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"Drought is a Relative Term:" Drought Risk Perceptions and Water Management Preferences among Diverse Community Members in Oklahoma, USA

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Abstract Recent hydrological studies of the Arbuckle-Simpson Aquifer in south central Oklahoma indicate the need for sustainable management of the amount of water extracted, especially in a drying climate. This study draws on the Cultural Theory of Risk to diagnose how cultural worldviews inform drought risk perceptions, which in turn guide water management preferences and ignite conflict or inspire cooperation among members of communities that rely on the aquifer. Results show that while drought risk perceptions are complex and often conflicting, community members largely agree water management is important but disagree about how and by whom. People oppose management options that threaten their worldviews or stated ideal ways of life. While surveys are useful indicators of people's stated preferences for management approaches, a deeper analysis is required to understand what management strategies people will accept and eventually comply with.

Keywords Drought · Risk perception · Cultural theory of risk · Water management · Climate change · Oklahoma · USA

Introduction

Drought is a challenge faced by communities across the United States and around the world, exacerbated by growing demands on water resources and climate variability and change (Hayes *et al.* 2004). Numerous studies anticipate that droughts will increase as the climate changes due to anthropogenic processes (Cayan *et al.* 2016; Dai 2011, 2013; Georgakakos *et al.* 2014; Sheffield and Wood 2007). Water management decisions can alleviate or exacerbate vulnerability to drought (Pulwarty 2003), and how people perceive drought risks influences their preference and support for management measures (Yung *et al.* 2015). The Cultural Theory of Risk (CTR), developed by anthropologist Mary Douglas and colleagues (Douglas 1966; Douglas and Wildavsky 1982; Rayner 1992; Thompson *et al.* 1990), treats risk as a "way of classifying a whole series of complex interactions and relationships between people, as well as between man (sic) and nature," including water resources in a drying climate (Rayner and Cantor 1987:5). In this way, risk is as much – or more – about social relationships as it is about the physical hazard (Thompson and Wildavsky 1982). This study applies CTR to persistent controversy over water management of the Arbuckle-Simpson Aquifer in south central Oklahoma, along the southern edges of the North American Great Plains in the United States, towards three interrelated goals: to diagnose why people have different drought risk perceptions and water management preferences by mapping CTR to a local context; to understand how people value water for various activities; and to explain ongoing debate among community members about local water management.

Anthropologists actively pursue research on disasters (e.g., Oliver-Smith 1996, 2002), risk (e.g., Boholm 2003; Rayner 1992), climate change (e.g., Crate 2011; Lazrus 2012), drought (e.g., McCabe 2002; Nelson and Finan 2009), and water resource management (e.g., Lansing 1987; Trawick 2001; Wutich *et al.* 2014). Yet, there are few examples of anthropological work that examine these topics together in order to advance understanding of drought as a "revelatory crisis" (Sahlins 1972) that exposes cultural frames, modes of production, and systemic vulnerabilities (Solway 1994) while simultaneously revealing people's worldviews, or "certain aspects of a people's conception of life and the universe" (Mead 1970: 311).

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Understanding social relationships as they are revealed through cultural worldviews and exposed during crises can help identify risk management strategies that are socially acceptable and can ultimately promote adaptation to a changing climate. Water management in the western United States has evolved into a deeply complex system of users, rights, and management strategies (Fort 2016; Libecap 2007). Water management is becoming increasingly multifaceted (Bruns and Meinzen-Dick 2000). Thus, management strategies that reflect diverse community values and cultural norms are imperative to maintain water resources in areas that are particularly susceptible to increasing drought challenges (Colby *et al.* 2005; Ostrom 1990).

Study Context and Site

The Arbuckle-Simpson Aquifer is the primary source of municipal water for several small towns in south central Oklahoma, including Tishomingo, Sulphur, and Ada, home to the Chickasaw Nation's tribal headquarters (Fig. 1). Rivers, wells, and springs that conduct water from the aquifer are also the sole source of water for rural, family-based ranching efforts as well as large corporate mining operations in the region. Several artisanal springs in the Chickasaw National Recreation Area, the Lake of the Arbuckles, and the Blue River, are favorite vacation spots for people throughout the state. The aquifer is charged by rainfall and therefore deeply susceptible to reductions in precipitation under present and future climate variability and change (Silvas *et al.* 2014). Municipalities, ranches, and tourism were all dramatically affected by drought in 2011. Dense networks of hydrological and meteorological instrumentation cover the area providing a detailed picture of physical processes related to availability of water resources. However, less is known about how people interact with and perceive water resources, especially under drought stresses and recent controversial water management changes.

