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Understanding Water Consumption in Qatar: Evidence From a Nationally Representative Survey

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ABSTRACT

This paper presents an analysis of a nationally representative (n = 1,002) telephone survey conducted in Qatar on habits, perceptions, and religious attitudes related to water use. Our empirical analysis yields three main findings. When asked whether religious obligation was a reason to save water, 89% of respondents agreed with the statement, showing it to be an important stated motive for water conservation. However, we find no statistically significant relationship between stated attitudes towards water use and actual water consumption. Second, when asked to estimate their monthly water use, participants' actual water consumption was similar to how they perceived it to be, on average, but different at the decile level. Third, certain household water usage characteristics are associated with significantly higher levels of water consumption. These include: nationality, education, number of adults in the residence, among others.

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Water conservation; religious attitudes; habits; perception in water consumption

1. Introduction

Qatar is at risk of extreme water stress. There are acute freshwater shortages. Groundwater is over-extracted and rapidly depleting. The country relies almost exclusively on desalinated water (99% of its water needs), which carries high costs for infrastructure and consumes large amounts of fuel energy. This dependency on desalinated water poses a significant risk for Qatar's water sustainability, and water security relies heavily on the availability of fuel energy and funding for desalination plants. Qatar also has one of the highest rates of water consumption per capita in the world. Qatar's high per capita rate of water consumption is often attributed to the high degree of government subsidization, leakages in the water distribution system, and a lack of public awareness. In recent years, the Qatar General Electricity and Water Company (KAHRAMAA) have made efforts to increase public awareness about water conservation through campaigns and research.

This paper aims to understand the attitudes, beliefs, and behaviors related to water consumption to discover how greater water efficiency can be encouraged. More specifically, we are interested in answering the following research questions: 1) Is there a difference between people's stated and actual water consumption? 2) What are people's religious and social attitudes towards water consumption? 3) Are there any specific household water usage behaviors that influence water consumption? To do this, we conducted a survey,[1] focusing on a better understanding of how people use water and their perceptions and attitudes regarding water efficiency. Ultimately, we hope that the survey can help inform interventions that promote more sustainable water consumption in Qatar.

It is important to understand people's water usage behaviors, attitudes, and perceptions in order to design better interventions. Individual specific behavioral interventions have been effective in encouraging water and energy savings in some contexts. For example, providing people with meaningful and easy-to-understand information has been shown to increase engagement with interventions (Kidd and Williams 2008). Several studies show that people's attention and responsiveness to interventions increases when they receive sensible breakdowns of their energy consumption (Buchanan, Russo, and Anderson 2014; Hargreaves, Nye, and Burgess 2013). A recent survey shows that very few Qatari people are aware of how scarce water is in their country. A significant portion of people are unaware of the depleting groundwater aquifers (48%) and freshwater reserves (61%) in Qatar (Mohammed 2018). The survey also shows that more than one-third (36%) of people's everyday water consumption is in the shower, followed by washing machines and dishwashers (Mohammed 2018). It is vital to determine whether providing people with more information on relevant issues such as Qatar's current water situation, their water consumption behaviors, and ways to change some of these behaviors might help reduce water consumption. We investigate whether certain household water usage behaviors are associated with higher water consumption levels.[2] This would help determine which actions could be targeted to help reduce household water consumption in Qatar.

It is also crucial to study the differences in water consumption patterns among different social groups to understand how to target interventions more effectively. One of the significant distinctions in Qatari society is between Qatari nationals and non-Qatari nationals living in Qatar. For example, Qataris and high-income non-Qataris have higher water consumption

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levels in gardens and car-washing (Mohammed 2018). Bigger homes and lavish lifestyles characterize these high-income groups, and it is unlikely that small financial rebates would effectively reduce their water consumption. Here, we hypothesise that:

Hypothesis 1.1. *Participants with Qatari nationality will be more likely to have higher levels of water consumption.*

These high-income groups might be more influenced by non-financial incentives that target their sense of environmentalism, religious, social, or self-identities. Through the survey, it would also be possible to understand which sectors of the Qatari population might be more susceptible to environmental interventions. These incentives have also been shown to be effective. Intervention with an environmental incentive (a tree would be planted if participants reached a pre-defined energy savings goal) successfully reduced energy consumption (Ghesla et al. 2018).

The survey also aims to understand people's perceptions of social influence in the context of water consumption. People like to follow the crowd. The role of social norms in behavior change is widely researched, and people's desire to conform to social expectations is consistent across contexts including energy conservation (Kantola, Syme, and Campbell 1984), recycling (Cialdini, Reno, and Kallgren 1990) and transportation behavior (Kormos, Gifford, and Brown 2015, Artinger et al., 2015; Levitt and List, 2007). The power of harnessing social norms has been demonstrated in experiments related to sustainable consumption. A series of experiments were conducted in partnership with Opower, which used descriptive norm messaging to induce households to save energy (Allcott 2011; Alcott & Rogers, 2014). Around 600,000 households participated in the study. The treatment group received Home Energy Reports (HER) containing information about their energy consumption relative to their neighbors. These messages brought about successful reductions in households' short and long-run energy usage. Another widely cited study used descriptive social norms to promote towel reuse among hotel guests, thereby indirectly promoting water conservation by avoiding unnecessary laundering. Placing a note in hotel bathrooms with the message 'Join your fellow guests in helping to save the environment' increased towel reuse from 35.1% to 44.1%, as compared to a control group in which guests were only provided with information on the benefits of reusing their towels (Goldstein, Cialdini, and Griskevicius 2008). The percentage of guests who reuse their towels was further boosted by adding the message that 75% of other hotel guests reuse their towels. In a similar context, another experiment showed that compared to messages framed in terms of environmental protection, social responsibility, and material self-interest, descriptive social norms proved to be the most effective in getting people to use fans instead of air-conditioners (Nolan et al. 2008).

