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Not a silver bullet: social perspectives on desalination and water reuse in Texas

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ABSTRACT

Climate disruptions threaten water systems and undermine economic growth in urban areas. Stakeholder perspectives for desalination and water reuse are not well known in Texas (USA) although utilities are implementing these water augmentation technologies for municipal and industrial purposes. We use a water portfolio-informed deployment of Q-methodology to identify three social perspectives: Diversification is Key, Conservation Before Desalination, and Private Sector Can Do It. We expected to find strongly supportive and opposed social perspectives, but found nuanced and contingent support for desalination and water reuse. Social perspectives were aware of the financial and political costs of desalination and reuse and did not want desalination and water reuse to reduce the importance of protecting currently sources of potable water in Texas. Cross-cutting themes include the predominance of desalination as the policy-relevant water supply alternative and concerns for human capital at levels ranging from desalination plant operators to legal experts.

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1. Introduction

Inadequate water delivery of acceptable quality increases threats to economic activities, human development, and hydrological systems in the world's growing urban regions (Larsen et al. 2016). Twenty-first century climate challenges, including reduced snowpack, increased precipitation variability, longer droughts, and stronger storms in a context of intensified water demand and increased pollution will stress 20th-century freshwater sources and systems. The number of residents in large cities exposed to water scarcity is projected to increase from 194 million to as many as 284 million by 2050 (He et al. 2021). At the same time, nearly one billion people will live in cities with perennial water shortage (annual water availability < 100 L/person/day) (McDonald et al. 2011) while 3.1 billion urban residents may confront seasonal water shortages despite continued large-scale infrastructure development (Flörke, Schneider, and McDonald 2018; McDonald et al. 2014). Texas cities are not an exception.

Climate disruptions, particularly drought, threaten water systems for urban and economic growth in Texas. Increased demand will occur at the same time as the region experiences increasingly common extreme weather, particularly severe droughts. The 2022 Texas State Water Plan argues that the state will need to supply an additional 9.5 billion cubic meters of water to meet projected demand in 2070 through a combination of measures, including developing water sources such as desalination and water reuse (Texas Water Development Board 2021). Utilities are pursuing several efforts to develop water reuse projects and marine desalination for municipal and industrial purposes.

Desalination and water reuse face different institutional, financial, and cultural barriers. The costs of implementing water augmentation strategies may fall unevenly across water users (March 2015; McEvoy 2014). Impediments to sustainable implementation include increased water prices, popular non-acceptance, lack of social legitimacy, reliance on technical expertise, pollution outflows, and energy demand and costs. Moreover, supply-led solutions unevenly impact regional water distribution and advance new business opportunities while side-lining the social and ecological value of water (Swyngedouw 2013; Swyngedouw and Williams 2016; Williams and Swyngedouw 2018). News media and public discourse help shape these views as consumer preference and public perception of desalination and water reuse influence the ability of utilities and municipal governments to undertake projects (Nemeroff et al. 2020; Al-Saidi 2021; Ormerod and Silvia 2017).

By contrast, studies on perspectives or rationalities of key stakeholders (e.g. water industry professionals, water utility managers, public officials, academics, consultants, and leaders of non-governmental and environmental organizations) who have direct bearing on water management or policymaking related to alternative water supply are less well known but critically important to understand changes in urban water portfolios (Domènech, March, and Saurí 2013; Iribarnegaray et al. 2021; Beckner et al. 2019; Strickert et al. 2016; Hassanzadeh et al. 2019; Gober et al. 2015; Bischoff-Mattson et al. 2020; Empinotti, Budds, and Aversa 2019; Romero-Lankao and Gnatz 2016). Stakeholders are important because they do critical institututional work of producing legitimacy

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for important changes in water portfolios, such as potable water reuse (Harris-Lovett et al. 2015; Binz et al. 2016). Stakeholders help produce framings of urban water security, defined by Romero-Lankao and Gnatz (2016, 47 our emphasis) as 'the *capacity of urban water actors* to maintain a sustainable availability of adequate quantities and quality of water, to foster resilient urban communities and ecosystems in the face of uncertain global change'. Stakeholders are influential in that they articulate urban water narratives, marshal resources, and leverage their role in management and policy making to maintain, shift, or transform how urban water systems operate (cf., Dobbie, Brookes, and Brown 2014). But stakeholders in urban water regimes are not necessarily aligned with uniform institutional narratives. Studies examining stakeholder perspectives illustrate how they 'decenter institutional narratives to reveal other frames and insights into the role of power dynamics' and participate as key actors in conflicts as urban water regimes change (Beckner et al. 2019, 1224–1225). Q method is well suited to empirically identify conceptual agreement (and disagreement) regardless of institutional affiliation (Robbins 2006). Rigorous analysis of perspectives on issues based on people's value priorities, rather than institutional narratives, is important to assess policies and technologies (Gilg and Barr 2006; Jones et al. 2011). Therefore, analyzing stakeholder positions on desalination and water reuse through Q method provides insights into the characteristics of key ideas that may influence decision-making and legitimacy.

Here, we examine stakeholder perspectives on desalination and water reuse in three study sites in Texas. We expected to find strongly supportive and opposed social perspectives owing to official recognition and support for desalination and water reuse to meet future demand (Texas Water Development Board 2021). Conceptually, we expected stakeholder subjectivities to reflect critical place-based factors (*c.f.*, Lee and Jepson 2020) that influence the pathways through which alternative water supplies are incorporated (or rejected) in growing urban areas as governments, industries, and utilities respond to changing water supply and demand. Therefore, we adopted a water portfolio-based approach that inquires about the wide range of desalination (brackish and marine) and water reuse options (direct potable; non-potable; indirect potable) rather than focusing on only one technical pathway. Water supply and augmentation strategies are frequently implemented together as municipalities and utilities try to respond to current and future concerns.

Our paper contributes, therefore, to the urban water security literature by examining stakeholder subjectivities as they relate to changing urban water supply portfolios critical to determining water security pathways for utilities and municipalities. By analyzing stakeholder positions on desalination and reuse, we can identify the parameters of decision-making in terms of both barriers to and opportunities for urban water security. These insights also offer policymakers an empirically grounded frame to navigate the range of options that hold value among a group of important decisions makers. Analyzing stakeholder perspectives also provides insight into sometimes overlooked consenus views for often contentious urban water policy. The legitimacy of environmental policy making can benefit from processes of consensus building and social learning informed by Q-method studies (Folke et al. 2005; Pahl-Wostl et al. 2007).

The paper first situates this research within a body of knowledge on public perception and stakeholder perspectives of water resuse and desalination. While significant work has advanced knowledge of public perception of alternative water sources, there are empirical and thus analytical gaps on stakeholder perspectives. The paper then proceeds with a description of the three case study sites then a review of the steps to execute Q-methodology, a qualitative-quantitative method of discourse analysis that measures social perspectives through factor analysis about a given topic in an empirically robust and replicable manner (Sneegas et al. 2021), to analyze stakeholder views on desalination and water reuse. The findings are organized around the description of three factors or social perspectives: *Diversification is Key, Conservation Before Desalination*, and *Private Sector Can Do It*. Although we expected to find dichotomous and contradictory social perspectives, we identified nuanced and contingent support for desalination and water reuse among three social perspectives. Our discussion addresses cross-cutting themes relevant to urban water issues. We conclude by situating our results in terms of public dialogue and policy discussions relevant to urban water security.

