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Social and environmental nudges and water usage: Evidence from a field experiment in Iran

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ABSTRACT

We nudged households in Torbat Heydarieh, a city in Iran, with social comparison and public environmental messages to decrease water consumption. In the former treatment, we provided subjects with their actual water consumption compared to their neighborhood's minimum and average consumption. In the latter one, we illustrated some facts about the water crisis in Iran and each individual's potential role in dropping it. We also incorporated perceptions and attitudes of our subjects on water consumption, extracted from our survey, to control for their possible impacts. Our results show that the social comparison nudge lessens the daily water usage of each family member by about 30 percent. In contrast, a nudge with public environmental messages does not have any effect.

1. Introduction

Iran has an arid and semi-arid climate, is undergoing a severe water crisis, is suffering from a terrible socioeconomic drought, and facing water bankruptcy [1]. It has been suffering from water shortage for decades, while rapid urbanization has provoked this crisis. The water crisis in Iran illustrates itself in the significant sinking of groundwater levels, overusing water supply sources, and severely worsening water quality.

Numerous droughts and the over-extraction of surface and especially groundwater have adversely accelerated the country's water situation to a critical level. This crisis is more than evidenced by drying lakes, rivers, and wetlands, diminishing groundwater levels, soil erosion, desertification, and dust storms, to name just a few. Madani et al. [1] argue that the country mainly suffers from a socioeconomic drought, i.e., bad governance, disintegrated planning, and managerial myopia in water management.

Climate change, particularly drought, has worsened in the last ten years. In this period, Iran's precipitation has declined by about 11 percent, surface water has diminished by about 44 percent, renewable water has decreased by about 32 percent, and the average temperature of main cities in Iran has increased by about 0.6-degree centigrade, all in comparison with their long-run average. Moreover, substantial probable changes in precipitation and temperature regimes are anticipated for the coming decades. Forecasts for the coming 15 years exhibit between 0.7 (in the intermediate scenario) to 1 (in the worst-case scenario) degree increase in temperature (The Research Center of Islamic Legislative Assembly, 2018).

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The Global Trends 2030 report of the US National Intelligence Council also predicts that average precipitation patterns will change such that wet areas will become wetter while arid areas will become more so. Especially in Iran, precipitation is forecasted to decline by 15.6 percent. The decline in rainfall in 2017 has been unsurpassed in the last five years, and almost 90 percent of the country is facing drought, though to different extents.

Since it is not possible in the short run to increase the water supply significantly, the only way to tackle the water bankruptcy problem, where water demand exceeds the natural water supply, in principle, is to implement aggressive water demand reduction plans. The average daily water consumption per head is about 157 liters in Iran.[2] At the same time, it may exceed up to 400 liters in metropolises such as Tehran, according to data from the Iran energy ministry.[3] These figures make Iran an exceptional case where over-usage of water is happening where the water is scarce.

This paper assessed whether nudging households with social comparison and public environmental messages decreases water consumption. The novelty of this paper comes from institutional as well as normative channels. First of all, non-price policies to reduce demand for water in all countries, disrespectful of their level of development and wealth, are concentrated in cases where the price of water is already high or at least not subsidies. Therefore, these countries only have a little room for a price policy that typically involves increasing prices.

What makes a country like Iran a distinctive and exciting place to study the effect of non-price policies is not the fact that the country is not wealthy, e.g., in terms of GDP per capita, but the fact that its economy is dependent on oil, enabling the government to subsidize different commodities including water. A multi-part tariff for water prices in Iran depends on the consumption level; the water price increases nonlinearly as its consumption increases. Nevertheless, water in Iran is heavily subsidized and very cheap by any measure, as its average price of a cubic meter is about 3 cents (per liter is about 0.003 cents).

So far, all typical behavioral interventions have been conducted in developed countries where drinkable water is not cheap. Therefore, one could not reduce water demand by increasing its price as it is already expensive. However, based on official data from the Iranian parliament's research center,[4] the selling price of water in urban areas is less than 48%, and in rural areas, less than 25% of its marginal cost. Since the water price is subsidized and dramatically low, people use drinkable water for other usages, such as cleaning and showering.

While there is much room to increase water prices in Iran, socio-political and security concerns hinder policymakers from adjusting its price to at least cover its production cost if not its opportunity cost. Moreover, price policies could not be applicable to lessen water consumption, especially given its low price elasticity of demand. Therefore, we are left only with behavioral policies to lessen the demand of urban residents for water.

Moreover, people in Iran, as an Islamic country, face different Islamic thoughts in their everyday lives, particularly to consume in parsimony. Therefore, one might not expect that another message on water consumption could have a marginal effect. Our paper explicitly demonstrates that even in extreme cases like Iran, where the water is very cheap, by any measure, and people are used to getting a lot of religious messages in their everyday lives on how to consume with frugality, non-price policies, particularly nudge in the sense of social comparison, could be still effective. In other words, a similar nudge with social comparisons works effectively in a very different institutional and normative setting.

