Water Policy 23 (2021) 291–309

Identifying diverging sustainability meanings for water policy: a Q-method study in Phoenix, Arizona

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Abstract

We identify and describe social perspectives on the sustainability of the water sector in the metropolitan area of Phoenix, Arizona. Using Q methodology, we find evidence for different meanings of sustainability when stakeholders are presented with concrete policy options and applications in spite of an apparently widespread agreement on the concept of sustainability itself. We put the social perspectives articulated by local stakeholders in perspective by analyzing whether they adhere to a commonly used set of sustainability principles when applied to water management and governance. The analysis indicates that although there is some level of acceptance of sustainability principles among the social perspectives identified, there are important discrepancies in the salience of different principles. Results suggest that when people are interacting in policy-making processes they tend to support their previously held own vision of the problems and that their normative considerations may be opposed to broadly accepted sustainability discourses. The different visions of water sustainability may have a direct impact on the water policy-making process depending on the position and influence of the actors involved in the governance scheme.

Keywords: Phoenix; Q methodology; Social perspectives; Sustainability; Water governance

Highlights

- Key research to debate water policy in Phoenix.

doi: 10.2166/wp.2021.033

- Identify key perspectives that affect water governance.
- Results suggest that when people are interacting in policy-making processes they tend to support their own vision of the problems and normative considerations.
- Findings are useful to develop questionnaires or surveys in Phoenix.
- Findings could be useful to minimize areas of conflicts

Introduction

The city of Phoenix, the capital and largest city in the State of Arizona (USA), was once described as 'the world's least sustainable city' (Ross, 2011). A primary reason for this controversial designation was an accusation of excessive natural resource use in this semi-arid desert environment, especially regarding water. The metropolitan area of Phoenix faces complex water management challenges involving patterns of urban development, population growth, the necessity to reconcile water availability and consumption, and the increasing competition between residential, industrial, and agricultural uses (Glennon, 2018). Some observers have portrayed these challenges as insurmountable, predicting the demise of Phoenix and similar places such as Los Angeles and Las Vegas in the not so distant future[1]. Water researchers argue that business-as-usual water management will not solve current water problems and that instead, a more holistic and open water decision-making is needed (Gober, 2018). On the other hand, strongly opposite discourses are also present, supporting the idea that 'meeting current and future water demands during times of drought does not require stopping (urban) growth....'[2] These conflicting narratives combined with extreme weather conditions have led some scholars to consider metropolitan Phoenix and other southwestern cities as 'testbeds for developing adaptation and mitigation strategies that cities with less extreme climates may need before the turn of the next century' (Hondula *et al*., 2019: 79).

Arizona has enacted several water management innovations and is advancing in terms of water law and policy. In fact, total water use in Arizona is approximately the same as it was half a century ago even though the state has grown by about five million people during that time (Glennon, 2019). Regardless, significant water resources will be required to sustain expected population growth and economic development. The greater Phoenix metropolitan area uses water from multiple watersheds as well as groundwater supplies, which are relatively secure due to both the diversity of sources and a significant reduction in regional agricultural demand (Gober *et al*., 2016). In spite of significant accomplishments to secure and manage water resources in the region, serious questions remain about the city's long-term sustainability, especially in light of new challenges and uncertainties related to future water availability, recurring drought conditions, climate change impacts, and population growth (Larson *et al*., 2015). In the context of these challenges, sustainability discourses have become an issue of debate and deliberation throughout the water sector. Water governance is a term that describes complex multi-actor and multi-level processes related to how people make decisions to solve (water) problems. Subjective perceptions are central to decision-making and influence discourses, and thus perceptions are a fundamental

[1] See: https://www.vice.com/en_ca/article/vb7mqa/phoenix-will-be-almost-unlivable-by-2050-thanks-to-climate-change (last accessed 8 February 2019).

[2] See: https://www.phoenix.gov/waterservices/resourcesconservation/drought-information/climatechange/water-supply-q-a (last accessed 21 September 2018).

unit of study for environmental governance processes (Dresner, 2002). But how do different stakeholders understand the concept of sustainablity in relation to water policy? Is there a correlation between general sustainability discourses and stakeholders' narratives when they are faced with water policy challenges? Understanding what factors drive transformative change from current modes of water governance to more 'sustainable' ones, and ascertaining to what extent personal sustainability perceptions and environmental values influence water decision-making processes, are both issues that require more investigation (Pahl Wostl, 2019).

In this work, our aim is to put the narratives articulated by different stakeholders involved in local water governance in perspective by analyzing how they understand and adhere to a given set of sustainability principles. We undertake an empirically based, qualitative-quantitative assessment of social perspectives to: (1) analyze how stakeholders understand sustainability in relation to water policy; (2) examine the correlation between shared sustainability discourses and stakeholders' narratives when faced with water policy challenges; and (3) discuss some implications of these findings for local water policy.

Our study of stakeholder perceptions is rooted in a well-established theoretical framework on the social perceptions of nature–society relationships (Grossman, 1977; Porter, 1978). The discursive turn in political ecology also provides a theoretical basis for using Q methodology in human-environment work. In fact, the 'plural approach' advocated as one of the key tools of political ecology implies acknowledging the existence and importance of different perceptions, definitions, and rationalities that shape people and discourse (Blaikie & Brookfield, 1987; Peet & Watts, 2004). The study of people's narratives also allows for a greater understanding of the relations between knowledge, power, and environmental policy (Robbins, 2006). At the same time, the identification and description of local discourses might favor coalitions among varied stakeholders aimed at addressing contested social-environmental problems, like water policy issues (Hajer & Versteeg, 2005).