2. Stakeholder perspectives on desalination and water reuse

Despite the importance of stakeholder views in developing alternative water supplies for growing urban areas, limited knowledge exists regarding water reuse (Ching 2015, 2016; Ormerod 2017) and desalination (Liu, Weng, and Sheu 2018; Heck et al. 2017). Ching (2016) identified eight discourses about water reuse among Singaporean stakeholders and found that the implementation of recycled drinking water did not erase human aversion but constructed a new institutional meta-narrative about water that made drinking direct potable water more acceptable. Ormerod (2017) identified two major perspectives on water reuse across water stewards in the U.S. Southwest. While finding no clear opposition to water reuse *per se*, Ormerod (2017, 84) considered the two narratives as potentially influential 'common sense' discourses that 'favor entrenchment in our current sanitary systems' despite disagreeing about a common water future.

Focusing on experts, a narrower category than stakeholders, Harris-Lovett et al. (2015) and Binz et al. (2016) have analyzed processes essential to the production of societal legitimacy in successful implementation of potable water reuse in southern California. Related to societal legitimacy, public trust around water governance is known to affect public acceptance and willingness to use desalinated water, as shown by Fragkou and McEvoy (2016) in Mexico and Chile, and Etale et al. (2020) in South Africa and Australia.

Knowledge is much better developed regarding public preferences for unconventional water sources, especially water reuse (Smith et al. 2018; Fielding, Dolnicar, and Schultz 2018; Kunz et al. 2016; Furlong et al. 2019; Ormerod 2016; Nemeroff et al. 2020). While there are clear differences between direct potable water reuse (DPR) and indirect potable water reuse (IPR), public perception remains a critical factor for developing alternative municipal water sources (Dobbie, Brookes, and Brown 2014; López-Ruiz et al. 2020; Moya-Fernández et al. 2021). Experimental studies have determined what information results in optimal cognitive, emotional, and behavioral responses for potable recycled water implementation (Fielding and Roiko 2014). Risk perception, trust in institutions, and affective reactions are tied to negative views of recycled wastewater (e.g. the 'yuck factor') while perception of scarcity (Dolnicar and Hurlimann 2009), planning participation (Baggett, Jeffrey, and Jefferson 2006), and place-based perceptions of water consumers inform broader views of municipal water reuse (Redman, Ormerod, and Kelley 2019). Fielding, Dolnicar, and Schultz (2018, 574, 575) found that 'acceptance of recycled water decreases with increasing human contact' and '[h]ealth risk perceptions are consistently and negatively associated with acceptance'. Knowing these factors is important for policymakers because negative public perception can mobilize significant resistance that results in water reuse policy reversals (Hurlimann and Dolnicar 2010; Kemp et al. 2012).

Public perception of desalinated water is less well studied but reflects some dynamics evident in public perception in water reuse studies. On the whole, public acceptance of desalination is high, with some studies reporting more than 70% of sampled residents of nearby plants supporting desalination (Gibson et al. 2015; Heck et al. 2016). Several significant studies in Australia have delineated key variables for desalinated water acceptance, including its use for close-to-body contact (drinking, bathing), reflecting a perception that desalinated water was less risky than water reuse from a public health perspective (Dolnicar and Hurlimann 2009, 2010; Dolnicar, Hurlimann, and Nghiem 2010; Haddad et al. 2018). Research has also reported that public environmental concerns may impact acceptance (Domènech, March, and Saurí 2013; Dolnicar, Hurlimann, and Grün 2011; Heck et al. 2018). For example, Dolnicar, Hurlimann, and Grün (2011) reported the likelihood of using desalinated water and indicated that more familiarity with negative environmental impacts of desalinated water may increase the reluctance to accept it.

We respond to the knowledge gap regarding stakeholder views of desalination and water reuse through empirical study of subjectivities by focusing on a specific context, Texas, where policymakers have implemented, or are considering developing, water alternatives in a context of increasing water scarcity and dire predictions for shortages. Their view are essential to undertsand water development because they are key brokers in public and internal debate on water security strategies while also participating in framing the scope of social legitimacy for water portfolios.

3. Case studies

Federal, state, and local regulations govern desalination and water reuse in Texas (Sanchez-Flores, Conner, and Kaiser 2016). Texas uses a bottom-up approach to water planning that is coordinated regionally, with municipalities and some special districts authorized by the state to implement, organize, and finance water infrastructure strategies and technologies. The Texas Commission on Environmental Quality (TCEQ) oversees permitting and reporting requirements for water quality, water rights, injection wells, and water and wastewater discharge. Groundwater in Texas is considered private property through the rule of capture, whereby landowners may pump and use groundwater beneath their property; meanwhile, surface water is managed by TCEQ, and desalinated and reclaimed water use and discharge permitted by TCEQ. The Texas Water Development Board (TWDB) leads the state's water and infrastructure planning, which creates and administers the Texas State Water Plan every five years. TWDB also administers the State Water Implementation Fund for Texas (SWIFT), which finances loans for Texas water projects in the state water plan.

We selected El Paso and San Antonio because they have successfully implemented brackish groundwater desalination and municipal water reuse, representing the leading edge of desalination and reuse in Texas through management of existing facilities or proposals for new water augmentation and conservation infrastructure. Corpus Christi, while not a leader in water management, is the location for the largest investment in seawater desalination in five competing projects under under consideration. One proposed project would be nearly double the capacity of California's Carlsbad Desalination Plant, the largest in the United States.

El Paso (population 684,000) shares groundwater and surface water from the Rio Grande with eastern portions of New Mexico and its twin city Ciudad Juárez, Mexico (population 1.5 million). The area averages 22.8 cm of rain annually. Following a major drought in 2011, El Paso Water (the city's public water utility) initiated water conservation measures resulting in a drop in consumption from 210 gallons (795 liters) per capita per day (GPCD) in 1986 to 128 GPCD (485 liters) in 2017. The Kay Bailey Hutchison (KBH) Desalination Plant is one of the largest inland desalination plants in the world. KBH was constructed through a public–public partnership between the city of El Paso and Fort Bliss, a U.S. military base, costing $90 million. After coming online in 2007, the plant can produce 27.5 million gallons per day (104 million liters per day) of desalinated water, comprising up to 10% of El Paso's water portfolio. In terms of water reuse, El Paso treats wastewater effluent in one of four treatment plants, but not to drinking water standards. The city's reclaimed water was discharged to the Rio Grande until 1999, when the Northwest Water Reclamation Project began using reclaimed non-potable water for municipal purposes, agriculture, and construction. El Paso reclaims 100 million gallons (379 million liters) of stormwater runoff annually after adopting a stormwater master plan in 2006. El Paso Water is currently designing an Advanced Water Purification facility for direct potable reuse; following a nine-month pilot test, the city is now approved by TCEQ to design a full-scale facility with planned 10 million gallons (38 million liters) per day capacity (Maseeh et al. 2015).