The paper's main contribution is to assess the non-price policy's effectiveness in reducing water usage outside of the Americas/Europe setting, where the very low price of water pushes the price policy. At the same time, the socio-politic concerns make this policy irrelevant in practice. Few studies apply behavioral economics to water usage in a low- or middle-income country (e.g., [2,3]).

We incorporated novel and unique information on the perceptions and attitudes of our subjects on water consumption. As the randomization was adequately executed, we used some control variables, namely household size and average age, for the precision of estimates. Moreover, we included some subjective variables extracted from our survey to control for their possible impacts on water consumption changes over the experiment. These combinations of objective and subjective variables give us an almost complete toolbox to assess the behavioral changes in water consumption.

By conducting a field experiment in Iran, we avoid the criticism of the experimental approach mainly being used in Western, Educated, Industrialized, Rich, and Democratic (WEIRD) societies [4], while non-European, less educated, non-industrialized, poor, and less democratic societies are mainly ignored. We nudged households with social and public environmental messages in a field experiment. In one treatment, we notified subjects about the substance of their water consumption and the minimum and average water consumption in their neighborhood. While in another treatment, we provided subjects with some facts about the water crisis in Iran and how they could reduce it.

The non-effectiveness of traditional tools, such as price policies, to reduce water consumption leads to the development of different policy tools based on social motives and behavioral biases that better motivate desired behavior change. In general, other than climatic conditions, water consumption is driven by the rational pursuit of self-interests given financial status and behavioral factors such as lifestyle, habits, social norms, and rising living standards. Frederiks et al. [5] illuminate the fundamental cognitive biases that may explain why energy-related behavior often fails to align with consumers' values or pecuniary interests. The usual way to behavior change in public policy has been to attempt to change minds by influencing how people think through information

[2] This includes 5 liters for drinking, 10 liters for cooking, 50 liters for taking a bath and shower, 20 liters for laundry, 15 liters for dishwasher, 30 liters for sanitary consumption, 10 liters for house cleaning, and 17 liters of miscellaneous consumption. Therefore, it is clear that in contrast to the Western standard, showers are the main component of water consumption in Iranian households where individuals used to take very long showers.

[3] https://financialtribune.com/articles/energy/80967/tehran-residents-warned-again-about-water-consumption#:~:text=According%20to%20data%20from%20the,Tehran%20may%20exceed%20400%20liters

[4] https://rc.majlis.ir/fa/news/show/1097109 (in Persian).

and incentives. However, there is increasing evidence to suggest that changing contexts by influencing the environments within which people act in mostly intuitive ways can significantly affect behavior [6].

There is also often a sizeable disparity between peoples' self-reported values and intentions and their observable behavior. Therefore, despite adequate water scarcity knowledge, many consumers might fail to take significant water consumption efficiency and conservation steps. We might break the knowledge-action gap and improve consumption behavior with a simple nudge that reminds consumers of their core values and change the architecture of their choices without forcing them to adopt a new consumption pattern. Providing simple, low-cost information about social norms can help individuals overcome salience and status quo biases and improve efficiency in many choice settings. Strategies that provide information about overconsumption behavior have helped encourage conservation behavior. Social comparisons are a popular behavioral nudge to promote conservative behavior, partially because raising prices is politically tricky.

Our findings exhibit that the social comparison nudge lessens the daily water usage of each family member by about 6%, even when it does not translate to saving money, while a nudge with public environmental messages does not affect changing consumption behavior. The rest of the paper is organized as follows. In Section 2, we reviewed the related literature. Section 3 describes the experimental design. We reported the results and provided some discussion in Section 4. Section 5 concludes.

2. Related literature

While some studies do not support the influence of non-price water conservation policies on households' decision-making regarding water conservation practices (e.g., [7]), the literature generally provides much evidence that non-price policies have been very successful in reducing residential water consumption. Policymakers generate and utilize behavioral innovations, e.g., norm-based messages, which nudge consumers to make better choices and promote conservation efforts. They make the implications of one's behavior salient in either absolute terms concerning damage to the environment and negative externalities (e.g., [8]) or comparison with oneself, either real-time (e.g., Gans, Alberini, & Longo, 2013; Jessoe & Rapson, 2014; [9]) or in offline mode [8], or with others (e.g., [10–13]).

In a randomized control trial (RCT) with real-time appliance-level energy metering, Asensio and Delmas [8] pointed out that non-price incentives such as tailored information about environmental and public health damages, which imply the externalities of electricity production, e.g., pollutant, childhood asthma, and cancer, defeat monetary savings information to motivate energy conservation behavior in the residential electricity sector. Tiefenbeck et al. [9], in a large-scale field experiment, gave participants real-time feedback on the consumption of showering and found that it lessened resource consumption by 22%, which is much larger than standard policy interventions that provide aggregate feedback on resource use instead.