Controversy over water management of the Arbuckle-Simpson Aquifer became heated in the early 2000s when a consortium of landowners began to explore opportunities to sell their groundwater to areas of new development and population growth adjacent to Oklahoma City[1], 90 miles to the northwest (Shriver and Peaden 2009). The Citizens for the Protection of the Arbuckle-Simpson Aquifer (CPASA), a local environmental group with diverse membership from municipal managers to ranchers, mobilized an effort to stop the sale of groundwater, resulting in the passage of Senate Bill 288 in 2003 which placed a moratorium on transporting water out of the basin until a hydrological study of the aquifer commissioned by the Oklahoma Water Resources Board (OWRB) could be completed by the United States Geological Survey. The hydrological study was completed in 2011(Christenson *et al.* 2011), and led to the Board's determination in 2012 of a maximum annual yield equivalent to withdrawal of 0.2 acre-foot per acre per year[2], an "amount that will not reduce the natural flow of springs and streams within the Aquifer basin" (OWRB no date). The ruling replaces a previous maximum annual yield of 2 acre-feet per acre per year that is used for water management throughout Oklahoma until superseded by a specific study (OWRB no date).

The order of magnitude reduction in the amount of water now allowed to be withdrawn from the aquifer further inflamed conflict between landowners and other community members including members of Citizens for the Protection of the Arbuckle-Simpson Aquifer. Landowners view the reduction as an infringement of their individual property and decision-making rights while others see the reduction as a way to sustain local water resources based on collective and equal principles. A decade of simmering dissension over water management became a polarizing issue; new alliances were made while differences of opinion divided neighbors and communities. The views were expressed vocally at a public hearing held in Sulphur, Oklahoma in May, 2012. Despite attempts by protesters – who labeled the process "socialist" and the new water management "un-American" (Arbuckle-Simpson Aquifer Maximum Annual Yield 2012) – to block policy based on the new figure by petitioning the Oklahoma Supreme Court, the OWRB ratified it in November, 2013. The conflict has played out against a backdrop of severe drought, especially during 2011 – the driest year to date since 1925 (Shivers and Andrews 2013) – and 2012, when interviews for this study were conducted. I became interested in understanding the role of cultural worldviews in community dynamics around the Arbuckle-Simpson Aquifer after learning about the United States Geological Survey's hydrological study and subsequent controversy over the OWRB's response. Recent research has shown that cultural worldviews are predictive of weather and climate perceptions (Leiserowitz *et al.* 2006; Goebbert *et al.* 2012). This study extends the application of worldviews to management of weather and climate risks, carrying implications for policy for adaptation to a changing climate (see also McNeeley and Lazrus 2014; Towler *et al.* 2016a).

Theoretical Framework

The Cultural Theory of Risk explains why diverse groups of people identify and perceive risks differently based on

[1] In Oklahoma, groundwater is considered private property that belongs to the overlying surface owner, although it is subject to reasonable regulation by the Oklahoma Water Resources Board (OWRB no date).

[2] An acre-foot is a common measurement used in U.S water management. One acre-foot per year is approximately 893 gal (3.38 m^3) per day.

