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When overextended surface allocation turns to groundwater: a Q methodology of well users in Oregon's high desert

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As legal battles over surface water allocation in Klamath County, Oregon, USA have gained national attention, earning the name “Water Wars,” authorities have been increasingly turning to groundwater to compensate for water shortfalls. This case study aims to identify the nuanced perspectives of household groundwater well users who are affected by groundwater extraction. Using Q methodology, we uncover groundwater well users' perceptions and to what extent they think water problems are dealt with fairly. We identify four water perspectives that differ in the degree to which respondents prioritize clean water accessibility, industry accountability, individual responsibility for water management, and trust in governments to manage water competently. This research contributes to the growing body of literature reshaping our understanding of human-water relations by exploring different water axiologies.

KEYWORDS

Q methodology, groundwater, high desert, water axiologies, hydrosocial

1 Introduction

Excessive groundwater abstraction in arid regions depletes aquifers, changes hydrological flows, and disrupts rivers' biochemical processes. While groundwater policy and public attention are usually directed toward agricultural withdrawals for irrigation, overexploitation also disrupts human access to water when household wells are depressurized. Although groundwater is the world's largest source of unfrozen freshwater, global agendas have prioritized surface water until fairly recently (Saccò et al., 2024). Globally, growing attention is being paid to communities' pivotal role in sustainable water governance (Shaikh and Birajdar, 2023). Recent developments in groundwater sustainability point to the need for inclusive governance with attention to collecting data and recognizing existing cultural water values, including domestic well owner water security (Huggins et al., 2023).

Sociohydrology is the study of the bidirectional feedback loops between nature and society (Sivapalan et al., 2012). The field has become an important way to examine and uncover paradoxes—situations that seem contradictory to what is expected. A famous example is when a levee designed to prevent flooding leads to more property damage because people forget about the risk and build in areas that eventually flood when storms overcome the levees (Di Baldassarre et al., 2013). Another instance of a paradox might be

when governments that have overallocated surface water turn to groundwater to soothe inter-user conflict, which leads to more conflict when wells run dry. To date, most sociohydrological studies have only been able to model human behavior writ large, as if all social groups are equally impacted by hydrological inputs and respond in unison (an excellent exception is Savelli et al., 2021). Hydrosocial studies arising from critical human geography remind us that this is not the case. Social groups can use what power is available to them to adjust their access to water, which can be visible (e.g., lawsuits) or discrete (e.g., everyday resistance such as ignoring permitting processes). In sociohydrology, all actions are important because they feed back into the system - neglected users can cause unintended consequences when they use the system in unexpected ways. Therefore, a better understanding of *all* user groups - whether small or large, powerful or ignored - is meaningful to the overall functioning of the hydrological and, indeed, the social system.

Thinking about the coupled human-water system as a hydrosocial territory helps illuminate how actors value their relationship with water and why these differ between groups within the same waterscape. In critical geography and political ecology, the hydrosocial cycle is “a socio-natural process by which water and society make and remake each other” (Linton and Budds, 2014). This means water is not an object for politicians to hand out. Instead, changes in the hydroclimate (e.g., drought, water flows) influence human behavior while humans manipulate the waterscape through engineering. The hydrosocial argument is that an area’s unique historical and geographical context leads to equally unique water and socio-political configurations that continuously change in tandem. Whereas traditional hydrological cycles separated humans and nature and contemporary attempts to calculate human impacts on the system (external relations), the hydrosocial cycle instead regards water and social power as *constituting* -or involved in creating - things (internal relations) (Swyngedouw, 1999; 2004; 2006; 2009). Any change in the physical water, institutional assemblages, or narratives around water can lead to new human-water relations. In other words, well water users do not have to be significant in number or even very loud to change the hydrosocial territory. Everyone within the system shapes and is shaped by the water system - a change in one can lead to a change in another (Linton and Budds, 2014). Drought is one such instance when (the lack of) water disrupts social power. Disruption can often lead to reorganization - protests and lawsuits, new policies, technology investments, the rise of new political leaders, and the fall of others. Linton and Budds (2014:117) suggest that a hydrosocial analysis can answer research questions about clashes over the meaning of water. Mukherjee (2020) explains that the cyclical patterns of hydrosocial histories can help us understand how power and control over water shape our hydrocultures. Analyzed through the hydrosocial cycle, groundwater well-users might reveal essential aspects of human-water relations that may otherwise be neglected.

In this paper, we argue that there is value in identifying water axiologies—the myriad values people have concerning water (Ioris, 2012; 2013). Ioris (2012) defines water axiologies as “the contrasting meanings, preferences, and priorities among water users, interested parties, and governments.” Sen (2008) theorizes that people’s meanings of fairness and justice can be organized into three categories: utilitarian, egalitarian, and libertarian. According to

Sen, a utilitarian leaning prioritizes “maximum pleasure” or the maximum outcomes for most people. Preferences for beneficial use, where water is given to those who will use it for economic goods (e.g., commercial agriculture, mining) fall into this category. Egalitarianism is defined as reducing gaps between societal groups. Accountability for equity, affordability, and access to water can be grouped into this category. Finally, libertarian values prioritize the right for people to have what “they themselves produced.” This motivation promotes individual agency. Preferences for personal responsibility and authority fall into this category.

Stakeholder perceptions about how water resources may be allocated are important. Ioris (2013) warns that a poor assessment of the multiple meanings people hold around water leads to “ill-conceived interventions” Indeed, Green et al. (2024) argue that the lack of proper stakeholder involvement in groundwater abstraction assessment can lead to false conclusions; they show this in their examination of the Doñana wetlands in Spain where researchers erroneously claimed withdrawals were not negatively impacting Ramsar marshes. Practitioners in the Rocky Mountain West of the United States have also used Q methodology to collect subjective data from diverse water users to inform strategies around challenging and entrenched water policies (Lyn et al., 2006).

