Reg Environ Change (2017) 17:565–577
DOI 10.1007/s10113-016-1048-6

ORIGINAL ARTICLE

Responding to the Millennium drought: comparing domestic water cultures in three Australian cities

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Received: 29 February 2016 / Accepted: 24 August 2016 / Published online: 8 September 2016

Abstract Adapting to water scarcity is a critical issue for many cities around the world as they respond to the influences of population growth, urbanisation and climate change. There is increasing recognition that geographic context has an impact on experiences of and approaches to domestic water use, but research comparing urban environments is scarce. This paper describes different domestic water cultures after the Millennium drought in three Australian cities—Melbourne, Perth and Brisbane. All three cities have experienced drought, or severe water shortages, over the past 15 years, and each city has responded differently. The experience of water scarcity and water restrictions imposed by governments impacted on people's everyday lives in varied and profound ways. Drawing on quantitative data from a national survey ($n = 5194$) and qualitative data from focus groups, we found that a sense of water crisis led to household water conservation in Brisbane and Melbourne. In contrast, access to alternative water sources in Perth through desalination plants and household bores de-emphasised personal responses to household water conservation. The implications are that urban specific policies and interventions are needed to provide durable change in domestic water cultures. We argue that greater water sensitivity and responsiveness to water availability should be promoted in different urban centres, and that water supply solutions should be accompanied by initiatives that promote adoption of sustainable water practices and future resilience.

Keywords Millennium drought · Cities · Domestic water use · Australia · Mixed methods

Editor: Erica Smithwick.

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Introduction

Water security is a critical issue: population growth, urbanisation and climate change are increasing water demand and undermining health of freshwater resources (Alcamo et al. 2007; Vörösmarty et al. 2000). There are many approaches to improving future water security: supply-side solutions include use of recycled water schemes, stormwater harvesting and desalination schemes. In contrast, demand-side approaches focus on reducing water use or improving the efficiency with which water is used (Sahin et al. 2015). It is increasingly accepted that introduction of new water management initiatives needs to consider the sociocultural context in which these are implemented. For example, recent research has shown that sociocultural and demographic characteristics such as ethnicity, household size, rural vs city upbringing, dwelling type and life stage influence water conservation and consumption (Allon and Sofoulis 2006; Fielding et al. 2012;

Jorgensen et al. 2014; Maller and Strengers 2013; Randolph and Troy 2008).

Geographical contexts can influence water practices and support for water-related policies, reinforcing the importance of location in understanding response to drought. Temperature variation may be one factor that influences water use: the degree to which temperature influences urban water use may vary according to urban landscapes and vegetation patterns (Breyer et al. 2012). Another factor that may influence practices and policy support is experience and familiarity with different water management approaches. Hurlimann and Dolnicar (2016) compared use and acceptance of alternative water sources across nine countries and showed that location significantly influenced perceptions of alternative water sources. They argue that variations in willingness to use alternative water sources derive from variation in experience of alternative water sources. The experience of water scarcity and water restrictions may also influence water practices and policy support. For example, Gilbertson et al. (2011) compared attitudes about water conservation between an Australian city (Darwin) and a rural area facing water shortages. They reported that the rural experience of drought was associated with greater adoption of water-saving behaviours and support for water conservation initiatives. Similarly, Dean et al. (2016a) report that rural or regional Australians demonstrate greater engagement in water-related issues, including greater support for alternative water sources and greater adoption of water-saving behaviours. It is likely that differences between urban and rural residents in attitudes about water relate to rural experience of non-reticulated water systems, connection with the land, and direct experience of water scarcity (Allon and Sofoulis 2006; Dean et al. 2016b). Research in South East Queensland (Australia) shows that regions which have experienced drought and severe water restrictions tend to use less water than locations which did not experience significant drought (Fielding et al. 2012). Aisbett and Steinhauser (2014: 167) show that residents of the Australian Capital Territory are more willing to voluntarily conserve water if they believe that water is scarce and the 'public value of the savings is greatest'.

These findings highlight that experience of drought influences domestic water practices and support for policies to address water scarcity. However, relatively less research has examined how different policy responses to drought may also influence how individuals respond with the issue of water scarcity. Kallis (2010) describes long-term responses to water scarcity in Athens, Greece, highlighting how technical solutions to increase water supplies have led to adoption of new water use practices and increased water use, which then acted as a barrier to water conservation initiatives. He draws on the theory of coevolution from ecological economics, which proposes that while humans do adapt to their natural environments, they also actively transform these environments and then adapt to these transformations (Kallis 2007). Within this framework, he argues that domestic water use practices and policy responses to water scarcity are mutually interdependent (Kallis 2010). Similarly, Loh and Coghlan's (2003: 1) research on domestic water use in metropolitan Perth (Australia) reports that households have a high uptake of private groundwater bores, with 'few restrictions in most areas to prevent householders sinking a bore for watering'. High rates of water use in these households, despite a drying climate, show that supplemented water source changes the way households engage with water.

Despite the importance of location in influencing water practices, there is a notable dearth of research comparing cities and exploring how domestic water practices and policy solutions coevolve in response to drought in different climatic contexts. In this paper, we address this gap by describing distinct water cultures in three Australian cities—Melbourne, Brisbane and Perth—which experience major differences in climate and policy responses to water scarcity (Fig. 1). Australia is considered to be a country at high risk of water scarcity, withdrawing 40–80 % of water relative to the available annual renewable supply (WRI 2016). All three cities have experienced recent droughts, and each has responded differently. Most recently, the Australian Millennium Drought (1997–2009) resulted in each city implementing diverse supply and demand management strategies. First, we use a quantitative survey to examine geographic variations in diverse water use behaviours, support for alternative water sources, social norms and exposure to information. We hypothesise that (1) Perth, with its experience of alternative water sources, will exhibit greater support for alternative water sources and lower uptake of water conservation behaviours. Second, we present a series of qualitative analyses exploring the relationships between location, water practices and cultures and policy solutions in more depth. We hypothesise that (2) access to alternative water sources reduces uptake and perceived necessity of household water conservation measures and (3) that a sense of water crisis increases household water conservation practices.