Exploring social perspectives on water sustainability using sustainability principles

The concept of sustainability is complex, ambiguous, and contested. The origin of this term can be traced to ideas by economists, scientists, and philosophers since the 18th century (Seghezzo, 2009). However, it was the report by the World Commission on Environment and Development (WCED) that put the notion of 'sustainable development' on the global agenda more than three decades ago (WCED, 1987). Several objections have been raised against this concept as articulated by the WCED, but its ambiguity was probably one of the main reasons for its worldwide acceptance (Mitcham, 1995; Tijmes & Luijf, 1995). Sustainability is also intrinsically difficult to operationalize, enforce, and measure under specific circumstances and in concrete social-ecological systems (Ostrom, 2009; Lockie, 2016; Orenstein & Shach-Pinsley, 2017). The use of sustainability 'indicators', despite continuing criticisms about their policy relevance, is arguably the most widespread approach to gauge sustainability (Bell & Morse, 2008; Van de Kerk & Manuel, 2008; de Olde *et al*., 2018). It is increasingly accepted that sustainability assessment is not only a technical exercise but also a markedly political activity, since the notion of sustainability depends, to a great extent, on people's worldviews, social perspectives, and interests (Stringer *et al*., 2006; Darnhofer *et al*., 2010). For those reasons, sustainability assessment is arguably best carried out with the help of local stakeholders via bottom-up, participatory, and trans-disciplinary processes (Dahl, 2012).

Sustainability principles underlie sustainability indicators and assessment systems (Gibson *et al*., 2005). Formulating sustainability principles is an attempt to define the core requirements of any sustainability-oriented governance system. As with sustainability itself, sustainability principles are by no means universal. Instead, such principles are context-dependent and inextricably linked to personal constructions and their normative, value-laden standpoints (Wiek & Iwaniec, 2014; Manuel-Navarrete, 2015). Wiek & Larson (2012) compiled a comprehensive set of general sustainability criteria or principles that could be used to assess the sustainability of the water sector by integrating concepts from physical engineering, water governance, and social learning. These principles were used to conduct a comprehensive analysis of Phoenix's water sustainability (Larson *et al*., 2013). Despite some general agreements between local stakeholders, debates persist between those who support supply augmentation policies and those who advocate for a drastic reduction of water consumption (Larson *et al*., 2013; White *et al*., 2015). Also contentious are issues related to stringent approaches to address water scarcity such as water pricing (Larson *et al*., 2009). This paper builds on this knowledge base and provides new evidence of the complexity of water-related decision-making processes, discussing linkages between generally accepted sustainability principles and local stakeholders' specific perspectives on sustainability.

Materials and methods

The Phoenix water sector

The Phoenix metropolitan area (PMA) is located in the northern Sonoran Desert of the southwestern US. With high temperatures and low precipitation, mainly produced during the summer monsoon and winter season, the PMA is one of the fastest growing urban regions in the US in the last decade. According to US Census Bureau, the current population of the PMA is close to five million residents. The region faces increasing uncertainties about water provision and the future of agriculture (Gober *et al*., 2016). PMA has four primary sources of water: local rivers in the Salt-Verde watersheds, water from the Colorado River, groundwater, and reclaimed water. All water sources are governed by different actors and institutions, resulting in a highly complex governance system. The PMA has over 50 regulated water utility systems that represent a loosely coupled regional water system (Sampson *et al*., 2016). The PMA has two main surface water suppliers: The Salt River Project delivers water from the Salt and Verde Rivers via a system of canals and pipelines, and the Central Arizona Project (CAP) transports water from the Colorado River. Water from the Colorado River potentially supports the long-term viability of the water system if local alternative water sources are managed in a sustainable way. However, projected climate change impacts introduce an important factor of uncertainty that requires water savings and accurate urban planning for water use in metropolitan sectors of the city.

The institutional context of the PMA's water sector includes complex interstate and international agreements to moderate the use of the Colorado River, securing water subsidies that ensure enough water to fulfill the demands of the city without permanently draining local water resources. Actors, including state agencies, scientists from local universities, non-profit organizations, and municipal water departments are important in the water governance of the PMA because of their direct impact on water management and their potential influence in local decision-making.

More than 50% of the water in the PMA is used for municipal and industrial purposes and the remainder for agriculture. Groundwater constitutes approximately 39% of water used in the PMA. Over the past few decades, all water-use categories have shown increases, but the largest rate of increase is for domestic use due to the high rate of expansion of the city. Prior to 1980, Arizona's law defined groundwater as a common resource. Water from the Colorado River alleviates overdrafting of groundwater supplies, and the State had to demonstrate that it maintained the political will to curtail the use of groundwater in exchange for surface-water deliveries through the adoption of the Groundwater Management Act (GMA) in 1980 (Kupel, 2003). While the GMA assured federal subsidy to allow water subsidies, water-import projects have been considered by some authors as controversial and expensive remedies for the overuse and deficient management of groundwater (Reisner, 1986). The act also established a timeline for reduction and elimination of groundwater pumping in certain areas of the State by creating 'active management areas' (AMAs) and irrigation nonexpansion areas. Within AMAs, development was limited to areas with an 'assured water supply', an area with an amount of water adequate for the needs of development for 100 years (August & Gammage, 2007). Despite that, urban developers can pay for 'credits' of water withdrawals based on surface water injections to groundwater, without verifying an aquifer's hydraulic connectivity. Another source of water is reclaimed water (5% of total water use), which is used for park irrigation, enhancement of riparian areas, and for recharging aquifers. Treated wastewater from some PMA municipalities is reused in a nuclear power station for cooling reactors.

Q methodology

Q methodology is well suited to assess sustainability narratives because it assumes that subjectivity on a specific issue is: (a) communicable, since it is self-reflexive and conscious; and (b) operant, because it gives shape to discourses and behaviors expressed by people with respect to a given issue in a given context (Robbins, 2005). Subjectivity is considered to comprise finite ideas that can be measured and organized, through factor analysis, into distinctive worldviews, narratives or 'social perspectives'. These perspectives reflect 'the sum of behavioral activity that constitutes a person's current point of view' (Watts & Stenner, 2012: 26).

Numerous applications of Q methodology to the water sector and water policy have revealed the usefulness of quantifying subjectivity with an aim to improve water policy. For example, Vugteveen *et al.* (2010) identified five perspectives that represent different ways of valuing water systems and their management in the context of Dutch freshwater management. Ching (2015, 2016, 2018) used Q methodology to study public perceptions and norm formation in recycled drinking water and narratives regarding a water supply project in Kathmandu, Nepal. Ward (2013) adopted Q methodology to assess what it means to water management experts in Paraguay to be involved in a policy and planning environment. Ormerod (2017) examined the subjective views of water stewards regarding the current planning discourse surrounding potable water reuse in the southwestern US. Iribarnegaray *et al.* (2014) used Q methodology to show that the limited success of water policies in Salta (Argentina) was partly due to ignorance or disregard of users' social perspectives on water management.