Our research leads us to the emerging topic of groundwater abstraction and the potential impacts on personal well-users. We specifically select a small-n technique, Q methodology, to illuminate differences in water axiologies among this group. Q methodology is a scientific mixed-method analytical approach that has been used in environmental studies to identify the nuances of “micro” discourses, especially to fill knowledge gaps among understudied groups (Addams and Proops, 2000, Ellis, Barry, and Robinson, 2007; Brannstrom, 2011; Parkins et al., 2015; Cotton, 2015; Walder and Kantelhardt, 2018, Sneegrass, 2021). Small purposeful sample sizes provide statistically valid results to analyze human subjectivity patterns across individuals (as opposed to demographic traits, for example, Webler et al., 2009; Stephenson, 1953). While large random samples can answer research questions around prevalence and proportion, they cannot answer questions in which the parameters are unknown, or minority opinions are important. Q methodology, on the other hand, is a technique that can answer the sorts of research questions like the ones posed in this study. Whereas surveys are used to measure the prevalence of known opinions, Q methodology is used to discover views previously unknown to researchers. After all, a strong minority can have an outsized influence on policy actions, while the vast majority might be silent on an issue (Jourdain, et al., 2023). In this section, we report on the four perspectives we found among groundwater well users.

Cowal and Leung (2021) note that narratives frame how people define problems and, therefore, solutions. The suite of possible solutions to issues grows when diverse narratives are considered. It raises crucial questions about the water perspectives of people experiencing water scarcity and how the historical and sociopolitical context might shape their narratives. This case study intervenes to reveal how water axiologies that are often conflated actually differ in nuanced ways. Research on groundwater well users is slim, but we

argue it will become more important in regions where utilities shift to aquifers to augment surface water withdrawals.

We chose a high-conflict area in which power struggles over water are rooted in centuries of watershed change. Here, we focus specifically on the headwaters in the Upper Klamath Basin to contextualize the sociopolitical history of the situation our participants find themselves in. Many researchers have investigated the implication of competition over Klamath Basin water resources for Indigenous nations (e.g., Diver et al., 2022), farmers (e.g., VanderMolen and Horangic, 2018), fish and wildlife (e.g., Benson, 2022), and institutions (e.g., Davidson, 2003). Other studies in this area focused on farmers, but household groundwater well-users are understudied. Zeroing in on domestic groundwater well-users, we use Q methodology to identify four water perspectives that emerge among well-users that differ in the degree to which respondents prioritize clean water accessibility, industry accountability, individual responsibility for water management, and trust in governments to manage water. We conclude by contextualizing these four perspectives within the context of the hydrosocial system and sociohydrology.

2 Materials and methods

2.1 Site selection

The Klamath Basin is a transboundary basin shared between Oregon, California, and Tribal governments. In this paper, we focus on Klamath County, Oregon, USA, a “high desert,” a relatively arid high-elevation region. Groundwater use is historically situated in a complex environmental, political, economic, and cultural system. Although Oregon established surface water codes as early as 1909, groundwater laws were not established until 1955 to administer permitting (Oregon Water Resources Department, 2024). Since then, water rights have been overallocated in the western United States’ *a priori* “first in time, first in rights” system to regulate surface water.

The various laws and treaties that had been established over time complicated water rights adjudication when a drought in 2001 led to conflicting claims over limited water. A Supreme Court lawsuit resulted, invoking the Endangered Species Act (ESA) to prioritize keeping water in the river for fish. Water was curtailed to Klamath Project irrigators, a loss estimated between \$37.5 and \$54 million in gross crop revenues (Jaeger, 2002). The federal government responded with \$36 million in emergency payments for irrigators (Jaeger, 2002). In response to the water shut-off, farmers staged a symbolic protest, passing buckets of water from the Upper Klamath Lake to the A canal (which supplies water to the Klamath Project). Later, the headgates were illegally breached.

The following year, the Bush Administration released full water allocation to irrigators. High-temperature water releases from the dams in 2002 were attributed to the cause of a parasitic bloom that led to the deaths of thousands of fish, especially Chinook salmon (*Oncorhynchus tshawytscha*), considered First Foods by Indigenous peoples, including the

Klamath, Modoc, and the Yahooskin Band in the Upper Klamath Basin. The national media had a field day, constructing a narrative of “farmers *versus* fish,” tearing the narrative into opposing parts without room for a middle (Doremus et al., 2003; Palomaki, 2014). Invoking antagonistic language, the Klamath Basin was deemed “the most troubled waterscape in the Pacific Northwest” (Robbins, 2004; Albertson, 2019).

The Bureau of Reclamation responded by increasing groundwater use, operating a “water bank,” and financially incentivizing farmers to use idle land (USGS, 2005). Between 2003 and 2004, groundwater pumping increased between 37% and 51% (Boehlert and Jaeger, 2010). A United States Geological Survey (USGS) study showed that agricultural wells depleted shallow wells (such as private residential wells) and had long-term impacts on regional groundwater levels (Boehlert and Jaeger, 2010). Tensions remained high. Several conflict resolution strategies were attempted, but negotiations were seen as leaving people out, with federal officials getting in the way (Gosnell and Kelly, 2010).

Years of talks (Rykbost and Todd, 2001) would set the stage for the next severe drought in 2021, worse than in 2001. Farmers were allocated 33,000 acre-feet compared to an average year of 350,000 acre-feet (Souza, 2023). Irrigation was once again shut off. The Oregon Water Resources Department began issuing emergency groundwater use permits to make up for the loss (Executive Order NO. 22-02, 2021). In November 2021, over 280 household wells went dry (Fu, 2021). A Domestic Well Financial Assistance Grant Program was implemented to help eligible well owners with the cost of deepening or drilling new wells (Klamath County, 2021). Local water managers say the surface water-groundwater connection is too complex to be treated with a general policy - the geology, evaporation rates, microclimates, and withdrawals across the state line play a role in whether one neighborhood goes dry while an adjacent neighborhood does not. Lack of staff and the “right kinds of research” are cited as barriers to developing a sustainable water use plan.