Social norms and pro-societal attitudes towards sustainable consumption are also shown to be key drivers in promoting sustainable consumption behaviours. Vivek et al. (2014) demonstrated that consumers who cared about social and environmental issues and the possible solutions for them, were engaged in sustainable consumption to a greater degree (Vivek et al, year). Another study showed that consumers that held beliefs of pro-social engagement and sacrifice for the common good, were more likely to engage in sustainable consumption (Griskevicius, Tybur, and Van den Bergh 2010). The positive influence of group social norms and personal attitudes on pro-environmental engagement and sustainable consumption have also been shown by Bombiak (2019), Maziriri et al. (2019) and Bouman, Steg, and Zawadzki (2020). Thus, we hypothesise that:

Hypothesis 1.2. *Participants who hold pro-societal attitudes towards water conservation will be more likely to consume less water on average than those who do not.*

Perceptions of others water usage behaviors can also play a role in influencing individual water consumption and motives for water conservation. Corral-Verdugo et al. (2002) observe that the more people perceive that others (neighbors) waste water, the less their conservation motives, and, therefore, the more their own water consumption. Therefore, we hypothesise that:

Hypothesis 1.3. *Participants with high levels of water consumption will be more likely to state that they consume less water than their neighbours.*

However, in specific cases, social norms have been shown to backfire and produce undesirable behavior changes. One of the common pitfalls associated with using social norms is the boomerang effect. In this phenomenon, households that consume below-average energy or water levels tend to increase their consumption to meet the average social norm (Cialdini 2007). One technique used to counter the boomerang effect is to pair the descriptive social norm with an injunctive norm (e.g. printing a happy face when consumption is below average or a frown when consumption is above average); the socially approved level of consumption. This technique was also used in the Opower experiment to counteract the boomerang effect (Allcott and Rogers 2014). Another approach is to only target consumers that are known to be the most responsive to social norm effects. For example, a field experiment examining the effect of social norm messaging on direct water conservation in a sample of 100,000 houses in Atlanta, showed that the group that was most responsive to the treatment were those that were relatively wealthy, owner-occupied and above-average water users (Ferraro & Miranda, 2013). The authors concluded that in order to make intervention programs more cost-effective, suppliers should only target subgroups that are known to be most responsive. Thus, the literature suggests that social norms can be powerful tools for behavioural changes in some contexts, but it is important to consider any boomerang effects and heterogeneity effects that could make social norms less effective in some situations. Through this survey, we aim to determine whether social norm interventions would be effective in the social context of Qatar and the types of social norms that would produce the highest impact on water consumption behaviours.

The survey also attempts to understand whether religious attitudes play a role in water use and conservation and whether religious messages might be effectively used in designing interventions. The literature on Islamic references to nature and the use of resources emphasize the importance of water and the optimal usage of this resource (Marzban et al. 2020). For instance, the Quran contains about 60 verses on water, providing a relationship between rainfall and the continuity of life (hydraulic flow theory). These religious teachings encourage people to reflect and contemplate on this issue (Ahmadi and Zareei 2017). Hence, we hypothesise that:

Hypothesis 1.4. *Participants will be more likely to agree that religious obligation is an important reason to conserve water.*

Islamic literature also mentions the existence of 12 types of water. It explains the correct usage of water-based on different climatic conditions and religious indicators to prevent the wastage and contamination of water (Dehdari and Dehdari 2018). Islamic religious practices encourage individuals to uphold environmental justice such that everyone has fair access and opportunities to use environmental resources (Ahmadi and Zareei 2017). Studies have shown that religious and spiritual messengers are powerful motivators for environmental protection (Dorm-Adzobu, Ampadu-Agyei, and Veit 1991; Ntiamoa-Baidu 1995; Omari 1990). In one study conducted in Iran, a significant positive relationship was found between religiosity and environmental protection (Ahmadi and Zareei 2017). The role of religious and traditional leaders was found to reduce forest loss in dry forests in Zimbabwe (Byers, Cunliffe, and Hudak 2001). A similar study exploring the relationship between humans and the environment found a significant association between religious traditions and the protection of nature and water resources (Chuvieco 2012). In Qatar's context, in 2016, Prime Minister Sheikh Abdullah bin Nasser bin Khalifa Al Thani described energy conservation as 'a religious, national and moral responsibility of all people in this country'. It may be fruitful to test this approach to designing interventions in Qatar. Thus, religious teachings emphasise the importance of conserving water and have shown to be powerful motivators for water consumption, and we hypothesise that:

Hypothesis 1.5. *Participants who hold strong religious beliefs and attitudes will be more likely to consume less water on average than those who do not.*

We also examine any differences between people's perceived and actual water consumption behaviors through this survey. Studies show that disparities in perceptions of perceived and water consumption exist in a variety of contexts. For example, in a study conducted in Mexico, the residents living in cities consumed a more considerable amount of water relative to society's other sectors. In reality, city dwellers' actual water consumption is only 11.5%, and agriculture uses 80% of total water suitable for consumption in Mexico (Pe'rez 2001). Another survey conducted in Sydney showed that only 19% of all respondents knew how much water they consumed during a quarter (Randolph and Troy 2008). The majority of respondents also perceived that they consumed average or below-average water levels. The majority of respondents also perceived that they consumed average or below-average water levels, compared with similar Sydney households. About 40% of respondents perceived their water consumption to be average, while almost half of the respondents perceived their water consumption to be below-average (Randolph and Troy 2008). Understanding people's awareness and perceptions of their water consumption behaviors is a useful policy development element. Thus, on the basis of previous research, we hypothesise that:

Hypothesis 1.6. *There will be a difference between participants' stated and actual water consumption, such that actual consumption will be higher than stated consumption.*

Other studies have reported discrepancies between people's perceptions of their water usage and their actual consumption (Millock & Nauges, 2010). One possible reason for these differences is the low correspondence between people's self-reported attitudes towards resource consumption and their actual consumption (Dolnicar and Hurlimann 2010). Studies have also observed people's tendency to reduce the cognitive dissonance between their attitudes and actual consumption behaviors by bolstering their initial attitudes (Kantola, Syme, and Campbell 1984). Another potential reason for discrepancies between these perceptions and behaviors is a conflict between people's good intentions and difficulties in acting upon them (Anker-Nilssen 2003). Some studies also explore whether certain socio-demographic groups have a greater tendency to over or underestimate their actual water consumption as compared to others. For instance, a study conducted in Australia found that people with lower incomes and levels of education, fewer children, and smaller household occupancy tended to overestimate their water usage and were less likely to possess water-efficient technology (Beal, Stewart, and Fielding 2011). On the other hand, people with higher incomes and larger families with young children were more likely to underestimate their water consumption and more likely to use water-efficient technologies such as water-efficient washing machines and low-flow showers (Beal, Stewart, and Fielding 2011). Establishing an understanding of these discrepancies and which sections of society are more prone to Qatar's perceptions will help determine water policy.