San Antonio (population 1.5 million) has historically relied on the Edwards Aquifer for water. Although the city's population has grown 150% since 1985, San Antonio's public water utility, the San Antonio Water System (SAWS), has halved its total water consumption in that time from 225 GPCD (852 liters) in 1982 to 117 GPCD (443 liters) using household water conservation incentives such as tax rebates and educational programming. In 2016 SAWS completed the H2Oaks Center, a brackish groundwater desalination facility, which can produce 12 million gallons (45 million liters) per day of fresh water. The H2Oaks Center also houses Aquifer Storage and Recovery and fresh Carrizo Aquifer groundwater production facilities. Unlike KBH in El Paso, H2Oaks is entirely owned and operated by SAWS. SAWS also owns and operates the largest direct recycled water system in the U.S., which can deliver 35,000 acre-feet of water annually (43.2 million cubic meters) of non-potable recycled water to public and industrial customers. The treated wastewater is also reintroduced into the San Antonio River and used to recharge the Edwards Aquifer. SAWS recently completed a controversial $3.4 billion, 228 km pipeline transporting groundwater into San Antonio accounting for 20% of its water portfolio to further reduce withdrawal from the Edwards Aquifer (Beckner et al. 2019).

Corpus Christi (population 326,000), located on the Gulf of Mexico, has historically relied upon surface water sources stored in Lake Corpus Christi and Choke Canyon Reservoir. The city's water utility supplies 500,000 people in the surrounding Coastal Bend. Corpus Christi began importing water from Lake Texana and the Colorado River following a severe drought in the 1990s, and again with one of its worst recorded droughts between 2011 and 2013. Such extreme weather events, combined with ongoing population growth and industrial water consumption, have led to an expected doubling of the city's water consumption by 2070. As a result, Corpus Christi was selected by TWDB as the site of the first seawater desalination plant in Texas, receiving a SWIFT grant in 2017 to identify preferred facility sites. A planned facility will produce an estimated 10 to 30 million GPCD (38 to 114 million liters) to meet residential and industrial water needs. Other proposals are under consideration, making Corpus Christi a competitive location for seawater desalination investment between public and private sectors. Industrial water use is particularly salient for the city's petroleum- and liquefied natural gas-oriented port and large petrochemical complex. However, proposed desalination has been controversial among city and surrounding area residents. Main concerns include potential impacts on water rates and effects on marine life resulting from intake and brine disposal.

4. Research design

We deployed Q-method to identify how keystakeholders cluster to form distinct subjectivities (Brown 1980; Watts and Stenner 2012). Scholars have applied Q-methodology on diverse topics related to environmental governance and management because it offers evidence-based results that inform policy debates, identify policy options, and in some cases, resolve conflicts (Sneegas et al. 2021). Q-method does not assess how widely or deeply views are held in a population, but it is valuable in empirically describing and analyzing the subjective positions regarding a particular topic or domain. In Q-method, the 'variables' are purposively selected individuals with informed views about given issues. Following Q-method protocols, we purposively selected desalination and reuse stakeholders in El Paso, Corpus Christi, San Antonio, and statewide (Texas). Our selection matrix identified stakeholders in public (utility managers, state agencies), private (consulting, engineering, operation & management), and civil society sectors (NGOs, think tanks, university researchers). Statewide stakeholders represent knowledge about Texas water planning. We identified potential participants using purposive sampling, which is used to select respondents based on criteria established by researchers (expertise regarding desalination and reuse, in our case), and snowball sampling (Rapley 2014). First, we conducted 48 semi-structured interviews with 51 participants between November 2019 and October 2020. The interviews were transcribed by a third party and corrected by the research team.

Next, we developed a concourse, defined as a body of subjective statements that represent the broader discursive domain being studied, by coding the semi-structured stakeholder interviews. We also reviewed 479 news media articles relating to desalination and/or reuse in Corpus Christi, El Paso, and San Antonio published in 19 newspapers between January 2000 and May 2020. We used a codebook generated by the research team with eight *a priori* codes and one emergent code (Supplemental Table S1) in MAXQDA (VERBI Software 2021), one of several softwares used in qualitative data analysis (Gibbs 2014).

Coding resulted in an initial total of 668 statements, which the research team reduced in two iterative passes to 209 statements, then grouped by theme according to the preliminary coding pass. We then used the Miro Board online collaborative whiteboard platform (https://miro.com/) to create the final Q-set of 36 statements (Table 4) after multiple iterative passes by the research team that represented the breadth and variability of the original concourse. We piloted the final Q-set among the research team and several other researchers familiar with the topic, making final adjustments based on the feedback to improve clarity and statement length.

We drew from the first-phase interview participants to select a smaller participant group (n = 21) with representation across the sectors and subsectors described in our original p-set matrix. We used a priority matrix to maximize representation across geographic location and sector affiliation. These participants conducted Q-sorts, in which they completed a forced-choice ranking of the 36 statements (Table S2) using the following condition of instruction: 'Please sort these 36 statements based on how well they align with your views on desalination and water reuse technologies, from most agree (far right) to most disagree (far left)'.

Owing to COVID-19 social distancing and travel restrictions, we conducted the Q-sorts using online Q-TIP software (Nost, Robertson, and Lave 2019). Members of the research team asked participants to conduct the online Q-sorts while using Zoom conferencing software's screen sharing function to provide technical support. The Q-sort was followed by four questions asking participants to explain their sorting rationale. We also asked participants to identify which column best represented a 'neutral' column in their Q-sort. Virtual Q-sorts and interviews lasted between 30 and 40 minutes. Research team members recorded the online Q-sorts and post-sort interviews, which were later transcribed to provide additional qualitative data informing the interpretation.

We analyzed Q-sorts with PQMethod 2.35 (http://schmolck.org/qmethod/; last accessed 21 July 2021). Digital versions of all

Table 1. Factor characteristics.

Variable	Factors 1:Diversification is Key	2: Cautious About Desalination	3: Private Sector Can Do It
Eigenvalue	8.068	3.155	1.616
Percentage of variance explained	38	15	8
Number of defining sorts	11	6	3
Average relative coefficient	0.8	0.8	0.8
Composite reliability	0.978	0.960	0.923
Standard error of Factor Z-scores	0.149	0.200	0.277

individual Q-sorts and factor exemplars were generated using Ken Q Analysis version 0.11.1 (shawnbanasick.github.io/ken-q-analysis/). Input files for PQMethod were generated with Ken Q Data version 1.0.3 from Excel files containing response data. All available Q-software packages perform at least the following three basic statistical processes: calculation of the correlation matrix, extraction and rotation of significant factors by principal components analysis, and definition of a set of values for each model factor.

