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A Behavioral Approach to Water Conservation

Evidence from Costa Rica

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Abstract

This paper presents the design a set of three simple and replicable behavioral interventions, which use stickers that can be added to water bills at low cost, and test their impact on water consumption in Belen, Costa Rica, using a randomized control trial. Two of the three interventions were found to decrease water consumption significantly in the months following the intervention. A descriptive social norm intervention using neighborhood comparisons reduces consumption by between 3.7 and 5.6 percent relative to a control group, while a plan-making intervention reduces consumption by between 3.4 and 5.5 percent. While the two interventions have similar results, they are effective on different subpopulations, with the plan-making intervention being most effective for low-consumption households,

while the neighborhood comparison intervention is most effective for high-consumption households. The results demonstrate that behavioral interventions, which have hitherto utilized sophisticated software to deliver customized messages, can be effectively implemented by local governments in developing countries, where technology and resource constraints render the sorts of customized messaging that has typically been used to deliver them in developed countries unfeasible. The results further confirm that raising awareness about how much water an individual consumes, and comparing this consumption level with peers, can go a long way in helping change individuals' behavior regarding the use of a finite resource such as water.

A Behavioral Approach to Water Conservation: Evidence from Costa Rica [1]

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I. Introduction and Motivation

A six-fold increase in global water use over the twentieth century has prompted many to identify the availability of fresh water as one of the most critical issues confronting policy makers in the present one. A number of factors - population growth, increased urbanization, rising income levels, and climate change - all point towards the likelihood of water scarcity concerns magnifying over time (Ferraro and Price 2013). Indeed, the United Nations estimates that by 2025 over two-thirds of the world's population will reside in regions considered water stressed (UNDP 2006).[2]

These concerns are increasingly salient to policy makers in growing urban jurisdictions in developing countries. Accelerating urbanization (UN 2013) means that demand often outstrips the ability of local bodies and governments to provide reliable access to drinking water, sewerage and wastewater treatment (Foster 2005). Indeed, despite the proportion of people with access to water and sanitation increasing globally, there were *more* urban dwellers without access to improved water sources and basic sanitation in 2010 than in the year 2000 (UN 2012).

Demographic and economic pressures mean that water management is emerging as a policy priority even in relatively water-rich regions like Latin America, which is home to nearly 31 percent of the world's freshwater resources (World Bank 2013). The scale of the problem is apparent from the recent introduction of water rationing in 38 cities in São Paulo, the largest province in Brazil, not a country known for water scarcity (Sganzerla 2014), as well as in Bogota, Colombia (El Tiempo 2014) and cities such as Barva in Costa Rica (La Nacion 2014). More generally, while the gains of recent decades mean that 94 percent of Latin Americans now have access to improved sources of drinking water (UN 2014), it is now widely recognized that protecting these gains in water security will necessitate a policy response (Akhmouch 2012).

The introduction of water rationing mentioned above highlights a key issue: in most urban jurisdictions in the developing world, there are limits on the ability to increase supply. This in turn means that *demand management* is a key component of any initiative to manage water resources. In an urban context, where household water use constitutes the bulk of water consumption, reducing the amount of water households consume thus emerges as a key priority for policy makers.

Several strategies have been used to promote water conservation in urban areas across the world. Prominent among them are *pecuniary approaches* involving price or tax increases, as well as *information or communications campaigns* intended to foster awareness of water scarcity and encourage water conservation.

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[2] Further, a significant share of global daily energy needs are dependent on water. Finding sufficient water resources to produce the required energy, however, is becoming more difficult. In the past five years, more than 50 percent of the world's power utility and energy companies have experienced water-related business impacts. At least two-thirds indicate that water is a substantive risk to business operations. As the world's population reaches 9 billion, competing demand for water from other sectors is expected to grow, potentially exacerbating the issue (World Bank 2013).