The present study also aims to understand the household water usage behaviours among the sample of participants in Qatar. The participants are asked to report in detail their daily water usage activities as well as any water saving appliances they have installed in their homes. The use of water-saving devices such as low-flow taps and toilets, drought-resistant plants, faucet aerators and so on, are common techniques of reducing water consumption. For example, a study of 100 resorts in the United States found that faucet aerators, low-flow devices, dual-flush toilets and greywater recycling systems were associated with reductions in water consumption of upto 23% (Bruns-Smith et al. 2015). A similar in-depth interview study found that the installation of low-flow tap fittings and sensors were the most popular water saving devices among 23 hotels in Hong Kong (Chan, Okumus, and Chan 2020). Gardens are an important feature of contributing to high water use in

houses, and using native and drought-resistant plants have been shown to be one effective technique for saving water (Kelly and Williams 2007). We therefore hypothesise that:

Hypothesis 1.7. *The use of water saving appliances will be associated with lower levels of water consumption.*

2. Materials and methods

2.1. Survey administration

To further investigate the attitudes, awareness, water usage behaviors, and perceptions of water consumption in Qatari residents, we conducted a telephone survey with 1,012 participants living in Qatar. The telephone survey was carried out by representatives of Qatar University. The participants recruited for the survey were randomly selected from a master dataset of all households in Qatar. The master dataset was obtained from Kahramaa (Qatar General Electricity and Water Corporation) which consisted of a dataset of all households in Qatar. From this dataset, 1,012 households were randomly selected to be part of the telephone survey in this study. Participants with incomplete information and those that did not give verbal consent to participate were excluded from the final sample. The final survey sample was 1,002 households in Qatar. The participants received no compensation for completing the survey (QU-IRB 1108-EA/19).

Table 1 shows the per capita water consumption per day in Qatar compared with other countries like countries in the GCC, European Union, United Kingdom and United States.[3] In terms of daily per capita water consumption, Qatar shows a moderate level of water consumption when compared with other GCC countries – it has higher levels of water consumption than Bahrain and Kuwait, but ranks lower than UAE, Saudi Arabia and Oman. When compared with the European Union and United Kingdom, Qatar shows higher levels of per – capita water consumption. Qatar has lower levels of per-capita water consumption than the USA.

The Qatar Water Use survey consisted of 74 items in multiple formats, designed to elicit information regarding various aspects of participants' household water usage and conservation, social and religious attitudes towards the water, and standard demographic and general household composition data. The survey questions ranged from using 5-point Likert scales, binary and categorical formats, and open-ended questions. Based on the demographic data provided, the sample's mean age was 46 years, and 92% of the sample was male. 74% of the sample was Non-Qatari, 16% had completed high school, 53% had a 'Bachelor's degree, and 12% had a Master's degree.

Table 2 presents summary statistics for the monthly continuous variables in the sample. We see that mean household consumption is 65.69 m^3 per month and perceived consumption is 45.36 m^3 per month. The average household head is 45.56 years old, with a little over 2 children, 3.5 showers and 6.77 faucets. Furthermore, the average home in our sample contains nearly 5 adults.

Table 1. Average daily per capita water consumption of Qatar and other countries/regions.

Country/Region	Liters
Qatar	1406
UAE	2387
Saudi Arabia	1933
Oman	1517
Bahrain	835
Kuwait	1171
USA	3794
United Kingdom	348
European Union	1287

Source: Worldometers

2.2. Survey questions

The survey consisted of 74 questions in total, divided into five sections. Section A focused on the participants' demographic details and included questions relating to gender, age, nationality, religion, and education level. Section B consisted of questions regarding the characteristics of the household. This section included several questions: the type of housing of the respondent,[4] how many adults and children lived in the household, and the family's total monthly income. Section C explored the water usage of the respondent's household. This section included questions about monthly water consumption, the amount of household's monthly water bill, who pays the water bill, the preferred method of managing drinking water, how many liters of drinking water used per month, and the amount of money spent on drinking water. This section also asked respondents to compare their water consumption to an average household of similar size and to provide an estimate of whether their consumption was more, less, or about the same as an average household. Lastly, respondents were asked whether they had made any attempt in the last month to store water and, if so, what measures they had taken.

Section D contained a detailed water usage inventory questionnaire that explored household dish-washing, clothes washing, vehicle and garden maintenance, bath and showers, faucets and toilets, and house cleaning and maintenance

Table 2. Summary statistics for monthly continuous variables.

	cons	perc cons	age	adults	children	bill	tubs	baths	showers	showers/w	faucets	pool size	leak duration
units	m^3	m^3	hhh	hh	hh	Riyal	hh	hh	hh	week	hh	m^3	days
1st Qu	13.78	20	37	2	0	178	0	2	2	21	3	29.40	3
Median	29.50	40	45	3	2	253	1	5	3	35	5	38	5
Mean	65.69	45.36	45.56	4.92	2.11	424.50	1.53	6.96	3.49	44.21	6.77	53.26	5.53
3rd Qu	73.28	65	53	6	3	450	2	11	5	56	9	70	8
NA's	0	892	23	5	35	386	24	927	3	272	11	988	989

Notes: The sample contains 1,002 Observations. Abbreviations: household head (hhh), household (hh), perceived water consumption (perc cons), actual water consumption (cons).

behaviors. Respondents were asked to report on the method of clothes, dish, and vehicle washing in their household, the frequency of washing, the number of vehicles, and whether their washing machine and dishwasher had a water use efficiency label. If a participant's house had a garden or swimming pool, they were asked whether they had low water-consuming plants, the type of watering system for their garden, the frequency and time of day of watering plants, and the water capacity of the swimming pool among many.

Section E contained questions regarding the respondents' attitudes towards water. A set of questions in this section focused on whether the respondents felt a need to rationalize their water consumption, whether they thought it was essential to conserve water, and whether they considered that Qatar has a water shortage problem or would have one in the future. We asked several questions to explore the individual motivations for conserving water including whether the participants felt that water conservation is important: because of religious or moral obligations to preserve water and to ensure water is available for future generations, to protect the natural environment, and for Qatari national security and the federal budget. Another set of questions focused on attitudes towards their neighbors' water usage and water conservation behaviors. This addressed topics such as whether respondents thought that their neighbors felt it was important to conserve water or rationalize their water consumption, whether they wasted too much water, and if they had ever had a conversation regarding water conservation with their neighbors. Individuals were also asked whether they thought society disapproves of people who waste water, and if they had ever heard of someone being praised for conserving water or admonished for wasting it. The religious attitudes towards water conservation were examined by asking respondents if they recalled anything in the Quran about conserving water and whether they recalled any specific verses from the Quran that emphasized conserving water (see the appendix).

2.3. Survey analysis

We received monthly water consumption data from January 2016 – March 2019 for all the households that participated in the survey through a team of RAs at Qatar University.[5] For the analysis conducted in this study, the average monthly water consumption for the most recent year (March 2018 – March 2019) was the dependent variable for water consumption. Linear regression (OLS), quantile regression (QR), and ordered probit analyses were conducted to establish the impact of individual differences, religious and societal attitudes, water usage behaviors, and perceptions of their neighbors' water usage behaviors on household water consumption. Our methods establish the links between the respondents' perceived and actual water consumption and whether any demographic variables impacted individual consumption.