2.2 Q methodology

Q methodology was chosen due to its strength in detecting perspectives that might be obscured by louder narratives. Q methodology is a mixed methods approach that begins by systematically selecting appropriate statements to cover a spectrum of possible values coupled with systematically selecting the appropriate respondents to elicit possible value amalgamations. The respondents sort the Q statements into their preferred combinations, and these are merged and arranged into statistically distinctive value sets that show not just one view or the majority view but the multiplicity of ways people in a specific group arrange the values that form their worldview. That is to say, Q methodology allows researchers to sample a small number of respondents from a targeted demographic to uncover nuance within a population (Brown, 1996; Watts and Stenner, 2012). Smaller sample sizes are needed because the individuals’ sorts are the variables, not items (Brown

1980; Watts and Stenner, 2012). Large sample sizes introduce noise into the model and serve to complicate interpretations rather than clarify them. Therefore, the rule of thumb is to recruit fewer participants than Q statements (Stenner et al., 2008). The objective is not to represent all water users in Klamath County but to demonstrate varying meanings and values of water within like groups.

2.3 Q sample (set of statements)

This study was part of statewide research and designed to encompass important water topics for all areas but this article focuses on the Klamath County participants. The Q methodology design began with developing a “concourse,” or the Universe of topics that could be relevant. First, we analyzed over 1,000 Oregon newspaper articles covering water issues starting in 2001 (Haeffner and Cowal, 2019). Articles on local water issues were identified using a web scraper using the search term “water” and are added to each year for a total of 28 newspapers in 22 of Oregon’s 36 counties (Supplementary Material). Each article was read to ensure it met the following criteria: 1) the place of concern is located in Oregon, 2) the article describes a water-related issue, and 3) the water issue relates to a social issue (e.g., as opposed to a weather report). A linguistic analysis was performed to identify the frequency and uniqueness of water-related words in each region using AntConc (McClellan et al., 2020). Using the keywords and sentiments found in the article dataset, we generated a set of 24 representative statements. We chose six statements that represented each of the four State’s water goals of safety, economy, health, and the environment (Cowal et al. forthcoming). We embedded the Q statements with fairness and justice values (utilitarian, egalitarian, and libertarian) regarding both economic and sociopolitical values to unveil potential tensions around water access, accountability, responsibility, and authority. The statements were sent to community members across the state for feedback. The Q statements were piloted with students and community partners to perfect the wording (Cowal et al., forthcoming). The Portland State University Institutional Review Board approved the study for human subjects research (#19632218).

2.4 P-sets (participant selection)

We purposely recruited respondents (the P-set) who fit our two criteria: 1) reside in Klamath County and 2) use well water and/or maintain their own well. First, we identified someone who had been working in this county on groundwater issues (Cowal et al., forthcoming). An employee of a government agency who worked with households with wells in this area initiated contact with potential respondents. We followed up by email to schedule a time for them to complete the survey when a researcher was available to answer questions or troubleshoot technology. Out of 13 contacts, we received ten completed Q sorts.

2.5 Q sorting process

Participants completed the study using the online tools Qualtrics and Q-Perspectives[®] (Walker et al., 2018). Before sorting the Q statements, participants completed a Qualtrics survey to collect data regarding age, occupation, primary language, highest grade level, race, ethnicity, gender, and water access (demographic data will not be reported for each factor to avoid unintentional identification). In addition, respondents were asked to what extent they agreed or disagreed with the Likert-scale statements “Overall, the quality of my drinking water is good” and “Overall, the state government is doing a good job meeting my water needs.” Then, the respondents were linked to the Q sort in Q-Perspectives[®]. The participants first sorted the statements into three categories: agree, disagree, or neutral. In this step, they could put as many statements into any type as they wanted. The second step was a forced ranking in which participants had to choose to place the statement into order on a grid from +4 most agreed to -4 least agreed. Lastly, the respondents were linked to Qualtrics to complete a written follow-up survey in which participants could respond to individual Q statements and provide feedback on missing or inadequately covered water value perspectives. Participants were compensated with a \$50 e-gift card for their time.

2.6 Factor analysis

Q methodology relies on mathematically identifying factors that are used to interpret the essence of different perspectives found in the population. We used the web application Ken-Q Analysis (version 2.0.1) to perform a principal components analysis (PCA) to calculate factors (Banasick, 2023). PCA provides a guide, but in Q philosophy, researchers should examine all factors and factor loadings to ensure that the factors chosen for Varimax rotation include theoretically important insights (Ramlo, 2016). Our analysis revealed three factors with eigenvalues over 1, meaning that at least a whole variable (in this case, a participant) loaded onto that factor. However, upon closer examination, we found one participant defined 90% of their factor, indicating that they have a significantly different perspective than the other groups but were attenuated by being forced into another factor. On the other hand, we were able to capture this perspective with a four-factor solution even though the fourth factor had an eigenvalue of 0.8144. In addition, the three-factor solution included a bipolar variable, indicating they had the opposite view (a “mirror image”) of the group they loaded onto. The four-factor solution resolved this. Lastly, the four-factor solution included a Q sort that did not load significantly on any factor. We reviewed the factor arrays both with and without this person. We omitted this participant from the definition of factors to reveal clear distinctions but included them in the demographic and qualitative analyses. The factors represent a set of idealized perspectives that emerge from the sample’s Q sorts (Table 1). The four perspectives were interpreted

TABLE 1 Distinctive aspects of the four water perspectives emerged from factor analysis of Q sort results.