Q methodology identifies social perspectives by analyzing the responses of a sample of purposively selected participants when confronted with a set of statements, rather than offering generalizations or predictions resulting from large-*n* studies. Participants must rate statements (or photographs) according to their degree of agreement or disagreement with each one. When the ratings of various participants have high correlation with each other, it indicates that those participants hold similar perspectives. The outcome of a Q study is a group of factors (social perspectives) that represent common views (narratives) that exist in a group of people about a subject. Each factor is summarized in a model Q-sort, namely, a weighted average sort that represents the opinions of the participants whose sorts 'loaded' (correlated) with a specific social perspective. Factors are statistical generalizations of the opinion people have on a certain topic.

We followed the methodological sequence described in Webler *et al*. (2009). The thematic universe or 'concourse' of statements was gathered during six months of field work in Phoenix during 2017 and 2018. Our sources for the concourse (statements) included scientific and technical papers, information gathered during workshops and seminars, local newspapers, and interviews with local researchers. From an initial set of almost 100 initial statements, we selected 42 that were locally relevant and captured the spread in discourse (see full list of statements in the Appendix). During the selection of the concourse, statements were deliberately classified into seven themes, following the sustainability principles proposed and discussed in Gibson (2006), Wiek & Larson (2012), and Larson *et al*. (2013), namely: (1) Social-ecological system integrity; (2) Resource efficiency and maintenance; (3) Livelihood sufficiency and opportunity; (4) Civil engagement and democratic governance; (5) Inter-generational and intra-generational equity; (6) Interconnectivity from local to global scales; and (7) Precaution and adaptability. Each theme contained six statements formulated in a way that could be interpreted to be either in favor of or against the sustainability principle behind that theme.

Respondents were selected from groups with potentially distinctive perspectives on the sustainability of the water sector in the PMA. Following a ratio close to 3:1 between total number of statements and participants (Webler *et al*., 2009), we interviewed a total of 13 respondents: two members of local water users' associations, a member from a water company, two government officials (one from the municipal water department and the other from the State water department), three scholars working on water-related issues, three members of local environmental NGOs, and two university students who were working on water-related issues and may have had distinctive opinions on the sustainability of water management in Phoenix[3].

Q interviews were conducted by sorting paper cards on a quasi-normal distribution following the structure shown in Table 1. Follow-up interviews were conducted via email with representative respondents of each factor for validation of the factors and additional feedback. Q sorts were processed with PQMethod 2.20, a free software developed by Peter Schmolck at the Federal University of Munich. This program calculates the correlation matrix, extracts and rotates significant factors by principal component analysis, and defines a set of values for each model factor. Factors were analyzed using a computer-automated rotation ('Varimax') that maximizes the amount of variance explained with as few factors as possible and minimizes the potential biases of manual rotation. The number of factors was selected according to the criteria proposed by Addams & Proops (2000), Watts & Stenner (2012), and Webler *et al*. (2009), which could be broadly defined as: (a) mathematical relevance (eigenvalue >1); (b) comprehensiveness (the highest possible percentage of variance explained); (c) accuracy (a minimum number of

[3] Q method assumes that n different 'tests' (statements about water sustainability in Phoenix, in our case) are scaled by m individuals (respondents). The statements are the 'subjects' of the Q method study, and the sorts conducted are the 'variables'. In this regard, it is highly relevant to emphasize that we identified the statements through a dedicated procedure and using an explicit framework to reduce the initial statements to the 42 final statements. Inverted factor analysis helps researchers determine Q method is based on a theoretical precept in discourse analysis, which we state in the discussion of Q method. Q method does not offer findings generalizable to a population, but rather describes and quantifies belief systems (social perspectives or factors) held regarding a particular domain. For a more detailed explanation of the Q methodology fundamentals see Webler *et al.* (2009).

Table 1. Structure of the distribution used in our study.

	Less agreement ← (or more disagreement)				Neutrality → (or indifference) ←				More agreement (or less disagreement) →		
Values	−5	−4	−3	−2	−1	0	+1	+2	+3	+4	+5
No. of statements	2	3	4	4	5	6	5	4	4	3	2

Arrows indicate the direction of agreement or disagreement.

consensus statements between factors); (d) unambiguousness (maximum amount of participants loading on different factors); (e) distinctness (minimum correlation between factors); (f) stability (clusters of participants remain relatively unchanged under different factor solutions); and (g) simplicity (in most cases, all else being equal, the lowest number of factors is preferable).

We also calculated the salience ascribed by the factors to the seven categories (themes) in which we divided the statements. Salience was calculated by adding the Z scores (absolute values) of the statements in each category and normalizing the sum to the number of statements in that category. This normalization allows for comparisons across categories and is a way of validating their relevance. Categories with low salience might not be relevant for the stakeholders interviewed and therefore their inclusion in the concourse could be questioned. 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 category as a whole. Although by itself it cannot be considered a comprehensive characterization of the factors, it can be useful to better understand their underlying rationale (Webler *et al.*, 2009).

Results and discussion

A three-factor solution best complied with established guidance (Webler *et al.*, 2009); moreover, it was also the most meaningful solution in the context of the study. The three factors selected showed all eigenvalues above 1, explained 68% of total variance, included all participants as loaders in the factors, presented stable clusters of participants after rotations, and were meaningful under the circumstances of the case study. A four-factor solution was discarded. Although the three-factor solution contained fewer consensus statements and showed a slightly lower correlation between the factors, the four-factor solution included a factor with an eigenvalue lower than 1 that was also difficult to interpret. The description of the factors provided below was based on the following information: (a) values assigned to statements in each model factor, particularly those statistically significant or 'distinguishing' statements (see Table 2); (b) the type of respondents who loaded on each factor (marked with X in Table 3); and (c) additional qualitative information gathered during the surveys.

Table 2 links a description of the factors with the corresponding statements and the quantitative results obtained through factor analysis, listing the normalized value assigned to the statement and its statistical significance. Information between brackets in the descriptions of the factors include the statement number (from #1 to #42), the normalized value assigned to the statement (from −5 to +5), and its statistical significance (* for $p < 0.05$ and ** for $p < 0.01$). We named each factor, selecting labels to both be consistent with the main characteristics but also to be acceptable to the participants loading on them. We also tried to avoid direct references to specific types of stakeholders or any other stereotyped

Table 2. Factor scores (Z) and values (V) for each statement in the three-factor solution selected.