3. Results

3.1. Perceptions of water use

Participants of the survey were asked to estimate their monthly household water consumption ranging between 'Less than 10 cubic meter' to '100 cubic meter or more'.[6] The mean values of the ranges were taken to represent participants' perceptions of their monthly water use. Table 3 shows the results for two regressions (with and without a constant), on two different samples. The first sample does not account for the top-coded data while the second omits top-coded observations.[7] The OLS column in Table 3 without an intercept of the 110 respondents shows that participants consumed significantly more water than they perceived – for every cubic meter of water that was estimated, the actual average monthly water consumption was 1.33 cubic meter higher (highly significant). However, when removing the households that report a top-coded value, we find the coefficient was0.97 cubic meter (highly significant), indicating that households are actually well informed about their consumption, on average, providing support for Hypothesis 1.6. However, it is not until we dig further and examine the QR results and find that the vast majority of deciles actually overestimate their usage by a significant amount, and underestimation occurs only for deciles above the 70th. Taken together, the QR results provide more convincing support for Hypothesis 1.6 than the OLS results. Participant age, gender, education and income were found to have no effect on determining the accuracy of perceptions.

Table 3. Quantile and OLS regression results for actual water consumption regressed on perceived water consumption (with and without a constant) for each decile.

deciles:	(0.1)	(0.2)	(0.3)	(0.4)	(0.5)	(OLS)	(0.6)	(0.7)	(0.8)	(0.9)
Full Sample Analysis, with and without a constant:										
perceived consumption	0.29***	0.42***	0.53***	0.65***	0.64***	1.37***	0.87***	1.00***	1.43***	2.55
	(0.10)	(0.14)	(0.08)	(0.10)	(0.11)	(0.24)	(0.16)	(0.27)	(0.39)	(1.55)
(constant)	3.24	2.57	2.50	2.98	5.88**	− 2.55	6.00*	5.68**	5.10*	− 0.53
	(2.05)	(4.30)	(1.69)	(2.46)	(2.36)	(13.28)	(3.03)	(2.31)	(3.01)	(55.16)
perceived consumption	0.34***	0.49***	0.61***	0.69***	0.83***	1.33***	1.01***	1.12***	1.71***	2.55**
	(0.07)	(0.08)	(0.05)	(0.07)	(0.08)	(0.14)	(0.12)	(0.23)	(0.32)	(0.98)
Observations	110	110	110	110	110	110	110	110	110	110
Partial Sample Analysis, with and without a constant:										
perceived consumption	0.14	0.38***	0.45***	0.54***	0.63***	0.68***	0.79***	0.89***	0.89***	0.87
	(0.10)	(0.09)	(0.09)	(0.12)	(0.13)	(0.21)	(0.14)	(0.14)	(0.27)	(1.29)
(constant)	5.88**	3.26***	3.69**	5.24**	5.91**	15.11*	7.41*	7.87*	15.08**	24.81
	(2.25)	(1.14)	(1.74)	(2.53)	(2.67)	(8.85)	(3.74)	(4.26)	(7.18)	(44.75)
perceived consumption	0.29***	0.49***	0.55***	0.67***	0.78***	0.97***	0.96***	1.06***	1.17***	1.90
	(0.07)	(0.08)	(0.05)	(0.07)	(0.08)	(0.12)	(0.08)	(0.14)	(0.19)	(1.17)
Observations	92	92	92	92	92	92	92	92	92	92

Notes: *p < 0.1; **p < 0.05; ***p < 0.01

3.2. Individual differences in water consumption

Nationality is a significant predictor of water consumption, with Qataris consuming significantly more water than Non-Qataris (48.66 cubic meter on average and highly significant), and this association was significant even after controlling for income, education and a variety of other factors. Thus, we accept Hypothesis 1.1. We also find evidence that Qataris in higher deciles consume more than Qataris in lower deciles. Furthermore, we find a similar result for years of education (which may be linked with income) and the number of adults in the residence. Table 4 shows a summary of the results of the OLS and QR regression. Figure 1 shows the differences in water consumption between Qataris and Non-Qataris. In Table 5 we regress household actual water consumption on the number of times per month the household reported cleaning their outside (int clean) and inside (int clean). We find that exterior cleanings significantly impact monthly consumption (10.76 cubic meter on average and highly significant), with the effect increasing for the higher quantiles. This suggests that higher usage customers may have a larger exterior.[8]

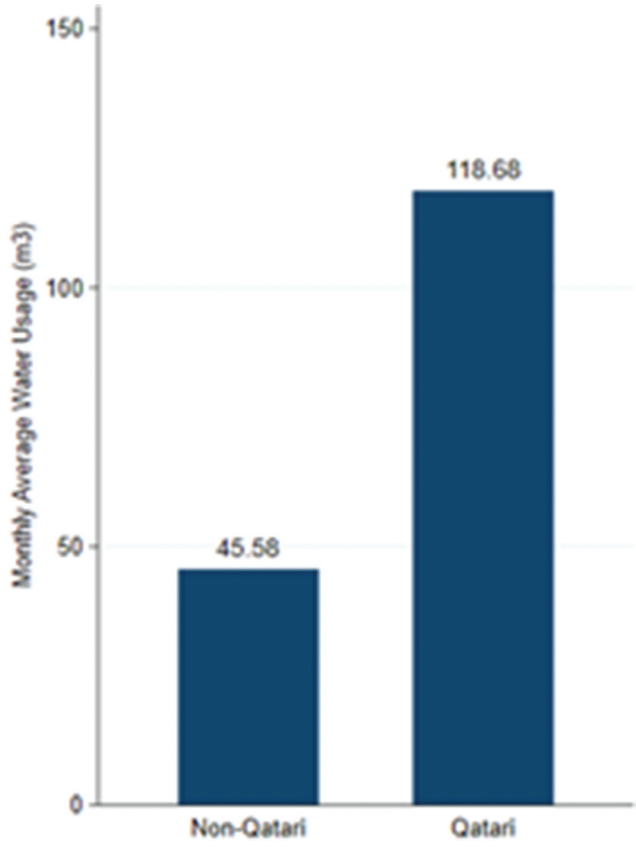

Figure 1. Average monthly water consumption (cubic meter) of Qataris and Non-Qataris.

3.3. Religious attitudes and water consumption

The survey sample's religious composition was 85% Islam, 9% Christian, 5% Hindu, and 1% classified themselves as 'None' or 'Other'. We tried to assess the importance of religious motives in water conservation through the following question: 'Using a 1 to 5 scale, do you agree or disagree that religious obligation is a reason to motivate conserving water?' Participants perceived religious obligation as an important reason to conserve water (Figure 2), with 64% of respondents strongly agreeing and 25% of respondents agreeing with the statement (for a total of only 11% with disagreeing or neutral responses). Therefore, we find evidence to support Hypothesis 1.4.