Factor and descriptive label	Top three most agreed statements	Top three most disagreed statements
1: Collective water justice (CWJ) A story of balance in responsibility	2. Lakes should be maintained in their natural state for the good of all 7. All people, no matter their income, should have equal access to drinking water 18. Businesses need to focus on keeping river systems clean for the good of all	9. Environmental regulations do more harm than good 10. It is more important to protect water for farmers than for fish* 19. It is worth it for industries to pollute water sometimes if they provide good jobs
2: Collective Water Affordability (CWA) A story of investing in our future	4. The impacts of climate change on access to water for all people concern me 17. We should invest in water systems that keep people healthy 22. We should make sure water is affordable for everyone	1. I care about the health of our water because of my religious or spiritual beliefs 13. Tribal nations have sovereign rights to protect the health of rivers 21. A good use of rivers is having large dams to create electricity
3: Individual Water Vigilance (IWV) A story of do-it-yourself water safety	7. All people, no matter their income, should have equal access to drinking water 17. We should invest in water systems that keep people healthy 20. I should be able to control my water use to keep me safe during a drought	1. I care about the health of our water because of my religious or spiritual beliefs 6. Cities should invest in better infrastructure to keep all homes safe during floods 19. It is worth it for industries to pollute water sometimes if they provide good jobs
4: Individual Water Control (IWC) A story of “trust me”	2. Lakes should be maintained in their natural state for the good of all 3. The government should make sure public water supplies come first in a crisis.* 20. I should be able to control my water use to keep me safe during a drought	1. I care about the health of our water because of my religious or spiritual beliefs 4. The impacts of climate change on access to water for all people concerns me 19. It is worth it for industries to pollute water sometimes if they provide good jobs

*Distinguishing statement at $p < 0.05$.

using the Z-scores, idealized Q statement arrays generated by Ken-Q, and participants' written responses to the follow-up survey. The rankings for each composite factor are reported in Table 2.

3 Results

Three out of the ten participants identified as female, with the remaining seven identifying as male. Half (50%) of the participants completed vocational school, some college, or an associate degree, and the remaining five completed a Bachelor's degree or higher. The sample included participants representing two age ranges: four people ages 30–49 and six participants ages 60–79. All participants responded that they use English as their primary language. Seventy percent identified as white only.

Most (80%) of participants said they have reasonably reliable running water in their homes. Two people also reported having water rights for irrigation. Eight somewhat or strongly agreed that their drinking water quality is good, while two somewhat or strongly disagreed. Two participants somewhat or strongly agreed that the state government is doing a good job meeting their water needs. At the same time, four somewhat or strongly disagreed with that statement, and the remaining four people were neutral.

The interpretation resulted in four overarching conceptualizations: Collective Water Justice (CWJ), Collective Water Affordability (CWA), Individual Water Vigilance (IWV), and Individual Water Control (IWC), explained below.

3.1 Factor 1 “collective water justice” (40% explained variance, eigenvalue 3.9983)

The name “*Collective Water Justice*” (CWJ) captures the defining aspect of this perspective, which is the prioritization of clean and safe water for everyone. The idealized factor that emerged ranked three egalitarian Q statements highest, focusing on all people and the good of all: “All people, no matter their income, should have equal access to drinking water” (7), “Businesses need to focus on keeping river systems clean for the good of all” (18), and “Lakes should be maintained in their natural state for the good of all” (2) (Table 1). Meanwhile, this factor ranked the following the lowest: “It is worth it for industries to pollute water sometimes if they provide good jobs” (19); “Environmental regulations do more harm than good” (9); and “It is more important to protect water for farmers than for fish” (10). This last statement is a distinguishing statement ($p < 0.01$) for Factor 1 with a ranking of -3 . This indicates a strong opposition to prioritizing agricultural water use over ecological needs, which sets Factor 1 apart from other factors.

CWJ included positive rankings of statements prioritizing government entities investing in clean, safe, accessible water for all (3, 6, 14). The focus on a collective approach to water justice is also reflected in this perspective's tendency to agree with statements about public access to clean and safe water and protecting water. A vital aspect of the CWJ perspective can be summed up as the belief that access to good water is an egalitarian collective goal “for the good of all” (6, 18) rather than one that prioritizes any industry or group over another. Participants who loaded highest on the CWJ factor lend nuance to their statistically significant distinguishing disagreement with the statement prioritizing farmers over fish (10)

TABLE 2 Perspective sorts for each factor by Q-statement. Distinguishing statements are marked where $*p < 0.05$ and $**p < 0.01$. The directionality of the Z-scores (standardization of scores) for statements compared to all other factors are marked ► higher or ◀ lower.

#	Statement	Idealized Q-sort statement position			
		Factor 1 collective water justice (CWJ)	Factor 2 collective water affordability (CWA)	Factor 3 individual water vigilance (IWW)	Factor 4 individual water control (IWC)
1	I care about the health of our water because of my religious or spiritual beliefs	-1	-4	-3	-3
2	Lakes should be maintained in their natural state for the good of all	3	1	1	3
3	The government should make sure public water supplies come first in a crisis	1	-1	-2	3
4	The impacts of climate change on access to water for all people concern me	2	4	-1**	-4** ◀
5	Landowners are capable of keeping water healthy on their own land	-1	-1	-1	2* ►
6	Cities should invest in better infrastructure to keep all homes safe during floods	1	-2	-3	0
7	All people, no matter their income, should have equal access to drinking water	4	2	3	-2** ◀
8	If you are not sure about the health of your water, it is your responsibility to get a water filter	-1* ◀	1	1	2
9	Environmental regulations do more harm than good	-3	-2	0	1
10	It is more important to protect water for farmers than for fish	-3** ◀	1	1	1
11	Private owners are better at regulating fishing than the government	-2	-2	-2	0
12	Having reliable access to clean water is worth paying for	0	2	-2** ◀	1
13	Tribal nations have sovereign rights to protect the health of rivers	2	-3	0	-3
14	Cities should raise taxes to protect their water safety	1	0	-1	-1
15	It's okay to limit public comment for stream restoration projects if it keeps costs down	-2	0	0	0
16	I should not have to pay the government for my water	0	1	2	0
17	We should invest in water systems that keep people healthy	2	3	4	2
18	Businesses need to focus on keeping river systems clean for the good of all	3	2	0	1
19	It is worth it for industries to pollute water sometimes if they provide good jobs	-4	-1	-4	-2
20	I should be able to control my water use to keep me safe during a drought	0	-1	3	4

(Continued on following page)

TABLE 2 (Continued) Perspective sorts for each factor by Q-statement. Distinguishing statements are marked where * $p < 0.05$ and ** $p < 0.01$. The directionality of the Z-scores (standardization of scores) for statements compared to all other factors are marked ► higher or ◀ lower.