However, recent advances in applied behavioral economics suggest that this toolkit could usefully be supplemented by simple *non-pecuniary behavioral interventions*, which may have a useful role to play in reducing water consumption and are, more importantly, inexpensive. Such behavioral interventions, or "nudges", have been found to be effective in changing other environmentally-related behaviors such as electricity consumption (Allcott 2011, Brown et al. 2013) or water consumption (Ferraro and Price 2013) as well as other socially beneficial behaviors such as organ donation (Thaler and Sunstein 2008) and the uptake of influenza vaccination (Chapman et al. 2010). Yet, despite water use reductions being a policy priority for many jurisdictions around the world, such behavioral interventions on water use remain relatively underexplored. This is especially true of developing countries, despite policy makers there arguably facing the strongest pressures to reduce the amount of water used by citizens. The development of cost-effective strategies informed by the literature on applied behavioral economics that could feasibly be used by policy makers in developing-country jurisdictions thus emerges as an important priority for research.

This paper describes the results of a randomized control trial evaluating the effectiveness of three simple, technologically undemanding and easily replicable behavioral interventions, or "nudges", on water consumption. The experiment was run in Belén, a municipality in Costa Rica seeking to reduce household water consumption, where all individually-metered households (5,626 households in all) were randomized into one of three treatment conditions or a control group. As described below, our three treatments, which were sent out[3] in July 2014, allow us to evaluate the effectiveness of two versions of a "descriptive social norms" intervention and a "planning prompt" intervention.

The designs of the interventions used in this experiment were based on insights from a series of focus groups conducted with residents of Belén in March 2014, which helped identify several classes of potentially useful interventions from the literature. The key insights from these focus groups, and the resulting intervention designs, were as follows.

First, while there was broad consensus on the importance of water conservation in general, few residents believed that they themselves needed to use less water. Secondly, residents did not know how much water they themselves used. Thirdly, residents could not evaluate whether a given level of water consumption was too high or reasonable, because they lacked a benchmark against which to compare their own consumption. Finally, few residents could identify concrete steps that would help them reduce water consumption.

These findings led us to hypothesize that an intervention that allowed consumers to benchmark their consumption against their peers (i.e. a "descriptive norm" intervention; Allcott 2011, Ferraro and Price 2013), would be useful. To further test the impact of the choice of peer group itself, we implemented two versions of this idea as our first two treatment arms. In the first ("Neighborhood Comparison"), the treatment group was told about how their consumption compared to that of the average household in their *neighborhood*, while in the second ("City Comparison") the relevant comparison group was the average household in Belén. The literature suggests that the Neighborhood Comparison would likely be more effective at spurring behavior change because the peer group chosen is more similar to the target

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[3] As discussed in more detail later, about 8 percent of this original sample (distributed evenly across our treatment and control groups) could not be included in our final sample due to changes in metering in Belén.

population. Our final intervention arm was a goal-setting and planning intervention ("Plan-Making"), which drew recipients' attention to how their own relative consumption and then facilitated the setting of concrete goals about *how much* they would reduce their water consumption by, and the formation of plans about *how* they would reduce water use, based on the literature on implementation intentions. Households randomized to the control group received the standard water bill with no changes.

Our key results are striking. Relative to the same season[4] in the year prior to our intervention, households in two of the three treatment groups significantly reduced their water consumption in the first two months after the intervention was implemented. Broadly speaking, both the Neighborhood Comparison and Plan-Making interventions led to statistically significant reductions in water use, while the City Comparison had no discernible effect on water consumption. Regression estimates suggest that the Neighborhood Comparison reduced average monthly water consumption over the period August-September 2014 by between 0.98 and 1.47 cubic meters per household, or between 3.7 percent and 5.6 percent of control group consumption for the same period. The Plan-Making intervention reduced the average of August and September 2014 water consumption by between 0.90 and 1.46 cubic meters per household, or about 3.4 percent and 5.5 percent of average monthly consumption for the control group for this two-month period. Our findings, especially those about the Neighborhood Comparison dominating the City Comparison, are broadly in keeping with the literature, which finds that more localized norms are typically more effective at spurring behavior change. Finally, we find that the Neighborhood Comparison intervention is most effective among high-consumption households, whereas the Plan-Making Intervention derives its effects predominantly from changes in the consumption of households who consume relatively little at baseline.

The plan of the remainder of this paper is as follows. In Section II, we describe the water situation in Costa Rica and in Belén, the country and city where our experiment took place. In Section III, we discuss various approaches available to policy makers seeking to reduce water use, their relevance to our context, available evidence on their effectiveness, and motivate the use of behavioral economics interventions. In Section IV, we discuss the rationale for our interventions in more detail. In Section V, we describe the timing and related logistical features of the implementation of the interventions. Section VI presents our results, and Section VII concludes by interpreting our results further in light of the literature and laying out its significance both for the issue of water conservation and for urban governance and public service provision in the developing world more broadly.