Table 4. Quantile and OLS regression results for actual water consumption regressed on nationality, income and other factors for each decile.

deciles:	(0.1)	(0.2)	(0.3)	(0.4)	(0.5)	(OLS)	(0.6)	(0.7)	(0.8)	(0.9)
Qatari	− 0.76	8.12	10.15	23.58***	33.87***	48.66***	35.31***	50.02***	46.77**	51.07
	(2.75)	(6.16)	(7.96)	(8.22)	(8.09)	(14.20)	(8.42)	(9.91)	(20.66)	(33.37)
monthly income 10–20 K	0.98	3.03**	2.78*	1.13	2.46	7.01	0.74	− 1.17	− 15.02	− 14.79
	(1.26)	(1.28)	(1.63)	(1.53)	(1.72)	(12.79)	(2.85)	(9.15)	(15.09)	(22.40)
monthly income 20–30 K	1.91	2.23	1.85	2.23	2.44	0.90	− 0.51	− 0.50	− 16.23	− 51.05***
	(1.17)	(1.72)	(2.38)	(2.13)	(2.08)	(14.84)	(3.37)	(9.32)	(16.24)	(19.50)
monthly income 30–40 K	1.49	2.29	4.77	1.57	1.59	1.25	1.96	1.93	− 18.72	− 41.26
	(2.10)	(3.19)	(3.16)	(1.79)	(2.29)	(16.42)	(4.40)	(10.67)	(15.43)	(25.06)
monthly income 40 K-	1.45	1.41	2.12	0.73	0.78	12.49	4.24	7.24	− 8.86	− 26.22
	(2.17)	(3.17)	(4.54)	(3.41)	(3.07)	(17.50)	(6.31)	(11.48)	(19.55)	(50.90)
education	1.34***	1.41***	2.25***	2.57***	2.83***	2.06	3.44***	4.12***	5.33*	3.71
	(0.33)	(0.48)	(0.70)	(0.53)	(0.56)	(2.77)	(0.77)	(1.44)	(3.18)	(4.70)
# of adults	0.25	0.59	2.32**	3.14***	4.38***	5.50***	7.21***	8.49***	13.34***	15.64***
	(0.18)	(0.58)	(0.92)	(0.81)	(1.11)	(1.26)	(1.16)	(1.68)	(2.20)	(2.07)
wash dishes	− 0.49	0.04	0.64	0.67	1.39**	2.64	2.19***	3.58**	5.00	− 1.78
	(0.50)	(0.48)	(0.58)	(0.49)	(0.61)	(4.11)	(0.59)	(1.68)	(3.83)	(6.23)
# of showers	0.58	1.12	2.00	2.43**	1.70*	4.68	1.01	− 0.33	− 0.20	10.68
	(0.79)	(1.27)	(1.79)	(1.21)	(0.91)	(3.82)	(2.41)	(3.67)	(7.87)	(13.07)
# of faucets	− 0.11	− 0.17	0.13	− 0.14	0.08	− 1.93	0.08	0.02	0.14	− 1.29
	(0.33)	(0.38)	(0.39)	(0.55)	(0.34)	(1.39)	(0.31)	(1.16)	(2.59)	(5.41)
# of toilets	− 0.01	− 0.08	− 0.76	− 0.17	− 0.24	− 3.72	− 0.56	− 0.73	− 1.65	− 3.07
	(0.93)	(1.35)	(2.39)	(1.44)	(0.87)	(2.32)	(3.17)	(5.15)	(9.63)	(16.30)
check leaks	0.33	1.39	2.98*	4.75***	5.80***	− 0.23	5.67***	7.67**	3.91	− 5.61
	(0.90)	(1.43)	(1.53)	(1.18)	(1.37)	(8.07)	(1.67)	(3.37)	(8.08)	(14.31)
constant	2.23	− 9.50	− 22.41***	− 39.16***	− 55.23***	− 35.99	− 62.72***	− 82.40***	− 69.34**	5.02
	(3.47)	(6.40)	(8.09)	(8.69)	(7.77)	(26.98)	(9.13)	(14.91)	(30.12)	(48.33)
Observations	665	665	665	665	665	665	665	665	665	665

Note: *p < 0.1; **p < 0.05; ***p < 0.01

Table 5. Quantile and OLS regression results for actual water consumption regressed on number of times interior and exterior cleaned for each decile.

	(1)	(2)	(3)	(4)	(5)	(OLS)	(6)	(7)	(8)	(9)
ext clean	0.77**	1.05	1.90**	3.19**	6.73***	10.76***	9.72***	13.71***	19.37***	19.74*
	(0.38)	(0.65)	(0.95)	(1.39)	(1.83)	(2.29)	(2.49)	(3.01)	(4.47)	(11.15)
int clean	− 0.24***	− 0.14	− 0.08	− 0.11	− 0.13	− 0.44	− 0.32	− 0.54	− 0.93	0.82
	(0.08)	(0.13)	(0.18)	(0.24)	(0.24)	(0.48)	(0.39)	(0.47)	(0.82)	(1.87)
constant	12.08***	15.49***	20.15***	24.73***	27.65***	50.10***	32.77***	44.62***	57.83***	119.33***
	(1.89)	(1.93)	(3.10)	(3.90)	(4.57)	(10.42)	(7.81)	(9.42)	(17.50)	(36.36)
Observations	442	442	442	442	442	442	442	442	442	442

Note: *p < 0.1; **p < 0.05; ***p < 0.01

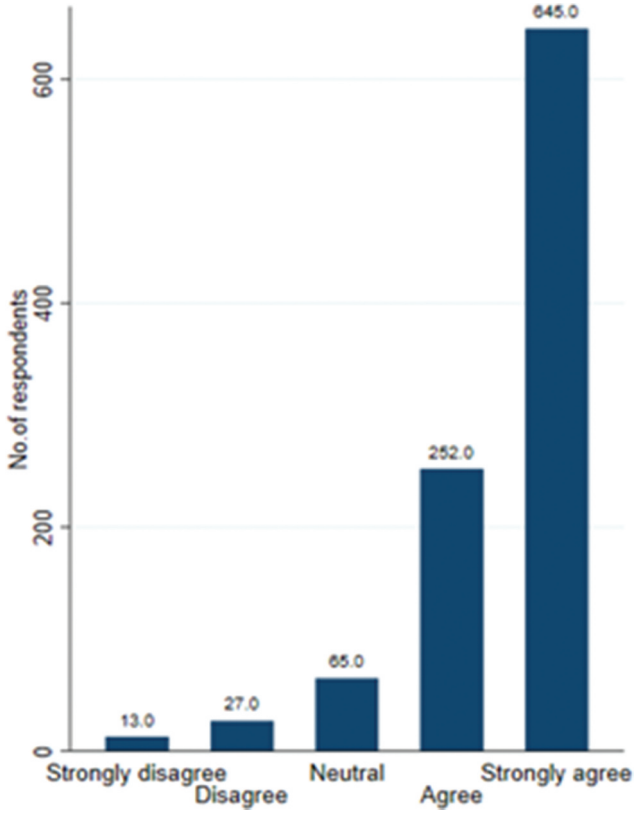

Figure 2. Importance of religious motives in water conservation: Do you personally agree or disagree that religious obligation is a reason to motivate conserving water?.