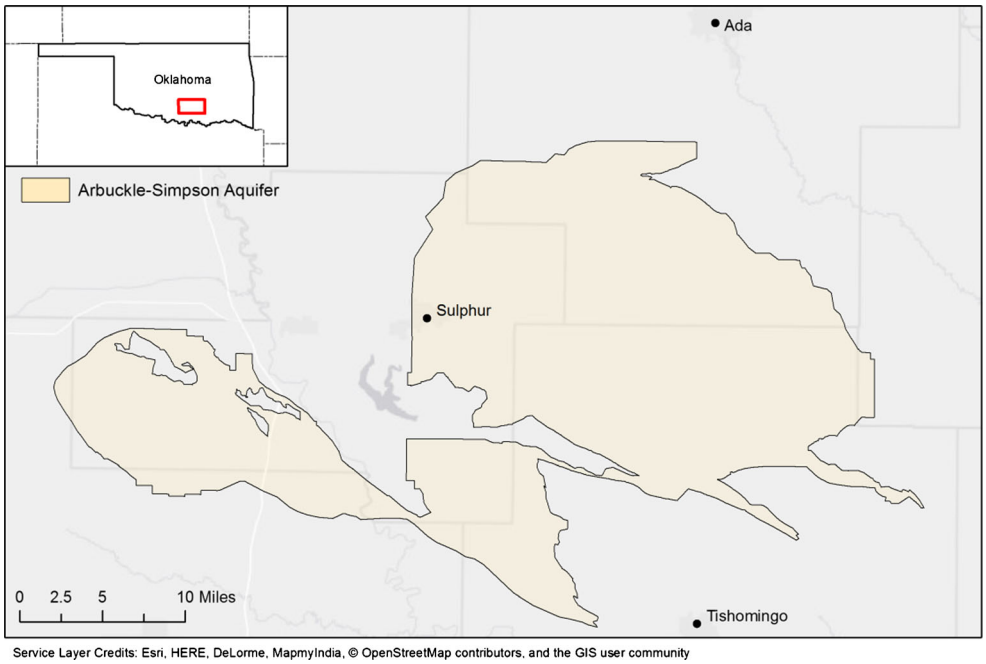

Fig. 1 Map of south central Oklahoma showing towns, surface water, and the Arbuckle-Simpson Aquifer

preferences for different forms of social organization and "consequently a commitment to the kinds of knowledge that goes with it" (Douglas 1999:411). The theory describes four worldviews, or cultural biases – individualist, egalitarian, hierarchist, and fatalist (Douglas 1999) – that represent four idealized forms of social organization including how society and nature should interact, based on how nature is seen to function (Thompson *et al.* 1990). People's worldviews help them navigate the complexities, uncertainties, and dangers they face in daily or extreme situations (Slovic and Peters 1998; Thompson and Wildavsky 1982). According to Thompson and Wildavsky, rather than existing objectively in the physical world, "risk and its absence are qualities that are *conferred upon* it by social processes" (1982: 147, emphasis in original). Risk is perceived when one's worldview is challenged. Moreover, because risk is a product of social processes, purely technical solutions can never fully address which risks exist and how they should be managed. Instead, worldviews provide "moral justification" for which risks and which solutions are prioritized (Thompson and Wildavsky 1982:155).

The four worldviews can be charted along two dimensions: that of "group" – how strongly people feel society should be interconnected – and that of "grid" – how strongly people feel society should be stratified and regulated. The individualist worldview is low group and low grid, favoring weak social bonds and minimal social structure, preferring individual competition and market-based transaction strategies; nature is seen as a resource that will adjust to human actions without suffering permanent harm. The egalitarian worldview is high group and low grid, preferring strong social bonds among people subscribing to few strict rules and a general philosophy of collectivity; nature is seen as fragile and existing in precarious balance with society. The hierarchist worldview is high group and high grid, and also has strong social bonds but these are highly stratified through society and subject to numerous rules and regulations; nature is seen as manageable and able to absorb human influence up to certain thresholds that can be identified in advance by experts. The fatalist worldview is low group and high grid, with weak social bonds among individuals who are resigned to a stratified society governed by many rules over which they have little influence; nature is seen as capricious and fundamentally unpredictable (Douglas 1996; McNeeley and Lazrus 2014; Thompson and Rayner 1998). While helpful as a diagnostic and predictive heuristic, the worldviews are idealized typologies and represent extreme positions not necessarily reflective of actual behavior (Jaeger *et al.* 1998).

Although initially developed with an anthropological focus on culture and context, CTR has more recently been adapted by political scientists and others to understand general population characteristics through survey-based measures (Dake 1991; Kahan *et al.* 2011; Smith and Leiserowitz 2014; Wildavsky and Dake 1990). For example, Kahan (2012) has been instrumental in developing a way to interpret and test CTR which connects the worldviews with psychological mechanisms that explain the role of culture in shaping risk perceptions. In another example, Leiserowitz (2006) has operationalized the worldviews to understand interactions between affect, imagery, and values.

While survey techniques remain effective for understanding the generalizability of worldviews and associated risk perceptions, they are not effective means to capture social context (Rayner 1992), take into account the specifics of place or time (Gross and Rayner 1985), or understand how people

collectively adapt their arguments and policy preferences while remaining faithful to fundamental values implicit in the worldviews (Douglas 1999; Verweij *et al.* 2011). CTR describes worldviews as emergent properties among collectives. That is, worldviews are cultural constructs which, although observed through various research methods, are made meaningful in the context of how they are negotiated and reaffirmed in social interactions. This study blends a quantitative survey approach with qualitative techniques to reconnect CTR with its anthropological and ethnographic roots and examine social conflict over differing perceptions of drought risks in a specific water management context.