Three members of the research team completed factor analysis separately, then compared results before determining the final analysis. Using Principal Component Analysis, we extracted eight unrotated factors, with each factor representing a shared perspective among the study participants. The team compared the results of two to five-factor solutions (each rotated using Varimax orthogonal rotation to maximize the explained variance) using a combination of differentially weighted criteria before arriving at a three-factor solution as the most robust empirical solution (Table S3). We interpret the three factors (Table 1, Table 2, Table 3) as social perspectives by relying on statistically significant ($p < 0.05$) and highly significant ($p < 0.01$) 'distinguishing' statements. References to non-significant statements are included only to reinforce each factor's narrative description. We use initial semi-structured interviews and post-sort interviews (Table 2) to interpret the social perspectives.

We also estimated the salience ascribed by the factors to the nine themes in which our 36 statements were grouped (4 statements per theme) (Table S4). We calculated salience by adding the Z-scores of the statements in each theme as absolute values and normalizing the sum to the number of statements in that theme. We then calculated the mean absolute Z-score per theme. Normalization allows for comparisons across themes and is one way of validating their inclusion in the study in the first place. Being related to the absolute value of the Z-scores, salience is an indication of the extent to which participants agree and/or disagree with a specific theme as a whole. Salience is often unreported in Q-methodology studies (Sneegas et al. 2021), but can help better understand the underlying rationale behind each social perspective (Webler et al., 2009). Themes with low salience may have been less relevant to the stakeholders interviewed in this study or could have been overshadowed by other, more urgent topics in the local context.

5. Social perspectives

Below we report our interpretations of three factors: (1) *Diversification is Key* (Factor 1); (2) *Conservation Before Desalination* (Factor 2); (3) *Private Sector Can Do It* (Factor 3). Table 4 presents factor scores and values for each statement in the Q-set.

5.1 *Factor 1: diversification is key*

Diversification is Key (F1) encompasses the idea that desalination and water reuse are important components in a suite of possible solutions for supporting urban water security including conservation, demand management, and improved storage. Rather than offering unambiguous and unreserved endorsement of desalination and reuse, this social perspective qualifies support using a particular notion of water security and

Table 2. Respondent affiliations and correlations with extracted factors (*indicates defining sort).

Respondent ID	Sectoral Affiliation	Diversification is Key	Cautious About Desalination	Private Sector Can Do It
08EP	Public utility	0.8461*	0.0622	−0.0264
10TX	University or research center	0.8271*	0.0762	0.2685
07TX	Private sector (engineering, consultancy, or services)	0.7577*	−0.0301	0.1155
15SA	Public utility	0.7309*	0.1998	0.3299
12TX	State water agency	0.7309*	0.1794	0.1623
02EP	Public utility	0.7122*	−0.0212	−0.0955
09SA	Public utility	0.6987*	0.2592	0.3246
06TX	Private sector (engineering, consultancy, or services)	0.6461*	0.1532	0.4432
18CC	Public utility	0.6033*	−0.0836	0.2353
20EP	Public utility	0.5376*	0.4689	0.2163
21TX	Private sector (engineering, consultancy, or services)	0.4031*	0.2814	0.2465
04SA	Public utility	0.0579	0.8597*	−0.0706
19TX	Nonprofit (water or conservation)	0.0129	0.8104*	−0.1977
05TX	Nonprofit (water or conservation)	0.0876	0.7837*	0.0771
03EP	University or research center	0.3667	0.7681*	0.2486
01EP	University or research center	0.0699	0.7013*	0.3146
13CC	University or research center	−0.0179	0.5819*	0.1881
14TX	Private sector (engineering, consultancy, or services)	0.1642	−0.1048	0.8466*
17CC	Private sector (engineering, consultancy, or services)	0.1197	0.1789	0.7529*
11CC	Private sector (engineering, consultancy, or services)	0.3475	0.2514	0.5737*
16CC	Private sector (engineering, consultancy, or services)	0.5597	0.1897	0.5797

Table 3. Correlations between factors.

Factors	Diversification is Key	Cautious About Desalination	Private Sector Can Do It
Diversification is Key	1	0.2702	0.4278
Cautious About Desalination	0.2702	1	0.1289
Private Sector Can Do It	0.4278	0.1289	1

keen awareness of the imperative of securing public support before, not after, launching a project. *Diversification is Key* had the lowest scores, compared to other factors, for statements that raised questions about desalination. Statistically significant statements distinguishing this factor include the claim that 'Diversification, not desperation, is our motivating factor when it comes to water supply' (No. 36; z = 1.90, $p < 0.01$). This statement was neutral or slightly negative for Factors 2 and 3 (z = 0.24 and z = –0.17, respectively).

Qualitative data from the range of respondents across sites, including public utility, private sector, and state water agency representatives, who loaded on this factor (Table 2) indicate the contours of the idea that diversified water supply is foundational to water security in Texas. One respondent defined water security as 'making sure you have an adequate water supply for your community' because 'one of the biggest threats to that is only relying on one source of water' (08EP; F1 = 0.8461). Another respondent argued for the need for a 'diversified portfolio of water supply projects [to mitigate] the potential impacts of a drought' (15SA; F1 = 0.7309). One participant who loaded on this factor supported DPR as part of their diversification strategy, claiming that 'Having a pocket of many sources to choose from … that's the motivating factor for us … especially for direct potable reuse' (08EP; F1 = 0.8461).

For *Diversification is Key*, an *a priori* solution to impeding water supply challenges was absent. Rather, views of alternative water sources were contingent on how it achieved diversified goals and public acceptance. This comes into sharper focus on responses related to desalination. *Diversification is Key* strongly supported a statement indicating that 'political leaders supporting desalination need to have public buy-in from the beginning' (No. 22, z = 1.14, $p < 0.01$) and opposed two statements that describe desalination as 'our only option' (No. 10, z = –0.83, $p < 0.01$), disagreeing with the idea that desalination creates a 'reliable supply of water … so that you don't have to worry about competition from someone else' (No. 11, z = –0.95, $p < 0.05$). Support for desalination is evident in significant statements regarding benefits of desalination for industry ('they won't have to shut down production during droughts' [No. 21, z = 0.86, $p < 0.01$]) and the idea that desalination '[eliminates] your barriers to water security' (No. 24, z = 0.28, $p < 0.01$). Support for desalination was partial and contingent, rather than unambiguous, as evidenced by the negative ranking for claims: 'Desalination is not a get out of jail free card for unfettered economic growth' (No. 4, z = –0.69, $p < 0.01$) and the admission of 'economic risks with desalination … It can exacerbate social inequalities in a community and create marginal hardship on ratepayers' (No. 7, z = 0.018, $p < 0.01$).