Methodology

In this paper, we draw on quantitative survey data and qualitative focus group data to compare the cities. Institutional ethical clearance was obtained prior to study commencement.

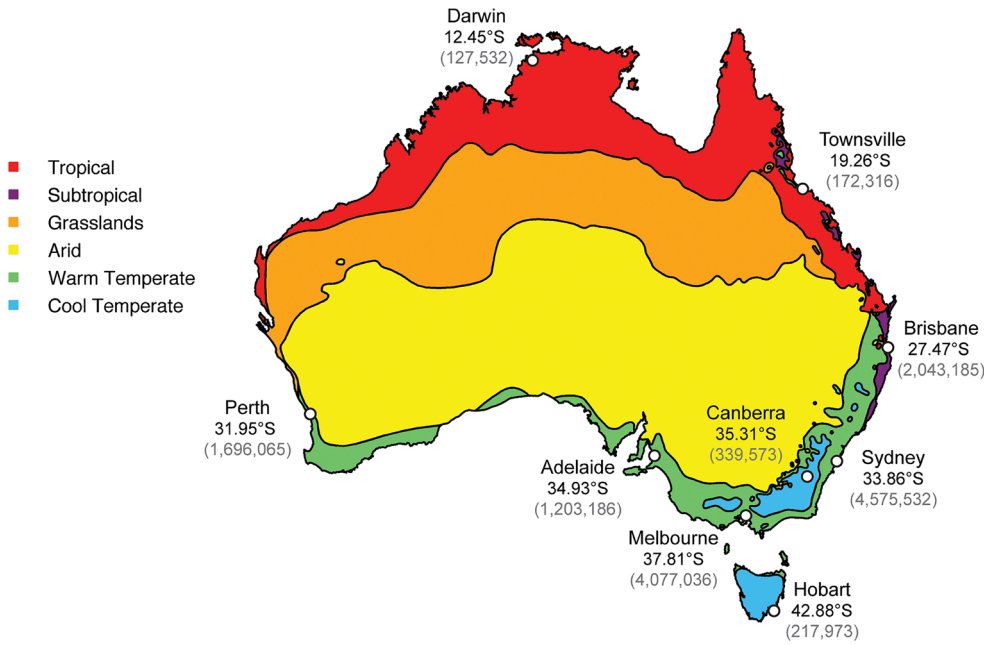

Fig. 1 Climate zones and the location of the most populous cities within Australia. *Source*: Patterson Ross et al. (2015)

Study sites: Three cities

As shown in Fig. 1: The three cities are geographically dispersed across the Australian continent and located in different climate zones and have different population levels (population levels in parentheses). Perth is located in the west of the country with a dry climate; Melbourne is a large city in the south-east of the country and has a warm temperate climate while Brisbane on the east of the country has a subtropical climate.

Perth

Perth has experienced a drying climate over the past four decades. Reduced rainfall and changes in rainfall timing have led to critically low dam levels (in 2015, storage was approximately one quarter of capacity). In the past decade, drinking water has been mainly sourced from desalination plants and groundwater. Water use per person in Perth is still greater than for other cities in the study, yet there has been substantial change over time. For example, daily water use in Perth reduced from 523 L per person in 2001 to 358 L per person in 2013–14 (Water Corporation 2014). Some water restrictions remain in place, including garden watering on occasional days. A plan to combat Perth's drying climate was implemented a number of years ago which relies on technological and behavioural changes (Water Corporation 2011). The water crisis in Perth has been largely overcome through the use of technological 'fixes': two desalination plants, recycled water recharge of the Leederville aquifer, and reliance on shallow and deep aquifers. The state-owned water supplier for Western Australia, Water Corporation, ran a positive and successful community engagement campaign that built support for recycled wastewater for aquifer recharge (Water Corporation, 2013). These solutions have seemingly mitigated any palpable sense of crisis. The technological fixes have been a deliberate strategy by the state government and the Water Corporation to ensure the community has 'independent' water sources to alleviate or avert future crises. The state is working towards 'drought-proofing' Perth to ensure continued and bountiful supply—'water forever, whatever the weather' (Water Corporation 2011).

Melbourne

The Millennium drought had a profound impact on dam storage in Melbourne. For example, dam storages dropped from 97.5 % in 1996 to only 33 % by 2010 (Bureau of Meteorology 2016). Melbourne residents experienced widespread water restrictions over the 12 years of drought and continue to have permanent restrictions in place. Residents are using less water than they did in 1998 (when the drought began), but not as little as they did at the height of the drought. Water use remains at low levels with residents continuing to use water efficiently, with consumption at 251 L per person per day which is similar to 2013 levels (Melbourne Water 2014). Importantly, they report that total water use in Melbourne has risen slightly, but remains lower than consumption pre-drought. For example, in 2000–01, the pre-drought water level was 408 L per person per day (Melbourne Water 2014). These figures show that residents of Melbourne are committed to reducing their water consumption.

Brisbane

The impact of the Millennium drought was profound in Brisbane, where dam levels were exceptionally low, falling from over 60 % to less than 20 % between 2004 and 2007 (Turner et al. 2010). The water authority asked people to reduce their water consumption to 140 L per person, per day (in Melbourne the target was 155 L per person, per day). This target was achieved mainly through people changing daily water use—shorter showers, no garden watering and no car washing. State and local governments offered incentives for showerheads, water tanks and other efficiency devices to further reduce household water consumption (Walton and Hume 2011). The drought ended in 2010 (Heberger 2011), and since this time Brisbane has experienced severe flooding (the worst occurring in 2011). Current projections suggest that Brisbane has adequate water security until 2030 (Seqwater 2015).