Study Methodology

Three main constituencies are engaged in the discussion of water management of the Arbuckle-Simpson Aquifer: landowners who are invested in market-based strategies to manage groundwater including selling water to large municipalities in the wider region, members of the Citizens for the Protection of the Arbuckle-Simpson Aquifer interest group and others who believe in collective action to preserve the groundwater, and scientists, managers, and officials from state and federal agencies (These are not strict categories and some CPASA members also own large areas of land while some who agree with CPASA are not official members of the group). In a CTR framework, these constituencies represent individualist, egalitarian, and hierarchist worldviews respectively. Because this study is focused on community-level dynamics that exert influence on the OWRB (the state management entity), only individualist and egalitarian worldviews are explored in depth.

Interviewees were selected following a purposive snowball sampling approach (Bernard and Russell 2002) whereby participants active in the controversy over water management (either for or against the new maximum annual yield figure) or particularly affected by the 2011 and 2012 drought were contacted initially, and additional participants generated from their suggestions. Interviewees in support of the increased levels of water management were initially contacted through Citizens for the Protection of the Arbuckle-Simpson Aquifer, while those against were contacted through the local Farm Bureau offices (although Farm Bureau staff and members actually represent diverse views). Thus, interviewees consisted of those aligned with CPASA, collaborators in the effort to sell groundwater out of basin, municipal water managers, non-profit and government tourism and recreation officers, and members of the Chickasaw Nation, a federally recognized Native American tribe that was forcibly removed to the area by the US government in the 1830s and continues to maintain tribal lands spanning the aquifer. Each of these groups included people whose families have lived in the area for generations and people who were newer arrivals, people who maintained ranches and people who held office or retail jobs, and an almost equal proportion of men and woman. Everyone who was contacted agreed to an interview with one exception, a landowner heavily involved in opposing the OWRB. Most interviews were conducted in interviewees' homes; a few were conducted in their workplaces or in nearby cafes and restaurants.

The interview protocol combined questions used by Smith and Leiserowitz (2014; in turn derived from Dake 1991, 1992; Peters and Slovic 1996; and Rippl 2002) with questions developed specifically to investigate the local controversy about water management in the Arbuckle-Simpson Aquifer basin. Smith and Leiserowitz' questions operationalize individualism and egalitarianism, the two worldviews that were determined to be particularly relevant in this study (Smith and Leiserowitz attempted to operationalize the other worldviews but did not achieve satisfactory statistical reliability of the scales).

In this analysis, the measures from Smith and Leiserowitz (2014) are referred to as 'universal'[3] (Table 1). These were coupled with questions designed specifically to understand how people's worldviews guide risk perceptions in a specific water management context. The 'contextual' measures address the importance of water, drought risks, and water management preferences in the Arbuckle-Simpson Aquifer (Table 2). This approach was designed to combine the generalizable survey measures used in other studies with insight into the "specific manifestations of the ways of life in a particular social domain at a certain time" (Verweij *et al.* 2011). The objective is to examine the relationship between distal, generalizable survey measures for worldview with the emergent worldviews and proximal perceptions among a local population involved in a specific case study, i.e., whether the general survey measures would effectively scale down to the local context. Both the universal and contextual measures were phrased as statements and answered with responses on a 5 point Likert scale, ranging from 'strongly disagree' to 'strongly agree.' The egalitarian and individualist indices produced high reliability. Interviewees were given the opportunity to explain their response in open-ended narrative answers that provide deeper insight into the range of views and more detailed knowledge of the context, and helped guide interpretation and analysis of the data from the agree/disagree statements. Direct quotes are presented below to contextualize and lend meaning to the quantitative results.

In June and July, 2012, 38 interviews were conducted and a satisfactorily high level of information saturation was achieved (Guest *et al.* 2006). Interviews lasted from 30 to 120 minutes. All interviews were recorded and transcribed verbatim.

[3] The term 'universal' is used here to distinguish the survey questions used by Smith and Leiserowitz (2014) from the contextual measures that reflect the specific water management and drought context of the Arbuckle-Simpson Aquifer basin. However, these measures were developed for the United States and it should not be assumed that they are truly universal or that they could be applied in any time, place, or context (Douglas 1999).

Interview transcripts were then analyzed using a combination of quantitative and qualitative approaches. Qualitative analysis was guided by a coding scheme, derived specifically for this project, which reflected major concepts in the CTR as well as inductively-derived concepts that emerged as particularly important to interviewees; it contained 79 codes that operationalized ten themes of relevance to the goals of this study (Bernard and Russell 2002): worldviews, water management preferences, how water is variously used and valued, environmental observations, drought risks, previous drought experience, sense of place and relationship to nature, sense of community, community organizations, and role of government.