II. Water Scenario in Costa Rica and Belén

With a population of over 4.4 million people of whom about 60 percent live in urban areas, Costa Rica has climatic characteristics that in conjunction with its mountainous topography make the country a water-rich nation. Despite this, water production capacity virtually matches current demand, so that there is considerable risk of a water deficit in the near future. In fact, there are already shortages and rationing of water in several parts of the country (Aguilar 2014). In addition to overall demand growth, spatially

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[4] Costa Rica has a rainy season (May-November) and a dry season (December-April). Our intervention took place during the 2014 rainy season, thus motivating the use of household water consumption during the 2013 rainy season as our key control variable for past water consumption.

unbalanced development (or the over-development of areas with limited water supplies, such as the coast of Guanacaste in the north-west of the country) threatens water security in parts of the country.

Approximately 99 percent of the urban population in Costa Rica is now connected to water supply systems, though only 82 percent has consistent access (see Bower 2014). The Instituto Costarricense de Acueductos y Alcantarillados (AyA) is the largest national potable water system operator, providing services to about 50 percent of the population. The population not served by AyA is served mostly by municipal water departments (as in Belén, the municipality where our interventions were implemented) and in rarer cases by autonomous municipal utilities in the urban sector, by Community Water Supply Systems (ASADAS) and some private organizations.

Figure 1: Map of Belén

Belén is a small town in Costa Rica and consists of three municipalities: Asuncion, La Rivera and San Antonio (see map in Figure 1). According to the 2011 Census, Belén has 21,633 inhabitants living in 6,011 individual dwellings with 3.59 occupants on average. 99.3 percent of dwellings have water service. Average water consumption in Belén is 27 cubic meters/month, 1.25 times the national average of approximately 22 cubic meters/month (Municipality of Belén 2010). It is estimated that Belén could face water shortages by 2030 if consumption remains constant and no additional production or investments are made. Reducing water consumption is thus a key policy priority for the Belén municipal administration.

III. Supplementing Policy Toolkit: The Need for Behavioral Interventions for Water Conservation

III.1 Tools Used by Policy Makers Seeking to Reduce Water Consumption

As discussed above, reducing water use is a key policy priority for policy makers in a growing number of urban jurisdictions, such as the municipality of Belén. In this section, we briefly discuss the broad classes of tools and approaches available to policy makers seeking to reduce water use and applications of these tools or approaches in the specific context of Belén and towns like it.

Broadly speaking, policy makers can attempt to directly reduce consumers' demand for water at a given price (i.e. they can use non-pecuniary approaches), or increase the price consumers pay for water (i.e. they can use pecuniary approaches).

The most widely used non-pecuniary interventions that directly seek to reduce the demand for water without explicitly changing how much is charged for it are perhaps communications and education campaigns. Examples of such campaigns in developing countries include South Africa's "Water Wise" campaign, initiated in 2007 or the "Save Water Campaign" initiated in Hyderabad, India in 2013, which – like most such campaigns – used radio and newspaper advertisements to "tell people about the benefits of saving water" (Times of India 2013). These have included marketing strategies to reduce water consumption, such as the installation of billboards advocating water conservation. Indeed, the municipal water department in Belén has experimented with communication-based approaches in the past as part of its effort to reduce domestic water consumption although few of our focus group participants recalled or mentioned these efforts. Despite their popularity, few such persuasive communications campaigns for water conservation have been experimentally or quasi-experimentally evaluated and there remains considerable debate about their effectiveness, as Syme et al. (2010) point out in their review of existing evaluations. The conclusions from evaluations of communications campaigns in related fields are also not encouraging. For example, Galiani et al. (2012) evaluate a marketing campaign promoting hand washing in Peru, which they find to be unsuccessful. Nevertheless, it is worth pointing out that such broad-based campaigns do not discriminate between consumers on the basis of ability to pay, and are thus less prone to affecting water equity negatively than the price-based interventions to which we now turn.