Diversification is Key ranked many water reuse statements with relatively low Z-scores, indicating either neutrality or indifference. This confirms that this social perspective prioritizes flexibility in water portfolios. For example, *Diversification is Key* respondents sorted the statement 'We're fortunate in Texas that there are no state Direct Potable Reuse standards. It's just a case-by-case situation' (No. 16, z = –0.09, $p < 0.01$) higher than the other factors. One loader on this factor agreed that 'there are some [reuse] regulations that can impede projects from happening' (08EP; F1 = 0.8461). Another respondent explained, 'It's best to regulate the outcomes rather than regulate how you get to the outcome … If the federal government dives in, they could then start regulating the pathway to the outcome, and then that actually becomes problematic [and] less efficient' (10TX; F1 = 0.8271). From this perspective, Texas' regulatory vacuum for DPR helps make the state more 'nimble' (07TX; F1 = 0.7577) in terms of options available for utilities and municipalities to chart their own path to sustainable water solutions.

5.2 Factor 2: conservation before desalination

Conservation Before Desalination (F2) is defined by statistically significant statements questioning the wisdom of prioritizing desalination over other technologies and actions such as conservation, wastewater recycling, or groundwater replenishment. This social perspective is strongly opposed to using desalination to encourage additional urban or suburban growth. This factor, the most cautious of all factors towards desalination, argues that Texas lawmakers should evaluate and implement water conservation measures before desalination. While positively correlated with the other factors, indicating that it is not wholly opposed to desalination, this factor does not take an unequivocally positive view of desalination as a solution to Texas water problems and is less agnostic about a pathway for securing water than 'Diversification Is Key'. The characteristics of the loaders, who included a utility firm representative and researchers across sites (Table 2), on this factor suggest that stakeholders can represent industries promoting desalination while also recognizing that it cannot be the definitive solution to the many water issues facing Texas municipalities and utilities.

A statement emphasizing 'conservation and demand management' as ways to 'stretch water supplies' instead of desalination and reuse was positive and significant (No. 3, z = 1.85, $p < 0.01$). For comparison, Factors 1 and 3 ranked this statement as negative (z = –0.79 and z = 0.30, respectively). As one respondent explained, 'It's cheaper to try to practice more water conservation to reduce our demand than it is to just keep adding sources … whether it's desalination, aquifer recharge, importing water, even direct potable reuse. All of these things are very expensive' (01EP, F2 = 0.7013). The claim that 'Desalination is not a get out of jail free card for unfettered economic growth' (No. 4, z = 1.91, $p < 0.01$) also received strong support. This statement acknowledged that desalination was technologically feasible, but would support 'unconstrained growth [that] creates other water problems down the road'. Although this statement might appear to suggest opposition to desalination, it refers more specifically

Table 4. Factor scores (Z) and values (V) for each statement. Significant ('distinguishing') statements for each factor indicated for p < 0.05 (*) and p < 0.01 (**). Z scores in standard deviations. Consensus statements indicated with **C.**

		Diversification is Key		Cautious About Desalination		Private Sector Can Do It	
Theme	Statement	Z	V	Z	V	Z	V
Water Security	4.Desalination is not a get out of jail free card for unfettered economic growth. We can technologically solve our water supply problem but unconstrained growth creates other water problems down the road.	−0.69 **	−1	1.91**	4	0.52**	1
	17. If the ultimate objective is reliable, sustainable, and drought-proof water, there's only one technology that checks those boxes indefinitely, and that's desalination.	−0.13	0	−2.09**	−4	0.09	0
	18. There is never water security in the sense that you have enough water. There will always be demands on water. You are always chasing a little bit more water even with desalination and water reuse in place.	1.29	3	0.97	2	−0.30**	−1
	24. When you introduce desalination, I think that you eliminate your barriers to water security. If you start producing water, you've eliminated the biggest barrier to water security.	0.28 **	1	−1.29	−2	−0.95	−2
Water Systems	3. Rather than implementing reuse and desalination, we should carefully consider how much conservation and demand management can stretch water supplies.	−0.79	−2	1.85**	4	−0.30	−1
	9. The biggest long-term water concern for Texas cities is not finding new sources of fresh water like desalinated or reclaimed water, but protecting the sources Texas cities already have. **C** (P > 0.01)	0.17	1	0.63	2	0.34	1
	20 Farmers would rather see cities use more desalination because if cities stop using so much of the fresh groundwater, it is freed up for farmers to use.	−0.13	0	−0.86*	−2	−0.13	0
	36. Diversification, not desperation is our motivating factor when it comes to water supply. That's why we should pursue desalination and water reuse.	1.90 **	4	0.24	0	−0.17	−1
Governance regulatory Environment	6. Managing desalination and water reuse has to include building trust and relationships with the community. If you lack credibility, nobody's going to care what you have to say.	1.96	4	1.02*	2	1.85	4
	15. TCEQ permits are woefully inadequate for considering the environmental impacts of desalination. They assume every proposed site is the same and that's just not the case.	−0.86 **	−2	0.28**	0	−1.81**	−4
	23. Government has to play a primary role in delivering desalinated water. There are too many risks associated with private water suppliers. Companies come and go. Government tends to be more long lasting. **C** (*P* > 0.01)	0.26	1	0.57	1	−0.12	0
	26. I think there's a critical regulatory role in the continuous monitoring for quality control for water reuse to maintain public trust to be able to reuse the water for drinking water purposes.	1.12	2	0.45	1	0.78	2
Barriers and Risks	7. There are economic risks with desalination. If it's not well thought out or it's in the wrong place, it can exacerbate social inequalities in a community and create marginal hardship on ratepayers.	0.18 **	1	1.16	3	1.42	3
	28. The private sector is better suited for running desalination because it has workforce experiences that municipal governments do not have.	−1.39	−3	−1.33	−3	1.55**	3
	30. Municipal utilities are subject to the political whims of the city council, and have a difficult time making long-term investments required for water reuse and desalination.	−0.10	0	0.57	1	0.09	0
	33. There's not a lot of communication between the engineers and environmental scientists around how to best implement seawater desalination because they don't necessarily look at problems the same way.	−0.08	0	0.31	1	−1.03**	−2
Promoters and Facilitators	2. To afford the water projects needed for long-term resiliency, we have to bring in Public-Private Partnerships for desalination projects.	−0.60	−1	−0.26	−1	1.71**	3
	11. The benefit of brackish desalination is that it is a reliable supply that no one else can use so you don't have to worry about competition from someone else.	−0.95 *	−2	−1.56*	−3	0.17**	1
	14. Non-potable recycled water is certainly superior to using drinking water to irrigate grass. It would be better to utilize this resource than further burden the potable water system.	1.48 *	3	0.88	2	0.56	1
	22. Political leaders supporting desalination need to have public buy-in from the beginning.	1.13 **	3	−0.03	0	0.05	0
Technological Transitions and Pathways	5. Resource recovery of concentrate is an opportunity that opens up with desalination. Rather than wasting it, concentrate can be turned into something and sold.	1.11	2	−0.45**	−1	0.77	2
	10. It's never going to rain enough in Texas for us to depend on water reservoirs so our only option is to go with desalination.	−0.83 **	−2	−1.76**	−4	0.21**	1
	16. We're fortunate in Texas that there are no state Direct Potable Reuse standards. It's just a case-by-case situation.	−0.09 **	0	−1.33	−3	−1.07	−3
	25. A centralized water system can't capture demand growth on the fringes of urban areas. Decentralized water reuse systems are more efficient. They capture and treat water close to the point of the origin as possible. **C** (*P* > 0.01)	−0.22	−1	0.31*	1	−0.56	−2
Cost Value Nexus	8. There is a need for more regionalization when it comes to investments in water. Urban areas have the population base to afford desalination and water reuse projects, but rural communities lack that ability.	0.55 *	1	−0.09*	−1	1.76**	4
	13. Rolled into the cost of desalination is certainty. It is the only drought proof source of water that you have. So, you're paying for that premium.	0.03 *	0	−0.97**	−2	0.77*	2
	27. Rate increases are needed to help us cover the rising costs associated with delivering a sustainable water supply using desalination and reuse technologies today and for years to come.	1.00	2	0.18	0	0.39	1
	29. The public is not provided the real information about the threats and the costs of desalination.	−1.80	−4	0.43**	1	−1.67	−3