Study 1. National survey

Quantitative data were sourced from a national survey of adults residing in Australia ($n = 5194$) utilising a social research company permission based, online panel. The sampling frame targeted a representative sample, based on gender, age, education and state of residence. Eligible panel members were invited to participate via email. The 25-minute online survey was administered during February–March 2014. In this paper, we use the subsample of participants residing in Brisbane, Melbourne and Perth ($n = 1580$).

Postcodes were used to identify residents of Brisbane, Melbourne and Perth using SA4 regions (Australian Bureau of Statistics). Three location variables were created for each city, each coded yes/no. The survey also quantified a series of water-related behaviours, policy support, norms and information recall (Table 1).

The relationship between each city of residence (independent variable) and water-related outcomes (dependent variables, listed in Table 1) were examined using a series of multiple regression analyses. For each city, a stepped regression analysis was conducted. Step 1 examined whether the city of residents influenced each outcome. For example, to assess whether residing in Perth influenced water-related outcomes, a dichotomous variable (1 = Perth resident; 0 = non-Perth resident) was entered as the primary independent variable. *Step 1 only assessed the impact of city, and did not adjust for other factors*. Step 2 added the following independent variables to the model: age, sex, education, history of water restrictions and regional rainfall. This permitted Step 2 to assess whether residing in a particular city influenced water-related outcomes, *after controlling for the effects of other factors known to influence water-related practices*: age, sex, education, history of water restrictions and regional rainfall. All models were checked to ensure assumptions of normality and homogeneity were met.

Study 2. Focus groups

We conducted focus groups in February–March 2015 to gather views and experiences of water use, water shortages and abundance. We conducted three focus groups in Melbourne, Brisbane and Perth (nine in total). Each focus group had 6–8 participants (62 participants in total; 30 men and 32 women, age range 20–81 years) across the three locations. Each focus group discussion was 90 min long. Participants were recruited according to three life stages—young people aged 18–35 with no children (<35); people aged 25–55 with families under 18 years (Family); and people aged 50 years and over with children older than 18 (50+). These three groups were chosen based on previous research indicating that young people use water differently to families and older people (Turner et al. 2010).

The focus groups covered three broad topics: 'Your household and water background'; 'The role of water in everyday life'; and the 'Water sensitive city'. Across these topics, we asked participants to discuss how their location in Melbourne, Brisbane and Perth had influenced their daily water habits. For example, had the recent drought affected how they used water in their household, and if so, how? We asked whether they had installed water-saving appliances in households as a means of conserving water. We also wanted to know what role water played in their everyday life. For example, we asked how important showers and gardens were to participants and how they would prioritise showering, clothes washing and dishwashing. We also wanted to know what it would mean to people if they could use as much water as possible, what it would mean if their water was severely restricted, and how these contrasting scenarios would change their everyday habits.

Focus groups were audio and video recorded and transcribed in full. Participants have been given pseudonyms in order to ensure anonymity. The transcripts were read several times by the authors and keywords/themes were identified using highlighting and commenting features in MS Word. Following Miles and Huberman (1994), a matrix was created which identified keywords and supported further analysis of the data. A higher level of abstraction was included in the matrix. The matrix also indicated locational similarities and differences across the three cities, as well as differences between the three life stages. Field notes were taken after each focus group, with initial findings and impressions recorded. There is considerable diversity

Table 1 Questions included in the national survey

Domain	Question	Response rating	Final score
Dependent (outcome) variables			
Support for alternative water sources	How much do you support: recycled water, desalinated water, and treated stormwater for drinking and non-drinking purposes	5-point scale (1=*do not support at all,* to 5=*completely supportive*)	Mean of six items (Cronbach's α=0.73)
Everyday behaviours in the home	How often do you do any of the following things? (e.g. fixing leaks, taking shorter showers, only running washing machine when full)	5-point scale (1=*never,* to 5=*always*)	Mean of 12 items (Cronbach's α=0.71)
Everyday behaviours in the yard	How often do you do any of the following things? (e.g. mulch garden, allow lawn to go brown, clean with a broom instead of a hose, watering garden in morning or evening)	5-point scale (1=*never,* to 5=*always*)	Mean of six items (Cronbach's α=0.77)
Water-saving devices in the home	Have you purchased and/or installed any of the following in your home? (eg. water-efficient taps, dual-flush toilets, low-flow shower heads)	Yes/already in the house / no	Number of 'yes' or 'already in house' responses (range 0–6)
Water-saving devices in the garden	Have you purchased and/or installed any of the following in your home? (e.g. rainwater tank, drought-tolerant plants, replacing lawns with drought-tolerant grasses)	Yes/no	Number of 'yes' responses (range 0–6)
Frequency of garden watering	How often do you water the garden during a typical week in the dry season?	Open ended	Single item
Showers (per person)	How many baths or showers does your household usually have per week? (adjusted for the number of residents in the household)	Open ended	Single item
Washing loads (per person)	How many loads of clothes washing does your household usually do per week? (adjusted for the number of residents in the household)	Open ended	Single item
Behaviour change during restrictions	To what extent have you changed your behaviour because of water restrictions?	7-point scale (1=*not at all,* to 7=*substantially*)	Single item
Water-saving social norms	Do people in your community saved water around the home? (adapted from Fielding et al. 2010)	5-point scale (1=*never,* to 5=*always*)	Single item
Exposure to water-related information	In the last 6 months, have you seen or heard any information about water from the following? (radio, television, newspapers, online news, water utility newsletter, water utility bill, water utility website, local government newsletter, social media)	Yes/No	Number of 'yes' responses (range 0–9)
Control variables			
Age	What is your age?	Open ended	Single item
Sex	What is your gender?	Male/female	Single item
Education	What is the highest level of education completed?	High school only/trade or technical/university	Single item
Experience of water restrictions	Have you ever experienced water restrictions?	Yes/no	Single item
Rainfall	What is your postcode?	Postcode was also used to calculate regional rainfall statistics, within Australian Bureau of Statistics (ABS) SA4 regions. Rainfall was measured at the weather station closest to the geographic centre of the region (with a bias towards regions with greater population density). Mean annual rainfall was quantified across the 20-year period closest to 2015 (BOM)	

among householders in each city: some participants are very committed to water saving and actively save water wherever they can, while others are disengaged and do not think about water use on a daily basis. In this paper, our aim is to draw out the commonalities and contrasts within each city.