Statements		Factors								
		A			B			C		
No.	Brief description	Z		V	Z		V	Z		V
1	Irrigation of parks needed	− 0.75		− 2	0.50	*	1	− 0.42		− 1
2	Farmland needed for urban growth	− 1.41		− 4	− 1.92		− 5	0.84	**	3
3	Water availability from streams	− 1.39		− 4	− 1.30		− 3	− 0.94		− 3
4	Restoration projects are limited	0.92		2	1.05		3	− 0.84	**	− 2
5	Aquifer drawdown causes problems	− 0.89	*	− 3	− 0.25		− 1	0.24		1
6	Water treatment ensures quality	− 0.72		− 2	− 0.42		− 1	− 0.07		0
7	Groundwater balance main goal	0.95		3	0.25		0	0.24		1
8	New water supplies must be sought	0.58	**	1	− 0.77	**	− 2	2.09	**	5
9	Groundwater decrease acceptable	0.19		0	0.03		0	0.91		3
10	Investments on reuse are a priority	0.19		0	0.87		3	0.17		0
11	Phoenix needs water saving policies	0.87		2	0.52		1	− 0.52	**	− 1
12	Technical efforts to find more water	− 0.29		− 1	− 0.49		− 2	0.73	**	2
13	Some water needs will not be met	0.21		0	− 1.35	*	− 4	− 0.52		− 1
14	Water-reliant industries essential	− 0.11		0	0.27		1	0.42		1
15	Golf courses, pools are important	− 1.14		− 3	0.11		0	− 0.49		− 1
16	Suburban users have not paid	− 0.25		− 1	− 0.62		− 2	− 0.98		− 4
17	Water supply is in good shape	− 0.06	*	0	0.63		1	1.36		3
18	Preserve agricultural land	0.72		2	1.58	*	4	0.66		2
19	Diverse perspectives problematic	− 1.35		− 3	− 1.22		− 3	− 0.14	**	0
20	Certain interests excluded	0.65	*	1	− 0.01		0	− 0.17		0
21	Decision-making more focused	− 0.49	**	− 1	− 1.54	**	− 4	0.70	**	2
22	All parties need information	1.03		3	0.33	*	1	1.43		4
23	NGOs can help manage the system	0.79		2	0.81		2	0.52		1
24	Some stakeholders are excluded	0.59	**	1	− 0.18		− 1	− 0.91		− 3
25	Heavier users should pay more	0.95		3	0.82		2	0.59		2
26	Water-intensive industries optional	− 0.70	**	− 2	1.25		4	1.08		3
27	Free water for basic human needs	1.25		4	0.96		3	− 0.59	**	− 2
28	New areas at risk of water scarcity	0.35		0	0.63		2	− 0.21		0
29	Some uses should be eliminated	0.53	**	1	− 0.94		− 3	− 0.91		− 3
30	Technology will solve water scarcity	− 1.65		− 5	− 0.14	**	0	− 1.19		− 4
31	State could help communities adapt	0.97		3	1.73		5	1.68		4
32	Governance constrained by laws	0.53		1	0.67		2	0.24		1
33	Nexus should be considered	1.77		5	1.53		4	1.68		4
34	Management focus on some basins	− 0.49		− 1	− 0.43		− 1	0.14		0
35	Water use connections problematic	− 1.55		− 4	− 0.79		− 2	− 0.91		− 3
36	Informal norms simplify systems	− 0.41		− 1	− 0.34		− 1	− 1.85	**	− 5
37	100-year supply affects progress	− 0.74	*	− 2	− 1.54		− 4	− 1.68		− 4
38	Water from rivers to meet demands	− 2.21		− 5	− 1.89		− 5	− 2.09		− 5
39	Political resistance hinders research	1.41		4	0.85		3	1.50		4
40	Managers customs block adaptation	1.09	**	4	0.04		0	− 0.70		− 2
41	Room for conservation initiatives	1.43		5	1.78		5	− 0.35	**	− 1
42	Halting farm spread unacceptable	− 1.35		− 3	− 1.08		− 3	− 0.77		− 2

Significant (or 'distinguishing') statements for each factor are indicated for $p < 0.05$ (*) and $p < 0.01$(**). Z scores are expressed in standard deviations. Description of the factors provided in the text. Full statements in the Appendix.

Table 3. Factor loadings obtained by extraction and rotation of significant factors by principal components analysis (Varimax) in the free software PQMethod 2.20.

Participants		Factor loadings with 'X' indicating defining sorts					
Sort No.	Group affiliation	A		B		C	
1	Water user's association	0.1949		0.2477		0.7842	X
2	Water user's association	0.4607		0.6744	X	0.1248	
3	Water company	0.1042		0.1156		0.8404	X
4	University student	0.1971		0.7367	X	0.3703	
5	University student	0.8040	X	0.1810		0.0621	
6	State water department	0.6265	X	0.4320		0.2297	
7	Scholar	0.7515	X	0.3695		0.1572	
8	Scholar	0.1903		0.7786	X	0.0499	
9	Scholar	0.2531		0.7667	X	0.1424	
10	Municipal water department	0.6322	X	0.0336		0.5059	
11	Environmental NGO	0.7232	X	0.3489		0.1645	
12	Environmental NGO	0.7894	X	0.3971		0.1440	
13	Environmental NGO	0.4096		0.5995	X	0.1133	

NGO, Non-governmental organization.

denomination (such as 'policy-makers' or 'water users') since factors can include stakeholders from different groups. After we describe the factors in detail, we provide an analysis of their differences and similarities.