Utilities and municipalities have also used relatively heavy-handed approaches to dampening the demand for water, such as quantity rationing or restrictions on what water can be used for and when it can be used. For example in the United States, Oklahoma City, Plano, Tampa, and San Diego all imposed restrictions on using water for "non-essential" purposes such as gardening, watering lawns, or filling pools at various points in 2013 and 2014. Such measures, of course, require a great deal of monitoring of compliance to successfully reduce water consumption, and are therefore rarely used on a sustained, non-emergency basis. De facto rationing is in place in many large cities in developing countries, where municipal water supply is restricted to a few hours a day, with citizens expected to rely on water from private sources, stored in tanks for periods when municipal water is not available. While in theory this is not inequitable since it affects everyone, it has been argued that it is in fact biased against the poor, who may lack the resources or the capacity to invest in storage mechanisms and may be forced to turn to higher-cost, privately-supplied drinking water.

The other traditional tool used by policy makers to reduce demand for water consists of pecuniary instruments such as prices or taxes. Two difficulties arise when attempting to institute such price-based measures in the context of water use. First, the price of water is often set through governmental rather

than market mechanisms, in part to prevent low-income households from being priced out of the market.[5] Such reasonable concerns about equity of access aside, the result of these regulations is in effect to render price increases - particularly those large enough to substantially deter demand - unfeasible. Thus, price-based mechanisms are often unfeasible to implement in situations where the theory suggests they might be useful. Second, such price increases –when feasible– have nevertheless been found to be less effective than expected: price elasticity of demand for water is often rather low within the range of feasible prices (see, for example, Olmstead et al. 2007). Recent research offers an interesting explanation for this: taxes and other price shifts are often ineffective in reducing consumption levels because individuals may fail to notice such taxes and effectively respond to them (Chetty, Looney and Kroft 2007). This is especially likely to occur in cases like water pricing, where prices on not imposed at point-of-sale, making it very likely that households will not effectively adjust to the price increases. Finally, a further important issue with price-based tools is that they generally work only for low-income households and not for the wealthy, who are often those with highest rates of consumption (Ferraro and Miranda 2013).

The experience of and regulatory environment in Belén illustrate several of these difficulties. Pecuniary disincentives - primarily a price increase in November 2012 - had limited impacts even though prices increased by more than 100 percent at the level of consumption of the average household. For example, fixed charges – for water use up to 20 cubic meters - increased by 70 percent from ₡1,200 *colones* (US$2.23) to ₡2,025 *colones* (US$3.76). Despite this large increase in prices, total household consumption only decreased by 15 percent in December 2012. Furthermore, these changes were short-lived. Total consumption in January 2013 and February 2013 were 1 percent and 5 percent higher than in November 2012, respectively. Meanwhile, scope for price increases are limited by legal provisions that stipulate that governments cannot increase prices beyond what is needed in order to recover costs, as elsewhere in Costa Rica.

III.2 Behavioral Interventions for Water Conservation: Need and Scope

The difficulty, expense or limited effectiveness of standard price- or communications-based approaches to reducing water consumption means that identifying and testing alternative approaches emerges as a research and policy priority. Behavioral economics provides a useful framework within which to think about such alternative interventions. The recent literature on applied behavioral economics (see Datta and Mullainathan 2014) suggests that the discipline's understanding of cognitive processes and the "situational" influences on human decision-making can help generate classes of interventions that can change behavior without necessarily resorting to price-based interventions or moral suasion. Such interventions could thus help tackle demand for water without needing to vary prices and without directly seeking to persuade people of the need to reduce the amount of water they consume.

Behavioral interventions have proven effective, especially in the energy domain – most notably in a series of experiments run with the utility company OPower, where a set of "social norm" interventions were able to reduce consumption of energy (an extremely inelastic good) by 2 percent – the equivalent of a 11 percent to 20 percent price increase (Alcott 2011). While peer-comparison based approaches have been the most heavily utilized, a broad range of other behavioral interventions are also possible, such as

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[5] Though of course, it is possible to design pricing functions that protect access for those least able to pay.

framing, commitment devices, defaults and implementation intentions (see Alcott and Mullainathan 2010 for a review of these tools in energy policy).