By providing feedback to customers on their energy usage at their homes, with a focus on peer comparisons, utilities can reduce energy consumption at a low cost. In particular, several studies (e.g., [12]) showed that nudging, highlighting social norms with peer comparisons decreases household water usage. In a natural field experiment, Ferraro et al. [10] exhibited that appeals to pro-social preferences influence short-run water use patterns, while only norm-based messages augmented with social comparisons permanently impact water demand. Ferraro and Price [11] also found that social comparison messages significantly influenced residential water demand more than simple pro-social messages or technical information alone. Moreover, social comparison messages are most effective among high water users identified as the least price sensitive.

In a randomized field experiment, where for one year delivered monthly reports of water consumption, including normative messages, Torres, Marcela, and Carlsson (2016) found that social information and appeals to norm-based behavior reduced residential water use by up to 6.8% in Colombia. The theoretical model of Taylor et al. [14] proved that social comparison messages that function principally by raising the psychic cost of consumption might improve welfare if the retail price of water is below its social marginal cost and lead to conservation for water use activities if consumers are below satiation.

Czap et al. [15] examined the effectiveness of complementing financial incentives with nudging for empathy in a framed experiment where an upstream farmer affects the downstream water quality by choosing the level of conservation. They found that empathy nudging, a message to the upstream farmer encouraging them to walk-in-the-shoes of a downstream water user, can counteract the exclusion of financial incentives. Moreover, empathy nudging and financial incentives have a synergic higher effect, especially in low conservation cases. Peth et al. [16] showed that nudging decreases the water usage of German farmers. However, the deterrent effect of the nudge with a social comparison (that the majority of farmers comply with the minimum-distance-to-water rule) is not more potent than that of the nudge with information and pictures (showing environmental and health damages caused by breaching the rule). Moreover, the nudge with social comparison increased the severity of non-complying behavior in the deviant subpopulation.

Andor and Fels [17] presented a systematic review of the empirical evidence of non-price nudge-like interventions, namely social comparison, commitment devices, goal setting, and labeling on energy conservation behavior of households. They find that all interventions could significantly decrease the energy consumption of households, albeit with different effect sizes. Results of Delmas et al. [18] meta-analysis of 156 published energy conservation field experiments between 1975 to 2012 showed that strategies providing individualized audits and consulting are comparatively more effective for conservation behavior than strategies that provide historical, peer comparison energy feedback.

In a RCT where information on individual and group water consumption was sent weekly to farmers equipped with smart-meters, Chabe-Ferret et al. [19] did not detect an effect of social comparison nudges on average water-saving behavior among farmers. However, they find that the nudge decreases water consumption at the top of the distribution while it increases consumption at the bottom. In two experiments, Brent and Wichman [20] investigated the interaction of prices and nudges. They find empirical support

that consumers respond to behavioral nudges due to personal economic benefits. However, they do not find consistent evidence that social comparisons are more effective in inducing higher-priced conservation or increasing consumers' price sensitivity. In a RCT at 105 schools, Visser et al. [3] demonstrated that detailed water usage data feedback from smart meters and an interschool competition encouraged responsible water usage and reduced water usage by 15–26%.

3. Experimental design

Torbat Heydarieh is considered one of the water-critical cities in the Khorasan Razavi province due to drought, over-abstraction of surface and groundwater through illegal and over-deep well digging, and cultivation of crops that require abundant water, such as beetroot, watermelon, melons, and cotton. Located in a semi-arid and dry area with a population of about 225,000, it is the agricultural hub of Khorasan Razavi province in Iran and the capital of Saffron of the World. In Torbat Heydarieh, there are 50,000 water subscriptions with per capita usage of 209 liters per day.

Among the numerous areas of Torbat Heydarieh, residents of the streets leading to the north of Shahid Modarres Blvd in the north and northwest were considered for this study due to the densely populated and relatively cultural and social homogeneity with the middle-class inhabitants. The selected subscribers, from over eight hundred households, were randomly divided into a control treatment, a social comparison treatment, and a public environmental messages treatment.

We collected every 20 houses as a block and considered the first and the fourth blocks to be in the control group while the second and the third ones for the social comparison treatment and the public environmental messages treatment, respectively. Houses in Iran generally border each other but are not double-sided in the sense that house fronts face roads while house backs face house fronts of the next street over. Houses in our sample were almost similar in size, materials, and architecture, with an interior yard mainly with a small garden. While households typically water their garden, the municipality is in charge of exterior plants in the streets. Growing grass inside houses or even in the streets is not typical in Iran. We did not prohibit occupants from talking about the treatment with each other. Nevertheless, as subjects in both treatments had the same opportunity to communicate with their neighbors, this should have the same effect in both treatments.