Results

Mapping the Cultural Theory of Risk to the Arbuckle-Simpson Aquifer Water Controversy

The first goal of the study was to understand why people have different drought risk perceptions and water management preferences by exploring how universal CTR measures relate to perceptions about a specific environmental issue, i.e., whether a distal explanation of risk perception helps explain the proximate preferences for water management in the Arbuckle-Simpson Aquifer (Slovic and Peters 1998). The first step was to determine the reliability of the worldview measures for this case study. As anticipated based on Smith and Leiserowitz' (2014) analysis, the universal indices for both egalitarianism and individualism resulted in relatively high internal consistency for each worldview indicated by high reliability scores according to Cronbach's alpha, a measure of internal consistency (α = 0.74 and 0.86, respectively; see Table 1. Note that a reliability coefficient of 0.70 or higher is considered acceptable in most social science research situations). The contextual indices for egalitarianism and individualism also resulted in high internal consistency and reliability, although less so for the individualism items (α = 0.75 and 0.68 respectively; see Table 2).

Results further indicate that there is high consistency across the universal and contextual items for both egalitarianism and individualism (α = 0.79 and 0.85, respectively). As expected based on CTR, the complete egalitarian and individualist indices, including both universal and contextual items, are negatively correlated ($r = -0.84$, $p < 0.01$), i.e., interviewees who agree with statements indicating egalitarian values tend to disagree with statements of individualist sentiment.

Thus, the differences among interviewees in how they perceive drought risks and prefer water management solutions can be explained in large part by their different worldviews. The connections between the abstract, universal concepts derived from the CTR worldviews and the locally-specific, contextual concepts representing how the CTR worldviews relate to water management in the Arbuckle-Simpson Aquifer are illustrated by the response of one interviewee, a rancher with strong individualist preferences, to the egalitarian-oriented, contextual statement, *Water should be managed by a communal process in which everyone has an equal say*: "No….Because that gets back to government being involved in things….I totally disagree" (Interview 9). Another interviewee, the manager of a recreational area, with strong egalitarian views responded to the individualist-oriented contextual statement, *Restrictions on how property owners can use water on their own property are an infringement of individual rights*:

Table 1 Universal egalitarian and individualist indices

	Mean	SD	Alpha
Universal Egalitarian Index (n = 38)			0.74
In my ideal society, all basic needs (food, housing, health care, education) would be guaranteed by the government for everyone.	2.05	1.138	
I support government programs to get rid of poverty.	3.29	1.271	
Discrimination against minorities is still a very serious problem in our society.	3.50	1.202	
The world would be a more peaceful place if its wealth were divided more equally among nations.	2.84	1.175	
Universal Individualist Index (n=38)			0.86
The government interferes too much in our everyday lives.	3.18	1.353	
Government regulation of business usually does more harm than good.	2.97	1.197	
People should be allowed to make as much money as they can, even if it means some make millions while others live in poverty.[a]	3.84	.916	
If the government spent less time trying to fix everyone's problems, we'd all be a lot better off.	3.03	1.345	
Our government tries to do too many things for too many people. We should just let people take care of themselves.	3.08	1.239	

Response scales range from 1 (Strongly disagree) to 5 (Strongly agree); based on Smith and Leiserowitz (2014).

[a] This question was difficult for some interviewees to understand, perhaps because it has two parts and one could conceivably agree with one part while disagreeing with the other. However, even if this measure is removed from the analysis, it does not affect Cronbach's alpha (alpha for this item if deleted is 0.863).

Table 2 Contextual egalitarian and individualist indices

	Mean	SD	Alpha
Specific Egalitarian Index (n = 38)			0.75
Water should be managed by a communal process in which everyone has an equal say.	2.84	1.220	
Individual water rights need to be limited for the sake of the collective good.	3.76	1.218	
Specific Individualist Index (n = 38)			0.68
Individuals should be able to determine how best to use water on their own property.	2.87	1.234	
Restrictions on how property owners can use water on their property are an infringement of individual rights.	2.79	1.318	

Response scales range from 1 (Strongly disagree) to 5 (Strongly agree)

> "I strongly disagree. You know … I feel like I'm out of step, certainly here in Oklahoma, but … we all need to live together, and in order to live cooperatively in a large dynamic society, there are times when you have to put some of your personal concerns aside in favor of what's in the … common good" (Interview 34).