Parallel efforts have also borne fruit in water conservation – for example, some water utilities have used similar social norm messaging to the Opower experiments. Experimental analyses of these programs have demonstrated large effects, reducing water consumption by approximately 5 percent (Ferraro and Price 2013). These effects have been observed to last for up to five years after the intervention although the effects wane over time (Ferraro, Miranda, and Price 2011; Bernedo, Ferraro, and Price 2014). In related literature, Goldstein, Cialdini and Griskevicius (2008) use a similar social norm message to decrease the need for hotels to wash towels – reducing utilization of energy and water resources.

These successes have led to a serious investigation into the uses of applied behavioral sciences within conservation policy. Datta and Mullainathan (2014) and World Bank (2015) argue that there is considerable scope for using behavioral insights to policy issues in the developing world, including those related to climate change and resource use. Despite this, however, the use of such behavioral tools in developing country contexts, such as that in Belén, is still rare. Indeed, there are few if any examples of subnational governments in developing countries using behavioral interventions, whether to tackle water use or other policy issues. In part, this may be because of the perception that developing country governments, especially subnational governments, lack the infrastructure and technological tools needed to successfully implement and track behavioral interventions.

IV: Designing Behavioral Interventions to Reduce Water Use in Belén

The current experiment tested three behavioral interventions to reduce water consumption in Belén. First, we used two peer comparisons, comparing a household's water usage to their "peers" - defined in one case as the average household in their local neighborhood (one of six neighborhoods in Belén) and in the other case as the average household in their city. The third intervention made relative consumption salient and used a planning prompt (Rogers, Milkman, John and Norton 2013) to help people set personal goals and create concrete plans to reduce their water consumption.

IV.1 Rationale for Interventions: Focus Group Findings

The rationale for the specific interventions we used came from the literature on behavioral interventions in related contexts (discussed in III.2 above) and from the findings from four focus groups with residents of Belén, which helped us understand which of the various classes of behavioral interventions might be useful in that context. These focus groups, conducted in March 2014 with residents of Belén from a variety of socioeconomic backgrounds, had several key insights that were helpful for the development of the interventions used.

Our key findings from these focus groups, and their implications for intervention design, were as follows.

First, while there was *broad consensus on the importance of water conservation in general, few residents believed that they themselves needed to use less water.* Apart from a small minority of individuals who saw water use as status-enhancing, the rest were broadly aware that water was scarce and that it *ought* to be used appropriately rather than being wasted. However, despite this general belief, participants did

not in general think that they needed to reduce their own water consumption, which they saw as "inevitable", or "justified" by Belén's climatic conditions. For example, one focus group participant said that "If someone were to suggest to me that I reduce the amount of water consumed, I would tell him that I am using the amount that is necessary", while several others referred to high water consumption as "a necessary evil". This finding steered us away from interventions aimed at increasing awareness about the importance of water conservation, but did suggest that helping from a personalized, concrete intention to save water might be useful.

Secondly, residents *did not know how much water they themselves used*. While most people paid attention to the total billed amount on their water bills, few paid attention to the information about water consumption. Almost none could say how much water they had consumed in the most recent month. Several people pointed out that the billed amount included charges for both water and sanitation services, and so the amount of water consumed was not salient. Indeed, as can be seen in an example of Belén's water bill (Figure 2), the information on how much the household consumed is not easily readable. This finding suggested that making residents' own water use *salient* to them could be a useful part of any intervention.

Figure 2: Belén Water Bill

MUNICIPALIDAD DE BELEN
TEL: (506) 2587-0000, FAX: (506) 2293-3667
WWW.BELEN.GO.CR

MUNICIPALIDAD BELEN

NOTA:

Si cancela después del vencimiento se cobrará cargos por mora y quedará sujeto a la suspensión del ser vicio de agua potable 8 días después

0000734193

Localización catastral: 302-0001
Nombre:
Cédula: 3101079006
Dirección: COSTADO OESTE DE TANQUES ELEVADOS LA ASUNCION DE BELEN
Fecha vencimiento: 30/Set/13