However, once we excluded those houses with zero water consumption in at least one period, we ended up with 266 households in the social comparison treatment and 236 households in the environmental messages treatment, where in each treatment half of these subjects were in the experimental group and the half in the control group. We conducted our field experiment in a year between November 2017 and November 2018. As water bills are issued in Iran every two months, we intervened six times by sticking an attached paper to water bills in the experimental treatments. A questionnaire, presented in the Appendix, was also filled out once by the head of subscribers' households. In this questionnaire, household characteristics (age, gender, education level, and occupation of each family member) and their views on the water crisis, their role, and the government in this issue were revealed.

We asked all households in control and experimental treatments to participate in the survey, though some did not contribute. The survey was conducted after the experiment was over. The reason was to prevent the priming effect and any possible contamination with the household behavior in water usage. We followed the world value survey style of questions, which is standard worldwide. We did not expect all subjects to answer truthfully. However, as it was similarly likely not to falsify preference, we expect to observe the same level of dishonesty in our randomized treatments.

For the SC treatment, we follow the typical messages that have been used already in the literature. On the piece of paper attached to the bill sent from the utility, we informed subjects about the amount of their water consumption and the minimum and the average water consumption in their neighborhood and the whole region in the last two months, all in liters. The household knew that the paper was coming from the local utility as it is the only authority with access to such data and sends the official bill. If the amount of water consumption of a subject was less than (equal to) the average of the neighbors, this message was written in pink with the star sign on the paper attached to the bill: "Fortunately, your water consumption is less than (equal to) the average consumption of your neighbors". However, this message was written in green for high-usage subjects with the cross sign: "Unfortunately, your water consumption is higher than the average consumption of your neighbors".

For the EM treatment, we used all available reliable figures about the city's water consumption and the extent of the water crises in the region. We gave all subjects some stylized facts about the water crisis in Iran and how they could reduce it. After the final data collection, some subscribers were excluded from the sample for various reasons, e.g., vacancy or subsistence. In both cases, households in the control group received nothing except the bill.

4. Data

To get the data on household water consumption, we teamed up with the Torbat Heydarieh Water and Waste Water Utility, which is responsible for collecting data on water usage and issuing and distributing bills. Once we cleaned our data on water consumption, we ended up with 266 households in the social comparison treatment and its correspondent control group and 236 households in the environmental messages treatment and its correspondent control group. We asked each household's head about the characteristics of each family, such as age and household size. The average age is the average of all household members' ages. We considered 1 for females and 2 for males. The gender diversity is the average of these values for each household between 1 and 2, by construction, and measures whether there are more males or females.

We also made some control variables out of the survey filled by each household. The income variable is the households' perception of their relative level of total income, including salary, retirement, and pension, compared with other households in the society, on a scale between 1 (the lowest) to 10 (the highest). The social norm is a self-reported level to which the family

Table 1
Mean of family characteristics in the social comparison treatment.

	Exp group	Ctrl group	*p*-value for difference
Water Usage Pre-policy (in cubic meter)	31.92	31.56	0.87
Household Size	3.39	3.58	0.17
Gender Diversity (female=1, male=2)	1.47	1.51	0.12
Number of Observations	118	118	

Table 2
Mean of family characteristics in the environmental messages treatment.

	Exp group	Ctrl group	*p*-value for difference
Water Consumption Pre-policy (in cubic meter)	26.38	26.40	0.99
Household Size	3.49	3.37	0.46
Gender Diversity (female=1, male=2)	1.5	1.54	0.20
Number of Observations	133	133	

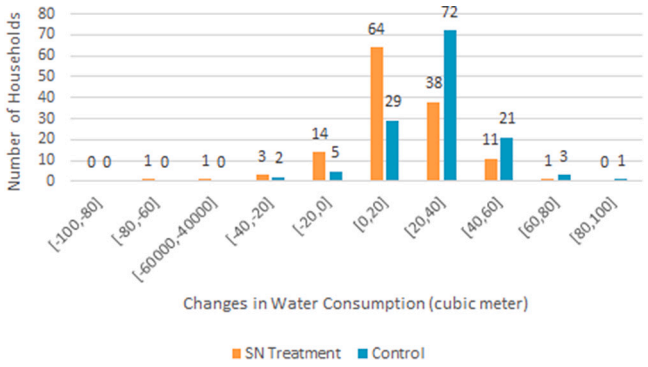

Fig. 1. SN treatment.

tries to follow social norms in its consumption decisions. On a scale between 1 (the lowest) to 5 (the highest), the government variable indicates how much the household believes that the government is the entity that is responsible for providing drinking water, independent of price or household consumption. Finally, the religiosity is a self-reported level to that extent, the head of the family considers himself/herself an adherent of Islamic orders.

Since we had many randomly selected observations over a year, we could expect subjects in different treatments to be comparable regarding factors affecting their water consumption. Tables 1 and 2 show the mean of family characteristics in the social comparison treatment and the environmental messages treatment. These characteristics include the level of water consumption per household in liters before the policy, household size, and gender diversity. Given the normal distribution of data, the t-test shows no significant difference in mean between the two groups in both treatments.