Despite the overall consistency across universal and contextual measures, in some cases interviewees with strong egalitarian or individualist preferences according to their responses to the universal measures answered differently to the contextual measures, demonstrating the complexity of how the role of water, water management, and cultural worldviews are related. For example, an interviewee, a well-known rancher very active in the ranching community, with strong individualist preferences on all universal measures, responded to the contextual egalitarian statement, *Individual water rights need to be limited for the sake of the collective good*:

> "Well … I've never answered that in any favorable way before, but since in this instance … that you're talking about, yes. It had to be or we were going to just die … Everything depends on water" (Interview 1).

Another interviewee, a business-owner, who also ranked highly on the universal individualist measures cautiously disagreed with the contextual individualist statement, *Individuals should be able to determine how best to use water on their own property*:

> "I think that you have to have some leeway in determining how to use that water, since it is your private property right in Oklahoma. However, we also have to be conscientious of our neighbors … But we have to have a set of rules that everyone understands. And once those rules are set - you can't have a bunch of water Nazis trying to make judgment calls about how someone's using their water. So, if I can use a certain amount - tell me what that amount is, and then stay the hell out of my business" (Interview 2).

Cultural Theory of Risk and the Importance of Water in the Arbuckle-Simpson Aquifer

The second goal of the study was to use CTR to understand how people value water for various local uses, and by extension, view risks from water shortages due to drought or water management. Describing the importance of water in the Arbuckle-Simpson Aquifer area, a woman who lives on land that has been in her family for generations observed: "It's the soul of our community" (Interview 27). Another interviewee elaborated: "Without water, we do not have anything to offer" (Interview 1), referring to ranching, a cornerstone of the local economy, and to recreational opportunities that draw visitors from across the state. According to a retired health-care provider, lack of water can have broad emotional impacts: "A long hot prolonged drought really affects people's attitudes I think. It gets kind of depressi[ng]" (Interview 16). A Chickasaw elder reflected that:

> "We all need to get along, and help each other, and not be greedy with each other…well, like with the Indians, they stole their lands and try to take their water rights - everything away from us that was promised to us during the removal to Oklahoma. As long as the water's blue and the sky's blue and the grass is green, but that didn't happen … And when the drought comes, everything becomes scarce. You can have all the money in the world. That's not [going to] help you if you have no food, no water, or anything" (Interview 32).

A series of interview questions related to the importance of water for maintaining various activities (Table 3; see also Towler *et al*. 2016a). Interviewees largely agreed that the local water resources are important for sustaining livelihoods, supporting habitats for plants and animals, and maintaining drinking water supplies in the area. When water is scarce, as it was during the drought of 2011 and 2012, ranching in particular suffers: "[B]y the end of the summer [of 2011] … there wasn't an animal in a field anywhere. Everybody had sold everything. They were all gone. It was pretty bizarre. Never seen anything like that before" (Interview 21).

Table 3 The importance of water

How important do you believe that local water resources are for…	N	Minimum	Maximum	Mean	Std. Deviation
Livelihoods	38	3	5	4.66	.669
Recreation	38	1	5	3.89	1.085
Spiritual fulfillment	38	1	5	3.68	1.544
Cultural practices	38	1	5	3.74	1.107
Habitat for plants and animals	38	4	5	4.87	.343
Maintaining drinking water supplies	38	4	5	4.95	.226

Response scales range from 1 (Not very important) to 5 (Very important)

There was less agreement among interviewees with diverse worldviews about the importance of local water resources for recreational opportunities, spiritual fulfillment, and cultural practices. While some of the variation may be due to how interviewees interpreted these activities, especially spiritual fulfillment, the spread in responses regarding recreation and cultural practices is at least partially explained by CTR worldviews. Interviewees with egalitarian preferences (across both universal and contextual measures) were very likely to think that local water resources are important for recreational activities ($r=0.45$, $p<0.01$) and cultural practices cultural practices ($r=0.42$, $p<0.01$). In contrast, those with individualist preferences did not see water as very important to maintaining recreational activities ($r=-0.40$, $p<0.01$) or cultural practices ($r=-0.29$, $p<0.1$ respectively). Gathering a sense of the importance people attribute to various local water-based activities helps to understand how they are affected by and perceive drought risks.