(*Continued*)

Table 4. (Continued).

Theme	Statement	Diversification is Key		Cautious About Desalination		Private Sector Can Do It	
		Z	V	Z	V	Z	V
Climate Change and Sustain-ability	19. Environmental interests should not be a speed bump for desalination projects or viewed as a delay that will cost developers money. Environmental concerns should be listened to and incorporated into the plans. **C** (P > 0.01)	1.09	2	1.19	3	0.73	2
	31. Seawater desalination intake and discharge should come from further off-shore in the Gulf. An intake and brine discharge system in the bay would be devastating to the ecosystem.	−0.29*	−1	0.25*	0	−1.50**	−3
	32. A misconception about water reuse is that it's a path toward resiliency. Yet, if an upstream city reuses 100% of water from their treatment plant, it could dry up a downstream river. **C** (P > 0.05)	−0.35	−1	−0.08	−1	−0.34	−1
	34. There are no positives to seawater desalination. It's destructive to the ecosystem, extractive and exploitative with negative externalities that are horrible for the natural environment.	−1.89	−4	−1.16**	−2	−2.23	−4
Industry Role	1. I'm skeptical when our leaders say, 'We have to have this desalinated water for our community'. I think that's a pretty loose usage of the word 'community'. Basically they mean it's for industry.	−1.38	−3	0.04*	0	−0.77	−2
	12. Long-term water reliability through desalination comes at a higher cost, but there is an issue of equity when current residents are subsidizing future growth and development that isn't their fault.	−0.72	−1	1.19**	3	−0.12	0
	21. The strength of desalination is the consistent supply of water for industry because they won't have to shut down production during droughts.	0.86 **	1	−0.52	−1	−0.31	−1
	35. The reason why industrial users want us to do desalination is because they want to maximize profits. They want government money and to offload cost onto the public because it's so expensive. **C** (P > 0.05)	−1.10	−3	−0.63	−1	−0.33	−1

to suburban growth. This is important because stakeholders think of both present conditions and future challenges with any water security strategy. Strong support for this statement indicates concern that desalination might be used as a way to support a phenomenon that it will never completely satisfy, and create future unintended consequences. As one respondent told us, 'Desalination is going to be an important part moving forward, but I think conservation and reducing demand still has to be an important part, too. We can't just keep adding more water supply, and we can't look at desalination as like it's the answer to our problem. It's not. By itself'. (01EP, F2 = 0.7013). Similarly, this perspective supported the claim that 'long-term water reliability through desalination comes at a higher cost' whereby 'current residents are subsidizing future growth and development' (No. 12, z = 1.19, $p < 0.01$), suggesting concern about urban (and suburban) growth.

Conservation Before Desalination disagreed with pro-desalination statements, such as 'It's never going to rain enough in Texas for us to depend on water reservoirs so our only option is to go with desalination' (No. 10, z = −1.76, $p < 0.01$) and 'If the ultimate objective is reliable, sustainable, and drought-proof water, there's only one technology that checks those boxes indefinitely, and that's desalination' (No. 17, z = −2.09, $p < 0.01$). In other words, when desalination promotes suburban development in Texas, it will lead to negative consequences, such as rate increases for existing rate payers. This position reflects a concern over the cost of desalination and, to a lesser extent, water reuse technologies. As one respondent noted, 'Unless those costs are managed and controlled, [desalination] might crowd out other spending using innovative technologies' and unfairly raise ratepayers' expenses (04SA, F2 = 0.8597).

HT Although these statements appear to indicate an anti-desalination position, other Q-statement scores demonstrate a more complex position. For instance, *Conservation Before Desalination* disagreed with the most critical statement of desalination in the concourse, which claimed that 'there are no positives to seawater desalination' (No. 34, z = −1.16, $p < 0.01$). When compared to Factors 1 (z = −1.89) and 3 (z = −2.23), this indicates caution rather than clear opposition regarding desalination development.

Qualitative data from loaders on this factor further support the idea that this social perspective is not anti-desalination, but prefers lower-cost interventions and, as one participant stated, 'the right water for the right use' (19TX, F2 = 0.8104). This participant explained, 'I think that there's a lot of other strategies available to us before we get to desal . . . I see a big investment in that technology and therefore, a potential to deinvest [sic] or not focus on other strategies which are less potentially environmentally destructive or extensive'. Another respondent noted that while desalination is not a 'silver bullet' solution, 'I haven't heard anybody say we don't want reuse and desal to be part of our water portfolio . . . The disagreement is how they get managed [and] by whom' (05TX, F2 = 0.7836). This respondent, self-described as 'cautious with desalination', went on to argue that 'there's a tendency to think of desal as being this like cornucopia, kind of like a silver bullet. [This view] underestimates the energy intensity and also how expensive it is to move water. People often forget that water is extremely heavy and where the marine desalination would occur would essentially have you pumping water uphill to the rest of Texas'.

5.3 Factor 3: private sector can do it

Private Sector Can Do It (F3) is the strongest pro-desalination social perspective among the three we identified. Statements such as '[desalination] is the only drought proof source of water' (No. 13, z = 0.77, $p < 0.05$) and 'It's never going to rain enough in Texas ... so our only option is to go with desalination' (No. 10, z = 0.21, $p < 0.01$) were ranked higher in agreement than other factors. This pro-desalination paired with a vision of the best pathway to implement this water security solution: the private sector, who represented all the loaders on this factor (Table 2).