Results

Survey

From the full sample of 5194 Australian adults, 1580 individuals were included in the current analysis. These included residents of Brisbane ($n = 296$), Melbourne ($n = 892$) and Perth ($n = 392$). The average age was 44.9 years (SD = 16.4; range 18–85), and 52.2 % (824/1580) were female.

Compared to Melbourne and Brisbane, multiple regression analyses indicate that Perth residents reported significantly higher support for alternative water sources ($p < 0.001$), higher uptake of water-saving devices in the garden ($p < 0.001$), more frequent showers ($p < 0.001$) and washloads ($p < 0.05$) per person and higher exposure to water-related information ($p < 0.001$). In contrast, Perth residents were less likely to report personal behaviour change during water restrictions ($p < 0.001$) and less likely to think that others in their communities saved water ($p < 0.01$). Each of these findings remained significant after controlling for demographic and climate characteristics (Table 2, Fig. 2). It should be noted that the observed finding about water-saving devices in the garden was primarily driven by the large proportion of householders who have watering systems in Perth. Perth has the highest rate of watering systems (52 % vs 20 % in Brisbane and 20 % in Melbourne). Excluding watering systems from this analysis resulted in no significant differences on water-saving devices in the garden (data not shown).

In contrast, residents of Melbourne reported significantly lower support for alternative water sources ($p < 0.001$), lower uptake of water-saving devices in the garden and lower rates of exposure to water-related information ($p < 0.001$). Compared to Brisbane and Perth, Melbourne residents reported fewer showers ($p < 0.001$) and washloads ($p < 0.01$) per person and less frequent garden watering (adjusted model only, $p < 0.01$). Melbourne residents were more likely to believe that others in their community save water ($p < 0.001$) (Table 2, Fig. 2).

Table 2 Influence of location (Perth, Melbourne and Brisbane) on water-related practices and attitudes, identified by multiple regression analyses

		Perth			Melbourne			Brisbane		
	Step	R^2	β	t	R^2	β	t	R^2	β	t
Support for alternative water sources	1	**0.02**	**0.15**	**5.50*****	**0.03**	**−0.17**	**−5.94*****	0.00	0.04	1.35
	2	**0.08**	**0.17**	**6.20*****	**0.08**	**−0.19**	**−5.78*****	0.05	−0.06	−1.46
Everyday water-saving inside home	1	0.02	−0.05	−0.60	0.00	0.02	0.59	0.00	0.03	1.08
	2	0.11	−0.04	−1.31	0.11	0.04	1.12	0.11	0.02	0.49
Everyday water-saving in the yard	1	0.00	−0.02	0.64	0.00	0.04	1.24	0.01	−0.03	−0.89
	2	0.13	0.00	−0.12	0.14	0.05	1.39	**0.14**	**−0.08**	**−2.06***
Water-saving devices in the home	1	0.00	−0.05	−1.90	0.00	−0.02	−0.67	**0.01**	**0.09**	**3.07****
	2	0.03	−0.05	−1.61	0.03	0.02	0.65	0.03	0.08	1.78
Water-saving devices in the garden	1	**0.01**	**0.12**	**4.24*****	**0.01**	**−0.09**	**−3.19****	0.00	−0.02	−0.73
	2	**0.05**	**0.13**	**6.31*****	**0.04**	**−0.12**	**−3.39****	**0.04**	**−0.12**	**−2.77****
Frequency of garden watering	1	**0.02**	**0.14**	**5.05*****	0.00	−0.03	−1.16	**0.01**	**−0.12**	**−4.28*****
	2	**0.03**	**0.14**	**5.10*****	**0.01**	**−0.10**	**−2.78****	**0.02**	**−0.19**	**−4.39*****
Showers (pp)	1	**0.01**	**0.10**	**3.64*****	**0.03**	**−0.17**	**−6.14*****	**0.01**	**0.10**	**3.71*****
	2	**0.04**	**0.11**	**3.89*****	**0.05**	**−0.15**	**−4.41*****	0.03	0.01	0.32
Washloads (pp)	1	**0.002**	**0.06**	**2.08***	**0.01**	**−0.10**	**−3.38****	**0.001**	**0.06**	**1.98***
	2	**0.03**	**0.06**	**2.09***	**0.03**	**−0.10**	**−2.93****	0.02	0.05	1.09
Behaviour change during restrictions	1	**0.01**	**−0.10**	**−3.50*****	0.00	0.03	0.88	**0.01**	**0.08**	**2.89****
	2	**0.16**	**−0.08**	**−3.02****	0.15	0.06	1.76	**0.15**	**0.10**	**2.45***
Others in my community save water	1	**0.01**	**−0.10**	**−3.49****	**0.002**	**0.06**	**2.02***	0.00	0.04	1.38
	2	**0.02**	**−0.10**	**−3.63*****	**0.03**	**0.13**	**3.88****	0.01	0.00	0.08
Exposure to water-related information	1	**0.02**	**0.14**	**4.96*****	**0.02**	**−0.12**	**−4.30*****	0.00	0.00	−0.11
	2	**0.05**	**0.15**	**5.40*****	**0.05**	**−0.16**	**−4.64*****	0.03	−0.08	−1.91

