Using Soft Infrastructure to Manage Uncertainty: Collaboration in the Phoenix Surface Water Governance Network

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Abstract

Water supplies for urban areas in the western United States are governed through complex, polycentric networks of actors and forums across multiple levels of government. Many of these areas are facing increased water stress and heightened uncertainty due to declining surface water supplies. One way to help mitigate these challenges is for policy actors to collaborate with each other to share information and other resources, develop common management strategies, and otherwise coordinate their actions. However, who collaborates, why they chose to do so, and with what effect on water management remain open questions. We explore these questions through an analysis of the Phoenix Metropolitan Area (PMA) surface water governance network. Water providers in the PMA, located in central Arizona, United States, face a particularly high level of uncertainty around their water supplies due to long-term drought and aridification of the Colorado River Basin. Drawing on policy documents and targeted interviews with water resources professionals in the PMA, we analyze how water managers, policymakers, and other stakeholders organize across jurisdictional levels and through collaborative forums within this polycentric network. Furthermore, we assess the role of the most established collaborative forum – the Arizona Municipal Water Users Association (AMWUA) – in facilitating collaboration among a subset of network actors, with a focus on what motivates actors to collaborate in AMWUA. Our findings provide insight into the design of water governance institutions to effectively facilitate collaboration in urban areas facing high water stress.

1 Introduction

Water challenges, particularly related to supply shortages, are and will continue to be a reality for the American Southwest. In this region, seven U.S. states and multiple major cities (i.e., Denver, Phoenix, Los Angeles), as well as two states in northern Mexico, rely on the Colorado River as the primary surface water source to meet their diverse and growing water needs. In addition to being historically overallocated (Kuhn and Fleck, 2019), the Colorado River's flows are now being reduced by climate change and consequent regional aridification (Milly and Dunne, 2020; Overpeck and Udall, 2020; Udall and Overpeck, 2017). For instance, in August 2021, the first ever federal water shortage was declared on the Colorado River, prompting reductions in water deliveries to Arizona, Nevada, and Mexico (Fleck and Castle, 2021). Coupled with a variety of other management uncertainties (Gerlak et al., 2021), these delivery reductions increase vulnerability and create a plethora of new challenges for water managers throughout the region. Through their responses to these challenges, Southwestern cities serve as key "testbeds for urban resilience" (Hondula et al., 2019) that can provide critical lessons for other aridfying basins across the globe. Many water governance systems are highly complex, involving many overlapping actors and decision-making forums (Franco-Torres et al., 2021; Heikkila, 2017). One promising way to help mitigate urban water supply challenges in this context is for policy actors to collaborate with one another to share information and other resources, develop common management strategies, and otherwise coordinate their actions in ways that reduce their collective vulnerability (Bodin, 2017; Lubell et al., 2014). Collaboration is expected to positively contribute to the development of adaptive capacities as "knowledge and learning," for instance, become shared pursuits among actors facing common challenges (Emerson and Gerlak, 2014). However, collaboration can also be time and resource intensive and may result in incremental progress that is difficult to connect to improved environmental outcomes (Koebele, 2015; Koontz and Thomas, 2006; Margerum and Robinson, 2016). Thus, understanding the role for collaborative forums in managing urban water supplies, as well as who chooses to engage in collaboration and why, is critical for advancing the success of this approach to managing water supply challenges.

We explore these questions through an analysis of the Phoenix Metropolitan Area (PMA) surface water governance system, located in central Arizona. As a result of its tenuous past and current relationship with groundwater, the PMA relies heavily on two surface water sources for the majority of its municipal water supply: the Salt and Verde Rivers, provided by the Salt River Project (SRP), and the Colorado River, provided by the Central Arizona Project (CAP). As such, water providers in this system face a particularly high level of uncertainty around their water supplies. The system is also highly polycentric, meaning that it consists of actors from multiple, overlapping jurisdictional levels who interact in different venues to manage water under a variety of existing institutions. We seek to understand how PMA actors interact with one another to govern surface water, and specifically, why they are motivated to participate in collaborative forums as part of this effort. Our analysis focuses on the role of municipal water users associations, and specifically the well-established Arizona Municipal Water Users Association (AMWUA), as key forums facilitating collaboration among water providers within this complex network. We investigate the following research questions:

1. How do water system managers, policymakers, and other stakeholders organize into a polycentric network of multiple jurisdictional levels and collaborative forums to manage surface water in the PMA?

2. What is the role of AMWUA in the network regarding collaboration among network actors?

(a) What motivates actors in the network to collaborate through AMWUA?

The first question is primarily a descriptive investigation of the polycentric system structure in the PMA through network analysis methods, while the latter questions focus on what animates collaboration among entities in the network to address shared water challenges. Understanding how AMWUA facilitates collaboration – which is affected both by its role and the motivations of the actors who engage in it – is key to either preserving desired collaborative arrangements or informing the design of new arrangements to better meet actors' needs and promote system resilience. Critically, we do not attempt to conduct a rigorous institutional analysis of all the institutions that actors must grapple with when managing water in the PMA; instead, our results provides an overview of the structure of the governance network and allow us to assess how a key collaborative forum facilitates connections among networked actors.

Section 2 lays out the theoretical approach we take to understand the polycentric system and how collaborative venues may impact its function, particularly given actors' diverse motivations to engage in collaborative venues such as AMWUA. Section 3 provides the empirical context for the study. Section 4 summarizes our methodological approach based on document and interview analysis, which builds up and advances traditional network development and analysis approaches. Section 5 presents the results of our empirical work, and Sections 6 and 7 discuss our findings and conclusions.

2 Theoretical Background

2.1 Polycentric Governance

Like other urban water systems, the system of actors that govern surface water in the PMA is highly polycentric. In contrast to prior ideals for the all-encompassing, centralized governance arrangements of "gargantua" in public administration, *polycentricity* or a *polycentric system* refers to a governance arrangement characterized by (i.) multiple centers of decision-making with a degree of formal independence and (ii.) varying levels of "taking each other into account" through competition, cooperation, conflict, and conflict resolution processes (Carlisle and Gruby, 2019; V. Ostrom et al., 1961). In short, polycentric governance is not a monolithic exercise, but it is rather one that involves the interactions of multiple individuals navigating institutional complexity in pursuit of their policy goals (Lubell and Morrison, 2021).

In addition to the two attributes listed above, there is also often a considerable degree of cross-scale decision-making by actors at various jurisdictional levels in polycentric systems, especially in situations like water governance (York et al., 2019). Recognizing the importance of multiple, interacting levels in a polycentric system is by no means novel: indeed, the presence of "nested institutions" is the eighth of Ostrom's design principles (E. Ostrom, 1990) and much of her later work on polycentricity emphasizes that multiple levels of decision-making must be involved in solving complex environmental challenges (i.e., E. Ostrom, 2010, 2016; E. Ostrom and Janssen, 2005). Despite this, scientists continue to struggle with understanding these intricate cross-scale connections among actors (Andersson and Ostrom, 2008; York et al., 2019). Thus, in addition to attending to the multiple centers of decision-making present in a polycentric system and the ways they take one another into account, we also emphasize the importance of carefully attending to scalar dynamics in polycentric governance systems.

Polycentric systems have been found to promote innovation and learning, bolster a system's adaptive capacity and resilience to shocks, support diverse institutions that "fit" well to local conditions, and produce equitable and sustainable outcomes (Andersson and Ostrom, 2008; Carlisle and

Gruby, 2019; E. Ostrom, 2010; Pahl-Wostl and Knieper, 2014; Pahl-Wostl et al., 2012). Empirical studies show that high-performing polycentric systems are also able to appropriately synchronize or coordinate among decision-making forums at different scales to achieve socially-desirable system-level goals (Bodin et al., 2020; Carlisle and Gruby, 2019; Ekstrom and Young, 2009; Heikkila et al., 2018; Lubell, 2013) even as a variety of collaborative, competitive, and conflictual relationships persist among entities within the system (Lubell et al., 2020). However, polycentric systems vary greatly in their ability to deliver the kinds of benefits listed above (Berardo and Lubell, 2019; Bissonnette et al., 2018; Sovacool, 2011). For example, polycentric systems that become highly fragmented or decentralized, with little coordination among actors, may lead to activities that conflict with one another or undermine system-wide benefits, increase transaction costs, and reduce accountability (Andersson and Ostrom, 2008; Carlisle and Gruby, 2019; Mudliar, 2021).

As has been noted in the broader scholarship community on polycentric governance (Thiel et al., 2019), Carlisle and Gruby (2019) point to a theoretical gap in connecting specific characteristics of a polycentric governance system to its functionality. They term these characteristics *enabling conditions*, which include diverse institutions present in the polycentric system, such as mechanisms for learning or accountability. Because all governance systems – and especially those around complex environmental problems – are polycentric to some degree (Lubell and Robbins, 2021), understanding how enabling conditions affect *function* of the polycentric system is critical for assessing and improving governance arrangements. This concern is brought to the fore in the Ecology of Games Theory (EGT), a theory of polycentricity that places the complex arrangement of actors and forums (i.e " games") at the center of analysis and highlights the interplay between the structure and function of the system (Berardo and Lubell, 2019; Lubell, 2013).

2.2 The Role of Collaborative Forums in Polycentric Systems

To improve the function of polycentric governance systems, public administration scholars have widely cited the need for inter-organizational innovation (to borrow from Mandell and Steelman, 2003). Much of this work has focused on elaborating the core dimensions of collaborative governance (i.e., Ansell and Gash, 2008, 2018; Bodin, 2017; Bryson et al., 2006; Emerson et al., 2012; Thomson and Perry, 2006), which is touted for its ability to create enabling conditions that improve the functioning of polycentric systems. As an approach to decision making and implementation, collaborative governance engages public and private actors in consensus-oriented deliberation around shared problems that cross traditional sectoral or jurisdictional boundaries (Ansell and Gash, 2008; Emerson and Nabatchi, 2015). While collaborative processes vary in their own institutional arrangements, they typically aim to foster the development of social capital, trust, and learning through face-to-face dialogue over extended periods of time (Emerson et al., 2012; Koebele, 2019; Leach and Sabatier, 2005; Leach et al., 2014). Whether implemented from the "top down," such as by an existing governmental agency, or forged from the "bottom up" by stakeholders, most collaborative processes share the goal of crafting mutually-acceptable policies or management actions, which are expected to have greater legitimacy and be easier to implement (Gerlak et al., 2013; Sabatier et al., 2005). Given these potential promises of collaborative governance, it is unsurprising that collaborative approaches have become nearly ubiquitous in the realm of environmental governance across the globe in recent decades (Margerum and Robinson, 2016; Newig et al., 2019).

An important vein of EGT research concerns the role of forums for collaborative governance (sometimes referred to as collaborative institutions or collaborative processes, but we maintain " forum" here), within polycentric governance systems. For example, research in the San Francisco Bay Delta found that collaborative forums were the most common type of decision-making forum in the polycentric system, and that these forums also served as key hubs of activity in the broader

network (Lubell, 2015; Lubell et al., 2014). Similarly, Fischer and Maag (2019) find that collaborative forums are particularly important centers of decision-making to policy actors, especially when they are perceived as improving learning or equitable resource distribution. Collaborative forums may also improve "institutional fit" within a polycentric system by better reflecting the cross-boundary nature of resource issues (Guerrero et al., 2015), which can strengthen governance continuity across the system (Ekstrom and Young, 2009). Additionally, collaborative forums may reduce the transaction costs of participating in complex governance (e.g. time, money, patience, etc.) by creating new opportunities for collaboration among policy actors (Lubell et al., 2020).

Despite these potential benefits of collaborative forums, they are often time- and resource-intensive, can lead to "lower-common-denominator" solutions due to consensus decision rules, and may fail to engage all relevant participants, among other challenges (Gerlak et al., 2013; Kenney et al., 2000; Koontz and Thomas, 2006). Particularly when initiated by government agencies, collaborative forums may have a bias toward engaging known policy actors to participate (Scott and Thomas, 2017a), skewing the power dynamics within the forum (Mudliar, 2021). These kinds of constraints have been found to reduce the impact of collaboration on the performance of the broader polycentric system in both the short- and long-term (Koontz and Newig, 2014; Marshall et al., 2013). Additionally, participating in a collaborative forum may actually increase, rather than decrease, the transaction costs of cooperation for some actors who must participate in multiple forums (Lubell et al., 2020. Increased transaction costs may also create negative "institutional externalities," or spillover effects for related decision-making forums that limit the ability of some actors to achieve their desired goals (i.e., Berardo and Scholz, 2010; Hileman and Bodin, 2019; Lubell et al., 2017; Mewhirter et al., 2019).

2.3 Actors' Motivations for Collaborating

Given the promises and challenges associated with collaborative governance and its potential effects on a polycentric system's function, it is critical to understand not only the role of a collaborative forum but also the participating actors' motivations to engage in the form. This perspective aligns with recent calls from Lubell and Morrison (2021) to place individuals, embedded within the polycentric system, at the forefront of our analyses. Focusing on actor motivations for participating in collaborative forums illuminates how and why actors strategically collaborate within a system and with what goals. Indeed, polycentric governance research relies upon the relationship between system structure and actor behavior (Thiel et al., 2019). As Ostrom (2005) highlights, participants are what *animate* action situations, but our knowledge of exactly what motivates them to engage remains limited.

The main collaborative forums in this study involve collaboration among municipal and state entities, in which individuals collaborate on behalf of their organizations (Rayle and Zegras, 2013. Thus, actors' motivations for collaborating in such a space may differ from those expressed by individuals participating in a collaborative form on their own accord. Hulst et al. (2012) outline numerous potential arrangements for inter-municipal collaboration, such as quasi-regional governments, planning forums, service delivery organizations and service delivery agreements. These arrangements vary in the types of tasks they take on, their authority, and the degree to which their members are integrated, among other factors. They may also be highly institutionalized or very informal (Bel and Warner, 2015), all of which may impact actors' motivations to engage (or not).