Private sector involvement is necessary, if not preferred, for implementing desalination projects because of technical capacity and risk management (No. 2, z = 1.71, $p < 0.01$). As one respondent explained, 'A given municipality in the region may not be the best positioned to make the capital investments or to have ... the wherewithal [human capital] to manage the regulatory process for desal development' (11CC, F3 = 0.5736). This respondent went on to tell us that private firms must 'produce the water at the costs that they signed the contract for', before reflecting that 'holding the government's feet to the fire on commitments is pretty loosy goosey. Holding the private sector's feet to the fire is an absolute contract', concluding that 'the private sector can do it more efficiently ... they have a better handle on being able to hire the right technical people to do the job, and then they can bring the financing'. In simple terms, 'the private sector does a better job of taking the risk, where if the government takes that risk and they screw it up, they just pass the cost on to mom and dad, and their customer'. Another participant noted, 'Private capital ... is better utilized' in developing desalination facilities since 'the ultimate incentive is on the bottom line and that means you cannot afford to fail' (14TX, F3 = 0.8466). This respondent also argued that private firms are better at 'transferring the risk in the development of new sources of water that are highly complex, like desalination, and in taking on that risk to ensure that it's successful ... when the private capital is at stake, the ultimate incentive is on the bottom'.

Respondents also noted the private sector's advantage in mobilizing human capital, as indicated by the statement that 'The private sector is better suited for running desalination because it has the workforce experiences that municipal governments do not have' (No. 28, z = 1.55, $p < 0.01$). One respondent explained,

> People who work every day in water treatment, you know, know how to treat water from a reservoir or from a groundwater resource. They have little to no experience in desalination. And so you're going from operating a water treatment plant that is used to pressures in the, you know, 50 to 100 PSI range. Well, when you go to seawater desalination, you're talking about pressures in 900 PSI. And when things start going bad, you know, bolts and flanges start flying around, people get killed. So, there is a level of expertise that does not exist in ... the work force that traditionally treats water for municipal governments (17CC, F3=0.7529).

Another distinguishing statement for *Private Sector Can Do It* focused on the appropriate scale of water governance in relation to desalination and water reuse, stating 'There is a need for more regionalization when it comes to investments in water' to address uneven access between urban and rural areas (No. 8, z = 1.76, $p < 0.01$). In other words, Texas would benefit from focusing more on regional as opposed to state or municipal scale governance. One respondent argued, 'There is no governmental structure to address issues that transcend municipal or county boundaries' (11CC, F3 = 0.5736). According to another participant, a regional water authority would be preferable 'because they're not held to the politics of any one city' (17CC, F3 = 0.7529). Indeed, this should not be surprising because the state's water supply systems are highly decentralized, with few shared operational policies and practices, and thus, for the large-scale projects, the private sector is faced with an array of actors and organization to realize these alternative water supply projects.

Environmental impacts of desalination emerged as another significant dimension in *Private Sector Can Do It* discourse; more precisely, desalination technologies are not inherently environmentally detrimental, and existing environmental safeguards in Texas are sufficient. This is demonstrated by the factor ranking several statements critical of desalination for environmental reasons lower than other factors, focusing on the role of TCEQ. For example, this factor strongly disagreed that 'TCEQ permits are woefully inadequate for considering the environmental impacts of desalination' (No. 15, z = −1.81, $p < 0.01$). Faith in TCEQ permitting suggests agreement with the Texas regulatory environment for desalination, indicating this social perspective is comfortable working within current institutions. A statement arguing that any seawater intake or discharge for desalination 'in the bay [in Corpus Christi] would be devastating to the ecosystem' was likewise ranked lower than other factors (No. 31, z = −1.50, $p < 0.01$). The strongly negative reaction to this statement suggests that investors in the Corpus Christi desalination see themselves as good environmental stewards. Respondents highlighted ways that desalination presents environmental benefits, such as allowing 'reservoirs when they're full to continue to allow fresh water to come into the bays and estuaries, which is important for the ecosystem' (17CC, F3 = 0.7529). In addition to positive views of TCEQ's regulatory capacity, a significant statement for this social perspective disagreed with the statement indicating poor communication 'between the engineers and environmental scientists around how to best implement seawater desalination because they don't necessarily look at problems the same way' (No. 33, z = −1.03, $p < 0.01$).

5.4 Stakeholder agreement and disagreement

Discussion on specific areas of agreement and disagreement between social perspectives is often overlooked in Q-studies, but it could be useful during policy discussions with local stakeholders in that it might help overcome stalemates on some apparently intractable social-environmental issues. Figure S1 displays agreements and disagreements among social perspectives. The darkest green or red central sections are statements with the highest agreement or disagreement, respectively, between all factors. The intermediate green or red sections show statements with the highest agreement or disagreement between pairs of factors, while outer sections show the most positive or negative highly significant ($p < 0.01$) distinguishing statements defining each factor. The greatest agreement between social perspectives was the idea that water reuse could help cities 'toward resiliency' and that reuse is compatible with the integrity of downstream rivers

(No. 32, non-significant at $p > 0.05$; F1:-1, F2:-1, F3:-1). Strong disagreement appeared regarding statement 28 (Figure S1b). F1 and F2 strongly disagreed with the idea that the private sector 'is better suited for running desalination because it has workforce experiences that municipal governments do not have' (No. 28; F1:-3, F2:-3, F3:+3).

Two statements (9 and 19), which relate to environmental issues, may also be considered 'consensus' (Table 4). All social perspectives agreed with the statement that the biggest long-term water concern for Texas cities 'is not finding new sources of fresh water like desalinated or reclaimed water', but instead 'protecting the sources Texas cities already have' (No. 9, non-significant at $p > 0.05$; F1:+1, F2:+2, F3:+1). They also agreed that environmental concerns 'should be listened to and incorporated into the plans' although they should not stop desalination projects (No. 19, non-significant at $p > 0.05$; F1:+2, F2:+3, F3:+2). Social perspectives also had consensus in their disagreement regarding a claim critical of industries seeking desalination (No. 35, non-significant at $p > 0.01$; F1:-3, F2:-1, F3:-1).

6. Cross-cutting themes

Two cross-cutting themes – desalination over water reuse and the water work force – emerged in the interviews and Q-sorts, providing further insight into the concerns, barriers, and approaches that inform stakeholder positions on urban water security strategies.

6.1 Desalination over water reuse

Stakeholders focused on marine desalination rather than water reuse or brackish water desalination. Our interviews allowed participant to discuss their views on various strategies for urban water security, opening the options to a broad range of water portfolio options. Responses, resulting statements, and sorting outcomes were dominated by the theme of desalination with very little concern for water reuse.

We had expected to observe environmental opposition evidenced in the reporting on desalination. Such issues are clear in Corpus Christi, where a desalination plant proposed by the Port of Corpus Christi evoked vocal public concern. Residents in Port Aransas, a fishing and tourist destination near the Port, opposed a wastewater discharge permit for the proposed 50-million-gallon-per-day Harbor Island desalination plant (Perkins 2019). Opponents argued that discharge from the desalination plant would damage marine life, in turn harming livelihoods of fishers and guides who depend on healthy fisheries. A fly-fishing guide phrased the potential impacts as a matter of survival: 'If you take my fish away, where am I going to work?' (Perkins 2019). In May 2021, the State Office of Administrative Hearings remanded the permit to the Port of Corpus Christi, ruling that the Port did not meet the burden of proof that the plant wouldn't cause environmental harm, mainly via adverse impacts to marine life on Harbor Island, an environmentally important and sensitive barrier island. Yet, strong opposition to desalination did not shape the larger discourse of policy-makers; rather it informed a broader set of nuanced ideas about desalination. This is important because these findings offer the first study to tease out the nuanced stakeholder perspectives on desalination in ways that are similar to water reuse literature (c.f., Ormerod 2017).