#	Statement	Idealized Q-sort statement position			
		Factor 1 collective water justice (CWJ)	Factor 2 collective water affordability (CWA)	Factor 3 individual water vigilance (IWW)	Factor 4 individual water control (IWC)
21	A good use of rivers is having large dams to create electricity	-2	-3	2* ►	-1
22	We should make sure water is affordable for everyone	1	3	2	-1* ◀
23	Government money should not be spent on flood aid	-1	0	-1	-2
24	We should save money by making current water systems better instead of building new ones	0	0	1	-1

through their written comments. For example, one participant commented, “The fish were here before the farmers, and preserving our natural lands is more important,” while another responded, “No. There must be balance.” The CWJ perspective not only prioritizes clean water for human and ecological health over industry (19) but also goes a step further by agreeing that businesses should actively protect the health of waterways for the good of all (18). Additionally, we can infer that the emphasis on ecological and human health combined with a perspective that generally favors environmental regulations (9, 10, 19), suggests that the CWJ perspective believes public institutions are necessary, have a responsibility, and are capable of ensuring ecological and human health.

CWJ’s statistically significant low ranking with the statement “If you are not sure about the health of your water, it is your responsibility to get a filter.” (8) distinguishes CWJ from the other perspectives in collective *versus* individual responsibility. The CWJ focus on collective water justice is further seen in the statement regarding concern about the impact of climate change for all people (4) which contrasts starkly with Factor 4, Individual Water Control, (discussed below), a perspective which focuses on human individual agency.

3.2 Factor 2 “collective water affordability” (14% explained variance, eigenvalue 1.3984)

The name “Collective Water Affordability” (CWA) shares a collective perspective with Factor 1, but emphasizes the economically oriented perspective with concerns for the future of healthy, accessible, and affordable water for all people. The highest-ranking statements for this factor include: “The impacts of climate change on access to water for all people concern me” (4), “We should invest in water systems that keep people healthy” (17), and “We should make sure water is affordable for everyone” (22). Meanwhile, this factor ranked the following statements the lowest: “I care about the health of our water because of my religious or spiritual beliefs” (1), “Tribal nations have sovereign rights to protect the health of rivers” (13), and “A good use of rivers is having large dams to create electricity” (21) (Table 1).

Specifically, climate change is highlighted as a significant threat to water and its availability for humans (4). The CWA perspective recognizes that protecting good water for all people is essential but expresses hesitancy to fully trust the government (13, 21) to carry out this important responsibility. One of the participants who loaded highest on this factor wrote: “Both State and Federal are reactionary. No forward vision, nor would I expect any for any governmental organization which by their very essence is unaccountable.” Given the Klamath context, the fact that two of CWA’s lowest-ranked statements are that Tribal Nations should have sovereign rights to protect rivers (13) and that large dams for electricity are a good use of rivers (21) demonstrates that the Water Wars narrative of fish *versus* farmers is more complicated than the usual binary presentation seems to suggest. The CWA perspective shows that a priority for fish does not necessarily equal a priority for tribal rights.

3.3 Factor 3 “individual water vigilance” (17% explained variance, eigenvalue 1.3984)

The “Individual Water Vigilance” (IWW) perspective tells the story of “do-it-yourself water safety.” The idealized factor that emerged for Factor 3 ranked three Q statements highest: “All people, no matter their income, should have equal access to drinking water” (7), “We should invest in water systems that keep people healthy (17), and “I should be able to control my water use to keep me safe during a drought” (20). With (7) and (17) as two of its most agreed statements, IWW prioritizes water being accessible for people’s use while emphasizing the rights of individuals to access water for health and safety (20). Meanwhile, this factor ranked the following the lowest: “I care about the health of our water because of my religious or spiritual beliefs” (19), “Cities should invest in better infrastructure to keep all homes safe during floods” (6), and “It is worth it for industries to pollute water sometimes if they provide good jobs” (19) (Table 1). These low ranking statements are less supportive of more collective measures.

This perspective stands out from the others by being the only factor to put the following statement for people’s use of water in a positive position “A good use of rivers is having large dams to

create electricity” (21). Additionally, this perspective is one of the two factors that emphasizes the rights of the individual over the collective in the most positive position (20). The IWV perspective agrees that we should invest in water systems contributing to human health (17), and that all people, regardless of income, should have equal access to drinking water (7). But the IWV perspective prefers allocating responsibility for water health, safety, and accessibility protection to individuals rather than the government (6, 8, 20). One participant who loaded highest on this factor wrote, “I agree they should be shut down” concerning environmental regulations (9).

The IWV perspective is distinguished from the other perspectives in its low ranking of the statement “Having reliable access to clean water is worth paying for” (12). This perspective was the only one to negatively rank this statement. It also connects to the aversion to governmental water control; one participant explains, “No, God gave us water. It does not belong to the government.” This statement indicates additional nuances in values and beliefs because the IWV perspective negatively ranks the connection between religious/spiritual beliefs.