5. Results and discussion

First, we illustrate the distribution of year-over-year water consumption changes in two different treatments in two different graphs (see Figs. 1 and 2).

As it is clear from these figures, compared to households in the control treatment, more households in the SN treatment reduced their water consumption while a smaller number of them increased their water consumption. However, changes in water consumption in the EM treatment are not substantially different.

We pooled our data to consider the household's overall water consumption in a year and compare the same period across treatments. In order to control for meteorological factors and learning effects, we subtract the pre-intervention level of Per capita water usage in November 2017, before starting our experiment, from per capita water consumption in the last round, November 2018, to calculate the dependent variable, i.e., the difference in per capita water consumption.

Eq. (1) indicates how we identify the effect of a nudge on water consumption in two different treatments:

$$DWC_i = \beta_0 + \beta_1 TD_i + \beta_2 HS_i + \beta_3 AA_i + \beta_4 CONTRL_i + \beta_5 TD_i * CONTRL_i + \varepsilon_i, \quad (1)$$

where DWC_i indicates the difference in per capita water consumption of household i in terms of a liter after one year, HS_i is the size of household i, AA_i is the average of members' age in household i, and $CONTRL_i$ is a vector of control variables, including the income perception of household i (IN_i), the social norms adherence, i.e., how household i acts following the social norms

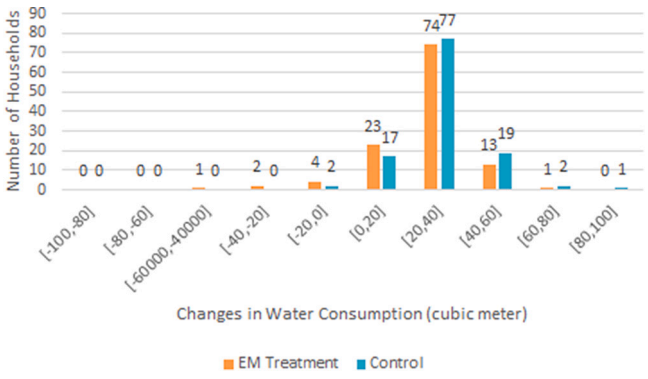

Fig. 2. EM treatment.

Table 3
OLS estimation: Effect of social norm nudge on differences in per capita water consumption.

Variables	Model I	Model II	Model III
Constant (C)	2933.584***	741.32	2394.953
	(518.63)	(3433.64)	(4077.38)
Treatment Dummy (TD)	−4006.410***	−3826.034***	−7699.402
	(811.063)	(873.59)	(5754.97)
Household Size (HS)	...	−50.596	−95.771
	...	(463.47)	(467.77)
Average Age (AA)	...	61.599	52.104
	...	(38.74)	(38.89)
Additional Controls		...	...
(Survey Variables)		...	...
TD*Additional Controls			...
			...
Observations	225	220	220
R-squared	0.098	0.179	0.2

Robust standard errors are in parentheses. ***, **, and * indicate the coefficients are significant at 1 percent, 5 percent, and 10 percent, respectively.

in consumption decisions (SN_i), the belief of household about the role of government, i.e., how much household i considers the government is responsible for providing cheap water (GV_i), and finally the level of household i's religiosity (RL_i). Moreover, TD shows the treatment dummy, which is 1 for households in the SC group and 0 for those in the control group in the nudge treatment on social norms. It is also 1 for households in the EM group and 0 for those in the control group in the nudge treatment with environmental messages.

Table 3 compares the SC treatment with the control group to examine whether our social norm nudges significantly impacted water consumption. In Model I, we only considered the treatment dummy, our main variable of interest, and the constant. We also added control variables in Model II, our main specification. Finally, Model III clusters subjects by including the interaction of the treatment dummy with control variables. The main reason for having different specifications is to check the robustness of the coefficients of different variables to the addition of other control variables.

Since we assess how per capita water consumption has changed after a year of sending the message, we should also not worry about seasonality. Therefore, we used a dummy variable to assess the effect of the policy. The treatment dummy is negative in all specifications in Table 3, indicating that awareness about a higher level of water consumption compared to others has a dampening effect. In Model II, controlling for all other factors, informing households about their relative water consumption reduces water usage of each of its members by about 3826 liters in each period (two months), which is about 63 liters per day, or about 30% of daily per capita water usage. Moreover, this result is almost robust between Model I and Model II.

The treatment dummy variable is insignificant in Model III, while the model suggests a correlation between the effectiveness of social norms treatment and greater adherence to norms. In other words, the more subjects' score on the norm adherence question is associated with the more reaction to the norms message to decrease water consumption. Therefore, the effect of a nudge with social norm comparison came mainly from those subjects who already care more about following social norms in consumption decisions. This result does not mean that the treatment was not effective. It just determines the source of effectiveness, i.e., intrinsic motivation for adhering to social norms, which only needs a nudge to be prominent.