Factor A: water conservation for restricted urban growth

This perspective accounted for 50% of the variance and included six participants: two from environmental NGOs, one from the municipal water department, one scholar, one from the State water department, and one university student. No one from water users' associations or the water company loaded on this perspective. This view is particularly critical of excessively centralized, technocratic approaches to water governance, and advocates for water conservation as one of the preconditions for more sustainable urban growth in the future. Respondents believe that technological optimism, common in current water management, conflicts with the adoption of new technologies. They are particularly critical of the customs of water managers that emphasize centralized, technocratic strategies and supply augmentation, and therefore block or undermine adaptation mechanisms such as harvesting rainwater or restricting water consumption (#40: + 4**). This factor is also critical of technological fixes as a solution to environmental problems such as aquifer drawdown, groundwater pollution, and land subsidence caused by excessive water use and urban sprawl (#5: − 3*). This perspective is not against some types of water-intensive industries that may create employment or benefit the city in other ways, even if the immediate economic benefits are not significant (#26: −2**). In this respect, this view considers that there will always be enough water to guarantee the city's future provided the authorities develop a more sustainable water management system (#37: −2*). Such a system should include a drastic reduction of water use for non-essential activities such as irrigation of golf courses and lawns (#29: + 1**). This factor seems neutral to the idea that new water sources are needed to ensure economic growth and human wellbeing in the future (#8: + 1**; #17:0*). This perspective is somewhat sceptical of the quality and efficiency of current water governance schemes, and is also critical of the degree of public participation during policy-making processes (#24: + 1**; #21: −1**; #20: + 1*). Some non-distinguishing statements may offer additional insight on some of the characteristics of this perspective. Even though respondents see that new water sources might be needed in the future, they are firmly against transporting water from distant places such as rivers and lakes in the Midwest, a management option that is regularly advocated by some water authorities (#38: −5). They are also consistent in their distrust of technological advances as the only way to secure water provision for future generations (#30: −5). They see room for improvement in terms of water conservation (#41: + 5) and advocate for more interactions between sectors dealing with issues of land, water, energy, and climate (#33: + 5).

Factor B: water sustainability through participation and equity

A total of five participants loaded on this factor, which accounted for 9% of the variance. Participants who loaded on this perspective also belonged to different groups: one from an environmental NGO, two scholars, one university student, and one member of a water users' association. Factor B is correlated to Factor A (0.69) but also shows some differences and unique features. This perspective is characterized by its strong rejection of centralized water governance, managed by only a few powerful organizations such as the SRP and the CAP governing board (#21: −4**). Basic water needs of some Phoenix-area residents are not being met (#13: −4*) and increased public participation in water-related policy-making processes is needed (#22: + 1*). This perspective favors preserving agricultural lands around the city, particularly in the face of climate change (#18: + 4*). New water supplies are not required to support the development of new urban areas (#8: −2**). However, this view supports irrigating parks and public areas to preserve tourism and recreation benefits in the Phoenix area, despite some potential impacts to water resources (#1: + 1*). This view is neutral about the capacity of technological advances to guarantee access to new water sources and to secure water provision for future generations (#30:0**). A look at the most relevant non-distinguishing statements reveals similarities with Factor A, in particular the idea that more water conservation initiatives are possible (#41: + 5) and a rejection of water transportation from rivers and lakes in the Midwest to meet growing demands (#38: −5). Respondents believe that capacity-building and improved communication between national and regional governmental agencies could help local communities cope with water problems and adapt to changes (#31: + 5). They also oppose urban developments on the few remaining agricultural lands surrounding greater Phoenix (#2: −5).

Factor C. Centralized water governance for urban development

This perspective explained 8% of the total variance and was defined by two participants: a member of the water company and a member of a water users' association. As indicated by Watts & Stenner (2012), two Q sorts that load significantly on one factor are enough to define an interpretable social perspective, especially if it makes sense under local circumstances and can help explain and understand empirical findings. Participants who loaded on this factor exhibited a very distinctive view, high factor loadings, and a strong stability during rotations, justifying their inclusion in a third social perspective. Relatively low correlations were observed between this factor and Factors A and B (0.43 and 0.41, respectively).

Views held under this factor indicate strong support for urban growth and development even if this implies that future water needs will require the search for additional sources (#8: + 5**). Centralized, rule-based, and interconnected water governance is highly positive while informal norms and customs shared by water managers and government planners at the local level may be obstacles to more integrated water systems (#36: −5**; #21: + 2**). To support urban expansion, farmland surrounding greater Phoenix, and its water allocation, should be formally available for urban development (#2: + 3**). Technical efforts need to be directed to find more water resources for maintaining development (#12: + 2**). This perspective is opposed to subsidies for water consumption (#27: −2**) but supports restoration projects to enhance the ecological integrity of aquatic ecosystems (#4: −2**). Participants who loaded on this factor are relatively sceptical of the potential of stronger conservation initiatives in the region (#41: −1**). Instead, they advocate for aggressive water-saving programs to minimize future water shortages as Colorado River water supplies shrink (#11: −1**). Despite support for centralized water management, this perspective is neutral regarding more public participation in water-related decision-making (#19:0**).

Consensus and disagreement

Results from a Q study can be useful to examine specific areas of consensus and disagreement between perspectives, which can be important to focus the debate, bridge gaps between different stakeholders, and even facilitate negotiations (Ormerod 2017; Lehrer & Sneegas, 2018; Huaranca *et al.*, 2019). Consensus and disagreement between social perspectives, often overlooked in Q studies, could be important to re-frame the debate, focus on the most important issues, help reach compromises, and eventually overcome apparently irreconcilable positions (Huaranca *et al.*, 2019).

Figures 1 and 2 show some specific statements with maximum and minimum level of agreement, respectively, between the factors. The central section shows the statement with the highest consensus (Figure 1) and the statement with the biggest differences between Z scores (Figure 2) between all factors. A key finding here is that all perspectives are against the idea of importing water from rivers and lakes in the Midwest to meet growing the demands of greater Phoenix (statement #38; A: − 5, B: − 5, C: − 5). On the other hand, as shown in the central intersection in Figure 2, the main point of disagreement between all factors was the statement regarding availability of all farmland surrounding greater Phoenix for urban development (#2; A: − 4, B: − 5, C: +3).

Intermediate sections show statements with the highest agreement (Figure 1) and the highest disagreement (Figure 2) between pairs of factors (statements were extracted from the descending arrays of differences between Z scores assigned to different statements by pairs of factors). We find strong consensus on the need to spend more economic resources on water reuse infrastructure (statement #10 between Factors A and C in Figure 1); such policies could fill the gap between water conservation concerns and a more managerial vision of water resources.

Finally, outer sections show the most positive (Figure 1) and the most negative (Figure 2) highly significant statements ($p < 0.01$) (distinguishing statements used in the description of the factors). For example, Figure 2 shows a strong disagreement regarding the idea that all farmland surrounding greater Phoenix should be formally available for urban expansion between Factors A and C (statement #2, Figure 2), exposing disagreements that should be discussed in appropriate spaces of deliberation.