Participants were also asked if they recalled any phrases from the Quran or the Hadith about conserving water, and 65% of the respondents answered positively to this question. Interestingly, respondents that recalled phrases from the Quran about water conservation consumed on average 19.34 cubic meter more water for every cubic meter of water consumed by those that reported not identifying any phrases ($F(1, 942) = 6.91, p < 0.01$). However, these effects were no longer significant after controlling for monthly income, indicating that there may be mediating factors such as education or class differences. Therefore, we do not find evidence for Hypothesis 1.5.

3.4. Societal attitudes and water consumption

In Table 6 we deploy an ordered probit regression framework to see which factors significantly impact perceptions. In each case, we find that actual water consumption was not a significant factor.[9]

The survey tried to assess the level of societal awareness and concern about the water crisis and its prevalence in everyday societal life through the following question (denoted by 'talk' in Table 6): 'People like to talk about different things going on in society. Using a scale of 1 to 5, about how often would you say that you talk about, or hear other people talk about, ways to save water?' Responses suggested that water conservation was not an important topic for discussion in everyday life, with 12% of respondents answering 'never', 34% responding, 'rarely' and 33% responding 'sometimes'. When asked whether participants had ever had a conversation with any of their neighbors or friends about the importance of saving water or strategies to save it, 57% of people responded 'no'. Participants were also asked how much they think society disapproves of people who waste water, and the majority of respondents (37%) answered 'somewhat'. Most participants reported that they had not heard of anyone being admonished for wasting water (58%) or being praised for saving water (78%) in society. There were no significant associations between perceptions of societal attitudes towards water consumption and actual water usage of the participants. Therefore, we do not find evidence to support hypothesis 1.2.

3.5. Perceptions of 'neighbors' water consumption

Participants showed a positive attitude towards the water consumption of their neighbors. When asked if they think that their neighbors waste too much water, 65% of respondents said 'no' and when asked how many of their neighbors they think wasted water, 47% responded 'none of them' and 27% responded 'very few of them'. Most participants (51%) reported that they consumed 'about the same' water as their neighbors. There were no significant associations between perceptions of water usage of neighbors and actual water consumption. Therefore, we do not find evidence to support Hypothesis 1.3.

We tried to assess people's perceptions of whether incentivizing people to conserve water by making their consumption public through a leader board would influence their neighbors. Respondents were asked: 'Suppose that water use was observable, such as if KAHRAMAA posted a database with water use by people in your neighborhood. Do you think people would care if they found out that their neighbors use a lot of water?' In this instance, 75% of respondents answered, 'Most or few of them', while 25% answered, 'No' (Figure 3).

Table 6. Ordered probit models.

	Dependent variable:					
	agree Q60 1	impconserve	talk	disapprove	nconserve	agree Q60 2
	(1)	(2)	(3)	(4)	(5)	(6)
log(water consumption)	0.03	0.02	− 0.01	0.01	− 0.01	0.01
	(0.04)	(0.06)	(0.04)	(0.04)	(0.06)	(0.04)
Qatari	0.09	0.04	0.41***	0.33**	0.18	0.01
	(0.17)	(0.22)	(0.15)	(0.15)	(0.22)	(0.17)
monthly income 10–20 K	0.10	0.17	− 0.03	− 0.04	− 0.35	0.32**
	(0.15)	(0.21)	(0.13)	(0.14)	(0.24)	(0.16)
monthly income 20–30 K	0.08	0.31	− 0.26*	− 0.26*	− 0.49*	0.43**
	(0.18)	(0.27)	(0.16)	(0.16)	(0.27)	(0.18)
monthly income 30–40 K	0.16	− 0.26	− 0.30*	− 0.10	− 0.67**	0.39*
	(0.19)	(0.26)	(0.17)	(0.17)	(0.30)	(0.20)
monthly income 40 K-	0.22	− 0.22	− 0.28	− 0.23	− 0.81***	0.32
	(0.21)	(0.29)	(0.18)	(0.19)	(0.29)	(0.21)
education	− 0.08**	− 0.15***	− 0.06*	0.02	− 0.03	− 0.12***
	(0.03)	(0.05)	(0.03)	(0.03)	(0.05)	(0.03)
# of adults	0.02	0.02	0.01	0.004	0.01	0.01
	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)
wash dishes	0.15***	− 0.15**	0.09**	− 0.07	− 0.15**	0.07
	(0.05)	(0.08)	(0.04)	(0.05)	(0.08)	(0.05)
# of showers	0.02	0.08	0.002	0.01	− 0.02	0.05
	(0.04)	(0.06)	(0.04)	(0.04)	(0.07)	(0.04)
# of faucets	− 0.03*	− 0.02	− 0.0002	0.003	0.03	− 0.01
	(0.02)	(0.02)	(0.01)	(0.01)	(0.02)	(0.02)
# of toilets	0.001	− 0.04	0.01	0.004	− 0.07	− 0.02
	(0.02)	(0.03)	(0.02)	(0.02)	(0.07)	(0.02)
check leaks	− 0.17*	0.27*	0.41***	0.31***	0.08	− 0.06
	(0.09)	(0.14)	(0.09)	(0.09)	(0.13)	(0.10)
Observations	607	661	643	628	307	561

*p < 0.1; **p < 0.05; ***p < 0.01

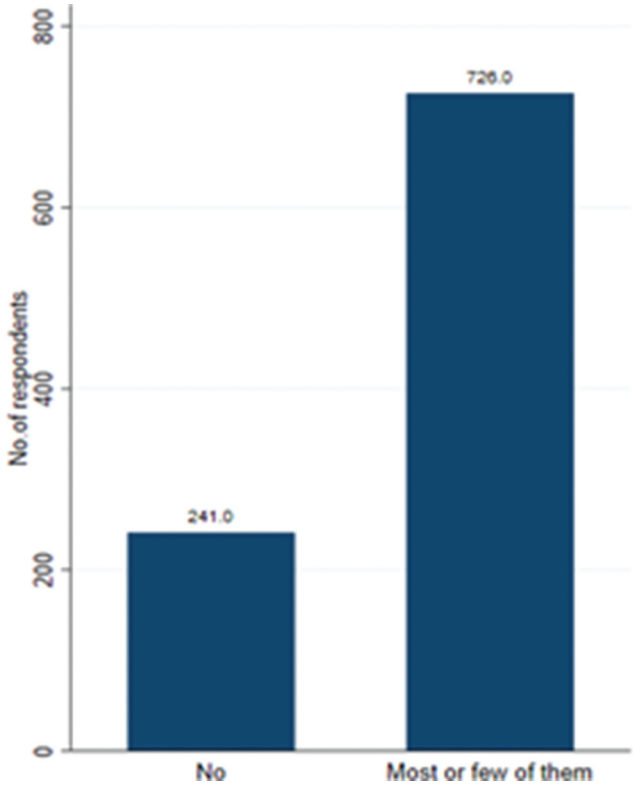

Figure 3. Perception of water consumption leader board: 'Suppose that water use was observable, such as if KAHRAMAA posted a database with water use by people in your neighborhood. Do you think people would care if they found out that their neighbors use a lot of water?'.