3.4 Factor 4 “individual water control” (8% explained variance, eigenvalue 0.8144)

The name “*Individual Water Control*” (IWC) prioritizes individual responsibility and limited government intervention, and tells the story of “trust *me*.” Inclusion of this factor, despite the eigenvalue of less than 1, provides a nuanced perspective that adds to the water axiologies in this region. The idealized factor that emerged ranked the following Q statements highest: an egalitarian statement, “Lakes should be maintained in their natural state for the good of all” (1), a utilitarian statement “The government should make sure public water supplies come first in a crisis” (2), and a libertarian statement, “I should be able to control my water use to keep me safe during a drought” (20). Meanwhile, this factor ranked more egalitarian and inclusive statements lower: “I care about the health of our water because of my religious or spiritual beliefs” (1), “The impacts of climate change on access to water for all people concerns me” (4), and “Tribal nations have sovereign rights to protect the health of rivers” (13) (Table 1).

The distinguishing statements and write-in responses lean libertarian. For example, this factor was more likely to rank “Landowners are capable of keeping water healthy on their own land” (5) higher than any other factor. This perspective sees protecting water resources that supply human communities as the top priority, with a specific concern for water control and allocation during crises such as drought. One participant who loaded highest on this factor wrote in response (3): “If I have to choose between people and nature, I will pick people every time.”

This perspective explicitly prefers that individuals have control over their own water to keep them safe during droughts (20) but also places responsibility on the government for protecting public water supplies in a drought (3). While the positive rankings of both these statements may seem contradictory, they indicate that this perspective primarily allocates responsibility for clean, safe water to individuals and only sees governmental intervention as

appropriate in water crises. The IWC preference for individuals’ rights and confidence in their competency stands out from the other perspectives in that it statistically significantly was the only one to rank positively (5) (that landowners can be trusted to keep their water healthy). The IWC’s general opposition to government control is also seen in their strong negative ranking of the statement regarding Tribal Nations’ sovereign rights to control rivers (10). The IWC’s focus on the individual can be seen by contrasting this perspective with all of the others in the following statements, for which IWC’s Z-score was statistically significant. For instance, IWC was the only factor to rank “We should make sure water is affordable for everyone” (22) and “All people, no matter their income, should have equal access to drinking water” (7) in a lower position.

4 Shared priorities and diverging values

We discovered some shared priorities when taking a closer look at the write-in responses to the post-sort survey. The goals of this section are to use qualitative analysis to find common ground that could be used to facilitate dialogue and consensus-building and to dive deeper into what respondents meant when they ranked their statements.

4.1 Shared priority: all people need access to clean drinking water

Given the evolution of human-water assemblages from conflict to collaboration described in our case study, it is unsurprising that our participants had differing conceptions about water values. However, it is important to note their similarities. Although the four perspectives (CWJ, CWA, IWV, IWC) differ in the distributions of their primary motivations (as shown by their top three Most Agree statements), all narratives affirm quantitatively or qualitatively that people need clean drinking water. For example, CWJ includes “All people, no matter their income, should have equal access to drinking water” (7) in its top three Most Agree statements. IWC explains, “There is a very small portion of the population that cannot control their income. Those persons should have access. The rest of us should take care of ourselves.” While all acknowledge that people need water to sustain life, some narratives distinguish between what they consider legitimate and illegitimate needs. One respondent added, “Drinking water, yes, but not for lawns and cars and bathing and pools and hot tubs.”

4.2 Shared priority: business and industry must be accountable

Another point of agreement in the qualitative responses across all narratives involves the responsibility of business/industry in preserving the health of the water. In response to the statement (18), “Businesses need to focus on keeping river systems healthy,” a participant associated with CWJ writes, “Absolutely. Renew ALL conservation regulations!” An IWC participant writes, “Yes, they should,” and a CWA participant

also confirms their agreement by writing, “Yes.” Another CWJ participant adds, “and pay for clean up, always.”

While the CWJ and IWV narratives are motivated by different values, both are firmly against the idea that economic considerations should take priority over clean water; e.g. (19) “It is worth it for industries to pollute water sometimes if they provide good jobs” were their three lowest ranked statements. Qualitative responses to this statement reveal that the other narratives are also firmly against the idea of prioritizing the economy over water. A CWA participant exclaims, “No, no, no,” and an IWC participant comments, “We have the ability to clean up our act. Why would we not do so?” The qualitative responses to this statement also reveal nuances associated with the CWJ narrative. While two participants express firm conviction: “not in a million years” and “never,” one participant qualifies this statement with, “There is some room for discussion here when looking at the type of pollution and effect the pollution will have on the water body. This is entirely a case-by-case scenario. Pollution types vary greatly.”

The shared priorities and perspectives articulated in the comments above may suggest that appealing to people’s more gracious instincts, common humanity, and water health may be a way to convene discussions among seemingly polarized stakeholders.

4.3 Diverging value: who has responsibility and authority and how much?

Who should be responsible and have the authority to manage water resources? The qualitative results across narratives show that answers vary based on individual *versus* collective responsibility beliefs and attitudes toward historical or traditional considerations in determining authority. Many differences and subtleties in beliefs regarding the responsibility of individuals *versus* the government emerge from the data. Responses to the statement (8), “If you are not sure about the health of your water, it is your responsibility to get a water filter,” show a range of perspectives. While IWC strongly emphasizes the individual’s responsibility, “yes it is,” CWA qualifies situations as “assuming a well which is on your property, if it is communal there should be a district or organization that has oversight.” CWJ explains, “All municipality-provided water should be safe to drink no matter what. All well water should be tested before ever being put into service. As long as it is safe to drink, the responsibility for getting rid of nuisance issues like sulfur smell often lands on the homeowner.”

The narratives express different and nuanced views regarding the responsibility and authority of the government to manage water in the first place. In response to the statement (16), “I should not have to pay the government for my water,” IWV writes, “No, God gave us water. It does not belong to the government.” One CWJ participant expresses a similar sentiment: “Water should be free for all. This is a water planet, and God gave us water to live here,” but without the focus on whom water does or does not belong to. A CWA participant appears to think the government should not be involved at all: “Don’t trust either state or federal with something of this nature.” Other CWJ responses make distinctions according to situations: “depends . . . cities with water treatment facilities, yes through taxes . . . well water, no” and “This depends largely on the condition of the water supply,

the logistics of supplying that water and what the water is being used for.”