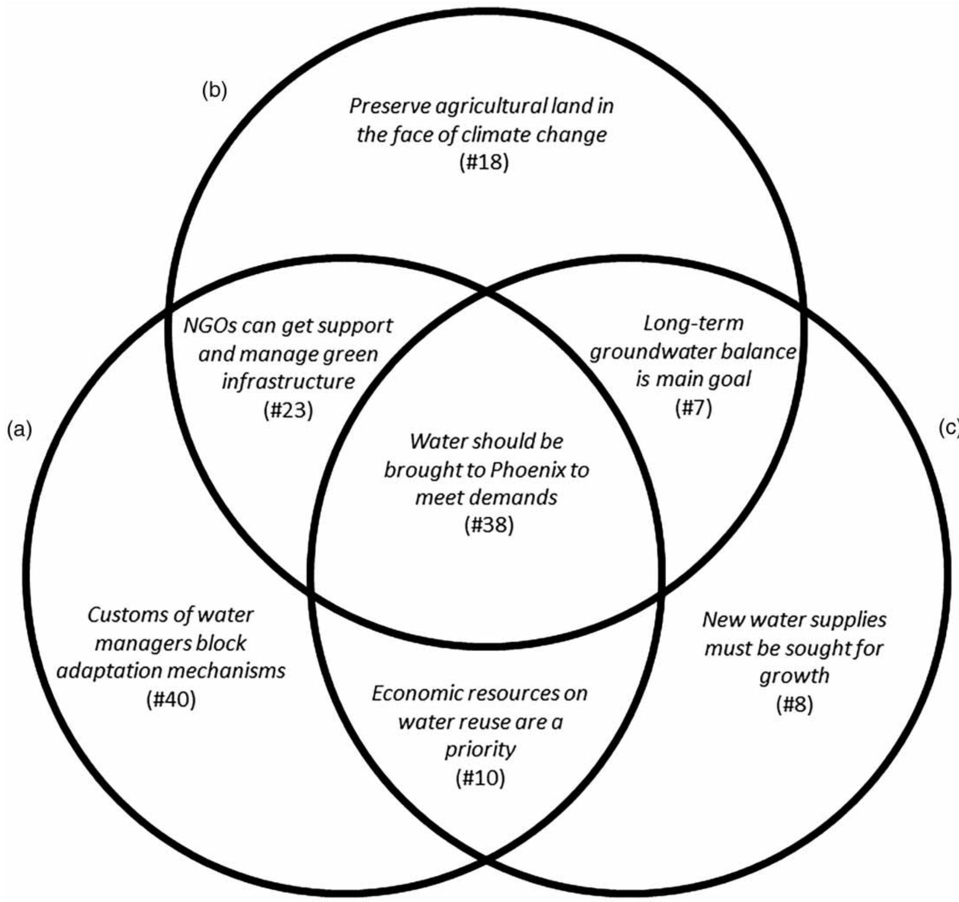

Fig. 1. Consensus. Statements with the highest level of agreement between Factors (a), (b), and (c). Numbers refer to statements. Full statements in the Appendix.

Salience and sustainability principles

As shown in Table 4 (last column), all categories have relatively high average normalized Z scores, which is evidence that all sustainability principles were considered important and provides empirical validation of their inclusion in the survey. Global average normalized Z score for all categories was 0.83 ± 0.17 ($\alpha = 0.05$). Sustainability principles 6 and 7 had the highest salience across all factors (normalized Z scores of 0.98 and 1.25, respectively). This indicates that all participants see issues related to precaution and adaptability (principle 7) and interconnectivity from local to global scales (principle 6) as the most relevant of the sustainability principles considered. However, this is not to say that the three factors necessarily agree on the interpretation and operationalization of these principles under local circumstances. In the case of principle 7, for instance, there is a reasonable agreement between the factors on statements 37, 38, 39, and 42 (see list of full statements in the Appendix), but factors strongly disagree on statements 40 and 41 (see values assigned to these statements by different factors in Table 2).

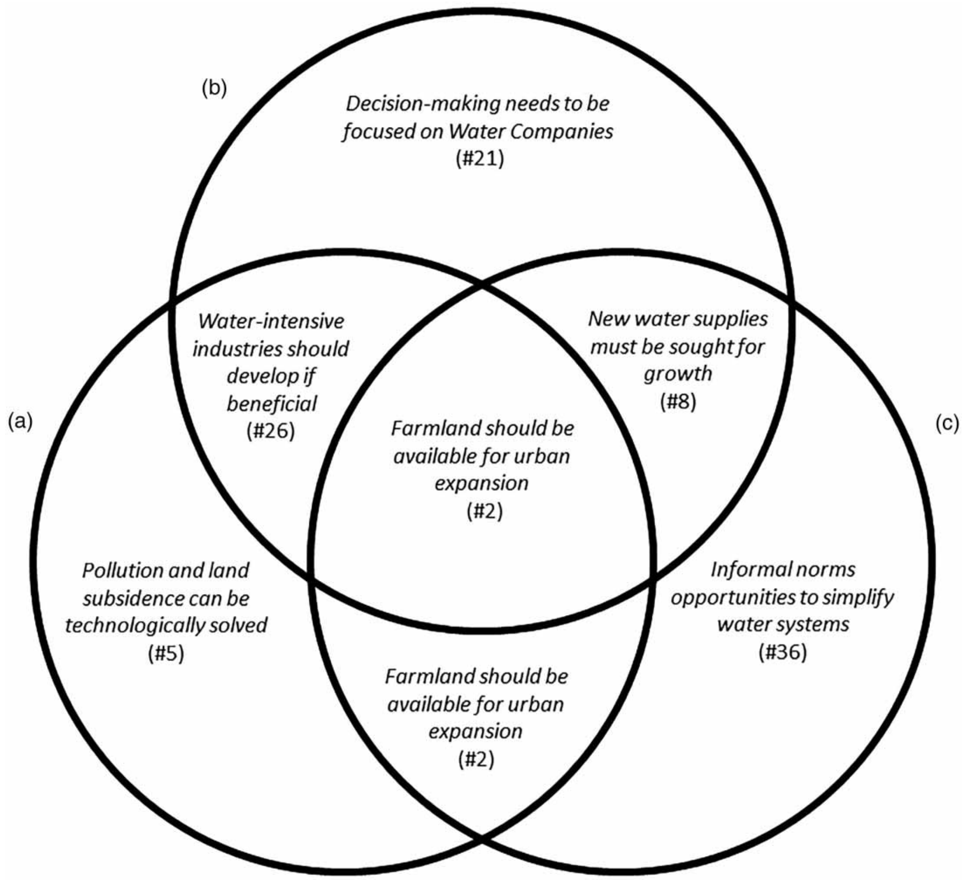

Fig. 2. Disagreement. Statements with the lowest level of agreement between Factors (a), (b), and (c). Numbers refer to statements. Full statements in the Appendix.