Myriad rational and institutional explanations exist for why governmental organizations enter into collaborations (Williams et al., 2009). Rational explanations often center around an organization's desire to work with individuals who can provide needed or desired resources, including information, to enhance efficiency or performance individually or in another forum via a spillover

effect (Agranoff and McGuire, 2003; Lubell, 2015). Participating in inter-municipal collaboration can also allow an organization to enter into a network that facilitates collective information processing through deliberation, which can potentially improve their performance (Koebele, 2019; Muraoka and Avellaneda, 2021). While low-capacity governments or those experiencing austerity may be motivated to collaborate in order gain resources or capacity, or to create economies of scale that reduce costs (Bel and Warner, 2015), McGuire and Silva (2010) suggest that high managerial and organizational capacity may also increase an organization's motivation and ability to collaboration, especially when collaborations concern a specific "program area" such as emergency management. Thus, some government organizations may simply be better prepared to engage in productive collaborations that achieve desired benefits than others.

Institutional explanations tend to focus on organizational norms or beliefs as motivators for driving collaboration, such as the desire for an organization to "do what's right" or strengthen their legitimacy (Mosley and Wong, 2021). In this vein, organizations may be more likely to collaborate with other organizations that are similar to them in structure or existing norms. Some organizations may even be required or coerced to join a collaborative initiative through regulation or other top-down mandates, which may help incentivize them to overcome differences with their collaborators (Monroe and Butler, 2016), while others may seek to collaborate with other entities in order to avoid coercion or interference from entities at other jurisdictional levels.

Additionally, factors such as greater interdependence among organizations (Hulst and van Montfort, 2012) and increasing severity of shared or common problems (McGuire and Silvia, 2010), such as water supply shortages, may enhance inter-municipal collaboration. For example, collaboration may be catalyzed when organizations face a common "opponent," stressor, risk, or uncertainty, especially one that can not be solved independently; when individuals have developed trust through previous interactions; or when individuals share common beliefs or goals (Calanni et al., 2015; Henry et al., 2011; Koebele, 2020).

3 Case Context: Surface Water Governance in Phoenix

This study uses a combination of document analysis and interviews with actors in the PMA to (i.) map the structure of the polycentric system for surface water governance in the PMA, and (ii.) understand the role of a key collaborative forum (AMWUA) in the system, including why actors across jurisdictional levels are motivated to participate in it. Moreover, we illustrate the construction of a network from qualitative data, which has a variety of potential advantages over typical methods for network construction. The concepts related to polycentricity, collaborative governance, and actors' motivatations presented in Section 2 provide the foundation for our deductive coding of the interviews, explained further in Section 4. While there are multiple insights that can be derived from this conceptual and methodological approach, we seek to understand how PMA actors interact with one another in a complex system, what role a key collaborative forum plays, and why. Here, we introduce the context of the study system.

The Phoenix metropolitan area (PMA), situated in an arid environment, has a long history of infrastructure development, both hard (built) and soft (institutional), to manage the provision of water. Much of the geographic region it is situated within, the Salt River Valley, already consisted of a vast irrigation network developed by the Hohokam (Haury, 1976) and ultimately providing the foundations for the irrigation of white settlements in the 1800s (Sullivan et al., 2017). The nineteenth century Salt River Valley consisted of primarily rural, agrarian life within this water infrastructure system, but disagreements about water entitlements in the nineteenth century, further catalyzed by promised construction of the Roosevelt Dam in 1902, compelled the creation of
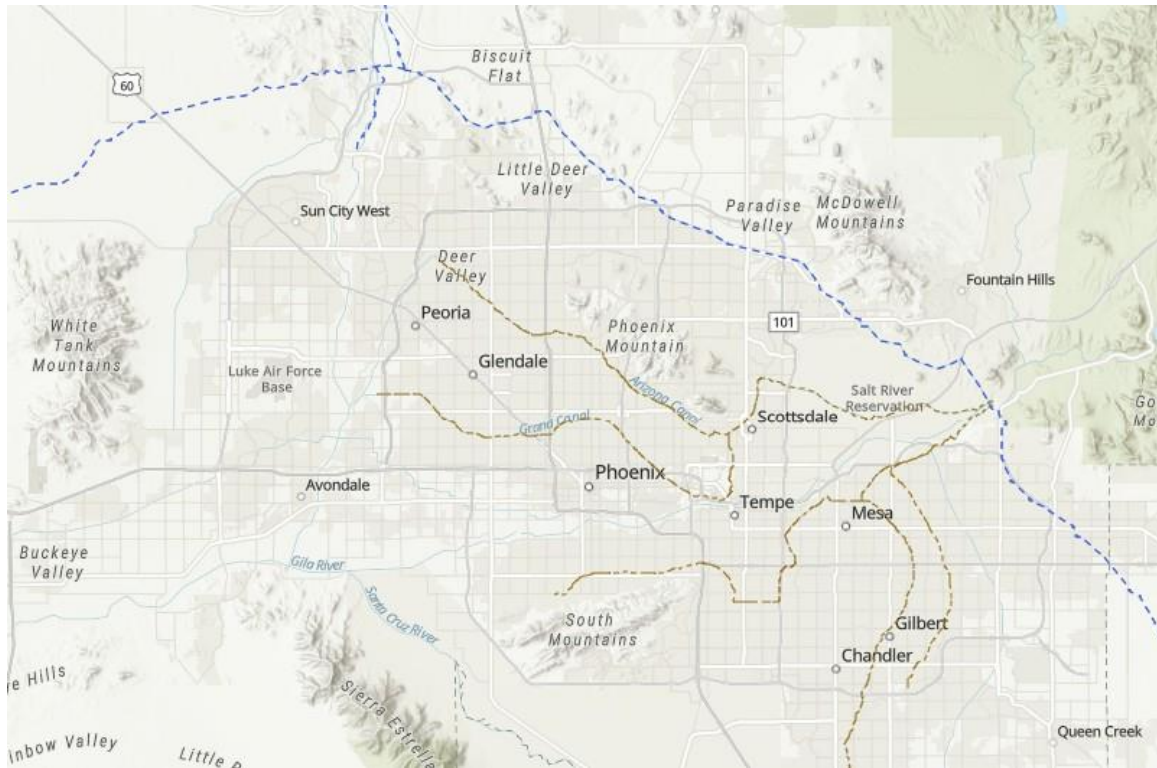
Figure 1: Map of the PMA cities and two major surface water sources: the SRP (brown) and the CAP (blue) canal systems. (Image Source: Kyl Center for Water Policy, Arizona Water Blueprint)

the Salt River Water Users' Association (now, Salt River Project or SRP) in 1903 and the litigation that brought about the Kent Decree of 1910, which to this day, serves as the recipe for Salt-Verde River water allocations (Feller, 2007; Phillips et al., 2009; Salt River Project, 2017). The Kent Decree established a land-based water rights seniority system, demarcating certain acres of land deemed to be pre-Roosevelt dam senior users and those worthy of post-dam allocations, the soft infrastructure underlying the SRP canal system.

While this built and institutional infrastructure arrangement provided a firm surface water source for the more established parts of the early PMA, heavy population growth during the post-World War II era, expanded groundwater use to keep pace, seriously threatening the valley's slowly recharging aquifer (Bolin et al., 2010). To address this doomed strategy, policymakers turned to the Colorado River and the potential Central Arizona Project to transfer water from the river to Arizona population centers in PMA and Tucson (Bolin et al., 2010). Figure 1 shows the spatial relationship of PMA cities and the two major surface water sources: SRP and CAP. As a compromise to federal legislators hesitant to provide such a supply switch without institutional reform, Arizona legislators brought forth the Groundwater Management Act of 1980 (CBolin et al., 2010; Connall Jr., 1982; Sullivan et al., 2017). Since the Groundwater Management Act of 1980, groundwater use among cities in PMA has been closely regulated in hopes of achieving "safe yield" (balancing recharge and extraction) in the aquifer according to a centralized management infrastructure in the Arizona Department of Water Resources (ADWR) and its Active Management Areas (AMAs) (Blomquist et al., 2004). Cities, like those in the PMA, need to demonstrate 100 years of Assured Water Supply (AWS) primarily through renewable sources like surface water and recharge-recovery programs that make up for heavy groundwater pumping (Larson et al., 2013).

Taken together, this institutional context has created a PMA water system made up of municipal water providers (i.e. Phoenix Water, City of Mesa etc.) all concerned with securing renewable water resources, which for the most part, have already been allocated (or even over-allocated). Moreover, while water supply remains fragile, demand in PMA continues to expand with the City of Phoenix experiencing the largest population growth of all large U.S. cities (Healy, 2021) and new cities like Buckeye becoming the fastest growing of all U.S. cities (Hing, 2021). Thus, monitoring, projecting, and responding to variability in the region's primary renewable water supplies, the Salt and Verde Rivers and the Colorado River, is crucial to sustainable water management and has been the subject of major scholarly endeavors like the Decision Center for a Desert City (DCDC) (i.e., Gober et al., 2010; Gober et al., 2016; Sampson et al., 2016). Work from DCDC scholars in the Phoenix context has supported calls for a paradigm shift in water planning towards adaptive management and proactive navigation of uncertainty (Gober et al., 2010), and a number of studies have been published on the unique perspectives of PMA water resource managers and the public regarding climate uncertainty (Larson et al., 2009; White et al., 2019; White, Withycombe Keeler, et al., 2015; White, Wutich, et al., 2015). However, while past work has diligently laid out the attitudes of individual agents and the complex problem context facing PMA water (i.e., possible futures, anticipatory modeling, etc.), a gap remains with regard to the coupled policy processes at work shaping PMA surface water governance. We contribute to this needed understanding by (i.) mapping the polycentric network underlying surface water governance, including the key actors, forums and their interconnections, and (ii.) identifying the motivating factors and possible barriers to collaboration among actors in a key collabortive forum, the Arizona Municipal Water Users Association (AMWUA).

AMWUA was formed in 1969 by five PMA cities - Phoenix, Scottsdale, Mesa, Glendale, and Tempe - to secure and maintain urban water rights through municipal cooperation. Early efforts of AMWUA included negotiating infrastructure and delivery agreements with SRP and the 1980 Groundwater Management Act, including its municipal conservation programs. In 1984, AMWUA assisted in the securing of municipal sub-contracts (M&I) from the new Central Arizona Project to deliver Colorado River water to the PMA. By 1989, AMWUA reached nine members, adding Chandler, Goodyear, Peoria, and Gilbert. Avondale was the last city to join AWMUA in 2007. AMWUA continued to serve a negotiating role in SRP and CAP hard infrastructure projects and new Arizona regulatory efforts like the Arizona Water Banking Authority (1996) and a facilitating role in crafting shared municipal strategies, including the "Water Use it Wisely" campaign in 1999.

AMWUA's mission is to "[protect its] members' ability to provide assured, safe, and sustainable water supplies to their communities." Further adding, "working collaboratively, we advocate responsible water stewardship that supports economic prosperity and safeguards Arizona's water supplies for future generations" (AMWUA). AMWUA holds its own executive staff to implement organizational goals, but it also convenes its members in three ways. The first way is the Board of Directors, which includes a representative from each member city who is also an elected city official (either mayor or council member). The Management Board makes recommendations to the Board of Directors and consists of utility directors from each member city. Lastly, a series of Technical Advisory Groups, comprising specialists from each member city (i.e., Water Resources Advisory Group contains water resource advisors from each city), advise the executive staff and Board of Directors. The Management Board and the Board of Directors meet publicly, but the advisory groups are often closed-door meetings.

4 Methodology

In line with the actor-focused nature of this effort, we utilize a data collection and analysis process conducive to actor-derived insights. Specifically, we draw on semi-structured interviews with representative individuals from the PMA surface water governance system to understand the polycentric network through the perspectives of agents *animating* it (E. Ostrom, 2005). The interviews yielded data of broad application, but this paper focuses on two insights: the structure of the relationships in the PMA surface water governance network and the motivations for participation in the network's primary collaborative forum, the Arizona Municipal Water Users Association (AMWUA).

4.1 Data Collection: Semi-Structured Interviews and Documents

The primary form of data collected for this study was semi-structured interviews conducted in the summmer of 2021 (June to August). Interviewed participants included water resource managers at PMA cities and connected Southern Arizona cities, the primary bulk surface water suppliers in the PMA (CAP and SRP), AMWUA executive staff (AMWUA is the only association in the PMA with separate staff), and state regulatory agencies (Arizona Department of Water Resources (ADWR)). While surveys (often online) are the most popular data of many network studies in the policy networks field (see Henry et al., 2012) due primarily to their ability to capture more easily quantified data from a large population of respondents, interviews were the preferred data collection method for this study for a variety of reasons: (i.) the much lower-N of the PMA surface water governance network, (ii.) the very low response rate of municipal water resource managers to online surveys, and (iii.) our desire to elicit qualitative descriptions of network relationships and underlying motivations for participation. While they introduce new challenges, interviews may help overcome recall bias, incomplete responses, and other issues associated with online surveys.

Before recruiting interview participants, we also collected and reviewed key policy documents associated with surface water governance in the State of Arizona, City of Phoenix, and other PMA cities (Appendix A3). The documents offered a foundational perspective of the polycentric governance structure (major actors, forums, and protocols) and assisted with (i.) deductively deriving codes for the codebook (ii.) compiling a list of potential interview participants, and (iii.) triangulating the statements of interview participants in network and motivations analysis. Gathering the documents and selecting potential interview participants was done in collaboration with boundary researchers at the Kyl Center for Water Policy at Arizona State University with past experience in the PMA policy network.