3.6. Water usage behaviours and consumption

In the survey, household water usage behaviors were classified into dish-washing, clothes washing, vehicle washing, baths, showers, faucets, toilets, gardens, house cleaning and maintenance. Certain water usage behaviors were found to be linked with significantly higher levels of water consumption. Washing clothes in the house by hand and using a washing machine was associated with significantly higher water consumption ($t = 75.95, p < 0.001$), and houses with washing machines having efficiency labels consumed significantly less water ($t = 8.75, p < 0.05$). A greater number of showers ($t = 7.46, p < 0.001$), faucets ($t = 6.24, p < 0.001$) and toilets ($t = 2.81, p < 0.01$) in houses were linked to significantly higher levels of water consumption. Certain water-saving appliances such as shower-head air compressors ($t = 2.36, p < 0.05$) and flow restrictors in faucets ($t = 1.99, p < 0.05$) were associated with significantly increased water consumption, while some appliances like low flush and dual flush toilets and low water-consuming plants had no effect on water consumption. Certain methods of watering the garden were associated with significantly higher levels of water consumption, which included flood irrigation ($t = 3.22, p < 0.01$) and sprinklers and dripping irrigation ($t = 2.61, p < 0.05$). The number of times that people cleaned the exterior of their houses with water was associated with significantly higher water consumption ($t = 4.71, p < 0.001$). Therefore, we do not find evidence to support Hypothesis 1.7. Table 4 shows a summary of the regression analysis for each of the household water usage behavior categories.

4. Discussion

This study investigates whether designing behavioral interventions using religious motives and social influence may reduce Qatar's household water consumption. There exist strong perceptions of the religious significance of water in Qatar, and religious motives to save water are essential. Public awareness campaigns in Qatar have previously stressed the religious obligation to conserve water. There is potential to conduct further interventions using behavioral science to tap into water conservation's religious importance.

The results show that participants tend to estimate their water consumption accurately on average, while higher deciles tend to underestimate, and lower deciles tend to overestimate. This is an important finding which helps to understand people's perceptions of their own water consumption and provides useful insights for policymakers formulating demand management strategies. For instance, in other international contexts strategies such as restrictions, pricing changes and water conservation education has been helpful in changing perceptions on people's water consumption (Arbués, Villanúa, and Barberán 2010; Koutiva 2015; Koutiva et al. 2017; Koutiva 2015). People' tendency to significantly underestimate their water consumption in the higher deciles suggests that water companies cannot rely solely on individual perceptions, attitudes and efforts towards water conservation. In some countries, introducing certain interventions such as information campaigns, introducing billing that is more informative and includes comparative measures that provide benchmark water usage figures for similar households and so on have shown to be useful in demand management (Beal, Stewart, and Fielding 2011).

Regarding the attitudes towards water use of neighbors and social awareness of water use and misuse, the survey shows a low level of concern and understanding in society around water use. This is not an essential part of people's social life. Participants are not very concerned about their neighbors' water use, and social conversations about praising or shaming community members for saving or wasting water are not common. It is unclear whether a social normative approach towards saving water would be as successful in Qatar's context as it is in other countries due to the lack of social punishment associated with high water consumption. However, this attitude seems to change when water use is made public and observable. When presented with a hypothetical scenario where a database of people's water use was available to everyone on a website, the majority of participants suggested that people would care about the high-water consumers in that situation. Therefore, there is good potential to test interventions that make water consumption public, for example, through a leader board, to see if they affect incentivizing people to reduce their water consumption.

Qataris consume significantly more water than non-Qataris, which may result from higher incomes, larger houses, or lavish lifestyles in addition of a full subsidy from the the government (the electricity and water bill is paid in full for Qatari by the government for one unit). The survey also shows that certain household water-saving devices are associated with reduced water consumption levels, such as washing machines with efficiency labels. These results imply that designing interventions that target increasing the uptake of these devices' might reduce Qatar's water consumption. Similarly, interventions that encourage people to move away from practices that consume higher wastewater levels, such as flood irrigation, sprinklers, and dripping irrigation in gardens, might reduce household water consumption. Certain water-saving devices, such as shower heads with air compressors and faucets with flow restrictors, increased water consumption. The possible reasons for this finding could be as follows. First, the people that are more likely to install these devices in their homes are the ones that use above average amounts of water. Second, installing these water-saving devices might trigger a form of boomerang effect whereby users start consuming more water due to inaccurate perceptions of how much water they are saving. Nevertheless, further inquiry into this finding to test the possibilities is needed. The study poses certain limitations. First, the survey questions the religious importance of saving water does not differentiate between religious conformity's social and moral aspects. For example, some people may be motivated to conserve water for religious reasons due to their inherent moral belief in that religious sentiment. In contrast, others may perceive it in the sense of greater acceptance from their religious community, which becomes a social conformity motive. Further studies should explore ways to better differentiate between the moral and social aspects of religious motives. Second, from the survey questions, there is no clear way of indicating how religious or how pro-environmental a participant is, in general, outside the context of water. This would allow us to take into account personal attitudes towards religion and the environment. Third, the analysis of the specific water usage behaviors might be influenced by certain other variables such as individual differences in water use behaviors, size of the household, differences in area and geographical context, and other factors that may not have been accounted for in the present survey.

Notes

1. QU-IRB 1108-EA/19.
2. Examples of selected water usages are: washing dishes and clothes, washing cars, watering plants, fitting household appliances with water-saving devices, and so on.
3. Source: Worldometers, Global Water Use. Retrieved from: https://www.worldometers.info/water/
4. See the detailed questionnaire and the IRB are in the appendix.
5. The survey data was cleaned in **STATA** and analyzed in **R**.
6. No respondenets reported exactly 10 cubic meter, with several reporting 5 cubic meter.
7. The survey question asks: "How much water is consumed per month in your household through Kahramaa?". The largest option here is: "100 M^3 or more", hence, the upper bound is censored.
8. These variables could not be included in the Table 4 regression without reducing the sample size substantially.
9. The marginal effects are available in the appendix, see Tables A1–A7.