Detalle	Cuenta	Finca	Monto Período	Monto Per.Anterior
VENTA DE AGUA POTABLE	49171	206743 000	984,740.00	.00
SERVICIO DE LIMPIEZA DE VIAS	49171	206743 000	97,495.20	.00
MANTENIMIENTO PARQUES Y OBRAS ORNAT	49171	206743 000	72,678.25	.00
IMP. SOBRE BIENES INMUEBLES	00436	006537 F000	8,801.10	.00
IMP. SOBRE BIENES INMUEBLES	00992	018539 000	111,798.95	.00
IMP. SOBRE BIENES INMUEBLES	01131	021433 000	101,759.30	.00
IMP. SOBRE BIENES INMUEBLES	04240	075533 000	80,798.00	.00
IMP. SOBRE BIENES INMUEBLES	04629	077718 000	93,568.40	.00
IMP. SOBRE BIENES INMUEBLES	05351	093003 000	1,107,949.30	.00
IMP. SOBRE BIENES INMUEBLES	07398	123301 000	9,963.00	.00
IMP. SOBRE BIENES INMUEBLES	08062	132835 000	50,500.90	.00
IMP. SOBRE BIENES INMUEBLES	08194	136328 000	26,629.65	.00
IMP. SOBRE BIENES INMUEBLES	08514	142447 000	58,974.50	.00
IMP. SOBRE BIENES INMUEBLES	08626	144675 000		.00
IMP. SOBRE BIENES INMUEBLES	09154	154499 000		.00
IMP. SOBRE BIENES INMUEBLES	11467	170065 000		.00
IMP. SOBRE BIENES INMUEBLES	11516	091108 000	7,601.50	.00
IMP. SOBRE BIENES INMUEBLES	11523	091106 000	25,021.20	.00
IMP. SOBRE BIENES INMUEBLES	12879	182372 000	491,699.45	.00
IMP. SOBRE BIENES INMUEBLES	13370	039811 F000	410,092.35	.00

Sub-Total	12,530,492.95
Multas	
Intereses	.00
Total	12,530,492.95

Historial de Consumo
Medidor No.:
0000009447

Año	Mes	Consumo
2013-09	00372	
2013-08	00330	
2013-07	00252	
2013-06	00297	
2013-05	00227	
2013-04	00282	
2013-03	00355	
2013-02	00467	

LUGARES DE PAGO:

Banco Popular, Banco Nacional de Costa Rica, Banco de Costa Rica, Grupo Mutual, Vía Internet www.bncr.fi.cr , www.banccobcr.com, www.popularenlinea.fi.cr

Visite nuestra página Web: www.belen.go.cr
Si tiene algún problema con este recibo favor llamar al 2587-0000 Ext. 101, también puede contactarnos al correo electrónico servicioalcliente1@belen.go.cr o diríjase a las oficinas de servicio al cliente en la Municipalidad de Belén.

Thirdly, residents could not evaluate whether a given level of water consumption was too high or reasonable, because they *lacked a benchmark against which to compare their own consumption*. People in our focus groups did not have an intuitive sense of whether a certain amount of water was small or large. Several focus group participants mentioned that they found water consumption figures in cubic meters hard to interpret. This suggested that a suitable *benchmark* that placed a household's own water consumption in a relevant context, as in the literature on peer norms, might be useful.

Finally, few participants could identify concrete steps they could take to reduce water consumption. While participants could name activities or behaviors that resulted in water usage, they raised issues such as the difficulty of knowing how much water such activities – like watering lawns, washing cars, or brushing teeth – used, and therefore which activities they could curb to reduce water use. This suggested that providing guidance about specific changes in behavior, rather than exhorting people to change water use in general, might be a useful part of any intervention. Such an intervention could help people to translate a concrete intention into actions that would reduce water use.

Thus, our first finding suggested that informing residents about water scarcity in Belén was relevant; our second finding suggested that it would be appropriate to make the information on consumption levels salient and provide a benchmark; and our final finding suggested the importance of providing residents with ways to follow through on any intention they formed.

IV.2 Design of Interventions and Mode of Implementation

Our intervention designs attempted to tackle the bottlenecks identified through our focus groups.

To address the broad problems of lack of salience of current consumption levels and the absence of a suitable benchmark against which to evaluate them, we designed stickers that would give people feedback about their water consumption relative to an appropriate reference point. This led to our first two treatment arms.

