in the Douglas Groundwater Basin. To build upon this work, future research could extend analyses to other cases to facilitate comparison and to help contribute to improving the frame analysis in this study. Additionally, as the policy change process is ongoing, future research could analyze the progression of the process and compare the progress to the water management and plan creation deadlines for the Douglas Groundwater Basin.

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CHAPTER 5

RESEARCH FINDINGS SYNTHESIS

This dissertation focuses on water governance in the American Southwest with an emphasis on institutions, water supply management, and the Colorado River Basin. My research contributes to ongoing conversations and studies about institutions' role and influence on how water resources are managed and governed. This research helps fill empirical gaps in governance research by incorporating and utilizing institutional theory as Sjöstedt (2019) highlights. Water governance is shaped by dynamics that are influenced by diverse factors such as the path dependency of institutions, perceptions of goals, strategies, and beliefs, how decision-makers frame the water problem under discussion or ongoing negotiations, and how the public frames water management problems and solutions. These factors also influence the ways water management and governance regimes are able to respond to changing environmental conditions, including decreased water supplies and water scarcity.

First, to understand the broader water governance system in the Southwest, I studied water governance at the large Colorado River Basin scale. Starting at the large scale was intentional to begin to understand and grasp the robust history and context of formal water governance and the changing water situation over the long, temporal scale. While there are a century's worth of rules and policies that must be navigated to understand the evolution of water governance, I argue that it is important to understand how we have arrived at today's tense water situation to help inform policy responses to current and ongoing water supply challenges. I found that incremental change has kept the Colorado River system afloat over the last 100 years, but sustainable water governance has not yet been achieved. This research provides an understanding of the water governance network structure and the path dependency of institutions, which shapes water governance and who is able to influence decision-making, that can help provide insight for informed decision-making for the Colorado River Basin system moving forward. Additionally, this study makes a methodological contribution to natural resource governance by using a novel combination of methods (i.e., detailed 100-year case history, content analysis, and network analysis) to conduct an institutional analysis (Ostrom, 2005b; Ostrom, 2007; Ostrom, 2011). Looking ahead, researchers could explore and incorporate changes to water management based on informal rules and norms, particularly across lower institutional levels in the Colorado and other river basins. One avenue to achieve this could be to incorporate shadow networks into future analyses of water resource management (Wutich et al., 2020). Another direction for future analysis could include a focus on dimensions of equity within formal and informal institutional analyses for a more holistic approach to understanding the formation and evolution of water governance.

Second, I narrowed in on the sub-basins that compose the larger Colorado River Basin for a more nuanced understanding of how water is managed on a smaller scale. This study focused on dimensions of coordination variability (i.e., organizational, hydrological positionality, and institutional dynamics) to analyze Colorado River water management change. The analysis found there was not a clear Upper and Lower Basin division based on the organization's goals, strategies, and beliefs about the risks and benefits of water management changes. Further, this study presents corroborating, empirical evidence that Colorado River water management does not always break down into an Upper and Lower Basin split, particularly based on water management strategies. This study highlights that to understand factors that have an influence on collaborative governance and coalition formation, it is also important to understand the impact of shared goals and strategies on coordination. Chapter 3 builds upon and advances previous research that applies advocacy coalition theory and collaborative governance theory via the novel inclusion of governance level and physical location as factors that shape the identification of advocacy coalitions (Bodin et al., 2020; Koebele, 2019b, 2019a). Additionally, this study makes a methodological contribution to water management and collaborative governance literature via a novel combination of content analysis, coalition identification based on commonalities across four themes (i.e., goals, strategies, risks, and benefits), and hierarchical cluster analysis methods to analyze Colorado River water management coalition formation and coordination between organization based on governance level and hydrologic positionality dynamics. This study makes a novel contribution to advocacy coalition literature and theory (Jenkins-Smith et al., 2014; Koebele, 2019b; Sabatier, 1988) as it demonstrates that coalitions can reorganization within a short time frame via the rearrangement of an organization's alignments based on how the situation is framed by decision-makers. Improved understanding of influencing factors can help provide decision-makers with information about how governance level and watershed position influence water governance coordination as well as aid in identifying spaces for opportunities for better collaboration. Future research could include a larger sample size to reflect more organizational perspectives, particularly at the Federal governance level. It would be interesting to incorporate and test to see if other governance dynamics, such as media and public framing of the water situation, have an influence on or shape common goals and strategies into theoretical framing based on the combination of both collaborative governance and advocacy coalition theory following Koebele (2019b) and this dissertation's application.

Lastly, as Colorado River water supplies decrease, groundwater supplies become more important as well as the magnitude and temporal patterns of water resources. Certain agricultural communities within Arizona are likely to have limited or no access to Colorado River water supplies in the upcoming decades as drought conditions in the region persist and impact water resources. Further, examining agricultural communities that are heavily groundwater-dependent with an emphasis on their challenges and water sustainability is useful as there will likely be more communities that will primarily depend on groundwater supplies in the future. It is important to understand groundwater management for the region as some communities are groundwater dependent such as the rural, agricultural community in the Douglas Groundwater Basin.