We conducted semi-structured interviews with 21 non-elected water resource professionals at multiple levels of jurisdiction (state, local, regional) and roles in the provision of surface water (i.e., bulk water provider, municipal manager, state regulator, etc.). All interview methods were approved by the authors' institutional review boards. Table 1 presents a list of the organizations sampled. To further insure adequate sampling, we added an off-the-record snowball sampling question to the end of interviews, asking if, given the questions heard, the interview participant recommended another person to speak with. We assumed saturation was reached when snowball sampling responses named people we had already interviewed or invited to interview and all actor and forum types represented in our document review were represented by interview participants. Due to the focus on AMWUA forum participation motivations, we sought interview participation from both AMWUA and non-AMWUA cities to compare experiences. There are ten AMWUA member cities, and we reached out to water resource and utility management professionals at all ten cities. We were able to set up interviews with eight of the ten cities. Additionally, while they are not geographically located in the PMA, we included two municipal providers from Southern

Table 1: Organizations represented by the interview participants

Type	Name	Acronym	N
State of Arizona	Arizona Department of Water Resources	ADWR	2
	Arizona Water Banking Authority	AWBA	1
Bulk Water Provider	Central Arizona Project	CAP	2
	Salt River Project	SRP	1
User Association	Arizona Municipal Water Users Association	AMWUA	10
	Southern Arizona Water Users Association	SAWUA	2
	West Valley Water Users Association	WVWUA	5
PMA City (AMWUA)	City of Phoenix		1
	City of Mesa		1
	City of Scottsdale		1
	City of Chandler		1
	Town of Gilbert		1
	City of Glendale		1
	City of Peoria		1
	City of Tempe		1
PMA City (Non-AMWUA)	City of Buckeye		1
	City of Surprise		1
	Town of Queen Creek		1
Southern Arizona City	Tucson Water		1
	Metro Water District	MWD	1

Arizona (Tucson Water and Metro Water District) due to their uncovered involvement, from policy document review and early interview snowball sampling, in PMA water policy networks, primarily through water banking agreements. Note, due to the absence of separate staff for the WVWUA and SAWUA, organizational representation for those agencies were sought from member cities. Thus, there was not a one-to-one match of interview participants and the organizations represented in Table 1.

Two objectives guided the interview design: (i.) trace the structure of the surface water governance network in the PMA, and (ii.) gain qualitative insight into actors' motivations for participating in collaborative forums. Our interview protocol (Appendix A4) consisted of multiple groups of open prompts asking participants to describe the water resource planning process for their organization and key collaborative processes they participate in. The water resources planning process questions included key infrastructural considerations (both hard/built and soft/policy), formal and informal components, types of information considered and its source(s), and their goals. Collaborative process questions maintained an open setup to allow for participants to freely describe their perspective, but probing questions made sure that each participant covered state, bulk water provider, inter-city, and water user association collaborations and forms of information they seek out from or provide to those collaborations. Participants were also asked to describe how water resources planning and collaboration changed over their time at the organization. To ensure adequate translation of academic concepts to relevant interview questions, the research team sought feedback from the Kyl Center colleagues with experience in the municipal water industry. For

instance, we recognize the colloquial association of "infrastructure" solely with hard human-made infrastructure, and referred to "policy" and "regulations" when trying to elicit responses about the soft human-made infrastructure. As this paper covers a sub-set of insights that can be tractably taken from the interview data, this analysis serves as a first-pass exploratory analysis of data that will illuminate multiple later analyzes.

All interviews were audio-recorded to create transcripts, and participant identifying information was recorded separately from the content of their responses to the study's questions. For the remainder of analysis, we refer to participant responses by the organization type (see Table 1) to promote confidentiality.

4.2 Codebook Development & Implementation

The interview transcripts were coded according to an *a priori* codebook developed from the study context and literature (see Appendix A2). The coding process served to link themes from narrative interview responses to the theoretical concepts of interest. It featured three broad categories – 1) collaboration structure, 2) planning process & information, and 3) motivations & strategies – though only a subset of coded data was used in this analysis. Specifically, we primarily rely on codes from the collaboration structure category, including those designed to identify forums and interactions among actors, which have been key units of analysis in EGT scholarship (i.e., Berardo, 2014; Lubell et al., 2010; Mewhirter and McLaughlin, 2021), as well as codes pertaining to actors' motivations for participating in collaborative forums.

We began with a list of known PMA surface water actors and forums from the document analysis and inductively added actors and forums identified by interviewees. Actors were identified as representatives associated with organizations that are involved in the management of water resources in some way in the PMA. Forums were identified, per Fischer and Leifeld (2015), as having (i.) a clear organizational boundary of forum members, (ii.) an issue-based purpose, (iii.) actor diversity, (iv.) repeated interaction of actors. We posit that policy forums are a particular type of action situation (E. Ostrom, 2011) in which actors collectively make decisions. While a variety of forums were detected, this analysis focuses on water users association forums in which municipalities collaborate with one another to solve address problems.

Regarding actor motivations, we began by listing types of motivations used by actors to participate in a collaborative forum from the literature reviewed above on institutional complexity and inter-municipal collaboration (e.g. MOTIV-CAPAC: actor participates to gain capacity through the collective support). To account for motivations not included in this deductive phase, we used the general code of MOTIV (motivations) to tag actor descriptions of their motivation that were later inductively sorted into categories by the research team.

The two coders coded two transcripts entirely together, one with a bulk water provider and one with a city-level actor, to gain shared understanding. Then, the coders coded four transcripts (three cities and one state-level actor) separately and compared all coded statements to ensure the robustness of the shared understanding. Finally, the remaining fifteen transcripts were split among the two coders, making sure that each sub-group of actors (i.e., AMWUA cities or state agencies) was also evenly split among the coders. Due to noticeable but analytically insignificant difference in the tendency of one coder to code more or less text, calculating Cohen's Kappa is not helpful in this case. The coders regularly met during the separate coding process to discuss any new questions or nuances uncovered in coding.

4.3 Analysis: Basic Network Mapping

From the coded transcripts, we assembled a network diagram of surface water governance in the PMA. Network mapping is a popular tool for characterizing and evaluating the structure of polycentric systems that has been applied in many EGT studies (i.e., Hileman and Bodin, 2019; Lubell et al., 2017; Lubell et al., 2014; Scott and Thomas, 2017b) and other work connecting the structural features of governance systems to system activities (i.e., Berardo, 2014; Berardo and Scholz, 2010; Bodin et al., 2017; Scott, 2016; Ulibarri and Scott, 2017), such as cooperation and coordination among system actors.

We began the analysis with a general undirected network diagram with only one type of non-weighted connection between nodes. Nodes are either actors of multiple types (i.e. bulk water providers, state agents, AMWUA cities, non-AMWUA cities, Southern Arizona cities, and tribes) or water user association collaborative forums (i.e. AMWUA, WVWUA, SAWUA) that participate in PMA water resources planning and governance. Nodes are connected by edges, which were compiled in an adjacency matrix derived from mentions of direct collaboration in the coded interview transcripts, specifically the PPL (actors) and FORUM codes (see Appendix A2). The PPL code identifies references to other actors (besides the participants themselves) involved in the water resources planning process. The FORUM code identifies and describes forums that the interview participants participate in. A connection (edge in the adjacency matrix) was recorded between the interviewee and another actor or forum if the statement described a direct collaborative relationship between the two entities, including built infrastructure partnerships (i.e., shared interconnect), one-on-one meetings for water resources planning, and direct flows of information. If two actors engage with each other through a forum (i.e., AMWUA), an edge was not recorded between the two actors, but instead the actors are linked through edges connecting them to the same forum.

While multiple actors and forums in the PMA were detected through the semi-structured interviews, including universities, federal agencies, agricultural districts, and developers, we limited the actors in this analysis to bulk water providers, state agents, municipal water providers (AMWUA members, non-AWMUA members, and Southern Arizona providers), and tribes. Excluded actors played either a targeted advising role (i.e., engineering consultant providing supply projections) or a non-involved information source role (i.e., Bureau of Reclamation Colorado River reports). Additionally, developers are a commonly noted actor in the PMA system because they are major sources of future demand, but due to their diversity, lack of formal jurisdiction over PMA surface water, and unspecified nature (i.e. participants largely referred to them as " developers" rather than naming a specific entity), we excluded them from the governance network. Similarly, many participants referred to collaborations with groundwater savings in agricultural irrigation or " water conservation" districts, but we excluded them because they were often unspecified and/or did not participate in major governance activities.

We use the network analysis and visualization software Gephi (version 0.9.5) to gain qualitative and quantitative network insights. Analysis involved a dialogue between the static network insights of the adjacency matrix and the qualitative context discussed in the PPL and FORUM codes. As will be highlighted in the Results section below, we rely on centrality metrics like degree, closeness, and betweenness (see Bodin et al., 2006) to highlight central nodes in the PMA surface water governance network, their relative positions regarding their ability to reach all network nodes quickly, and their bridging capacities respectively. However, with the added context of the statements associated with each link (note, each edge had a corresponding set of statements that it was derived from), we can add description of how the central position of the node operates (*what the line means*). Such a dialogue between computational network analysis and qualitative data provides a rich picture of the polycentric system's structure. Future work can add directed network ties to

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illustrate connections such as information flows or break down edges into types of collaborations (e.g. hard infrastructure ties vs. collaboration ties).

4.4 Analysis: Motivations

Motivations are the justifications provided by actors for their participation strategies in collaborative forums. We coded for eight types of motivations (see Appendix A2), drawn from prior work: capacity, common goals, deliberation, externalities, information sharing, requirements, deliberation, trust, and uncertainty. Capacity motivations describe capacities gained by the city when participating. Common goals refer to shared objectives referenced by participants with other actors in a given forum. We included sub-codes within this type for water related goals (i.e., co-managing a shared water-scarce context) and media related goals (i.e., maintaining common messaging for media framing). Externalities refer to cases where participation in a certain forum offers benefits for another forum that the actor participates in. Information sharing motivations involve descriptions of beneficial information that an actor gains from participating in a forum or needed information that an actor must convey through participation in a forum. Deliberation reflects an actor's desire to use the forum for collective discussion or consideration of shared strategies or forum outputs beyond just sharing information. Requirement motivations simply acknowledge that the reason an actor participates is due to an institutional requirement. Trust-based motivations refer to the pull of trusting relationships to the collaborative forum. Uncertainty involves a discussion of uncertainty in the system context that motivates an actor to participate in the forum.

While we extracted multiple forums in the interview data, we focus this analysis on motivations for participation in AMWUA, the major collaborative water users association forum. We coded a total of 376 statements that discussed motivations for engaged in collaboration via AMWUA across these eight categories. We then inductively determined qualifying sub-types of motivations within each of the categories. For example, we inductively found out that lobbying is a beneficial capacity offered by AMWUA, so we created a lobbying sub-type for capacity motivations. With those sub-types, we noted the number of actors, including cities, AMWUA staff, and other agencies that engage with AMWUA (i.e., ADWR), that had statements falling within those sub-types. We illustrate these sub-types with representative quotes in the Results section below.

5 Results

5.1 Surface Water Governance Network in the PMA

First, we discuss the structure of the PMA surface water governance network (Figure 2a), as derived from interview data. The full network has 29 total nodes, including actors and water user association forums, and 137 edges, providing a graph density of 0.337. The average degree (number of connections) is 9.448, and the distribution of degrees is right skewed (see figure in Appendix A5). This is primarily due to the presence of much higher degree actors like CAP and ADWR, who have a large bulk water contracting base and comprehensive regulatory status, respectively, and therefore directly interact with many entities in the network. The prominent roles of CAP and ADWR are illustrated in Figures 2b and 2c, which highlight their individual networks. These two actors each have very high betweenness centrality (see Appendix A5), indicating that they exist as bridging agents among the other network actors. CAP and ADWR also have relatively higher closeness centrality than other network actors, which can indicate whether an actor exists as a potential "broadcaster," able to reach the whole network quickly. Notably, the difference is much less distinct, which indicates that while there are clear bridging organizations in the PMA

(a) All connections

(b) ADWR Connections

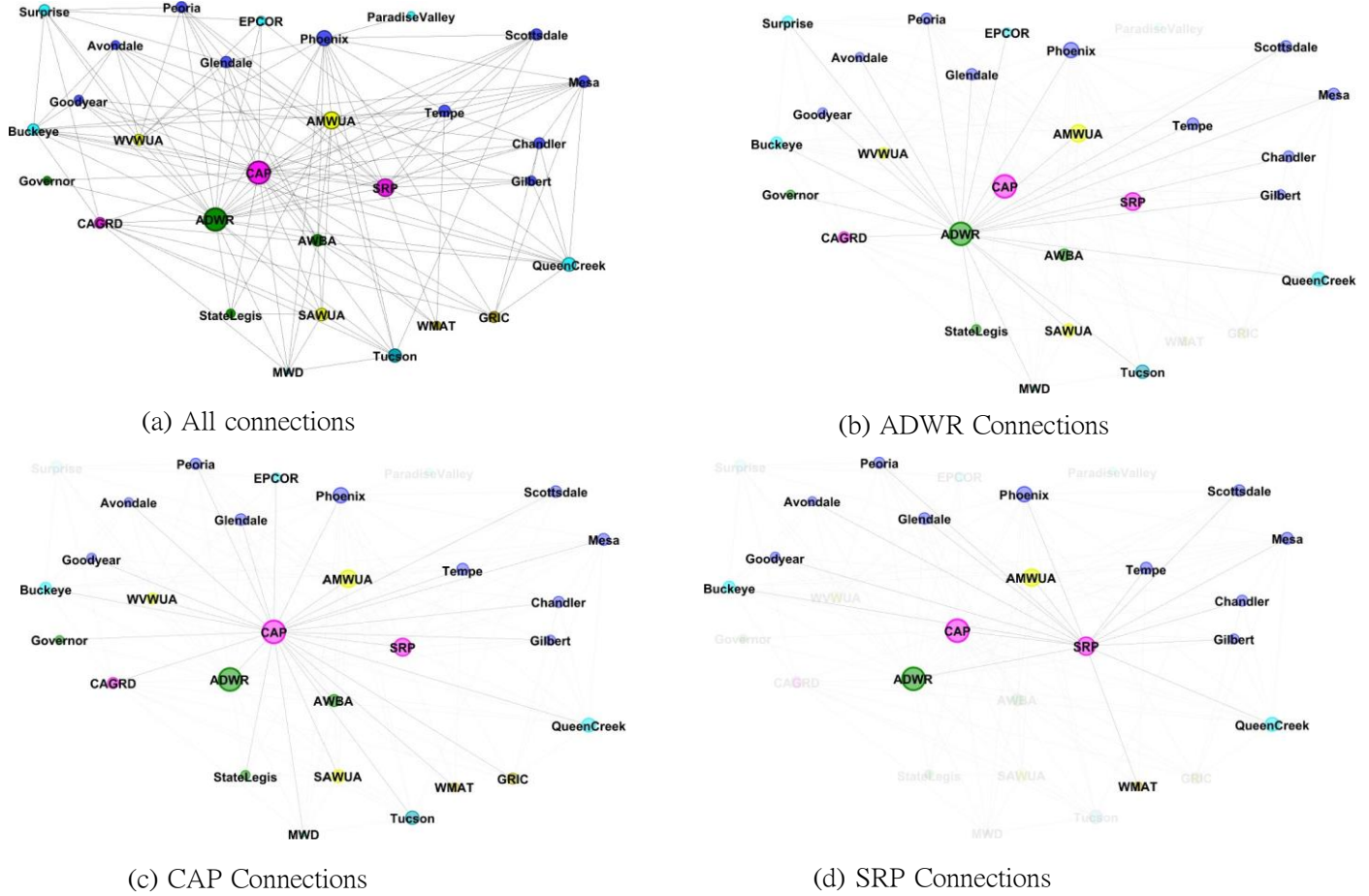(c) CAP Connections

(d) SRP Connections

Figure 2: Summary of connections in PMA surface water governance gathered from interviews. Key bulk water provider (pink) and state (green) nodes are highlighted in sub-figures. Nodes are sized according to degree. See Appendix A1 for acronym definition Dark blue nodes are AMWUA municipal providers, and light blue nodes are non-AMWUA municipal providers.

network, at a surface level, actors appear to be well connected among one another, able to reach many actors across the network if needed. Of course, the potential for an actor to act through a certain network path is a function of the embedded transaction costs, which is an insight that can be provided from the qualitative context (see Capacity-based motivations in the next section).