The case of statement 41 is particularly relevant to highlight this point. For example, Factor C does not view additional water conservation initiatives as part of a future water management system for the study area, while the other two perspectives indicated water conservation as important for the adaptability of the region to future water shortages. This indicates a clear difference regarding characteristics of a sustainable water system, revealing nuanced disagreements on the interpretation and implementation of a sustainability principle that, as a whole, is salient among diverse stakeholders. A similar analysis for sustainability principle 6 highlights that Factor C disagrees with the other factors on statement 36 despite overall consensus on the other statements within this principle (31 through 35). Statement 36 expresses the idea that decentralized water governance that relies on local knowledge might be more sustainable than centralized systems. Discrepancies on this statement also reveal differing interpretations of the concept of sustainability and can help researchers understand how different stakeholders interpret these principles in specific case studies.

Interesting differences are also observed when the salience ascribed to different sustainability principles by individual factors is assessed. As shown in Table 4, principle 7 had the highest salience values for all factors (normalized Z scores of 1.37, 1.20, and 1.18 for factors A, B, and C, respectively).

Table 4. Salience of the different thematic categories. A, B, and C: factors.

Category			Aggregated Z scores			Normalized Z scores			
Sustainability principle		n	A	B	C	A	B	C	Average
1	Social-ecological system integrity	6	6.1	5.4	3.4	1.01	0.91	0.56	0.83
2	Resource efficiency and maintenance	6	3.1	2.9	4.7	0.51	0.49	0.78	0.59
3	Livelihood sufficiency and opportunity	6	2.5	4.6	4.4	0.42	0.76	0.74	0.64
4	Civil engagement and democratic governance	6	4.9	4.1	3.9	0.82	0.68	0.65	0.71
5	Inter- and intra-generational equity	6	5.4	4.7	4.6	0.91	0.79	0.76	0.82
6	Interconnectivity from local to global scales	6	5.7	5.5	6.5	0.95	0.92	1.08	0.98
7	Precaution and adaptability	6	8.2	7.2	7.1	1.37	1.20	1.18	1.25
		42							0.83

n: Number of statements.

The second most important salience was assigned to principle 1 by Factor A (normalized Z score = 1.01) and principle 6 by Factors B (normalized Z score = 0.92) and C (normalized Z score = 1.08). Third in order of decreasing salience was principle 6 for Factor A (normalized Z score = 0.95), principle 1 for Factor B (normalized Z score = 0.91), and principle 2 for Factor C (normalized Z score = 0.78). There were also differences between the factors on the principles with the least salience, namely: principle 3 for Factor A (normalized Z score = 0.42), principle 2 for Factor B (normalized Z score = 0.49), and principle 1 for Factor C (normalized Z score = 0.56).

Besides these differences between factors in terms of the emphasis given to different sustainability principles, a more in-depth analysis of the statements contained in each principle shows that the salience assigned to each principle is coherent with the overall description of the factors. For instance, Factor A, characterized by its advocacy for water conservation and controlled urban growth, is particularly concerned with the social-ecological integrity of the water system (#2: − 4) and does not rely on simple technological fixes (#5: − 3*). This factor offers less concern, however, for the preservation of some local livelihoods and ways of life, i.e., the promotion of local industries that might have high environmental impact (#14:0), or the preservation of golf courses (#15: − 3). Factor B, which promotes more open water governance and equity, is more concerned with local livelihoods than Factor A and strongly rejects the idea that some residents will inevitably never meet their basic water needs (#13: − 4**). This factor is less concerned with issues of resource efficiency and maintenance such as the search for new water sources for the development of urban areas (#8: − 2**). Finally, Factor C, in favor of more centralized water governance and the promotion of urban development, does not assign top priority to social-ecological issues. This is indicated by agreement with the idea that farmland surrounding the city of Phoenix should be available for urban development (#2: + 3**). Contrary to Factor B, Factor C emphasizes the importance of resource efficiency and system maintenance by agreeing that new water supplies should be sought to facilitate urban growth (#8: + 5**).

Policy implications

Policy processes are political contests involving core human values and the meaning of basic goals that are continuously reconstructed, contested, and re-interpreted (Gober, 2018). Studying social perspectives and their alignment with general sustainability principles is useful to detect consensus and disagreements on specific water policies, providing opportunities to reach basic agreements and move forward on collective action. Discrepancies between stakeholders are grounded on contested truths and different ethical standpoints, but also on economic interests, power disparities, and diverging knowledges (Robbins, 2006). The empirical study of these perspectives improves our understanding of the relationships between knowledge and power related to the formulation of water policies. Social perspectives described have important discrepancies in the salience of different principles and how they should be implemented. Our results suggest that when persons are interacting in policy-making processes they tend to advocate for their own subjective interpretation of the problems and that their personal normative considerations could sometimes seem at odds with broadly accepted sustainability discourses.