Step 1 = unadjusted; Step 2 = adjusted for age, sex, education, history of water restrictions and regional rainfall. Significant findings highlighted in bold

* $p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$

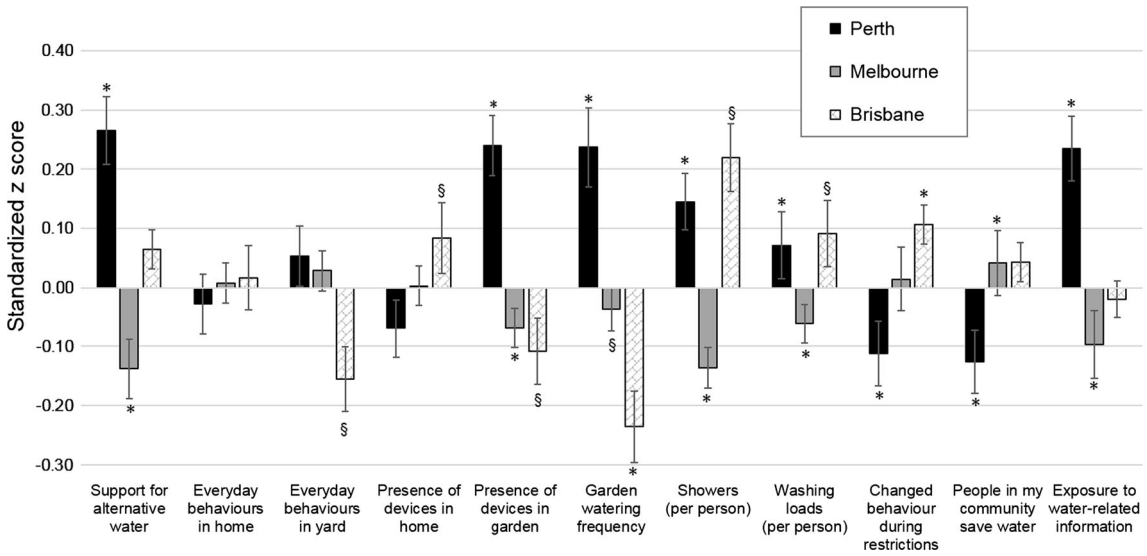

Fig. 2 Standardised scores indicating differences between Brisbane, Melbourne and Perth on key factors related to water use cultures. *significant in *both* steps of regression model, §significant in *only one* step of regression model

Brisbane residents were more likely to report greater uptake of devices in the home (unadjusted model only $p < 0.01$). Brisbane respondents had lower ratings of everyday behaviours in the yard (adjusted model only $p < 0.05$) and lower rates of water-saving devices in the garden (adjusted model only $p < 0.01$). They did report lower frequency of watering the garden during the dry season ($p < 0.001$), but greater frequency of showering (unadjusted model only, $p < 0.001$) and washloads (unadjusted model only $p < 0.001$) per person. Brisbane residents were more likely to report changing their behaviour during water restrictions ($p < 0.01$) (Table 2, Fig. 2).

Focus groups

The focus groups provide a more contextualised view of householder experiences.

Perth

A sense of not 'running out' of water and 'a crisis averted' was evident in the way Perth participants talked about their everyday water use. For example, Daisy (Family) stated, 'it doesn't seem like we really [will run out] in Perth *we kind of just keep flowing*'. We asked participants whether they saw themselves as water savers, water users or 'in the middle'. Most Perth residents viewed themselves as water savers or 'in the middle' but their discussion revealed heavy domestic water use, including frequent showering and use of artesian bores and reticulation systems to water their gardens. Even with a drying climate, participants placed a great deal of emphasis on the appearance of their lawn, making green lawns a distinct feature of Perth suburbia. Unlike Melbourne participants who stated that people did not worry about their lawns anymore, Perth residents continue to pursue green lawns, such as Joshua (<35) who 'ensures that my lawn is green to the point where it's green … because I'm so sick of it turning to a shade of not green'.

Showers were viewed as a high priority by all age groups particularly younger Perth residents who took frequent showers not only for cleanliness, but also to cool down, wake up in the morning or relax after a day at work. As Zelda (<35) explained 'I grew up in a household of girls, so long showers were one of those things we didn't ever really think about, washing your hair, take your time'. Melissa agrees that her showers also take longer but explains 'I value that time'. Long showers were the norm for the younger Perth group:

> … as I got older the longer showers have gotten worse. I might stand there putting the conditioner through my hair and I probably should turn the water off because I'm not really using it at that point but I just don't so that's really quite a waste. (Zelda, <35).

Bore water is relatively common in Perth with 25 % of households having a bore (ABS 2010). Residents in Perth make a qualitative distinction between scheme water and bore water. Scheme water is supplied by the Water Corporation and is paid for according to use and supply. Bore water is regarded as 'private' water, much like Head and Muir (2007) and Moy (2012) found in their research on rainwater tanks. Perth residents believe that water collected from bores is for their private use and the same responsibilities to conserve are not applicable. Using bore water is almost unconscious and taken for granted for Perth

participants. Maggie (Family) exemplifies this 'state of mind': 'And the garden gets watered using bore water but like two days a week or something'. Rosa (50+) is more reflective about their water use and water consciousness, but there is still an implicit understanding that bore water is 'free water': 'I think we're very water conscious or the majority of people are here. I mean, yeah, the water restrictions I think are policed quite rigorously. Yeah, we're lucky we've got a bore, our garden's not that big, although my husband complains about it. But, we manage to, yeah just the three times a week and we grow our own vegetables and things'.