The bulk water provider SRP is a high-degree actor, but due to its much smaller customer base than CAP, it does not have as central of a role in the system. Its betweenness and closeness centrality metrics are also much lower than CAP and ADWR (see Appendix A5). However, the interviews revealed (see Figure 2) that SRP's network extends beyond its primary customers (i.e., the original Kent Decree land areas that circumscribe where it delivers water) to include newer cities like Buckeye and Queen Creek. While these cities do not have direct rights to Salt-Verde River water, which is provided by SRP, they are trying to gain access to new water available in the Bartlett Dam expansion project. In this project, SRP plans to expand the size of one of its dams to store more water along the Verde River that would have otherwise been lost flood water. Multiple PMA cities, including some non-AMWUA cities like Buckeye, have contributed to the project financing to gain access to some of the additional stored water (when the reservoir water

level is beyond the prior capacity).

This unweighted, undirected network does not allow for us to identify the nature of each edge, which can signify everything from a formal partnership established by hard infrastructure connections (i.e., an interconnect between Phoenix and Tempe), required interactions (i.e., a city submitting their annual reporting to ADWR), one-on-one advising (i.e., "joint coordination meetings" with CAP and a municipal provider), or regular advocacy (i.e., AMWUA lobbying state legislators on relevant legislation). For instance, the central position of CAP and ADWR suggests that they may be the key bridging actors in the PMA surface water governance network. However, interviews data shed light on the nature of those connections and add nuance about other key network actors, which will be discussed next. For CAP, much of their interaction with municipal providers occurs in three ways: (i.) monthly meetings of the CAP Board of Directors (open to the public) and an annual User Briefing, (ii.) one-on-one meetings and informal phone calls with users, and (iii.) formal transference reports in both directions (i.e., water orders from users and supply projections from CAP). ADWR's centrality reflects the primarily regulatory role of the agency, which largely manifested in the network via interactions with municipalities around reporting. Since the 1980 Groundwater Management Act and the codification of the 1995 Assured Water Supply Rules, ADWR has a central role in regulating the state of surface water in the PMA by confirming that municipal providers conform to renewable water supply standards as they receive their official Designation of Assured Water Supply.

CAP and ADWR's broad scope of responsibilities in PMA governance, encompassing multiple water use types and municipal regions, necessitates the presence of bridging actors at intermediate levels of organization between the individual city scale and state or regional scale. Water user associations, most notably, the Arizona Municipal Water Users Association (AMWUA), play this role. Consequently, they also hold central roles in the PMA surface water governance network. Figure 3 displays the individual networks of AMWUA (3b), WVWUA (3c), SAWUA (3d), and the largest metropolitan water provided, the City of Phoenix (3a).

Specifically, AMWUA had the third highest degree (17) behind CAP and ADWR, surpassing SRP. Recall that AMWUA is an intermediate organization, acting as a collaborative forum for a subset of ten network actors (i.e. "AMWUA cities") who hold SRP water rights. In addition to convening the cities, AMWUA communicates the collective position of its members to other relevant actors and forums in PMA water governance. The betweenness and closeness centrality metrics provide further insight into this role. AMWUA's betweenness centrality is between 20-30% of the betweenness centrality of CAP and ADWR. While Phoenix also has a higher betweenness centrality than AMWUA, possibly due to its concurrent membership in the WVWUA, AMWUA's closeness centrality is higher than Phoenix and much closer to CAP and ADWR. This suggests that AMWUA's "broadcasting" capacity is a key feature of the PMA surface water governance network which makes sense due to its role in advocating "up" to high levels of governance on behalf of its member cities.

Importantly, the AMWUA node and its edges correspond to both AMWUA as a forum and AMWUA as a collection of staff who carry out the activities of the forum. As a forum, AMWUA convenes its members to deliberate on policy positions and collective messaging and to share information on supply and demand trends, regulatory changes, and possible infrastructure solutions. As an actor, AMWUA's staff facilitates discussions among members, synthesizes information from state and federal agencies, and advocates for shared policy goals in multiple other forums. Critically, AMWUA is the only municipal user association in the network that has its own staff. However, because AMWUA generally uses consensus-based rules, meaning its staff only communicates messaging or executes advocacy and other activities that all of its members agree upon, we consolidate these two roles into one node.

(a) Phoenix Connections

(b) AMWUA Connections

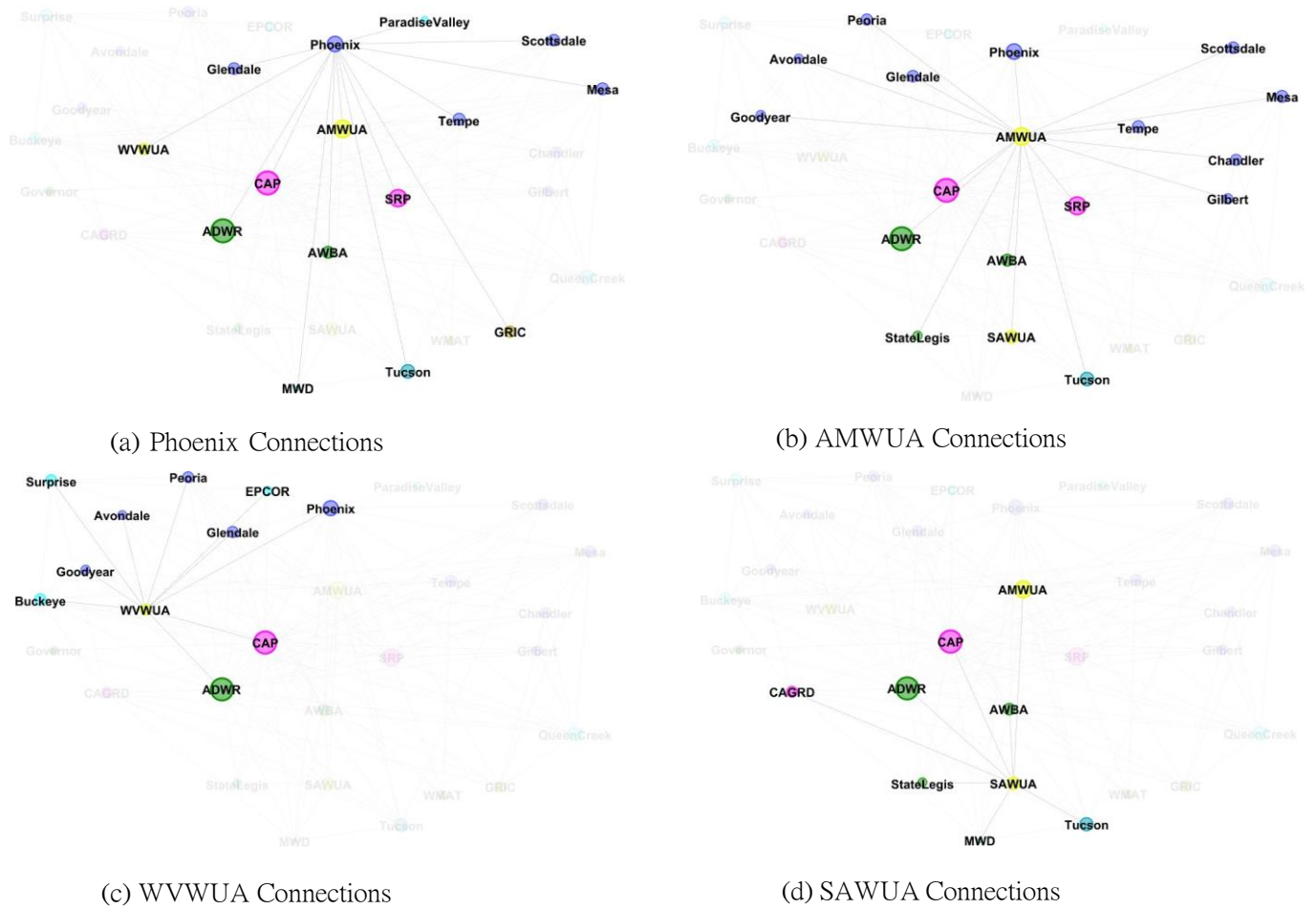(c) WVWUA Connections

(d) SAWUA Connections

Figure 3: Summary of connections in PMA surface water governance gathered from interviews. Key cities (Phoenix) and water user associations (yellow) are highlighted in sub-figures. Nodes are sized according to degree. See Appendix A1 for acronym definitions. Dark blue nodes are AMWUA municipal providers, and light blue nodes are non-AMWUA municipal providers.

In addition, mentions of two other water user associations emerged from the interview data that are connected to key PMA governance actors: the West Valley Water User Association (WVWUA) and the Southern Arizona Water Users Association (SAWUA). Both of these associations differ from AMWUA in that they 1) do not have a separate association staff and 2) are open to non-municipal water user members like agricultural users and private water companies. We focus the network analysis on municipal providers, does play a bridging role across the West Valley providers as emphasized by their above average betweenness centrality. While the qualitative insight does not suggest that WVWUA has a strong broadcasting capacity, its primary function being technical convening of West Valley users for local information sharing, they have an equivalent closeness centrality to Phoenix, possibly brought about through the connections of their members with higher degrees. We do not closely evaluate the network metrics for SAWUA because it has a peripheral role, primarily through its members' collaborations with Phoenix in groundwater banking agreements and policy coordination with AMWUA at the state level.

According to interviews with SAWUA and WVWUA members, bridging connections across the three water user associations occur in two forms: joint membership and strategy coordination.

AMWUA cities that are located in the West Valley" (Peoria, Glendale, Avondale, Goodyear, and Phoenix) are members of both MWUA and WVWUA, but generally view AMWUA as the "number one way [they] collaborate in the valley with [their] peer cities" (West Valley AMWUA Member City). This means that cities like Buckeye and Surprise, who are members of the WVWUA but not AMWUA, are not represented in strategic policy coordination and deliberation efforts that occur primarily through AMWUA and influence key members of the WVWUA.[1] Additionally, SAWUA members, Tucson and MWD, who are not members of AMWUA, noted in interviews that SAWUA and AMWUA regularly coordinate advocacy strategies on state or regional policies to make joint support or opposition statements, among other activities. This ensures that, in state lobbying efforts, a unified Arizona municipal voice can be expressed. Tucson and MWD have partnerships with Phoenix to bank some of Phoenix's CAP allocation in their local recharge projects, but such partnerships exist between the individual cities, not between the water user associations.

5.2 Motivations for Water User Association Participation

Next, we further investigate the role of AMWUA by analyzing actors' motivations to participate in AMWUA as a key collaborative forum. We found that cities and other actors in the PMA surface water governance network are motivated by multiple reasons to participate in AMWUA. While we coded for eight types of motivations, analysis of the coded interview data revealed five dominant motivations: capacity, common goals, information sharing, deliberation, and trust.[2] AMWUA member cities are required, through membership rules, to participate in the multiple boards outlined in Section 3, but the requirement (i.) does not explain the decision to seek or sustain membership and (ii.) was not salient in the motivations articulated by AMWUA member cities in the conducted interviews. Furthermore, we analyzed ten sub-types of motivations, which are nested within the five dominant motivations and provide qualification specific to the AMWUA context. Tables 2-5 present these motivations along with representative quotes from the interview transcripts; they also and indicate the number of interview participants that expressed the motivation to give a general sense of its prevalence, though we emphasize that this quantification is inherently challenging due to the nature of the qualitative data underlying it.[3]

Critically, sharing common goals with other actors is a central motivation to participate in AMWUA. We note two categories of common goals (see Table 2): water-related and media-related. PMA surface water context consists of two key water sources that satisfy the vast majority of municipal demand – Colorado River conveyed by the CAP and Salt-Verde River conveyed by the SRP – which both have strictly defined water rights systems. Due to the common water rights context across municipal providers in AMWUA (i.e. everyone has SPR rights, in addition to CAP rights), it has been a forum for municipalities to negotiate agreements with these major bulk water providers (AMWUA Staff Transcript). Moreover, the common water sources and similar socioeconomic and demographic trends in the PMA have created common water management

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[1]Since this study focuses on surface water governance, we note that Surprise is a groundwater-dependent city that does not currently use its CAP allocation.

[2]While we coded for motivations that discussed uncertainty in supply or demand as a separate type (of the eight), we chose not to keep such motivations analytically separate because the uncertain context underlies other motivations, especially the common goal and information sharing motivations. Similarly, discussions around externalities were captured under deliberation (common policy position sub-type) and information-sharing (distribution of information from higher levels).

[3]We did not prompt interviewees with all motivation types, so some individuals may simply have failed to express a motivation that was actually present. Furthermore, some interviewees simply spoke in more detail than others and, as a result, may have discussed sub-types that other actors experience in reality but simply failed to mention in the interview.