There is a wide range of awareness about Tribal rights as a source of authority for water policy. Due to historical treaties in Oregon, Tribes have water rights. The responses to statement (13), “Tribal nations have sovereign rights to protect the health of rivers,” reveal differences in awareness of these rights and nuances of perspectives regarding these rights. Two of the four narratives (CWA, IWC) ranked this statement in their three lowest-ranked statements. An IWC participant writes, “I guess we have given them that right, but it is like most other rights it was given by the government, not by God,” and a CWA participant emphasizes, “No, no, no, no, no, what makes them smarter or more proficient given a birthright.” The other end of the spectrum is expressed in the CWJ narrative. One participant associated with CWJ explains, “The First Nation always took care of the earth first, money was not an issue, food, and clean water was most important to live good.” Other participants associated with CWJ qualify the statement: “They do have some sovereign rights and I would think this would rate high on the list” and “Yes. But those rights should not absolutely supersede other rights. There needs to be conversations and balance, but the river’s health should carry more weight in the end.”

4.4 Diverging values: trust in agency and ability to manage resources

Separate from the issue of who has responsibility and/or authority over water is the question of what entity(s) people trust to manage water resources. Who has the competency and agency to manage water? The narratives reveal a range of attitudes concerning levels of trust in individual citizens’ abilities to make and implement sound decisions. For example, in response to statement (20), “I should be able to control my water use to keep me safe during a drought,” one participant associated with CWJ seems to trust individuals to act appropriately and writes a simple “yes.” In contrast, another CWJ participant is more cynical: “Not everyone thinks of the entire community. Many people only care about themselves.” The CWA narrative expresses a similar mindset: “No, we the people are lemmings and hoarders, sad state, we are no longer selfless.”

Responses to statement (11), “Private owners are better at regulating fishing than the government,” also reveal a range of trust. A CWJ participant emphatically states, “I should think not.” A CWA participant responds, “Ahh, not sure on this.” At the same time, an IWC participant explains, “If the owner is managing the water and the fish, then they would do a much better job. What does not work is to tell a bunch of people to try and manage the same water and fish.”

Statement (5), “Landowners are capable of keeping water healthy on their own land,” elicits a range of nuanced responses. At one end of the spectrum, an IWC participant writes, “Most landowners are and would do so by their own choice given a lack of government regulations. It is too risky to try and do anything with water right now.” A CWA participant, at the other end, states, “Strongly disagree. My neighbor buys far more herbicides/pesticides, etc., etc., etc. because they want to transform their patch of soil into an oasis,” while a CWJ participant, in the middle, explains, “SOME

responsible landowners are capable. Some need to be informed on how to do so, and some just do not care at all.”

The levels of trust in the government to manage water are also wide-ranging. This is illustrated in the quantitative and qualitative responses to statement (9), “Environmental regulations do more harm than good.” At one end of the spectrum, distrust and skepticism are revealed in reactions such as “I agree they should be shut down” (IWV narrative), “oftentimes they do desire to make things better with more government almost never works” (IWC narrative), and “regulations are political more so than not” (CWA narrative). In contrast, the CWJ narrative ranks this statement as one of the lowest-ranked statements, showing that they do indeed trust that the government can make and implement good policy.

5 Discussion

Human-water systems co-evolve - humans extract water, causing shifts in water flows, which humans respond to by shifting extraction to areas of new flow, thereby again changing flows. A hydrosocial lens contributes by recognizing that some humans benefit from this arrangement while others are left out. If one were to only focus on the hydrological fluxes and flows of surface and groundwater, one would not understand why this issue from rural Oregon would go to the Supreme Court or why people would cross state borders to get involved. Water is not “merely a liquid” (Linton, 2010). As surface water was produced by ignoring certain actors over others, so too is groundwater today. Of course, there is very little difference between surface and groundwater. Groundwater can rise up out of a spring only to be absorbed into the soil rather quickly. It is through global and local markets and agricultural, energy, and urban development policies that makes knowing where water *is* and where *it is not* necessary (Barreteau et al., 2016).

Our analysis of Klamath County directed us to the emerging topic of groundwater distribution in a space where surface water allocation causes significant conflicts. The hydrosocial lens was developed from the observation that hydrological processes, like groundwater flows, are shaped by human activity, such as extraction, and that this process is socially constructed and politically mobilized (Budts et al., 2014). Water can stabilize communities when water is plentiful or disrupt them when water is scarce. The Klamath County is one example where many actors continually redefine their relationships with each other and water, impacting the hydrologic cycle. However, the poor assessment of the many water axiologies among different water users in this area has led to ill-conceived interventions (Ioris, 2013), such as supplementing surface water with under-regulated groundwater use. Building on Ioris’ work, we argue that the Water Wars narrative may change as groundwater supplies become more critical to supplement surface water supplies. In fact, there are many narratives. Even in this small dataset, quantitative and qualitative data show that nuanced values and motivations underlie well-users’ perspectives in this hydrosocial system. While the “Water Wars” narrative portrays inevitable conflict over increasingly scarce water resources, our results show that there are multidimensional sides and unclear boundaries of the water stories of Klamath County. Our results uncover complex frames, shared priorities, and other considerations that may

suggest ways to move past extremely polarized “Water Wars” discourses.

The fact that our study uncovers overlooked stories is significant for any policy that seeks to be equitable. As mentioned previously, narratives frame how people think about problems and, therefore, possible solutions (Cowan and Leung, 2021). Dominant, un-nuanced narratives in the media (and elsewhere, such as institutions) often lead to inequitable outcomes, especially for non-dominant communities whose voices are often muted or left out (Ball, 2012; Fairclough, 2013). Cowan et al. (2023) describe how media portrayals amplified some people’s stories while omitting others; this contributed to creating two different groups, resulting in inequitable material consequences.