Water reuse as a non-issue among stakeholders also merits further consideration. This confirms Ormerod's (2017) finding that no clear opposition to water reuse *per se* could be identified among water stewards. This is understandable in the context of urban Texas, where water reuse is a long-standing practice. San Antonio successfully runs one of the oldest water reuse facilities in the U.S. Texas also has experience with direct potable water reuse (DPR) projects in Big Spring and Wichita Falls, with several others proposed to TCEQ. Texas water rights law also incentivizes direct over indirect potable reuse because downstream water rights holders do not apply in DPR (Steinle-Darling 2015; Wester and Broad 2021). Downstream considerations also influence ecosystem services and concerns about return flows from wastewater treatment plants, but again, not to the level of polarizing public concern (19TX). In addition, El Paso has developed reclaimed non-potable water for municipal purposes, agriculture, and construction for years and, as mentioned earlier, is designing an Advanced Water Purification facility for DPR. As part of its work plan, El Paso implemented a third-party review by an independent advisory panel and public outreach plan (Maseeh et al. 2015), which may explain why we found no public backlash against desalination in El Paso. In addition, recent water reuse plans operate at what one respondent called the 'microscale', describing a city ordinance-based approach requiring any building over 250,000 square feet to offset non-potable use with on-site water, which does not generate broad public controversy (19TX).

6.2 The water workforce risk

An unexpected theme in relation to development of alternative water supply for urban water security was the challenge of human capital. Water workforce concerns include policy-makers, lack of diversity, human resource development (Kane and Tomer 2018; Lacey 2012) and essential workers during the global pandemic (Kane and Tomer 2021; Spearing et al. 2020). But our finding that concerns about human capital are a barrier to advance water reuse or desalination options as a water security strategy is novel, and may help explain the complex views on desalination as a significant alternative water source with concern across the human resources pipeline from workers to professionals.

Stakeholders across the social perspectives shared a concern about human capital at all levels, from plant operators to legal experts, in an emerging technological water environment. Statement 28, which mentioned 'workforce experiences', was highly significant for *Private Sector Can Do It* while other factors disagreed (Table 4; Fig. S1). Nevertheless, loaders on other factors expressed concerns about human capital. One respondent remarked that 'the workforce in water is aging and they're retiring, and they are mostly older white men. They don't have women, they don't have people of color, and they also just don't have bodies . . . there is a risk in not providing a means for the workforce' (03EP). This issue of reduced workforce is compounded by the technical issues related to alternative water supplies. One stated, 'I'm concerned about our workforce and our knowledge and managing discrete water systems and more distributed type water supply versus centralized' (19TX).

Participants were concerned about not having the workforce, noting 'institutional turnover' in the water sector 'insufficient young people plugging into the sector' (05TX). Another respondent stated 'the training of water facility operators, as we move from conventional water supplies [which] we have been doing for years, and we … shift to more technological intensive approaches, [means that] we need to have trained operators in those facilities' (25TX). This respondent continued by making reference to a technically incompetent television character: '[t]here is always a risk that a Homer Simpson is going to show up and you don't know what is going to happen … we need to always be vigilant that our operators have the training that they need to operate [desalination and water reuse] facilities' (25TX).

Participants also recognized the risk of human capital related to professionals, from government officials to the judiciary, not well trained in the emerging challenges of changing water systems and supplies. 'We have a judiciary in Texas that handles water litigation without any real training or knowledge about water', according to one respondent (21TX), while another mentioned insufficient investment in the next generation of water leaders in Texas (05TX). Overall, participants understood the current and future gaps of the water workforce, especially in relation to alternative water sources that required new skills. They articulated the risks, but disagreed on which entity could manage and address the challenge.

7. Discussion and conclusion

Social perspectives regarding desalination and reuse in Texas are complex and contingent. We did not identify an unambiguous and unapologetic pro-desalination subjective position among respondents who represent the desalination industry. Our analysis confirms our expectations that stakeholder subjectivities are place-based and relational across the water portfolio. Stakeholders did not consider only one policy option; rather, alternative water supply options to address to urban water insecurity operated in a common policy space where decision makers considered how they operated in relation to one another. This provided, then, the context for identifying the social perspectives that indicated contingent and nuanced support for desalination, rather than outright rejection or endorsement. Future research could use a Q-method approach to understand whether other desalination and water reuse stakeholders frame their understandings in similar or different subjectivities, while also considering whether these subjectivities influence decision-making and the production of social legitimacy. Probabilistic sampling and rigorous survey design, informed by our findings, could explore determinants of public acceptance.

Another surprise, given its absence in previous studies of desalination and reuse, was concern across stakeholder perspectives over the availability of a qualified workforce necessary to operate desalination and water reuse facilities. For *Private Sector Can Do It*, the lack of skilled workers and human capital framed the solution to be solely in the hands of the private sector. But for others, human capital issues underscored the barriers to any transition to alternative water sources because of the involvement of not only water operators and technicians but other professionals, even in the judiciary. Future research could advance understanding on this potential constraint through more complete understanding of workforce needs in desalination and career pathways that would support this critical dimension of water security and portfolio.

Study limitations include the effects of the COVID lockdown, which impeded our ability to access a wider variety of stakeholders, especially in civil society, to complete Q-sorts. Although we conducted semi-structured interviews before the pandemic, we necessarily had to conduct Q-sorts during the restrictions on travel and face-to-face interviews. This may explain why we did not identify a social perspective opposed to desalination, even though our initial semi-structured interviews identified many claims opposed to desalination. We also recognize that the three factors cannot be generalized to a population in the way that large-*n* studies, with rigorous sampling, may be generalizable.

Areas of convergence or agreement across social perspectives could provide foundations for productive dialogue across stakeholder groups and positively contribute to water policy development about urban water security. Consensus statements, relating to protecting water sources and incorporating environmental concerns into desalination, provided insights into how to navigate public dialogue on urban water insecurity moving forward. There is agreement that environmental considerations need to be addressed but not used to increase development costs; in addition, there is agreement that water reuse can be a path toward resiliency and water source protection is a long-term concern. All social perspectives believe in 'protecting the sources Texas cities already have', perhaps because they are keenly aware of the financial and political costs of desalination and reuse. Indeed, participants do not want interest in desalination and reuse projects to reduce the importance of protecting the thousands of reservoirs, streams, and groundwater basins that currently support Texas drinking water. Concern for environmental impacts is also notable, given the reputation of low environmental regulation in Texas. Resiliency and acceptance of water security pathways that include reuse and source-water protection suggest that enhancement of these policies can be developed without opposing desalination in ways that would alienate other stakeholders.

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