Table 4 compares the EM treatment with the control group to show the effect of the environmental nudge on the difference in per capita water consumption. The right-hand side variables in different models of Table 4 are the same as those in models of Table 3. Our results show that the treatment dummy is insignificant in all specifications in Table 4. In other words, providing households

Table 4
Effect of nudge with environmental messages on differences in per capita water consumption.

Variables	Model I	Model II	Model III
Constant (C)	3384.758***	6970.932**	6498.686*
	(472.01)	(2980.8)	(3534.84)
Treatment Dummy (TD)	361.005	379.76	−87.687
	(815.24)	(865.89)	(4988.86)
Household Size (HS)	...	−1060.809**	−1020.718**
	...	(413.7)	(420.1)
Average Age (AA)	...	23.13	14.679
	...	(32.15)	(32.95)
Additional Controls		...	...
(Survey Variables)		...	...
TD*Additional Controls			...
			...
Observations	176	174	174
R-squared	0.001	0.095	0.118

Robust standard errors are in parentheses. ***, **, and * indicate the coefficients are significant at 1 percent, 5 percent, and 10 percent, respectively.

Table 5
Panel regressions for differences in water consumption.

Treatments	Social norm	Environmental messages
Constant	−2976.942***	−883.339
	(909.42)	(1654.35)
Treatment Dummy	−852.247***	813.982
	(315.16)	(642.17)
Household Size	287.837	214.182
	(175.95)	(372.66)
Average Age	29.38	−92.754
	(13.99)	(314.70)
Observations	1339	1037
R-squared	0.069	0.142

Robust standard errors are in parentheses. ***, **, and * indicate the coefficients are significant at 1 percent, 5 percent, and 10 percent, respectively.

with public and general messages about the water crisis in Iran and their significant role in reducing it would not affect them to change their consumption behavior. This finding contrasts the practical policy that targets private consumption in the SC treatment. Moreover, subjective survey variables do not influence the per capita water consumption change between treated and untreated households.[5]

In order to check the robustness of our result, we also estimated a fixed effect panel regression which incorporates the five bimonthly treated observations in periods that were not included in previous regressions:

$$DWC_{i,t} = \beta_0 + \beta_1 TD_{i,t} + \beta_2 HS_{i,t} + \beta_3 AA_{i,t} + \alpha_i + \varepsilon_{i,t}.$$

The dependent variable is the difference in per capita water consumption in each bimonthly treated observation compared to the consumption before any treatment. The new results in Table 5 confirm that the treatment was significantly effective in the social norm treatment, while it had no significant effect in the environmental message treatment.

We also included the results of the difference-in-differences estimations,

$$WC_i = \beta_0 + \beta_1 TD_i + \beta_2 TI_i + \beta_3 TD_i * TI_i + \beta_4 HS_i + \beta_5 AA_i + \beta_6 CONTRL_i + \varepsilon_i,$$

for both treatments in Table 6, where WC_i indicates the per capita water consumption of household i in terms of a liter, and the time trend dummy TI is 1 for water consumption in the last period, after the series of nudges, and 0 for water consumption in the period before the nudge. While the water consumption in the very last period always significantly increases in both experiments, the interaction of the time variable and the treatment dummy is only significant in the social norm experiment, confirming our previous findings.

The non-effectiveness of environmental messages could not be because people do not believe in Iran's water crises or underestimate their role in mitigating water shortage. Households in the EM treatment almost wholly disagree with the statement that "The water crisis in Iran is not a severe issue", with an average of 1.27 on the scale between 1 (completely disagree) to 5

[5] We dropped 46 households in estimations of Table 3 and 70 households in estimations of Table 4 because of missing data. As we had expected such missing data beforehand, we collected enough data to be able to run different estimations.

Table 6
Difference-in-differences estimations for water consumption.

Variables	Social norm	Environmental messages
Constant	21082.91***	15956.43***
	(2534.57)	(2357.068)
Treatment Dummy (TD)	668.001	−550.072
	(860.45)	(922.6387)
Time (TI)	2933.584***	3384.758***
	(725.85)	(717.9061)
TD*TI	−4249.676***	460.856
	(1154.24)	(1254.31)
Household Size	−3016.074***	−2787.998***
	(338.59)	(323.3165)
Average Age	68.147**	72.688***
	(28.3)	(25.12343)
Additional Controls	...	...
(Survey Variables)	...	...
Observations	440	448
R-squared	0.294	0.35

Robust standard errors are in parentheses. ***, **, and * indicate the coefficients are significant at 1 percent, 5 percent, and 10 percent, respectively.

(completely agree). They also almost disagree with the statement that "reducing household water consumption does not have a significant effect on reducing water scarcity", with an average of 2.74 on the same scale.