"Water is Made for Fighting. Whiskey is Made for Drinking"[4]: Linking Drought Risks and Controversial Water Management in the Arbuckle-Simpson Aquifer

The third goal of the study was to use CTR to help explain the controversy over how water should be managed, especially in light of the new maximum annual yield from the aquifer. Many interviewees, especially those who exhibited egalitarian values but also some who reflected individualist values, shared the sentiment expressed by one rancher: "You've got to manage the water responsibly so that during a time of drought, you've minimized the effects" (Interview 24). Interviewees also claimed that the aquifer provides a natural and essential mechanism for reducing the effects of drought by "buffering out those peaks [of extreme rainfall or lack of rainfall]. 'Cause you just want to shave those peaks off and stick them underground. 'Cause we can't afford to build lakes anymore, but we can fill our aquifers back up" (Interview 2). In spite of the general agreement among interviewees about the need to manage water effectively to lessen drought impacts, a farmer interviewee explicitly described, from an egalitarian perspective, the conflicting values at play:

> "The water is critical, but when there was a proposal - this was [what began] the Arbuckle-Simpson Aquifer Senate Bill 288 argument - it was a proposal to build an 88 mile pipeline up to central Oklahoma and supply water to Central Oklahoma communities, we realized that Oklahoma water law is odd…. [G]round water rights are treated like mineral rights in that property owners saw the opportunity to sell water….I knew fundamentally the water is of course … the source of rural economy. It's a core source of human life, necessity for human existence, but yet *it was being treated in the marketplace as a marketable commodity* akin to mineral [rights]. Some of the opposition [claimed]… "these are my private property rights" and [set up] that distinction between water as a necessity for human existence…. And so that's a fairly recent what I would call political awareness of water that I really didn't have before and I know that the times of drought makes it hard for people" (Interview 12; author's emphasis).

In contrast, consider this comment from a business-owner's individualist perspective:

> "[W]ater's always run uphill to power and money. There … are stakeholders who have more in the game, and should have more say in it. The people who actually own the resource, they should have more influence than someone who's merely a consumer of the resource. If we were talking about oil instead of water, or say gasoline instead of water, it's not like we all sit around and decide what the price of gasoline should be. It's market driven. And I definitely think that … the whole water market idea is one that's coming quickly. In fact, that's why I got into it. I started selling water, doing water leases" (Interview 2).

As the above quotes illustrate, preferences for different forms of water management institutions corresponding to

[4] Interview 1.

different worldviews – from communally sanctioned measures reinforced by managers that are accountable to community members to entrepreneurial market-based strategies – are at the heart of the Arbuckle-Simpson Aquifer controversy and are exacerbated under drought situations.

Discussion

Periods of drought become more frequent and intense under climate projections for much of the United States (Georgakakos *et al*. 2014), including south central Oklahoma (Towler *et al*. 2016b). Thus, it is important to understand how perceptions of drought risks influence water management decisions that can lead to adaptive responses to increased incidence or intensity of drought. Drought affects people in different ways, depending on vulnerabilities to freshwater shortages; livelihood dependence on water; spiritual, cultural, and recreational interactions with water; and wellbeing. All of these variables were discussed by interviewees, one of whom reflected that because of the various ways in which drought interacts with both environmental and social processes, "drought is a relative term" (Interview 37). In this analysis, the relativity of drought risks is related to worldview and a cultural sense of where one stands (Rayner 1992).

According to CTR, preference for or against different resource management strategies will be consistent with worldview so that, for example, someone who favors individualist values, including competition and market- based institutions, will support resource management strategies that reflect those preferences – such as allowing individuals to make their own decisions about how best to manage groundwater on their property. Those with an individualist worldview will discount drought risks, believing that individual initiative, technology, and market strategies will resolve them (Slovic and Peters 1998). Conversely, someone with egalitarian tendencies would favor community-based negotiations to manage water resources which they perceive as threatened by drought. The egalitarian perspective also considers the role of externalities and recognizes the impact of individual actions, that is, with a common pool subtractable resource one individual's withdrawal of water affects the amount left for others.

Results show that there is relatively high consistency between people's worldviews and preferences for local water management in the Arbuckle-Simpson Aquifer, confirming a theoretical contribution of the study that the distal measures used in CTR survey research are predictive of how people perceive and behave towards a proximate case (Slovic and Peters 1998); that is, the broad generalizations about cultural patterns of difference among individuals as measured through distal or universal survey items are confirmed as an effective lens through which to understand specific, local dynamics (Thompson and Wildavsky 1982). However, digging more deeply into the qualitative results also shows that, regardless of worldview, interviewees are concerned about water availability in the face of drought risks. The controversy about water in the area is thus more about the modes of management than the need to limit water withdrawal overall – insight that cannot be achieved through the universal survey measures alone.

Results also connect worldview with how important people believe water is for various activities in the region. Consistent with willingness to accept some form of water management, all interviewees, regardless of worldview, agreed that local water resources are important for some activities such as maintaining drinking water supplies and most agreed they are also important for local livelihoods. The greater divergence about the importance of water for other activities, such as for recreation and cultural practices, is in part explained by worldview.