Within the Phoenix water sector, it is increasingly recognized that business-as-usual is no longer a viable option, and the need for deeper water conservation and reuse has become a shared concern (Glennon, 2018). Despite that, our results indicate the issue of urban growth is an important disagreement. Our results show that the three diverging perceptions of water sustainability view technological optimism and water augmentation policies in opposite ways. These diverging conceptions of water sustainability are, according to each perspective, based on sustainability discourses but with political narratives that will lead to very different scenarios and outcomes. For example, the vision of water augmentation to support urban growth is considered one of the least useful policies to support water sustainability within the PMA (White *et al*., 2015). This perspective, which views continued expansion processes within urban areas as necessary to preserve economic growth, aligns with some official communications from local government agencies. City of Phoenix media states that 'meeting current and future water demands during times of drought does not require stopping growth', and that ' … most people in Phoenix and the region support policies that favor managed growth'[4]. It seems only natural that stakeholders leading key institutions believe that they have more power to influence local discourses and policies if decision-making is centralized or not deliberated between a wide range of stakeholders. Patterns of overuse and rapid urban growth can neutralize conservation, reuse, and sustainable management efforts, and stakeholders supporting centralized growth may be less likely to consider the value of taking precautionary action to reduce environmental vulnerabilities in the face of climatic uncertainty (Gober, 2018).

The necessity of policies that secure 'short-term economic gain' or policies that seek to integrate all visions of water sustainability need to be openly discussed (Hirt *et al*., 2008). In line with that, the second perspective that our results found ('water sustainability through participation and equity') supports stronger citizen participation processes and greater equity in decision-making. Q methodology is useful to clarify and understand existing narratives. Unpacking these diverse values, motivations, and expectations may help PMA stakeholders reach consensus and move forward on collective action. Understanding the different views also signals several opportunities to engage with sustainability principles. First, different types of stakeholders that have not always historically worked together on water management in the PMA may not realize that they have overlapping goals and perspectives (e.g., water users' associations, NGOs, and scholars that all prioritize open governance and equity). Second, representatives of the same type of stakeholder might hold different perspectives (e.g., water users' association members that prioritized open versus centralized governance). Identifying both the common ground between stakeholder types as well as potentially conflicting perspectives within a

[4] See: www.phoenix.gov/waterservices/resourcesconservation/drought-information/climatechange/water-supply-q-a. (last accessed 21 September 2018).

single stakeholder type is useful for structuring participatory processes and assisting stakeholders in clearly articulating their organization or group's policy preferences and positions, which can advance decision-making efforts (Raadgever *et al*., 2008). Identifying points of agreement can aid in connecting apparently irreconcilable stakeholder types and positions (Bredif *et al*., 2017).

Venn diagrams are not commonly used in Q studies (Huaranca *et al*., 2019). In this work they were useful not only for showing the disagreements about urban growth discussed above, but also to make visible several points that deserve further attention from policy-makers. Graphical visualization has the potential to highlight the most important statements and can be particularly useful to engage stakeholders in decision-making processes. Most consensus statements represent an opportunity to bring stakeholders together to communicate areas where their visions for sustainable water governance overlap. Further, discussing consensus may provide a concrete opportunity to strengthen trust among diverse water stakeholders, something that is currently fractured and needed to move collaborative water governance forward in the PMA and the lower Colorado River basin more broadly (Sullivan *et al*., 2019). Starting from shared ideals can facilitate more difficult debates about divergent perspectives and can build the foundation for different stakeholders to work together to envision alternative water futures and eventually implement more sustainable policies (Lehrer & Sneegas, 2018).

Conclusions

Our results show that there are at least three distinctive social perspectives on the sustainability of water management in Phoenix. One social perspective advocates for water conservation and a more restricted type of urban growth, while a second believes that water governance should include more stakeholders and promote more equitable water distribution, and a third is comfortable with centralized water governance to support urban growth and development. The perspectives differed in their understanding of a number of selected principles of sustainability when applied to water management and governance. The three social perspectives indicate that despite seemingly widespread acceptance of sustainability principles, they are not interpreted in the same way. Future research could use our findings to structure a large-*n* study that would evaluate the presence and impact of these perspectives among stakeholders rigorously sampled. The study suggests a complicated linkage between discursive support for sustainability principles and more specific social perspectives held by individuals involved in water decision-making. Understanding these differences can help better comprehend water governance processes and outcomes. Since the three perspectives also showed some areas of agreement and potential consensus, these findings could be useful in future decision-making processes to minimize areas of contention and conflicts between and among stakeholders.

It is possible that the representatives of the different stakeholder types participating in our study (e.g., water users' associations, environmental NGOs) did not capture the full diversity of stakeholder types. In most Q studies, however, additional participants are usually redundant and fall into one of the same factors that could be revealed by a reduced number of sorts, as there are a limited number of independent views that can be held about a given topic (Brown, 2009). Nevertheless, we deployed a rigorous procedure for determining the concourse, as statements comprise the 'tests' that respondents scale in Q-sorts. Future efforts could use the social perspectives to develop questionnaires or surveys in large-*n* studies on water sustainability in the PMA. In any case, recognizing the three social perspectives in decision-making processes could be an important starting point to improve decision-making related to water sustainability in the PMA.

Our findings are consistent with prior results obtained using survey research that identified two distinct visions for water in central Arizona: one in favor of supply augmentation to serve metropolitan development, and another that advocated for broader public engagement, reduced water consumption, restoration of ecosystem services, and limited metropolitan expansion (see White *et al*., 2015). Our research provided a more nuanced description of social perspectives and may serve as a foundation to explore stakeholder perspectives on sustainable water governance in other geographic locations. We argue that more sustainable water governance in Phoenix (and elsewhere) is unlikely unless relevant local stakeholders work towards consensus on both their understanding of sustainability and options for its concrete and realistic application under local circumstances. One way forward is a more open debate on the sustainability principles (or guidelines) that would come to define a mutually agreed upon definition of a sustainable water system. To achieve such a shared vision of sustainability, at least some of the sustainability principles most salient to diverse stakeholders should also be operationalized, enforced, and monitored using appropriate sets of qualitative and quantitative indicators. The study of social perspectives and their evolution in time could be a useful complement of a parallel, mid- to long-term assessment of the sustainability of the PMA water governance system.

Acknowledgments

The article was funded by CONICET (Project PIP 11220150100331), UNSa (Project 2341), INTA (Project PNNAT 1128031), and ANPCyT (Agency of Scientific and Technological Promotion of Argentina) (Project PICTO 2014-0049). This study was also supported by the US National Science Foundation under award number SES-1462086. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation. Special thanks to all people from DCDC. We are particularly grateful to all the confidential respondents of the Q survey. The usual disclaimers apply.

Data availability statement

All relevant data are included in the paper or its Supplementary Information.

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Received 11 February 2020; accepted in revised form 6 December 2020. Available online 19 January 2021