Table 2: Motivations for Participation in AMWUA: Common Goals

Type	Sub-Type	Representative Quote	N Actors
Common Goal - Water	Water Rights	*[What] AMWUA does is to help its members protect their hard fought rights to water supplies.* (AMWUA staff)	2
	Hard Infrastructure	*AMWUA has historically ... negotiated agreements with the Salt River Project, and that includes the interconnection agreement where the canals were connected in different ways to get the city's water to their treatment plants... These are sort of broad kinds of ways in which AMWUA has aided its members and helped with the infrastructure needed to allow them to deliver this surface water.* (AMWUA staff)	7
	Water Management Challenges	*The way that I approach AMWUA is I'm willing to talk about the problems we're facing ... we've got this resource in abundance, that we would be willing to leverage, to help somebody else with something else out if it helps us with a different problem that we have, so, not just your problems, but also some of the tools you have, some of the strengths you have that others might be able to help with their problems.* (AMWUA City)	8
Common Goal - Media	Coherent Media Messaging	*Now things that are actually happening on the Colorado River ... all the media stories that are out there, and one of the things that was really important for our members was that we are speaking with a consistent collective voice, so one of the things that AMWUA has done well in the last couple of years is helping our members know how to have a consistent collective message, so, some really key or core messages about the shortage so that they can use those when they are being asked questions by the media...* (AMWUA Staff)	2

challenges that necessitate the opportunity for collective action that AMWUA provides for its member cities. For instance, one AMWUA City noted that even though they share common sources of water rights, the exact distribution of SRP and CAP rights (as a percentage of a city's portfolio) is quite heterogeneous, so AMWUA provides a means for the cities to coordinate to ensure that water supplies are efficiently used across municipalities. Even beyond water rights, many AMWUA members share hard infrastructure systems, including interconnects, water treatment and wastewater treatment plants, recharge systems, and storage infrastructure, creating deeper water management interdependencies.

Regarding common media goals, the PMA municipal providers have a collective need to communicate the status of water reliability in their shared arid context to users and decision makers. As local, regional, and national media highlight the worrying state of Southwest surface water availability, AMWUA members seek to provide a coherent message to media outlets. AMWUA Staff referenced consistent communication about the recent state of the Colorado River and AMWUA cities's municipal supply reliability as a critical common need, specifically that CAP M&I supplies

Table 3: Motivations for Participation in AMWUA: Information Sharing

Type	Sub-Type	Representative Quote	N Actors
Information Sharing	Distribute Information from Higher Levels	*We communicate a lot with AMWUA and then they kind of take that information and spread it to those AMWUA cities that are part of the organization, but I think, the things that AMWUA communicates they're not as specific to just reporting requirements, they are very granular.* (ADWR)	10
	Share Individual Perspectives on Common Issues	*I think collectively as we work on issues in the valley, [AMWUA is] a great sounding board, because you sit around the table and you hear everybody else's perspective. It's a great opportunity to really get a holistic view of a particular issue, kind of like.. the disconnect between recovery of credits in [Aquifer A], and we're pumping them out, let's just say in [City B] there's a hydrologic disconnect there, and that cannot continue to occur... that's just kind of an example per se, but those are discussions we have at AMWUA* (AMWUA City)	3
	Informal, Spontaneous Information Sharing	*In AMWUA, we can be talking about specific things and it comes out, somebody says something, oh, that's interesting, curious about that, you know, and you start a conversation that way, but it generally, they get consummated through the informal, let's go get together, let's talk about this... [Another city] just after the meeting was telling us about something that they were doing and it kind of started driving some thought process in my head and, they're going to do a formal presentation at AMWUA about that and we have gotten together to talk about how we might work together on something, kind of tangentially related to that project. It's the information sharing sometimes in a formal way that leads to things really happen in informal you know one on one basis.* (AMWUA City)	7

were not going to be affected by 2021 Colorado River Tier 1 shortages. Even though individual AMWUA cities have different water portfolios, local nuance may be lost in the explanation of regional media outlets, so common messaging is crucial to assuage worried residents.

The most common motivation to participate in AMWUA cited in the interviews was information sharing. We present this motivation in Table 3, with three sub-types: distribution of information from higher level sources to AMWUA cities, informal and spontaneous information sharing among AMWUA cities, and sharing individual city perspectives on common issues. Water resources management is an information-intensive enterprise that requires processing of information from multiple levels regarding supply, demand, regulatory expectations, and possible solution opportunities. Multiple cities and higher-level jurisdictional actors identified AMWUA as a key forum for distributing

Table 4: Motivations for Participation in AMWUA: Capacity

Type	Sub-Type	Representative Quote	N Actors
Capacity	Lobbying & Advocacy Capacity	*By advocating on member's behalf in situations where the members themselves don't have as much sway as a collective ... The state legislature is a good example, and then these larger efforts, like the 7D, or Colorado River operating terms renegotiation, those things are are where really the power of AMWUA is very impactful.* (AMWUA City)	8
	" Think Tank" for Policy Idea Creation & Development	*AMWUA does a good job at helping develop policy ideas based on the data that they have from their ten members, so if there's a particular issue that we're looking at, they'll also collect data from us that they think will be helpful for understanding the scope and the size of the problem, ... and so they have the ability to act like a think-tank and develop potential solutions, and then run them by us* (AMWUA City)	3
	Processing External Information	*I think the majority of us have a hard time attending all the different meetings, so they have staff that are able to be the analyst and digest information that I just as a municipal employee [cannot].* (AMWUA City)	4

information pertinent to all member cities through a streamlined communication channel. While an ADWR participant noted that this channel does not replace one-on-one communication between member cities and ADWR regarding specific individual reporting, municipal providers often do not have the capacity to attend all relevant water management forums and briefings, so AMWUA staff often act as a conduit to convey needed information to all member cities.

At a local level, even though the individual cities have idiosyncrasies in their water management context, multiple AWMUA cities expressed a desire to learn from the individual perspectives of each city on a common water management issue. One AMWUA city called it a " sounding board" to get a " holistic view of a particular issue." Moreover, since AMWUA consists of multiple types of board meetings, including boards of elected city officials and boards professional water managers, multiple individuals at each city are exposed to the individual contexts and shared needs of other member cities. Finally, while AMWUA is a formal convening opportunity for member cities, the majority of AMWUA cities emphasized the importance of informal and spontaneous information sharing among member cities. AMWUA brings cities together for regular meetings, but informal conversations can emerge based on serendipitous ideas or realized needs that can even evolve into formal agreements and projects.

In addition to being a convener, AMWUA affords its members multiple capacities that compel ongoing participation by its members. The most cited capacity was the collective lobbying and advocacy potential. AMWUA' s executive staff and its contracted lobbyists advocate for the shared policy agenda of member cities in state and regional forums. The state legislature, as noted by an AMWUA city in Table 4, is a notable example of such lobbying. All interview participants referencing this capacity noted that AMWUA does not advocate for a policy position that does not have unanimous agreement among member cities. Multiple AMWUA cities expressed that advo-

cating with a common voice through AMWUA affords a much stronger influence than individual city advocacy. Additionally, AMWUA cities noted that AMWUA staff provide policy and strategy development capacity akin to a "think tank" where the staff use data from all member cities to draft ideas for utility personnel that do not have the bandwidth for such solution searching. Finally, since many municipal water providers are resource and personnel strained, AMWUA staff provide an information processing capacity where they can attend external water management forums and gather information from higher level management entities like CAP, SRP, ADWR, and the Bureau of Reclamation (BoR), and summarize important takeaways for water resource managers, utility directors, and elected officials in member cities.

Table 5: Motivations for Participation in AMWUA: Deliberation & Trust

Type	Sub-Type	Representative Quote	N Actors
Deliberation	Collaborate on Shared Water Resource Management Strategies	*We share our plans in terms of our intentions... There have been recent discussions about cities that are considering whether or not they are going to activate their drought management plans. Folks have been very candid about either 'I am,' or, well, 'the city is or the city is not.' We talk about the relative merits of that, we collaborate on a number of things, we have ongoing conversations about the impacts of supply shortages because at varying levels, even though we all have different portfolios, most of the cities at AMWUA share the same water resources elements. Some might have more or less Colorado River water or more or less Salt and Verde water, but we all basically share the same water resources so we have conversations about what would be the impact of a loss of this supply or that supply, 'what would you do?' We look for opportunities to assist each other in terms of infrastructure. So it's actually a very robust collaboration and an ongoing conversation about these issues.* (AMWUA City)	7
	Arrive at Common Positions for External Forums	*AMWUA... is a unanimous consent organization so, unless we agree to something, they're not going to go out and represent it, but there's an awful lot of things that all members agree on and they can go and represent. So, they will go represent all 10 cities at the CAP board meeting. They've done, that very, very frequently. Same thing at SRP.* (AMWUA City)	7
Trust	Common Sense of Trust and "Family"	*AMWUA members have really grown, and we talk about some really good deep things and we share information. Sometimes we fight like brothers and sisters, but it is a venue where it's open and, and we all know that's more important to share and that's how we grow.* (AMWUA City)	3

The fourth type of motivation observed among interview participants for participation in AMWUA was the need to deliberate on (i.) shared strategies for water resource management among the member cities and (ii.) common policy positions to take in other Arizona water management forums. Beyond information sharing, AMWUA provides an opportunity for member cities to deliberate on common water resource management strategies. These can range from built infrastructure partnerships to common drought management policies, for instance. In fact, at the time of interviews, a salient example was the coordination of drought management plan triggers among AMWUA member cities (see Table 5). With common media messaging during periods of water shortage, cities also coordinate on the formally prescribed conditions that trigger drought management tiers in their individual drought management plans. The plans are required by state statute, but their exact definition is not. Outside of the jurisdiction of AMWUA cities, AMWUA is the primary means for member cities to deliberate on such common positions. As mentioned above, AMWUA is a unanimous consent organization, so cities much reach a shared understanding on their advocacy agenda before AMWUA staff and lobbyists can implement it.

The last type of motivation that drives participation in AMWUA gathered from our interviews is a strong sense of trust among the representatives of member cities. Participants noted a sense of familiarity between member cities brought about by repeated interaction and shared understanding of their water management context, creating a sense of "we're all in this together." In fact, multiple cities invoked family archetypes when referring to the AMWUA members. This motivation, in particular, serves as an example of a positive feedback through which the repeated interaction facilitated by AMWUA perpetuates mutual trust among members that further supports future participation, a form of bonding social capital.

6 Discussion & Conclusion

Our approach to mapping the network of PMA surface water governance offers a novel way to understand polycentric system structure and the role of collaborative forums therein. From interviews with system actors, we extracted direct connections among them that allow for computational network analysis and visualization. Furthermore, we contextualized network relationships with qualitative insights derived from the interview data. In this way, data analysis becomes a dialogue between emergent network properties and underlying qualitative insight from interview subjects. This allows us to clarify the structure of the network and the centralizing roles of crucial agents in the network, including the main bulk water providers, CAP and SRP, state water agencies, water user associations, and even individual cities (Research Question 1).

For example, CAP and ADWR were found to play central roles due to their nearly comprehensive bulk water customer base and regulatory authority, respectively, which is not surprising given that government actors often engage in multiple forum types (Lubell et al., 2014). However, PMA municipal providers cannot meet all of their water resources planning and strategic needs by engaging with those central actors alone. Instead, we found that AMWUA plays a crucial intermediate centralizing role for bridging together multiple municipal users in the PMA, as well as connecting them with higher level actors inside (ADWR, CAP, etc.) and outside (SAWUA) the PMA. AMWUA provides a crucial two-way conduit between actors of local/municipal scales and statewide or regional scales that allows for the cross-scale flow of information necessary to address water resource challenges that transcend jurisdictional boundaries (York et al., 2019).

However, as uncovered in the above presented analysis, non-AMWUA municipal providers in the PMA do not have access to this crucial bridging social capital (Berardo, 2014). Southern Arizona providers are able to link with AMWUA through SAWUA-AMWUA interactions, but

the WVWUA is only linked to AMWUA through the joint membership of certain cities (i.e., Peoria, Glendale, Phoenix). While basic network analysis would reveal this situation, the added insight of interviews with network participants revealed that such joint membership prevents the development of equivalent capacities in WVWUA because joint members perceive AMWUA to be their *primary* collaborative forum. Inclusion of current non-AMWUA members in AMWUA could grant them access to these capacities (highlighted in the Results section) and increase potential for learning in AMWUA as the participant diversity increases (Bodin et al., 2017; Mewhirter et al., 2019). On the other hand, increasing inclusion can disrupt the strength of the forum as preference heterogeneity increases (Lubell, 2013). The strong bonding social capital among AMWUA members facilitated by repeated forum interactions is multi-faceted, as depicted in the interview results, but increasing homophily (connections with similar actors) in AMWUA can prevent actors from gaining direct insight into the wider policy context and thereby reduce learning outcomes (Berardo and Lubell, 2019; Bodin et al., 2017; Mewhirter et al., 2019; Siddiki et al., 2017). Learning is an understudied function in the ecology of games literature (Berardo and Lubell, 2019), but empirical studies of diversity effects on institutional externalities in a policy network are emerging (Mewhirter et al., 2019). The AMWUA case offers a valuable opportunity to explore the relationship between inclusiveness, cooperation, and learning.

Additionally, the motivations analysis helps to elucidate the unique role of AMWUA in the PMA and the motivations that continue to animate it among its members and collaborators (Research Question 2). We find that a wide array of motivations lead network agents to participate and work with AMWUA. The PMA is situated within an arid environment that relies primarily on surface water delivered by two bulk water providers, SRP and CAP, in a shared canal system. With a large amount of common infrastructure and water sources, municipal providers feel a strong sense of shared understanding, creating common goals at the core of AMWUA (see Table 2). Such common is a commonly cited feature of successful collaborative governance regimes (Ansell and Gash, 2008). The water resources environment faces a strong degree of uncertainty in both demand and supply, but since the municipal providers largely share common contextual considerations, AMWUA provides a fruitful space to share information horizontally among cities and vertically from higher to lower governance levels in both formal and informal environments. In fact, the combination of formal and informal interactions facilitated by AWMUA speaks to the mutually-reinforcing role of formal and informal institutional mechanisms in municipal collaboration (see Park et al., 2021). AMWUA provides a formal opportunity for engagement that spurs informal interactions among cities that might then encourage further development of formal partnerships and shared infrastructures.