The controversy surrounding water management in the Arbuckle-Simpson Aquifer stems from the fact that individualists favor market based strategies based on private property rights that are incommensurate with egalitarian principles of communal management based on equal shares. Water management is designed to mitigate the adverse effects of water shortages, including during periods of drought. CTR tells us that management is actually about minimizing social risks. Thus, for egalitarians, underlying the management preferences for equal distribution of natural and capital resources is the threat that landowners who sell the water on their property will benefit financially and thus increase economic discrepancies in the communities, already among the poorest in the US.

Overall, results demonstrate that while those with egalitarian and individualist worldviews may not agree about how water should be managed, they do agree that water is important to the existence of the communities, that water resources are subject to drought risks, and that some form of water management is therefore desirable. In controversial resource management settings such as this, insights from CTR may help identify and leverage common ground among community members (Ostrom1990). Management strategies that encompass this common ground, or include at least some elements of each worldview, have been termed "clumsy solutions" (Verweij *et al.* 2006), and are in line with the "institutional bricolage" (Cleaver 2012) of constant renegotiation of accepted norms with new management arrangements. Normatively, a clumsy solutions model to risk management that encourages collaboration in the Arbuckle-Simpson Aquifer area would identify and include at least some of the ideals and preferences associated with the various worldviews held by constituents (Verweij *et al.* 2006).

The Cultural Theory of Risk explains why conflict has arisen due to the different social priorities, ideas about property and ownership, and opinions about what counts as valid evidence and credible knowledge among community

members. Neither set of preferences corresponding to either the egalitarian or individualist worldview is correct or complete, and both could contribute to a clumsy solution management framework. One possibility is a management strategy that reflects the priorities of each constituency; for those with egalitarian preferences this means implementing and enforcing a common limit on the amount of water each property owner can withdraw from the aquifer, while for those with individualist preferences, this would be retaining control over the decision-making and use of groundwater – up to the stated limit – on their own property, including the right to sell water. These goals are not mutually exclusive and, through a collective process in which community members are actively and meaningfully engaged, could be achieved (Rayner and Cantor 1987).

Effective water management decisions that meet their management goals and also succeed socially are essential in the drying climate of the southern Great Plains. As this case study demonstrates, geographic scale is also important: while it may be adaptive at a sub-state scale for larger municipalities to purchase water from rural landowners, water sources and communities may suffer at a more local scale. The CTR helps us understand how adaptation is not just a scientific activity, but rather a complex process guided by moral justifications embedded in the worldviews people bring to bear on their perceptions of risks and preferences for diverse management strategies.

Conclusion

Recent hydrological studies of the Arbuckle-Simpson Aquifer indicate the need for sustainable management of the amount of water extracted from the aquifer, which serves as the primary water resource in the area. However, conflict has arisen among community members with diverse worldviews and opposing management preferences. The drought of 2011 and 2012 was experienced among rural community members in south central Oklahoma as a "revelatory crisis," revealing worldviews that guide their perceptions of drought risks and water management preferences. Community members interviewed show strong preferences for either egalitarian or individualist values, and demonstrated strong consistency in their values across more abstract CTR measures as well as case-specific items related to water management.

Differences among interviewees in their risk perceptions and water management preferences can be explained to a large extent by the different worldviews to which they adhere. Egalitarians, preferring management strategies based on collective decision making and equal shares, subscribe to a worldview that is threatened by the potential financial benefits gained by landowners who sell their water for high profits. In turn, individualists, favoring market-based strategies and entrepreneurial solutions, feel threatened by the Oklahoma Water Resources Board's determination of the maximum annual yield from the aquifer as an infringement of their private property rights. Interviewees holding egalitarian worldviews are more likely to think that water is important for a broader range of activities than those holding individualist worldviews, thus potentially increasing their perceptions of drought risks as well as the risks of selling water. However, despite divergent management preferences, interviewees agree that sustainable water management in the face of drought risks is desirable. This broad responsiveness to management indicates the potential for a "clumsy solution" to water management in the Arbuckle-Simpson Aquifer that incorporates both egalitarian and individualist values. Understanding that risks are socially derived, as demonstrated by this application of CTR, underscores the need to manage social and physical risks together, not in isolation, especially in a changing climate that can amplify both sets of risks. By combining the universal measures derived from CTR with context-specific interview questions, the study reconnects CTR with its anthropological roots and demonstrates an effective approach to identifying adaptation solutions in a changing climate.

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Compliance with Ethical Standards

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