To continue narrowing the scale of water management in the American Southwest, Chapter 4 is a case study analysis of the Douglas Groundwater Basin, located within the larger Colorado River Basin, where there is no allocated Colorado River water supply to augment the groundwater supply that the community is greatly dependent on. This study includes an analytical approach to study and understand how voters and local-level stakeholders can drive environmental policy change. In this case, particularly, policy change that has implications for future natural resource governance that is reflective of local perspectives including public framing of problems and solutions. The empirical study of grass-roots, bottom-up approaches, such as initiatives that begin as social movements, as is the case in this research, to enact environmental policy change can help contribute to knowledge and understanding of how local-level stakeholders can drive change to manage natural resources. This study found that local-level, public stakeholders identify problems, centered around financial and water access limitation as well as having groundwater supplies to support their livelihood, and solutions including solution pairs to address issues via groundwater regulation implementation but do not identify who is responsible for taking action to implement solutions in the management goal-setting process input comments. This lack of motivational framing is unlike other recent framing studies (Jones et al., 2022; Ojeda-Matos et al., 2024) that find motivational frames occur least compared to diagnostic and prognostic frames. The absence of motivational framing speaks to a disconnect between the community and those responsible for groundwater management, a lack of a community mandate for ADWR since the agency was not identified as being responsible for implementing solutions, and the possibility that motivational frames may not be as salient to the community as problem and solution frames. Future research could be conducted in other groundwater-dependent communities to study public perspectives of water resource problem-solving and policy. Additionally, it would be interesting to research and compare groundwater governance in other agricultural communities within Arizona.

144This dissertation has some limitations that are important to mention when interpreting the results and findings. While the findings can help inform other water basins and communities grappling with changing rules and a changing climate, these three case studies are not directly generalizable for communities outside of the American Southwest. Rules and policies surrounding water governance in other basins will vary and have different implications based on their water management regimes, influential dynamics, laws, policies, etc. My dissertation focuses on formal policy and does not capture important informal factors that could influence the findings. While this dissertation is a small progression and part of understanding water governance, particularly in the Southwest, I contribute some insight into a very complex water problem and system that is useful to the larger puzzle that is Colorado River Water governance in the Anthropocene that many people have and are working on. The role that institutions play in shaping water governance decision-making and policy change should continue to be studied, analyzed, and questioned to improve understanding, contribute to knowledge production, and to help provide evidence-based insight for water governance now and moving forward.

Through analyzing water supply management and governance institutions across spatial and temporal scales, I contribute to the breadth of literature and study of the Colorado River Basin (Huckleberry & Potts, 2019; Hundley, 2009; Rivera-Torres & Gerlak, 2021; Sullivan et al., 2017) as well as water governance in the American Southwest. The findings from this dissertation can aid in providing insights into water governance, policy change, and the ongoing water scarcity in the West. Broadly, this research provides information that could be useful for other transboundary watersheds grappling with water supply challenges and rule changes.

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APPENDIX

INSTITUTIONAL REVIEW BOARD APPROVAL DOCUMENT

EXEMPTION GRANTED

Dave White
GFL: Sustainability and Innovation, Global Institute of (GIOSI)
480/727-9234 Dave.White@asu.edu

Dear Dave White:

On 6/12/2023 the ASU IRB reviewed the following protocol:

Type of Review:	Initial Study
Title:	Coordinating Colorado River Water Management: Governance and Upstream-Downstream Dynamics
Investigator:	Dave White
IRB ID:	STUDY00017942
Funding:	Name: National Science Foundation, Grant Office ID: AWD00034864, Funding Source ID: FP00020515
Grant Title:	*CAREER: Balancing Local and Systemic Resilience in the Western Water Network*
Grant ID:	AWD00034864;
Documents Reviewed:	• Consent_Form_02-06-2023 v3.pdf, Category: Consent Form; • FP20515 Garcia FP.pdf, Category: Sponsor Attachment; • IRB Social Behavioral Protocol v3.docx, Category: IRB Protocol; • recruitment_methods_email_02-06-2023 v2.pdf, Category: Recruitment Materials; • supporting_documents_02-06-2023 v3.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions);

The IRB determined that the protocol is considered exempt pursuant to Federal Regulations 45CFR46 (2)(i) Tests, surveys, interviews, or observation (non-identifiable) on 6/8/2023.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103). When consent is appropriate, you must use final, watermarked versions available under the "Documents" tab in ERA-IRB".

If any changes are made to the study, the IRB must be notified at research.integrity@asu.edu to determine if additional reviews/approvals are required. Changes may include but not limited to revisions to data collection, survey and/or interview questions, and vulnerable populations, etc.

Sincerely,

IRB Administrator

cc: Krista Lawless
Dave White
Margaret Garcia
Amber Wutich Krista
Lawless