Moreover, AMWUA provides multiple added capacities to the water resources planning processes of its member cities, including lobbying capacity, think tank-like policy development, and processing of external information. As municipal providers are often short-staffed and the wider Arizona water policy environment is quite complex, AMWUA provides a streamlined means for municipal representation in the network within and outside PMA. This supports open deliberation on shared strategies and common policy positions among AMWUA members. In these deliberative spaces, AMWUA balances the common collaborative need for shared understanding (i.e., Ansell and Gash, 2008) to guide its external advocacy efforts while simultaneously elevating the contextual diversity in city-specific needs of its members through internal deliberative processes. The contextual diversity allows for cities to both learn from the wider municipal community in the PMA and uncover ways that their heterogeneous infrastructure portfolios can mutually support one another. This, again, points to the literature connecting collaboration, learning, and diversity, but also highlights that such diversity must be checked by the need for common policy positions to ensure that AMWUA's advocacy work remains coherent. Regarding trust, the regular interactions

facilitated by AMWUA function as a positive feedback that creates strong trusting relationships (bonding social capital) among member cities' water resources staff and elected officials that further motivate participation in the forum (see family archetypes highlighted in Table 5).

Overall, AMWUA provides a wide range of benefits to its participants that far exceed the transaction costs of participation (Lubell et al., 2017) and in fact, lower the transaction costs of other water resources forums and planning processes, creating positive institutional externalities and further entrenching its role in the network (Lubell, 2013; Lubell et al., 2017; Mewhirter et al., 2019).

6.1 Limitations & Opportunities for Further Research

The presented results are a sub-set of possible insights to be derived from our broader interview data-set, and hence the analysis pursued here possesses limitations that should be noted. Regarding the network analysis, representing rich, ongoing collaboration that is a feature of PMA water governance through reductionist techniques like adjacency matrices and their corresponding network diagrams does not fully illustrate every instance of collaborative interaction among network agents. We use the qualitative insight from our interviews to enrich the potential of the adjacency matrix, but we are careful not to offer our analysis as all-inclusive. As identified in the motivations analysis, significant collaboration in the PMA occurs through spontaneous and informal interaction, often facilitated by forums like AMWUA, but nevertheless, it is difficult to arrive at a firm picture of PMA collaboration through an adjacency matrix alone. This is precisely why the network analysis benefits from the additional support of qualitative perspectives. Future research may benefit from sub-dividing the network through multiple adjacency matrices representing various types of relationships, including hard infrastructure interdependency, formal or informal partnerships among actors, or different types of information sharing (i.e., supply information, demand information, etc.).

The integrity of the motivations analysis benefited from an open interview protocol as participants were not led to provide certain motivations of interest. They instead, spoke from their direct, re-callable experience. Of course, this creates its own limitation because it can lead to differential treatment of talkative and non-talkative participants, who respond differently to open interview questions. We attempted to remedy this challenge through probing questions that maintained the open integrity (see questions in Appendix A4) and further remind readers to take care when interpreting the number of actors mentioning any given motivation. However, this research provides a critical first step in assessing the structure of the PMA's polycentric water governance system, its key actors, and the role of collaborative forums in improving governance.

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Appendix

A1: Acronyms

Table 6: Acronyms Used

Acronym	Definition
CAWCD	Central Arizona Water Conservation District
CAGRD	Central Arizona Groundwater Replenishment District
SRP	Salt River Project
ADWR	Arizona Department of Water Resources
AWBA	Arizona Water Banking Authority
GWAICC	Governor's Water Augmentation, Innovation, & Conversation Council
GRIC	Gila River Indian Community
WMAT	White Mountain Apache Tribe

A2: Codebook

In the following four pages, we present the codebook used to process interview transcript data.

Planning Process, Protocols, & Information

Institutions
- **INST:** describes an institution relevant in the water resources planning process.
    - **INST-RULE-N:** describes a national-level formal (written) rule followed by the participant in the water resources planning process.
    - **INST-RULE-S**: describes a state-level (Arizona) formal (written) rule followed by the participant in the water resources planning process.
    - **INST-RULE-L**: describes a local-level (city) formal (written) rule followed by the participant in the water resources planning process.
    - **INST-NORM**: describes a norm followed by the participant in the water resources planning process. Norms may be formal or informal but do not contain "or else."
    - **SHSTR-INST**: describes a shared strategy followed by the participan, including goals/heuristics ("rules of thumb"). These do not contain "or else" or deontics.

Process Description
- **PROC-STEP:** describes the steps in the water resources planning process
- **PROC-NAT:** describes the nature of the water resources planning process (i.e., what the process is like - collaborative, ongoing, competitive, salient).
    - **PROC-NAT-UNC:** nature of uncertainties in the planning process.
    - **PROC-NAT-PIP:** nature of public infrastructure provider's role (i.e., city council)
    - **PROC-NAT-PI:** nature of public infrastructure agents' (i.e. utility) role
    - **PROC-NAT-RU:** nature of water users' role, including public attitudes.

Information
- **INFO-PROC:** describes how the received information is processed.
- **INFO-SHAR:** describes an instance of information sharing between two+ agent(s)
    - **INFO-SHAR-FB:** direct information sharing, federal agency & bulk water provider
    - **INFO-SHAR-FC:** direct information sharing, federal agency & city (any)
    - **INFO-SHAR-FS**: direct information sharing, federal agency & state agency
    - **INFO-SHAR-CE:** direct information sharing, city & engineering consultant
    - **INFO-SHAR-CD:** direct information sharing, city & developer
    - **INFO-SHAR-CPr:** direct information sharing, city & private water provider
    - **INFO-SHAR-ACAC:** direct information sharing, 2+ AMWUA cities
    - **INFO-SHAR-ACNC:** direct information sharing, AMWUA city & non-AMWUA city
    - **INFO-SHAR-NCNC:** direct information sharing, 2+ non-AMWUA cities
    - **INFO-SHAR-SC:** direct information sharing, state agency & any city
    - **INFO-SHAR-BS:** direct information sharing, state agency & bulk water provider
    - **INFO-SHAR-SS:** direct information sharing, 2+ state agencies
    - **INFO-SHAR-BC:** direct information sharing, bulk water provider & any city
    - **INFO-SHAR-BB:** direct information sharing, 2+ bulk water providers
    - **INFO-SHAR-WUA:** info. sharing through non-AMWUA water users association
    - **INFO-SHAR-UNIV:** information sharing involving a university (i.e., ASU)
    - **INFO-SHAR-T:** information sharing involving a tribal organization
    - **INFO-SHAR-AMWUA**: information sharing that utilizes AMWUA as a conduit.
    - **INFO-SHAR-INTRAORG:** information sharing that occurs within organizations
    - **INFO-SHAR-AG:** information sharing involving an Association of Governments
    - **INFO-SHAR-CG:** information sharing with a county government

Collaboration Structure & Roles

Forum Structure
- **FORUM:** identifies and describes a collaborative forum (non intra-organizational).
    - **FORUM-AMWUA:** describes AMWUA.
    - **FORUM-SAWUA:** describes Southern Arizona Water Users Association.
    - **FORUM-WVWUA:** describes West Valley Water Users Association.
    - **FORUM-NAMWUA:** describes Northern Arizona Municipal Water User's Association
    - **FORUM-GWAICC:** describes the GWAICC (state water policy council)
    - **FORUM-CAP:** describes CAP stakeholder meetings.
    - **FORUM-MP:** describes the management plan development meetings
    - **FORUM-GUAC:** describes the Groundwater Users Advisory Council
    - **FORUM-RPAG:** describes the Recovery Planning & Advisory Group
    - **FORUM-DCP:** describes the Drought Contingency Plan process
    - **FORUM-ARC:** describes the Arizona Reconsultation Committee
    - **FORUM-CRWUA:** describes the Colorado River Water Users Association
    - **FORUM-SROG:** describes the Sub-Regional Operating Group

Participants/People (Roles)
- **PPL:** identifies an actor that the participant collaborates with, not the same organization.
    - **PPL-N**: describes a national-level participant involved in water resources
    - **PPL-NL:** describes the role of national legislators in water resources.
    - **PPL-S**: describes a state-level (Arizona-wide) participant
    - **PPL-SL:** describes the role of state legislators in water resources.
    - **PPL-BP:** describes a bulk water provider (SRP or CAP), including CAGRD.
    - **PPL-CU:** describes a city utility participant not affiliated with the interviewee
    - **PPL-CC:** describes a city council participant
    - **PPL-CNU:** describes a non-utility (i.e., development, city manager) participant
    - **PPL-WUA:** describes water user association *staff* (i.e., AMWUA) as participants
    - **PPL-ENG**: describes an engineering or consulting company as a participant
    - **PPL-PA:** describes a professional association's (i.e. WEF, AZ Water, etc.) role
    - **PPL-PR:** describes a private water provider (i.e., private utility).
    - **PPL-TR:** describes a tribal government participant
    - **PPL-UNIV:** describes a university participant.
    - **PPL-NGO:** describes an NGO participant (includes environmental groups).
    - **PPL-DEV:** describes the role of private developers in water resources planning
    - **PPL-AG:** describes the role of the (i.e., Maricopa) Association of Governments
    - **PPL-WCD**: describes the role of a Water Conservation District
    - **PPL-FR**: describes the role of farmers
    - **PPL-PF**: describes the role of private funds
    - **PPL-CG**: describes the role of the county government

Social Capital
- **SC:** describes an instance of social capital in water resources collaborative activities.
    - **SC-BR:** describes an instance of bridging social capital (new relationships) in water resources collaborative activities.
    - **SC-BOND:** describes an instance of bonding social capital (furthering existing relationships, repeated interaction) in water resources collaborative activities.

Transitions in Collaboration

- **TRANS-COLLAB:** describes transitions in the participant's collaborative activities.
  - **TRANS-COLLAB-I:** describes collaboration effort increased
  - **TRANS-COLLAB-D:** describes collaboration effort decreased
  - **TRANS-COLLAB-SS:** describes collaboration effort staying the same

Actor Motivations & Strategies

Actor Motivations
- **MOTIV:** describes the motivation for participating in the ***collaborative forum.***
    - **MOTIV-REQ:** identifies a requirement as the reason for participating (mandatory).
    - **MOTIV-UNC:** identifies uncertainty as a reason for participating.
        - **MOTIV-UNC-SUP:** identifies uncertainty on the variability of supplies as a reason for participating.
        - **MOTIV-UNC-DEM:** identifies uncertainty on the demands as a reason for participating.
    - **MOTIV-CAPAC:** identifies capacity benefits as a reason for participating.
    - **MOTIV-TRUST:** identifies trusting relationships among actors in the collaborative forum as a reason for participating.
    - **MOTIV-CG:** identifies a common goal as a reason for participating in the collaborative forum
        - **MOTIV-CG-EFF:** identifies water scarce context and supply efficiency
        - **MOTIV-MEDIA:** identifies media salience about water scarcity
    - **MOTIV-INFO-SHAR:** identifies information sharing as a reason for participating
    - **MOTIV-EXT:** identifies other forums that benefit from participating.
    - **MOTIV-DELIB:** identifies collective deliberation as a reason for participating.

Barriers
- **BARR:** describes a barrier to participating in the ***collaborative forum***.

Satisfaction
- **SATIS:** expresses satisfaction with another agent or forum they collaborate with.
    - **SATIS-FOR:** expresses satisfaction with a collaborative forum.
    - **SATIS-CITY:** expresses satisfaction with a city (another city if participant = city).
    - **SATIS-CC:** expresses satisfaction with the city council
    - **SATIS-STATE:** expresses satisfaction with a state agency.
    - **SATIS-BWP:** expresses satisfaction with a bulk water provider.

Participation Strategies
- **PSTR:** describes a strategy for participation in a ***collaborative forum*** (not info sharing)
    - **PSTR-COLLAB-NINFO**: describes a participation strategy involving an instance of collaboration not related to information sharing (separate super code for this)

Technical Strategies
- **TSTR:** describes a technical strategy adopted or advocated by the participant
    - **TSTR-CONS:** describes a water conservation or demand management strategy.
    - **TSTR-REC:** describes a recharge and recovery strategy.
    - **TSTR-NEW:** describes a strategy based on securing new water supplies.
    - **TSTR-SHAR:** describes a strategy based on sharing existing infrastructure.
    - **TSTR-SHAR-NEW:** describes a strategy based on new shared infrastructure.
    - **TSTR-GW:** describes reliance on strong groundwater reserves.
    - **TSTR-SRP:** describes a strategy with reference to their SRP allocation
    - **TSTR-CAP:** describes a strategy with reference to their CAP allocation
    - **TSTR-WSHD:** describes a strategy based on watershed health and protection.

A3: Pre-Interview Document Analysis

Table 7: Documents analyzed (see Appendix A1 for acronym definitions)

Type	Year	Document Name	Author
Legal	2019	Arizona Lower Basin Drought Contingency Plan Framework Agreement	State of Arizona
Plan	2014	Recovery of Water Stored by the Arizona Water Banking Authority	AWBA, ADWR, CAP
Plan	2021	2021 Update: Recovery of Water Stored by the Arizona Water Banking Authority	AWBA, ADWR, CAP
Report	2020	ADWR Annual Report 2020	ADWR
Plan	2019	Fourth Management Plan: Phoenix Active Management Area	ADWR
Plan	2021	2021 Plan of Operation	AWBA
Report	2020	2020 Annual Report	AWBA
Legal	2019	Agreement to Exchange Long-Term Storage Credits Between AWBA and [Cities]	AWBA, multiple cities
Plan	2004	Arizona Drought Preparedness Plan	Governor's Drought Task Force
Report	2020	Arizona Drought Preparedness Annual Report	ADWR
Report	2020	GWAICC Annual Report	GWAICC
Report	2021	GWAICC Post-2025 AMAs Committee Issue Bief	GWAICC
Study	2012	Colorado River Basin Water Supply and Demand Study	Bureau of Reclamation
Plan	2022	2022 Strategic Plan	CAWCD Board of Directors
Legal	2017	CAP System Use Agreement	CAWCD
Plan	2015	2015 Plan of Operation	CAGRD
Plan	2019	Mid-Plan Review	CAGRD
Legal	2007	ROD: 2007 Interim Guidelines for Lower Basin Shortages and the Coordinated Operations for Lake Powell and Lake Mead	Bureau of Reclamation
Legal	2019	Lower Basin Drought Contingency Plan Agreement	Bureau of Reclamation
Plan	2021	2021 Water Resource Plan	City of Phoenix
Plan	2011	2011 Water Resource Plan	City of Phoenix
Plan	2015	Drought Management Plan	City of Phoenix
Policy	2021	Capital Improvement Program Policy	City of Phoenix
Study	2015	Salt and Verde River Reservoir System SECURE Reservoir Operations Pilot Study	SRP, Bureau of Reclamation
Public	2017	The Story of SRP: Water Power, and Community	SRP

A4: Interview Questions

The following 11 pages lay out the interview protocol and questions used.