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Appendix

Table A1. Marginal effects for if Qatar has a water shortage? (agree Q60 1).

	effect 1	effect 2	effect 3	effect 4	effect 5
log(water consumption)	− 0.012	0.005	0.001	0.005	0.001
Qatari	− 0.037	0.016	0.004	0.013	0.004
monthly income 2	− 0.041	0.017	0.004	0.015	0.005
monthly income 3	− 0.033	0.013	0.003	0.012	0.004
monthly income 4	− 0.062	0.024	0.006	0.024	0.008
monthly income 5	− 0.087	0.034	0.008	0.034	0.011
Education	0.031	− 0.013	− 0.003	− 0.011	− 0.004
no of adults	− 0.008	0.004	0.001	0.003	0.001
wash dishes	− 0.059	0.025	0.006	0.021	0.007
no of showers	− 0.007	0.003	0.001	0.002	0.001
no of faucets	0.011	− 0.005	− 0.001	− 0.004	− 0.001
no of toilets	0.000	0.000	0.000	0.000	0.000
check leaks	0.068	− 0.029	− 0.006	− 0.025	− 0.008

Table A2. Marginal effects for how important do you personally feel it is to use water efficiently? (impconserve).

	effect 1	effect 2	effect 3	effect 4	effect 5
log(water consumption)	0.000	0.000	0.000	− 0.002	0.003
Qatari	0.000	0.000	0.000	− 0.006	0.007
monthly income 2	− 0.001	− 0.001	− 0.001	− 0.025	0.028
monthly income 3	− 0.002	− 0.001	− 0.001	− 0.042	0.046
monthly income 4	0.002	0.002	0.002	0.045	− 0.051
monthly income 5	0.002	0.001	0.001	0.036	− 0.040
Education	0.001	0.001	0.001	0.022	− 0.025
no of adults	0.000	0.000	0.000	− 0.002	0.003
wash dishes	0.001	0.001	0.001	0.023	− 0.026
no of showers	− 0.001	0.000	0.000	− 0.012	0.014
no of faucets	0.000	0.000	0.000	0.003	− 0.003
no of toilets	0.000	0.000	0.000	0.006	− 0.007
check leaks	− 0.002	− 0.002	− 0.001	− 0.041	0.046

Table A3. Marginal Effects for how often would you say that you talk about, or hear other people talk about, ways to save water? (talk).

	effect 1	effect 2	effect 3	effect 4	effect 5
log(water consumption)	0.001	0.002	− 0.001	− 0.001	− 0.001
Qatari	− 0.077	− 0.086	0.038	0.073	0.052
monthly income 2	0.005	0.006	− 0.003	− 0.005	− 0.003
monthly income 3	0.054	0.050	− 0.030	− 0.045	− 0.029
monthly income 4	0.064	0.056	− 0.037	− 0.051	− 0.032
monthly income 5	0.057	0.055	− 0.032	− 0.048	− 0.032
Education	0.010	0.012	− 0.005	− 0.010	− 0.007
no of adults	− 0.002	− 0.002	0.001	0.002	0.001
wash dishes	− 0.017	− 0.019	0.008	0.016	0.011
no of showers	0.000	0.000	0.000	0.000	0.000
no of faucets	0.000	0.000	0.000	0.000	0.000
no of toilets	− 0.002	− 0.002	0.001	0.002	0.001
check leaks	− 0.076	− 0.085	0.038	0.072	0.051

Table A4. Marginal Effects for how much do you think society disapproves of people who waste too much water? (disapprove).

	effect 1	effect 2	effect 3	effect 4	effect 5
log(water consumption)	− 0.001	− 0.001	− 0.001	0.001	0.001
Qatari	− 0.062	− 0.036	− 0.031	0.044	0.085
monthly income 2	0.008	0.005	0.004	− 0.006	− 0.011
monthly income 3	0.054	0.028	0.017	− 0.038	− 0.062
monthly income 4	0.020	0.011	0.009	− 0.014	− 0.026
monthly income 5	0.047	0.025	0.018	− 0.033	− 0.057
Education	− 0.003	− 0.002	− 0.002	0.002	0.004
no of adults	− 0.001	0.000	0.000	0.000	0.001
wash dishes	0.012	0.007	0.006	− 0.009	− 0.017
no of showers	− 0.001	− 0.001	− 0.001	0.001	0.001
no of faucets	− 0.001	0.000	0.000	0.000	0.001
no of toilets	− 0.001	0.000	0.000	0.001	0.001
check leaks	− 0.058	− 0.034	− 0.029	0.041	0.079

Table A5. Marginal Effects for how important do you think most of your neighbors feel it is to use water efficiently or to conserve water? (nconserve).

	effect 1	effect 2	effect 3	effect 4	effect 5
log(water consumption)	0.000	0.001	0.001	0.001	− 0.003
Qatari	− 0.007	− 0.017	− 0.020	− 0.027	0.071
monthly income 2	0.016	0.036	0.038	0.044	− 0.135
monthly income 3	0.029	0.057	0.055	0.043	− 0.183
monthly income 4	0.048	0.084	0.073	0.036	− 0.241
monthly income 5	0.046	0.089	0.087	0.080	− 0.302
Education	0.001	0.003	0.004	0.005	− 0.013
no of adults	− 0.001	− 0.001	− 0.001	− 0.002	0.005
wash dishes	0.006	0.015	0.016	0.023	− 0.060
no of showers	0.001	0.002	0.002	0.003	− 0.008
no of faucets	− 0.001	− 0.003	− 0.003	− 0.004	0.011
no of toilets	0.003	0.007	0.008	0.011	− 0.029
check leaks	− 0.003	− 0.008	− 0.009	− 0.012	0.032

Table A6. Marginal Effects for if Qatar will have a water shortage problem in the future (agree Q60 2).

	effect 1	effect 2	effect 3	effect 4	effect 5
log(water consumption)	− 0.002	0.000	0.000	0.001	0.000
Qatari	− 0.005	0.000	0.001	0.003	0.001
monthly income 2	− 0.118	0.005	0.015	0.079	0.019
monthly income 3	− 0.157	− 0.003	0.018	0.111	0.031
monthly income 4	− 0.139	− 0.004	0.016	0.099	0.028
monthly income 5	− 0.119	0.004	0.015	0.081	0.020
Education	0.047	− 0.004	− 0.006	− 0.030	− 0.007
no of adults	− 0.003	0.000	0.000	0.002	0.000
wash dishes	− 0.026	0.002	0.003	0.016	0.004
no of showers	− 0.019	0.002	0.003	0.012	0.003
no of faucets	0.003	0.000	0.000	− 0.002	0.000
no of toilets	0.009	− 0.001	− 0.001	− 0.006	− 0.001
check leaks	0.024	− 0.002	− 0.003	− 0.015	− 0.003