Residents viewed it as the responsibility of government to 'drought proof' Perth with technical solutions. When asked about how they would react to the prospect of heavier water restrictions there was a sense that they would be resisted,

> I think it would take a pretty ambitious government with a death wish to pull that one off and would take a long lead time to school and educate the public that that was coming, because they'd be pretty hard to stomach. You know, there's a whole lot of options (Ian, 50+).

Melbourne

Melbourne participants discussed their water use and water-saving practices both across the drought and since the drought eased. The Melbourne groups discussed a strong sense of water crisis, especially during the drought. Many remember stringent water restrictions, and those who were parents recognised that their children had grown up with different water cultures compared to their own childhoods. However, since the drought broke in 2009 they no longer felt the sense of crisis so acutely. Many continue the practices they undertook throughout the drought, such as reduced garden watering, filling dishwashers and washing machines before use and turning the tap off when brushing teeth. However, most now take longer showers than they did during the drought. In the garden, those who installed water tanks continue to maintain their gardens from this water source. Many who turned off their irrigation systems have not turned them on again, preferring to water by hand. All these changes indicate that people became more water conscious during the drought. Importantly, participants acknowledge that they have not returned to their pre-drought water use habits, they continue to conserve water albeit in different ways than those imposed during the drought. A number mentioned feeling guilty if they used excessive water, especially in their gardens.

Overall, the Melbourne participants saw themselves as 'water savers' and appeared to be more 'water conscious' than the other cities outlining the changes they had made to both inside and outside water use. For example, Drasko (Family) stated that car washing was now done at specialised car washes as a direct result of the drought: 'Washing the car at home is pretty much dead with all these car washes coming up'. Inside the house, Stella (50+) still uses a bucket in her kitchen sink when washing vegetables and then empties the water onto the garden. The use of buckets throughout the drought was notable. During the drought, when no garden watering was allowed from the mains water supply, many people used buckets in their kitchen sinks to collect surplus water for gardens. People also used buckets in their showers to capture cold water before it warmed up, again for use on their gardens. A number of people across life stages have continued this practice post-drought. Chloe (Family) explains how she was influenced by other people's habits and use of buckets in the shower: 'I house sat for a lady who was very, very … environmentally [aware], and she recycled her shower water and would catch it in a bucket and put the plug in the bath and then put it in the garden, and she was really, really mindful, she didn't waste anything'. Beatrice (+50) commented, 'it's just all of those things are automatic now' though she would love to water her garden more frequently than she does.

Melbourne participants, across all three life stages, used the word 'adapt' frequently. In particular, when asked to contemplate future severe water restrictions many discussed the need to adapt to the changed water conditions. Participants in the Family group believed that if water were restricted they would have no choice but to adapt to new conditions:

> William: You'd have to do it. If it was the law, I think you'd have to do [it].
> Anders: Just have to adapt.
> William: Drink your cordial straight I suppose. <laughter>.
> Krishan: Anything that should be done; can be done. I think going to those steps would be step by step, rather than straight away. Just straight on would be hard. So they can be adjusted accordingly as a step, won't be too hard.
> Drasko: Similar to when we didn't have gas for a while, it is what it is, you just adapt and deal with it (Family).

Participants in Melbourne (and the other cities) believed that if severe water restrictions were to return they would have to be introduced slowly and people would need to be 'educated'. Vicky and Krishan both make this point—

adapting to changed water conditions needs to be undertaken incrementally.

Brisbane

Brisbane participants discussed in detail the extent of the drought, with many focusing on the lack of water in Brisbane dams at the height of the drought. The sense of water crisis was expressed most poignantly by Rita (50+): 'in Capalaba, if you watched it a couple of years ago, you could see it visibly shrinking until it was almost a muddy puddle in the middle. And that was *frightening*, because that's what served all our area … but it was *very concerning* to watch this dam going smaller and smaller, so I'm sort of turning the tap off all the time'. Many participants reflected on the ways in which they changed their habits throughout the drought in order to conserve water, and the changes they have made since experiencing water abundance after the drought. The Brisbane participants see themselves as 'in the middle' between water savers and water users—depending on current weather conditions in their city. Many participants discussed a 'conscious' effort to save water, but the Brisbane climate—tropical, humid and hot—necessitates water use, especially for regular showers. Oliver, Minnie and Janet illustrate the diversity of approaches to water use: all changed their habits in response to the drought but their ongoing maintenance of water-saving practices varies. Oliver (<35) describes how many of his water habits changed in response to water restrictions:

> Turning the tap off when you're brushing your teeth, you know, I was doing that every day… I make a conscious effort. I look at the level of the dams almost daily in the paper and I still turn the tap off when I brush my teeth.

Minnie's (<35) drought habits have also continued post-drought. As with others in Melbourne and Brisbane, buckets in showers form an integral part of her daily practice. For example, she collects shower water in a bucket to water her outdoor plants. She states: 'So like you say, that's always in the back of your mind, how can I maximise the water that I use?' Other habits Minnie discussed related to the specific use of her dishwasher. Minnie is so expert at packing her dishwasher, which she only operates once a week that her boyfriend calls her the 'dishwasher ninja': 'I have that skill ... I can fit everything in no matter how much we've used in a week'.

Janet (Family) highlights the cyclical nature of drought and flood in Brisbane. Her family installed a water tank during the drought in order to keep watering the garden and as she mentions below tank water is piped into her laundry. She recognises that the drought had an impact on her life, but now with 'abundance' of water she no longer maintains her drought habits. She stated in the focus group discussion that she feels like a 'water waster', although she has not returned to her pre-drought water use habits:

> I had all those habits when the drought was on, but since the floods, no. Now we've got an abundance of water so I use it. But we do have a rainwater tank, which is plumbed in my laundry, so all our washing is done with tank water, as well as watering the garden. I also use tap water for the garden, because the tank only reaches one side of the house easily. So I'm not as stringent as I was when the drought was on. I've lapsed. Probably a water waster in the view of you guys here.