Adam Wiechman
Sara Alonso Vicario
PI: John Marty Anderies, Ph.D.
Co-PI: Margaret Garcia, Ph.D.

Interview Questions: Mapping the "Soft" Infrastructure of Water Supply in Phoenix

<u>All Interviewees</u>

\<Begin "Identity/Consent" Recording>

Project Introduction: We are researchers from the School of Sustainability and the School of Sustainable Engineering and the Built Environment at Arizona State University conducting a study on the information networks, institutional landscape, and collaborative efforts that shape the water resources planning in the City of Phoenix. Specifically, we are interested in the way supply variability from the Salt-Verde and Colorado Rivers are understood and processed by the multiple levels of collaborating agents and decision-making venues as Phoenix, along with other Arizona municipalities, addresses potential water stress.

We are inviting you to participate in an interview that will last no more than one hour. We will now briefly touch on the information from the short consent form that we sent you.

Anonymity & Data Management Statement: If you agree to participate, we will audio record this interview to create a transcript for later analysis. You may skip any questions without any negative consequences, and you may withdraw from this study at any time. Any information gained from this interview for our analysis will be anonymized by keeping separate audio recordings for your consent statement and your actual responses to the study-related questions. All recordings will be accessible only by the researchers affiliated with this project. We will keep aggregate statistics of the total number of participants interviewed, participants per organization and per role, and number of years of experience, but we will not connect that with the content of your responses. Do you have any questions you would like to discuss with us?

If you agree to be part of the study, we ask that you verbally state your agreement for our recording.

Do you agree to be interviewed for this study and have your responses audio-recorded as outlined previously?

Q0 (2 min): Can you please provide your professional title, organization that you work for, and the number of years you have been working for that organization? You do not need to provide your name. (This will be recorded separately from the rest of the questions)

\<End "Identity/Consent" Recording>

Content Questions: Local Water Providers (i.e. Phoenix)

<Begin "Content" Recording>

Q1: From your city's perspective, what are the most pressing challenges that affect your long-term water supply?

Q2: This question will begin very broad, but there will be follow-up questions. Can you describe the water resources planning process for the city?

<Probing questions - use to follow-up if not addressed in the initial response>
   A. What are the primary goals that guide the planning process?
   B. Do these goals have specific quantitative thresholds or targets?
      a. Is there a buffer between projected demand and available supply that the city tries to achieve?
   C. What existing built infrastructure and policy considerations steer the planning process?
   D. Which parts of the water resources planning process are formally prescribed?
   E. Who does your department formally collaborate with while undergoing this planning process?
   F. How would you describe your role in that process?
   G. How has this process changed over the course of your time in this role?

Q3: What sources of information does your department consider when undergoing water resource planning?

<Probing questions - use to follow-up if not addressed in the initial response>
   A. Who provides this information?
   B. Who processes the information in your department?
   C. Specifically, how does your department gather information and make predictions on the state of the Colorado River and Salt and Verde Rivers?
   D. How frequently does this information change?
   E. What is the most important information in water resource planning?

Q4: Is the drought preparedness planning process for your city distinct from the water resources planning process? <Wait for response> If so, can you describe the drought preparedness planning process for your city?

<Probing questions - use to follow-up if not addressed in the initial response>
   A. Who is formally involved in this process?
   B. Which parts of this process are formally prescribed?
   C. How has this process changed over the course of your time in this role?

Q4.5: What sources of information does your department take into account when considering activating a water reduction stage in response to drought?

<Probing questions - use to follow-up if not addressed in the initial response>
  A. How frequently do you gather this information?
  B. Who provides this information?

Q5: How does your city collaborate with the regional and state level organizations that manage and monitor Arizona water resources to plan for changes in water availability?

<Probing questions - use to follow-up if not addressed in the initial response>
  A. What information do you share with them?
  B. What information do you gather from them?
  C. How frequently do the collaborative activities you mention occur?
  D. What is the role of AMWUA (Arizona Municipal Water Users Association) in these regional and state level collaborations?
  E. How has this changed over the course of your time in the department?

Q6: How does your city collaborate with other city water systems to plan for changes in water availability?

<Probing questions - use to follow-up if not addressed in the initial response>
  A. What information do you share with them?
  B. What information do you gather from them?
  C. How frequently do the collaborative activities you mention occur?
  D. How has AMWUA (Arizona Municipal Water User Association) helped these collaborative efforts?
  E. Has collaboration changed over the course of your time in the department? If so, how?

Q7: How does your department communicate information regarding water resource conditions and plans to the rest of your city's departments managing the water system?

<Probing questions - use to follow-up if not addressed in the initial response>
  A. How frequently is this conveyed?
  B. Does this affect other departments' decisions?

<END CONTENT RECORDING>

Q8: Is there anyone else you recommend we speak with at your organization or in the broader water resources community in Arizona or the Valley?
  A. If we contact them, can we use your name?

Content Questions: Local Non-AMWUA Water Providers (i.e. Surprise)

<Begin "Content" Recording>

Q1: From your city's perspective, what are the most pressing challenges that affect your long-term water supply?

Q2: This question will begin very broad, but there will be follow-up questions. Can you describe the water resources planning process for the city?

<Probing questions - use to follow-up if not addressed in the initial response>
   A. How would you describe your role in that process?
   B. What are the primary goals that guide the planning process?
   C. Do these goals have specific quantitative thresholds or targets?
        a. Is there a buffer between projected demand and available supply that the city tries to achieve?
   D. What existing built infrastructure and policy considerations steer the planning process?
   E. Which parts of the water resources planning process are formally prescribed?
   F. Who does your department formally collaborate with while undergoing this planning process?
   G. How has this process changed over the course of your time in this role?

Q3: What sources of information does your department consider when undergoing water resource planning?

<Probing questions - use to follow-up if not addressed in the initial response>
   A. Who provides this information?
   B. Who processes the information in your department?
   C. Specifically, how does your department gather information and make predictions on the state of the Colorado River and Salt and Verde Rivers?
   D. How frequently does this information change?
   E. What is the most important information in water resource planning?

Q4: Is the drought preparedness planning process for your city distinct from the water resources planning process? <Wait for response> If so, can you describe the drought preparedness planning process for your city?

<Probing questions - use to follow-up if not addressed in the initial response>
   A. Who is formally involved in this process?
   B. Which parts of this process are formally prescribed?
   C. How has this process changed over the course of your time in this role?

Q4.5: What sources of information does your department take into account when considering activating a water reduction stage in response to drought?

<Probing questions - use to follow-up if not addressed in the initial response>
    A. How frequently do you gather this information?
    B. Who provides this information?

Q5: How does your city collaborate with the regional and state level organizations that manage and monitor Arizona water resources to plan for changes in water availability?

<Probing questions - use to follow-up if not addressed in the initial response>
    A. What information do you share with them?
    B. What information do you gather from them?
    C. How frequently do the collaborative activities you mention occur?
    D. What is the role of collaborative water user groups in these regional and state level collaborations?
    E. How has this changed over the course of your time in the department?

Q6: How does your city collaborate with other city water systems to plan for changes in water availability?

<Probing questions - use to follow-up if not addressed in the initial response>
    A. What information do you share with them?
    B. What information do you gather from them?
    C. How frequently do the collaborative activities you mention occur?
    D. How have collaborative water user groups helped these collaborative efforts?
    E. Has collaboration changed over the course of your time in the department? If so, how?

Q7: How does your department communicate information regarding water resource conditions and plans to the rest of your city's departments managing the water system?

<Probing questions - use to follow-up if not addressed in the initial response>
    A. How frequently is this conveyed?
    B. Does this affect other departments' decisions?

<END CONTENT RECORDING>

Q8: Is there anyone else you recommend we speak with at your organization or in the broader water resources community in Arizona or the Valley?
    A. If we contact them, can we use your name?

Content Question: Regional Suppliers (i.e. SRP)

<Begin "Content" Recording>

Q1: From your organization's perspective, what are the most pressing challenges that affect long-term water supply for the water system you manage?

Q2: Can you describe the water resources planning process for your organization?
    A. How would you describe your role in that process?
    B. What existing built infrastructure and policy considerations steer the planning process?
    C. Who does your department collaborate with while undergoing this process?
    D. Are they formally involved in the water resources planning process?
    E. Which parts of the water resources planning process are formally prescribed?
    F. How has this process changed over the course of your time in the organization?

Q3: What sources of information does your agency consider when undergoing water resource planning?
    A. Who provides this information?
    B. Who processes the information in your organization?
    C. Specifically, how does your department gather information and make predictions on the state of the Colorado River and/or Salt and Verde Rivers?
    D. How frequently does this information you gather change?
    E. What is the most important information in water resource planning?

Q4: Is the drought preparedness planning process for your organization distinct from the water resources planning process? If so, can you describe the drought preparedness planning process for your organization?

<Probing questions - use to follow-up if not addressed in the initial response>
    A. What is your role in that process?
    B. What existing built infrastructure and policy considerations steer the planning process?
    C. Who does your department collaborate with while undergoing this process?
    D. Which parts of the drought preparedness planning process are formally prescribed?
    E. How has this process changed over the course of your time in the organization?

Q5: How does your organization collaborate with other regional and state level organizations that manage water resources in Arizona to plan for changes in water availability beyond your direct jurisdiction?
    A. What information do you convey to them?
    B. What information do you gather from them?
    C. How frequently do the collaborative activities you mention occur?
    D. How has this changed over the course of your time in the organization?

Q6: How does your organization collaborate with municipal water systems that receive water from the systems you manage to plan for changes in water availability?
   A. What information do you convey to them?
   B. What information do you gather from them?
   C. Does AMWUA (Arizona Municipal Water Users Association) assist the information sharing and coordinating efforts, or do you primarily engage its municipal system members (like Phoenix, Mesa, Goodyear, etc.) directly? If so, how?
   D. How frequently do the collaborative activities you mention occur?
   E. How has this changed over the course of your time in the agency?

Q7: How does your department communicate information regarding water resource conditions and planning decisions to the rest of the organization's departments managing the water system?
   A. How frequently is this conveyed?
   B. Does this affect other departments' decisions?

Q8: [For SRP Personnel] How have the watershed management practices changed over time in response to water management challenges?
   A. What information do you use to propose a change in the watershed management practices?
   B. What are the most common watershed management practices implemented in SRP (cleaning forest, dam augmentation)?
   C. When did you implement it?

<END CONTENT RECORDING>

Q9: Is there anyone else you recommend we speak with at your organization or in the broader water resources community in Arizona or the Valley?
   A. If we contact them, can we use your name?

Content Questions: State Agencies (AWBA, ADWR)

<Begin "Content" Recording>

Q1: From your organization's perspective, what are the most pressing challenges that affect long-term water supply?

Q2: Does your organization undergo water resource planning processes? If so, could you describe the organization's water resources planning process? If not, could you describe the organization's role in the water resources planning process of implicated water users?
   A. How would you describe your role in that process?
   B. What existing built infrastructure and policy considerations steer the planning process?
   C. Who does your department formally collaborate with while undergoing this process?
   D. Which parts of the water resources planning process or your role in the water resources planning process are formally prescribed?
   E. How has this process changed over the course of your time in the organization?

Q3: What sources of information does your organization consider when undergoing water resource planning?
   A. Who provides this information?
   B. Who processes the information in your organization?
   C. Specifically, how does your department gather information and make predictions on the state of the Colorado River and/or Salt and Verde Rivers?
   D. How frequently does this information you gather change?
   E. What is the most important information in water resource planning?

Q4: Is the drought preparedness planning process for your organization distinct from the water resources planning process? If so, can you describe the drought preparedness planning process for your organization? **Does your team play a role in drought preparedness planning at the state or municipal level?**

<Probing questions - use to follow-up if not addressed in the initial response>
   A. Who is formally involved in this process?
   B. Which parts of this process are formally prescribed?
   C. How has this process changed over the course of your time in this role?

Q5: How does your organization collaborate with other regional and state level organizations that manage water resources in Arizona to plan for changes in water availability beyond your direct jurisdiction?
   A. What information do you convey to them?
   B. What information do you gather from them?
   C. How frequently do the collaborative activities you mention occur?
   D. How has this changed over the course of your time in the organization?

Q6: How does your organization collaborate with municipal water systems to plan for changes in water availability?
   A. What information do you convey to them?
   B. What information do you gather from them?
   C. How does AMWUA (Arizona Municipal Water Users Association) assist the information sharing and coordinating efforts, or do you primarily engage its municipal system members (like Phoenix, Mesa, Goodyear, etc.) directly? If so, how?
   D. How frequently do the collaborative activities you mention occur?
   E. How has this changed over the course of your time in the agency?

Q7: How does your department communicate information regarding water resource conditions and planning decisions to the rest of the organization's departments managing the water system?
   A. How frequently is this conveyed?
   B. Does this affect other departments' decisions?

<END CONTENT RECORDING>

Q8: Is there anyone else you recommend we speak with at your organization or in the broader water resources community in Arizona or the Valley?

If we contact them, can we use your name?