As the government is the monopoly in providing water in Iran that highly subsidizes its price, the mistrust of people towards the government in Iran makes them believe that the saved resources might not be used in their interest. Therefore, since people in Iran mostly do not trust the government to efficiently use the public resource for their benefit, nudging to save water to give the government more chance to serve its people does not salient this fact in people's minds. Households might think the government does not use the resource they save for public welfare but rather for its ideological and political interests, even against their will.[6] Therefore, taking the results of the social-comparison treatment at face value, they should collaborate with NGOs rather than local governments to successfully scale up social norm-based nudges.

6. Conclusion

Iran suffers from water crises while its price has been kept very low due to socio-political concerns. Therefore, non-price policies based on social motives and behavioral biases might help reduce urban residential water overconsumption. We nudge households, in a field experiment, with social comparison (i.e., the amount of their water consumption in contrast to the minimum and the average in their neighborhood) as well as public environmental messages (i.e., some facts about water crises in Iran, and their potential role in decreasing it).

Our findings exhibit that informing households about their relative water consumption lessens the daily water usage of each family member by about 30% while providing them with facts about the water crises in Iran and their significant role in decreasing it does not affect changing their consumption behavior. Despite the remarkable impacts of such social comparisons in promoting conservative consumption behavior, experimental analyses have concentrated solely on short-run effects. However, from a policy-making viewpoint, whether and how such nudges could change behaviors lastingly, in the long run, is of equal interest.

CRediT authorship contribution statement

Mehdi Feizi: Conceptualization, Methodology, Validation, Formal analysis, Writing – original draft, Writing – review & editing, Supervision. **Navideh Khatabiroudi:** Conceptualization, Investigation, Writing – review & editing, Supervision, Project administration.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

[6] On 12 November 2017, the earthquake in Kermanshah was followed by a massive wave of empathy from fellow Iranians and their support through volunteering and donating to various campaigns of celebrities on social networks. However, this civil movement's meaning was a deep distrust of the government and its affiliated organizations. Indeed, public trust in the government has been damaged deeply by the waves of corruption cases lately. See https://en.radiofarda.com/a/why-iranians-trust-celebrities-more-than-ir/28940854.html

Data availability

Data will be made available on request

Appendix

A.1. Questionnaire

Please comment on the following sentences:

- We try to act following social norms in our family's consumption decisions:

Completely Agree	Agree	Somehow Agree	Disagree	Completely Disagree
☐	☐	☐	☐	☐

- The government should provide drinking water, as much as we want, without expecting an extra cost or reducing consumption.

Completely Agree	Agree	Somehow Agree	Disagree	Completely Disagree
☐	☐	☐	☐	☐

- Our family's water consumption is significantly more than our neighbors'.

Completely Agree	Agree	Somehow Agree	Disagree	Completely Disagree
☐	☐	☐	☐	☐

- Reducing household water consumption does not have a significant effect on reducing water scarcity:

Completely Agree	Agree	Somehow Agree	Disagree	Completely Disagree
☐	☐	☐	☐	☐

- Increasing water price has a significant impact on reducing our family's water consumption (water consumption in our family is very sensitive to its price).

Completely Agree	Agree	Somehow Agree	Disagree	Completely Disagree
☐	☐	☐	☐	☐

- The water crisis in Iran is not a severe issue:

Completely Agree	Agree	Somehow Agree	Disagree	Completely Disagree
☐	☐	☐	☐	☐

- Where does your family, in terms of its total income including salary, retirement, pension, etc., located on the scale between 1 (the lowest) to 10 (the highest)?

The Lowest Income Level	...	...	...	...	...	...	...	...	The Highest Income Level
1	2	3	4	5	6	7	8	9	10

- To what extent you consider yourself an adherent of Islamic orders

Very Little	Little	Average	Much	Very Much
☐	☐	☐	☐	☐

- To what extent do you consider yourself to be ethical

Very Little	Little	Average	Much	Very Much
☐	☐	☐	☐	☐

All households in the public environmental messages treatment received all messages below, attached to their bi-monthly water bills. Here is the translation of these messages:

- *According to the global standard, countries that use more than 40 percent of their renewable water sources are at serious risk. Iran, with 110 percent usage of these resources, is in a critical condition, and if this process continues, there will not remain any water in the country in about 15 years.*
- *By saving water, in addition to preserving the country's water resources, you will also reduce your household expenses.*
- *Rainfall in Khorasan Razavi province is about one-quarter of the global average rainfall, which makes this province among the world's less rainy areas.*
- *Torbat Heydarieh, with an average annual rainfall of 8.246 mm, is in the semi-arid region.*
- *If you reduce your showering time by 1 minute, the water saved will be 600 liters in 1 month.*