Like other Brisbane residents, Janet is willing to reflect on her water use in response to both environmental cues and social cues, in this instance comparing her household's water use to others in the focus group setting.

Discussion

Our quantitative and qualitative data combine to show distinct water cultures in the three cities. Perth residents can be characterised as *heavy water users reliant on technology*, Melbourne residents can be described as *still water conscious after drought*, and Brisbane residents can be characterised as sitting between these cities as *responsive water users*. These water cultures reinforce the important influence of social and policy context on water-related practices and support our hypotheses. A sense of water crisis in Melbourne and Brisbane encouraged household water conservation and support for sustainable water practices. In contrast, in Perth, the focus on supply solutions has diminished the perception of water crisis and has weakened household conservation and support for demand reduction measures.

The distinct water culture of Perth residents was characterised by support for technical innovation in water provision in line with the policies of the Water Corporation (Water Corporation, 2013). They are more likely than residents of other cities to support alternative water sources. Indeed, now that substantial public investment has been made in large-scale infrastructure (desalination plants and aquifer recharge), residents expect the government to continue to provide plentiful water supply to Perth households, regardless of the drying climate. To maintain green suburban gardens, many Perth residents install devices in their gardens such as backyard bores and watering systems. Research has found that towns supplied by groundwater tend to use more water than towns with other water supplies (Graymore and Wallis 2010). Perth residents also

report greater recall of water-related information. This may result from major information and education campaigns about recycled water undertaken by the Water Corporation (Water Corporation 2013). Importantly, research indicates that provision of information improves support for alternative water sources (Dolnicar et al. 2010; Fielding and Roiko 2014). Yet, saving water appears to be a low priority for Perth residents as they were less likely to change their behaviour during restrictions. Water-saving norms were also limited, with fewer supporting the proposition that 'people in my community save water'. The low rates of water-saving norms aligns with the focus group data describing individuals' awareness about community members flouting water restrictions and lack of perceived enforcement of these restrictions. Our focus group data also showed that most Perth residents were passionate about frequent and long showers, while older residents and parents valued well-watered gardens for relaxation and leisure.

The focus group data indicated a strong water-saving consciousness among Melbourne participants and substantial adaptation in gardening practices in particular. This, however, was not consistently displayed in the quantitative data. On the one hand, Melbourne residents reported fewer showers and washloads per person and were significantly more likely than those in other cities to support the statement that 'others in my community want me to save water'. Yet, Melbourne residents were less likely to report changing their behaviour in response to restrictions and exhibited no differences in other curtailment or efficiency behaviours in the home, and exhibited *lower* rates of installing devices in their gardens. There are a number of possible explanations for this disparity between qualitative perceptions of water consciousness and self-reported adoption of specific practices. Firstly, it is important to note that the reference point for each of these is different: identifying oneself as a water saver is likely to be referencing the same community, possibly distinguishing between behaviours from a pre-drought period; in contrast, the survey data are referencing current behaviour in comparison cities. So it is possible that while actual behaviours are similar, the extent of behaviour change in Melbourne participants has generated a strong water-saving consciousness. According to our survey data, Melbourne residents have less exposure to water-related information and were less likely to support alternative water sources. There appears to be less support in Melbourne for large-scale technical innovation than in other states which perhaps reflects the contentious political history of the construction of a large-scale expensive desalination plant which was completed just as the drought broke and has not yet been used.

Brisbane residents report more varied water practices than other cities and in the focus groups describe themselves somewhere between water savers and water wasters. This reflects their experience of the most varied changes in climate, from years of severe drought followed by severe flooding. They can be characterised as responsive water users. The survey data show they were most likely to have changed their behaviour during restrictions and take up devices in their home. This is consistent with findings from the Target 140 campaign indicating significant reductions in domestic water use during this campaign, from approximately 300 L per day in the pre-drought period, to less than 140 L per day (Beal et al. 2014; Walton and Hume 2011). The lack of strong identification as water savers may represent a 'rebound' effect triggered by the removal of water restrictions and media campaigns to conserve outdoor water (Beal et al. 2014). Survey data suggest that Brisbane residents report low adoption of outdoor water-saving behaviours and devices. Higher average rainfalls, especially in summer months, may also reduce the need for Brisbane residents to target outdoor water use during periods of demand reduction. This aligns with our survey results, which found that Brisbane residents reported watering their garden less frequently than residents in the other cities. Consistent with the hot climate, Brisbane residents reported more frequent showers than Melbourne residents; unfortunately, data on *duration* of showers (the focus of the Target 140 campaign) are not available.

Implications for policy

Many approaches to managing water scarcity require fostering community support—not only for targeting household water demand or individual behaviours, but as a means of building support for new policies or investment in infrastructure. Our findings indicate that focusing on water supply solutions may inadvertently weaken support for demand management. In fact, creating new water supplies may actually increase water use or allow dependence on unsustainable water practices to persist (Kallis 2010; Wiener et al. 2016). This has been described as a 'ratcheting' feature of water supply expansion—once new water practices become established, they can be very difficult to reverse (Wiener et al. 2016). Our findings also suggest building public support for new water supplies may de-emphasise the role of individual demand reduction approaches and personal responsibility, making it politically more difficult to introduce demand reduction strategies in future. This raises the challenge of how to provide secure water supplies while maintaining sustainable water practices and ensuring communities are resilient to future climate stressors.