How Klamath groundwater issues are framed and manufactured through the inclusion of narratives of some groups while omitting others demonstrates the social construction of environmental risk that is relevant to other regional and international case studies. This article briefly summarized some of the ‘political field [s] of negotiation’ (Stensrud, 2016) that contextualize water allocation in the basin today. The hydrosocial territory has been reconfigured into a narrative of water scarcity through centuries of large-scale infrastructure investment, environmental habitat degradation, and local-scale collective water governance. The state’s promotion of water extraction in this region has complicated social relations and challenged material, cultural, and ideological practices.

This study is also relevant to policy and management. Q methodology has been important for identifying stakeholder perspectives to inform water management and encourage engagement on a wide variety of water-related topics (e.g., Ching, 2020, on village people’s views of hydropower dams in Mekong; Alfie-Cohen and Garcia-Becerra, 2022, on ejido members’ views on drought resilience; Hassanzadeh et al., 2019, on agriculturalists’ view on water quality in Canada; Buckely, 2012, on farmer’s views on nitrate regulations in the Republic of Ireland; Bumbudsangpharoke et al., 2009, on farmers’ views on best management practices in Thailand, to give an idea of the breadth of work that has been conducted). As a mixed-method approach, Q methodology can be a “bridge” between qualitative and quantitative methods (Nost et al., 2019). Sociohydrologists can incorporate results with hydrological models to explore if what is hydrologically sustainable is culturally sustainable. Hydrological models have revealed numerous regions around the globe that face groundwater fluctuations due to irrigation abstraction, such as the Wadi As-Sirhan in Saudi Arabia (Alshehri and Mohamed, 2023) and the Great Artesian Basin in Australia (Kaushik et al., 2023). However, scientists also note that sustainable solutions require understanding local perspectives and engaging communities. For example, Shaikh and Birajdar (2023) call for community involvement in groundwater governance to solve over-extraction in Maharashtra, India. Q methodology can be combined with hydrological modeling to fill in the gaps left by the limitations of either method. Understanding how hydrological inputs lead to different social outcomes for different water users may prevent a new sociohydrological paradox from forming, one in which institutions solve one problem by creating another.

6 Conclusion

This analysis is a first step to understanding the water axiologies of groundwater well users in Klamath County, Oregon. We identified four

groundwater well user perspectives that value different ways of viewing fairness in utilitarian, egalitarian, and libertarian ways: Collective Water Justice (CWJ), Collective Water Affordability (CWA), Individual Water Vigilance (I WV), and Individual Water Control (IWC). We found some common ground in the qualitative analysis that may help facilitate consensus-building, especially around the topics of access to clean drinking water and business accountability. The qualitative results across narratives show that answers vary based on individual *versus* collective responsibility beliefs and attitudes toward historical or traditional considerations in determining authority and varying levels of trust in institutions to manage water resources.

The respondents in our sample are not passive users but are bound up in the hydrosocial situation they find themselves in - their axiologies are a product of sociohydrological and hydrosocial inputs. Understanding multiple perspectives in the hydrosocial waterscape contextualizes how watersheds and politics create or *constitute* the context for everyday people. Water decisions across spatial and temporal scales constrain their relations with water, impacting who they trust, how much responsibility they take, and who they consider part of their community. Our study did not support media narratives of two categories, “Us” and “Them.” Instead, there are a plethora of water perspectives in this area. These disparate perspectives regarding trust, responsibility, and agency are valuable to practitioners working to achieve consensus among polarized stakeholders. Recognizing these different narratives in the media can lead to promoting more constructive dialogue among stakeholders. We need to pay close attention to *how* people are invited (e.g., *who* is doing the inviting in the first place?), how voices are brought to the table, and how they are heard at the table, as much as *whose* voices are present.

Some limitations of this study warrant mention. Q methodology uncovers some microdiscourses from opinionated participants. It does not reveal all possible perspectives in the community. The small sample allowed us to identify groups of individuals with typical subjective constructions at the micro-level and how they relate to macro-level issues. This can provide the foundation for, but cannot take the place of, in-depth qualitative interviews or randomly sampled surveys to explore how these value patterns track across larger populations. We also narrowed our analysis to Klamath County, but the entire transboundary basin is more complex and involves many more actors - and points of conflict and consensus.

This research contributes to the growing body of literature reshaping our comprehension of human-water relations by exploring the different axiologies around water in this area. Understanding the “microdiscourses” within these spaces helps us critically reflect upon how water management decisions affect individuals (Jourdain et al., 2023). In this article, we attempted to show how water and society have been co-constructed and how stakeholders have internalized water-society relationships that are more nuanced than portrayed in the media. Our results point to separate values and concerns, often unknowingly conflated, underlying how various stakeholders may understand trust, responsibility, and agency around water management. While interconnected, these are different sentiments. It is one thing to believe an entity has the responsibility and authority to manage water. Trusting that an entity can and competently manage water is quite another. Knowing where constituents fall on this spectrum will aid practitioners in making better-conceived interventions. We risk losing sight of who people really are if we fail to recognize nuances in

perspectives. Moreover, we risk alienating those on the fringes of the conflict’s center.

Data availability statement

The raw data supporting the conclusion of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Portland State University Institutional Review Board. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

MH: Conceptualization, Formal Analysis, Funding acquisition, Investigation, Project administration, Supervision, Writing–original draft, Writing–review and editing. JC: Conceptualization, Formal Analysis, Funding acquisition, Investigation, Project administration, Writing–original draft, Writing–review and editing. BW: Formal Analysis, Methodology, Software, Writing–original draft, Writing–review and editing. CMcC: Data curation, Formal Analysis, Investigation, Writing–review and editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fenvs.2024.1398439/full#supplementary-material>

SUPPLEMENTARY TABLE S1

List of Oregon newspapers scraped.

SUPPLEMENTARY TABLE S2

Factor correlation matrix.

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