Content Questions: AMWUA

<Begin "Content" Recording>

Q1 (5 min): From AMWUA's perspective, what are the most pressing challenges that may affect long-term water supply for the Valley?

Q2 (10 min): Can you describe AMWUA's role in the water resources planning process for its member municipalities?
   A. What is your role (as Executive Director) in that process?
   B. What existing built infrastructure and policy considerations steer the planning process?
   C. Which parts of this role are formally prescribed?
   D. How has this process changed over the course of your time in this role?
   E. Does this role for AMWUA vary across different member municipalities?
   F. Does AMWUA contribute to the water resources planning process of non-member municipalities in the Phoenix metropolitan area?

Q3 (10 min): What sources of information does AMWUA consider when crafting its water resources planning recommendations?
   A. Is there a difference between AMWUA's considerations in state venues versus municipal planning venues?
   B. Who provides this information?
   C. Who processes the information in AMWUA?
   D. Specifically, how does AMWUA gather information and make predictions on the state of the Colorado River and Salt and Verde Rivers?
   E. How frequently does this information change?
   F. What is the most important information in water resource planning?

Q4 (2-8 min): Is AMWUA's role in drought preparedness planning distinct from the water resources planning process? If so, can you describe AMWUA's role in the drought preparedness planning process for its member municipalities?

<Probing questions - use to follow-up if not addressed in the initial response>
   A. What is your role (as Executive Director) in that process?
   B. What existing built infrastructure and rules or policy considerations steer the drought planning process?
   C. Which parts of this process are formally prescribed?
   D. How has this process changed over the course of your time in this role?
   E. Does this role for AMWUA vary across different member municipalities?
   F. Does AMWUA contribute to the drought planning process of non-member municipalities in the Phoenix metropolitan area?

Q5 (10 min): How does your organization collaborate with other regional and state level organizations that manage and monitor Arizona water systems to plan for changes in water availability?

A. What information do you convey to them?
B. What information do you gather from them?
C. How frequently do the collaborative activities you mention occur?
D. How has this changed over the course of your time in the agency?
E. Specifically, in your leadership role for the Post-2025 Active Management Areas (AMAs) Committee of the Governor's Water Augmentation, Innovation, and Conservation Council, how have you combined or plan to combine the perspective of AMWUA members with non-member stakeholders?

Q6 (5-10 min): How does your organization collaborate with local municipal water systems to translate municipal needs to the state and regional organizations you engage with?

A. What information do you gather from the member municipalities?
B. Are formal meetings the primary channel of collaboration, or does AMWUA rely on informal engagement with member municipalities?
C. How frequently do the collaborative activities you mention occur?
D. How has this changed over the course of your time in the agency?

<END CONTENT RECORDING>

Q7 (2 min): Is there anyone else you recommend we speak with at your organization or in the broader water resources community in Arizona or the Valley?

B. If we contact them, can we use your name?

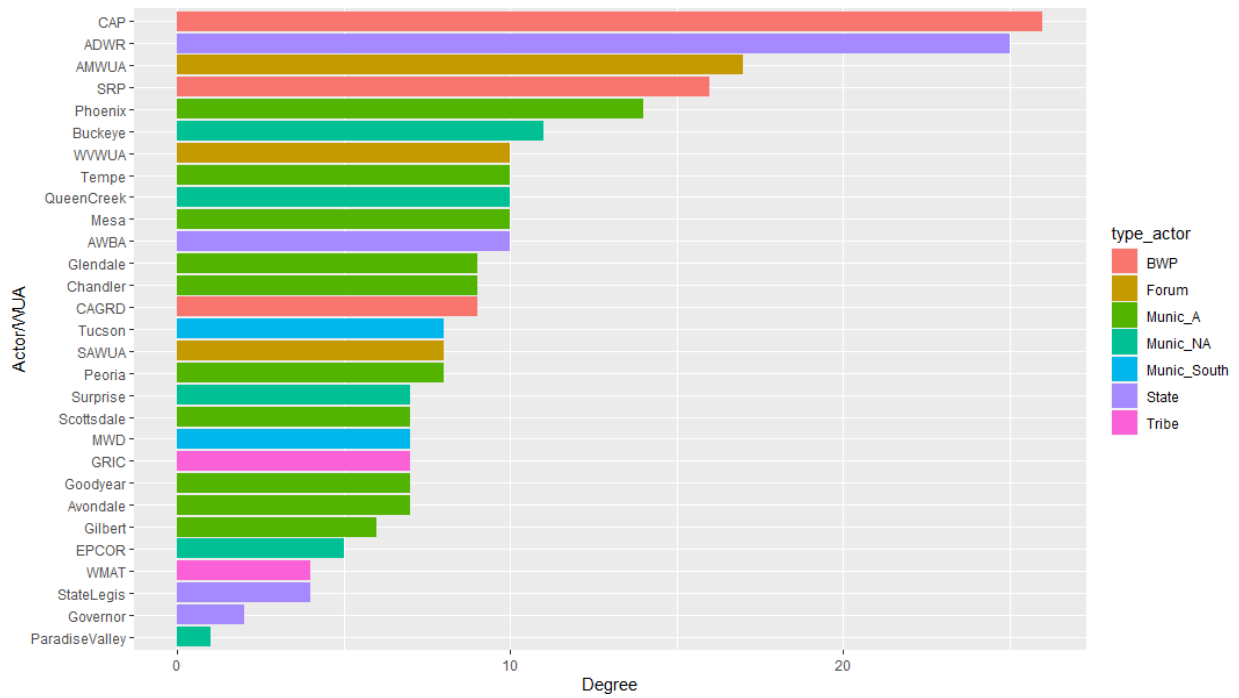## A5: Additional Network Analysis Figures

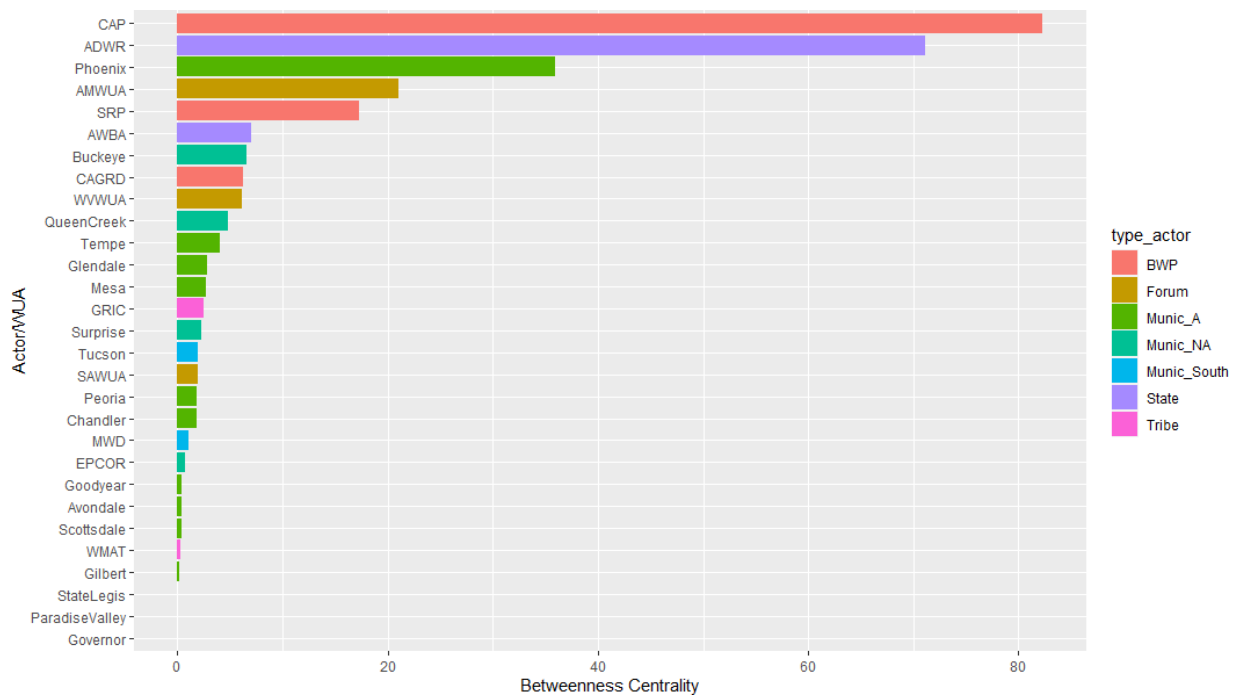Figure 4: Degrees of each node in PMA surface water governance network.

Figure 5: Betweenness Centrality of each node in PMA surface water governance network.
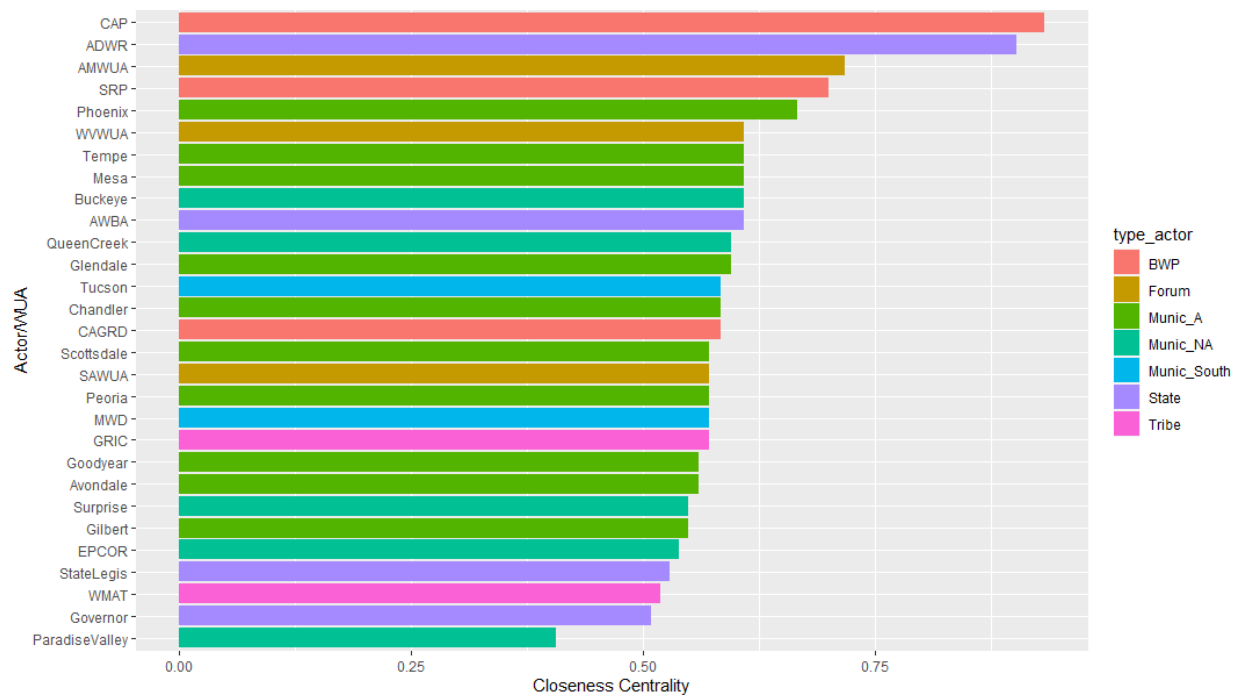
Figure 6: Closenesss Centrality of each node in PMA surface water governance network.
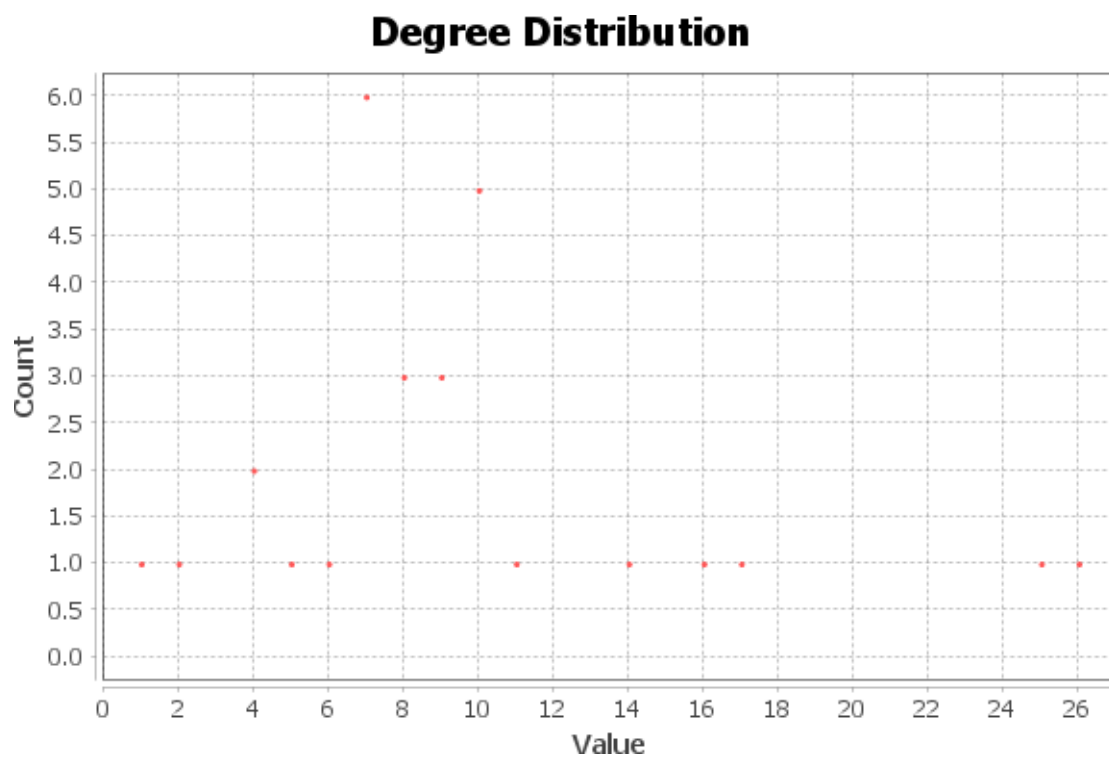

Figure 7: Degree distribution of PMA surface water governance network derived from interview transcripts.