When planning for new water supplies, community engagement should also incorporate strategies to foster personal responsibility and sustainable practices, to prevent

the perception of future water abundance. It is possible that characterising such an initiative as a partnership approach, where both communities and institutions adopt sustainable water practices and policies, may promote a sense of fairness. An element of the successful Target 140 campaign in Brisbane was that, in addition to targeting domestic water use, it also promoted demand reduction in workplaces and organisations and fostered sustainable water practices into building codes (Walton and Hume 2011). Research indicates that aligning community engagement with values of the target audience can enhance engagement effectiveness. Our findings suggest that Perth residents value gardens as spaces for recreation and technological solutions. Initiatives targeting domestic water use in Perth could align with these values by promoting technological solutions within the household (such as efficiency devices) or emphasising the importance of conserving water to create sustainable backyard gardens. Although commitment to gardens can generate high levels of water use (Graymore and Wallis 2010), the high value placed on these gardens can potentially motivate individuals to adopt water-saving behaviours (Allon and Sofoulis 2006; Head and Muir 2007).

In contrast, if large-scale technical supply-side solutions are required in cities such as Melbourne or Brisbane, it would be prudent to prevent any weakening of strong water-saving consciousness by incorporating initiatives that maintain strong water-saving identity and social norms, both of which can be effective for promoting support for sustainable practices and policies (Fielding et al. 2013; Walton and Hume 2011). It might also be valuable to recognise the importance of social capital when building resilience to future water challenges. Higher social capital is associated with greater engagement in water-related issues and stronger policy support (Dean et al. 2016a, 2016b). Working in collaboration with community groups has the potential to not only strengthen community networks, but also may build the trust and support necessary to develop climate-resilient cities and communities.

Limitations

One of the limitations of our research is that our quantitative data do not capture the degree to which individuals have engaged in a particular behaviour. For example, individuals in all cities may have reported adopting shorter showers, but it is possible that this is interpreted differently across cities. A respondent in Perth may consider shorter showers as a shift from 10 to 8 min, whereas a Melbourne or Brisbane respondent may consider shorter showers to be a shift from 8 to 4 min. This highlights the importance of also considering objective measures of water use when evaluating the effectiveness of demand management initiatives. The quantitative analysis demonstrates a significant effect of location on many outcomes, but the size of this effect is small, demonstrated by the low R^2 values. Low R^2 values are expected when examining a small number of independent variables, as there are many factors that influence water use practices and attitudes. These include (i) demographic characteristics such as socio-economic status or ethnicity; (ii) household characteristics such as homeownership, the age 'mix' of other householders, or garden size; (iii) psychosocial characteristics such as life satisfaction, social capital and social identity; (iv) pricing and regulations; and (v) climatic factors such as temperature and humidity (Dean et al. 2016a, 2016b; Dolnicar et al. 2012; Randolph and Troy 2008). Within this context, we would not expect location to explain a large amount of the variation in water-related practices and attitudes. Our findings indicate that location makes a *small, but significant*, contribution to variation in these outcomes.

Conclusion

We have found different water cultures in each urban location: according to the severity of the drought experienced (Melbourne, still water conscious), the current degree of water 'abundance' (Brisbane, responsive water users) and the number of independent water sources available (Perth, heavy water users reliant on technology). We argue that there is a 'new normal' of household engagement with water use in each city after the Millennium drought. The 'new normal' can be defined as 'a previously unfamiliar or atypical situation that has become standard, usual, or expected' (Oxford dictionary 2015)). The new normal assumes that people recognise that there was a 'crisis' or that something has fundamentally changed and that they now do things differently. This is true for Melbourne and Brisbane participants—the Millennium drought affected people's everyday lives profoundly. In response, participants developed a new water consciousness and adopted varied water-saving practices, many that they have continued after the drought. By contrast, Perth householders did not experience 'drought' as a phenomena but a slower process of climate change—a drying climate, low rainfalls, longer summers—that has been addressed by large-scale technological solutions such as desalination plants and aquifer recharge. This in combination with the ready availability of groundwater through domestic bores for garden watering has resulted in the persistence of existing water practices and stymied the shift to practices enabling longer-term sustainability and resilience.

Our research reinforces the importance of considering the social and policy context when implementing water sustainability initiatives. Geographic location, climate

and policy responses all influence domestic water cultures. The way householders value and use water changes in response to crisis; but post-crisis (when the drought has broken or technology has solved shortages), habits can partially revert or new habits can form. Our findings demonstrate that Australians are open to changing their water consumption patterns and willing and able to adapt to water regulations/restrictions once convinced of the need for change, but different strategies are required in different urban settings (cf. Allon and Sofoulis 2006). In parts of rural Australia, residents expect, and respond to, variation in water availability (Gibbs 2006, 2010). The experience of drought can alter how water is viewed, from an unlimited resource, to something that needs to be carefully managed (Graymore and Wallis 2010). We argue that greater water sensitivity and responsiveness to water availability should be fostered in urban centres. We further suggest that, ideally, urban citizens would be engaged with water, they would have a good knowledge of water variability, they would value sustainable water use, and they would take action to conserve water when needed (Dean et al. 2016a). In our research, Brisbane residents come closest to this ideal, and in this tropical city, the residents are responsive water users substantially reducing their water use during the drought and using more, now that water is abundant. Melbourne residents, with their temperate climate, retain a water-saving consciousness since the shock of the Millennium drought, but could do more to prepare their households for future water shortages. By contrast, heavy water users in hot, dry Perth require contextually suitable initiatives to foster a stronger understanding of ongoing water scarcity in their city and willingness to conserve water to augment technical and institutional approaches to managing water scarcity.

Acknowledgments The authors wish to thank Paul Satur for help in conducting the focus groups in Perth and Brisbane. We are grateful to the participants for sharing their thoughts with us. This research was supported by the Cooperative Research Centre for Water Sensitive Cities, Commonwealth of Australia RM4 Project Number—2013001906. RMO Code—CF13/580.

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