- *If in Torbat Heydarieh, with a population of about 224626 people, each person only reduces 1 minute of shower use, the amount of water saved during the one month will be 134775600 liters, which is equal to 89850400 bottles of 1.5 liters of mineral water.*
- *The Iranian Students Polling Agency (ISPA) reported that 67.7% of the people agree with the statement that "the country is in a water crisis and the main duty is on citizens to save."; 23.2% agree that "Iran is in a water crisis, but the main responsibility is on the government, and not the people"; 6.1% agree that "the country's water level is appropriate and not a concern." while the rest did not have an opinion on the water issue in Iran.*
- *By preventing tap water drain, we could assuage 150 people per day.*
- *By using a washing machine only when it is full, we can save 50 trees annually.*
- *By closing the tap while washing dishes, we can water the 5 meters of grass.*
- *By using a bucket, 300 liters of water could be saved when washing a car.*
- *By closing the tap when brushing, we can save 5000 liters of water annually.*

References

[1] K. Madani, A. AghaKouchak, A. Mirchi, Iran's socio-economic drought: challenges of a water-bankrupt nation, Iran. Stud. 49 (6) (2016) 997–1016.
[2] S. Datta, S. Datta, J. Josï, L. Zoratto, O. Calvo-Gonzï, M. Darling, K. Lorenzana, A Behavioral Approach To Water Conservation: Evidence from Costa Rica, World Bank, 2015.
[3] M. Visser, M.J. Booysen, J.M. Brühl, K.J. Berger, Saving water at cape town schools by using smart metering and behavioral change, Water Res. Econ. 34 (2021) 100175.
[4] J. Henrich, S.J. Heine, A. Norenzayan, The weirdest people in the world? Behav. Brain Sci. 33 (2–3) (2010) 61–83.
[5] E.R. Frederiks, K. Stenner, E.V. Hobman, Household energy use: Applying behavioural economics to understand consumer decision-making and behaviour, Renew. Sustain. Energy Rev. 41 (2015) 1385–1394.
[6] P. Dolan, M. Hallsworth, D. Halpern, D. King, R. Metcalfe, I. Vlaev, Influencing behaviour: The mindspace way, J. Econ. Psychol. 33 (1) (2012) 264–277.
[7] D.P. Dupont, S. Renzetti, Household behavior related to water conservation, Water Res. Econ. 4 (2013) 22–37.
[8] O.I. Asensio, M.A. Delmas, Nonprice incentives and energy conservation, Proc. Natl. Acad. Sci. 112 (6) (2015) E510–E515.
[9] V. Tiefenbeck, L. Goette, K. Degen, V. Tasic, E. Fleisch, R. Lalive, T. Staake, Overcoming salience bias: how real-time feedback fosters resource conservation, Manage. Sci. 64 (3) (2016) 1458–1476.
[10] P.J. Ferraro, J.J. Miranda, M.K. Price, The persistence of treatment effects with norm-based policy instruments: evidence from a randomized environmental policy experiment, Amer. Econ. Rev. 101 (3) (2011) 318–322.
[11] P.J. Ferraro, M.K. Price, Using nonpecuniary strategies to influence behavior: evidence from a large-scale field experiment, Rev. Econ. Stat. 95 (1) (2013) 64–73.
[12] D.A. Brent, J.H. Cook, S. Olsen, Social comparisons, household water use, and participation in utility conservation programs: evidence from three randomized trials, J. Assoc. Envir. Res. Econ. 2 (4) (2015) 597–627.
[13] M.M.J. Torres, F. Carlsson, Social Norms and Information Diffusion in Water-Saving Programs: Evidence from Randomized Field Experiment in Colombia, Department of Economics, Göteborg University, 2016.
[14] M.H. Taylor, K. Rollins, C. Lott, Exploring the behavioral and welfare implications of social-comparison messages in residential water and electricity, Econom. Lett. 168 (2018) 65–69.
[15] N.V. Czap, H.J. Czap, G.D. Lynne, M.E. Burbach, Walk in my shoes: Nudging for empathy conservation, Ecol. Econom. 118 (2015) 147–158.
[16] D. Peth, O. Mußhoff, K. Funke, N. Hirschauer, Nudging farmers to comply with water protection rules–experimental evidence from Germany, Ecol. Econom. 152 (2018) 310–321.
[17] M.A. Andor, K.M. Fels, Behavioral economics and energy conservation–a systematic review of non-price interventions and their causal effects, Ecol. Econom. 148 (2018) 178–210.
[18] M.A. Delmas, M. Fischlein, O.I. Asensio, Information strategies and energy conservation behavior: A meta-analysis of experimental studies from 1975 to 2012, Energy Policy 61 (2013) 729–739.
[19] S. Chabe-Ferret, P. Le Coent, A. Reynaud, J. Subervie, D. Lepercq, Can we nudge farmers into saving water? Evidence from a randomised experiment, Eur. Rev. Agric. Econ. 46 (3) (2019) 393–416.
[20] D.A. Brent, C.J. Wichman, Do behavioral nudges interact with prevailing economic incentives? Pairing experimental and quasi-experimental evidence from water consumption, in: The AEA Meeting, Atlanta, Georgia, 2019.