In the "Neighborhood Comparison", a brightly-colored sticker on the water bill provided people with direct feedback on their own water consumption in comparison to that of the average household in their neighborhood. The exact content of the sticker varied depending on whether the household's consumption was higher or lower than the median. Those households whose billed consumption in July 2014 was above the median consumption for their neighborhood received a sticker with a "frowny face" and a message alerting them to the fact that their water consumption exceeded the neighborhood average, thus visually illustrating the negative feedback about past behavior. On the other hand those households whose July 2014 billed consumption was below the median for their neighborhood received a sticker with a "smiley face" and a message congratulating them for having consumed less water than the average household. The designs of the stickers used for this treatment arm can be seen in Figure 3.

Figure : 3: Sticker Designs - Neighborhood Comparison Intervention

The second treatment, the "City Comparison", was identical except that the reference point was the average consumption in Belén. Here, too, the sticker on a household's bill either had a smiley face or a frowny face, and either commended them for consuming less than the average household in Belén, or informed them that their consumption was above that average.

By using two different reference points, we hoped to measure whether people's responsiveness to a comparison to a reference group varied (we hypothesized inversely) with the perceived social distance from that group. The designs of the stickers used in this treatment arm can be seen in Figure 4.

Figure 4: Sticker Designs - City Comparison Intervention

Our final intervention ("Plan-Making") built on the literature on goal-setting (see Harding and Hsiaw 2014), and planning prompts to address the absence of a clear plan for saving water and the related lack of information about how to do so. Those randomized into this treatment arm received a worksheet printed on a postcard along with their July 2014 bill. This worksheet prompted them to enter their water consumption (making it salient) with that of the average Belén household in the same month (providing a benchmark), which was printed on it. Further, however, the postcard asked people to write down a personal goal for (further) water use reduction and to check one or more of six listed tips about ways to use less water (for example, limiting use of water while gardening, or turning the tap off while brushing teeth). The goal of this intervention was thus to supplement making relative consumption salient with the formation of clear intentions about water conservation and plans to accomplish these goals (see Figure 5).

We favored simple interventions that did not require elaborate software to implement, as for instance personalized bills that had messages about relative consumption printed on them might. While fully personalized bills may be feasible when the implementer is a highly-resourced US or developed country utility company, the technological constraints on developing country municipalities and utilities are likely to be greater, as indeed they were in Belén. Our interventions required only that the municipality in Belén was able to print out color stickers and that the office in charge of stuffing bills into envelopes had access to a spreadsheet which told staff which sticker or postcard to use with each bill on entering the meter number of a household in the experimental sample.

Figure 5: Plan-Making Intervention Design

V. Experimental Design and Implementation

Our sample was drawn from a list of active residential water consumers [6] in Belén in April 2014. Households in Belén receive water bills each month. Not all households receive their bills at the same time; however, bills are generated according to a schedule of "postal routes", with each household belonging to one of 25 routes. [7] We therefore stratified households by postal route in addition to neighborhood and average monthly consumption in the 12 months prior to June 2014, and randomized into three treatment groups and a control group.

The first treatment arm (n=1,399) received the "Neighborhood Comparison" treatment. The second treatment arm (n=1,399) received the "City Comparison" treatment. The third treatment arm (n=1,399) received the Plan-Making intervention. The Control group (n=1,429) received no additional information during the experiment, and continued to receive a utility bill without a sticker or postcard. The final number of households in our experiment was slightly smaller, as a change in billing meters in Belén in June 2014 forced us to drop some households from our experiment. [8]

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[6] We excluded commercial establishments and residential condominium associations, which receive a joint bill rather than a household-level bill.

[7] Postal route determines the date on which households receive their monthly water bill, and inter alia, the dates of consumption that this bill covers, the latter being the month prior to its generation. Thus, one household might receive a July water bill that is based on water consumption between June 2 and July 1, whereas another's July water bill might be based on consumption between June 8 and July 7. Regardless, however, bills are generated based on the water consumed during the month since the last bill for that route was generated.

[8] In June 2014, the Municipality of Belén started to change water meters. Due to the inability to merge post-experiment houses by their unique identifier (meter number), we lost approximately 8 percent of the original randomized sample. The numbers of observations dropped are homogeneous across treatment arms.

Our interventions were implemented during the July 2014 billing cycle in Belén, when households received water bills that were based on their water consumption in a 31-day period prior to this bill being generated.

We call our post-intervention consumption variables 'August 2014 Billed Consumption' and 'September 2014 Billed Consumption'.[9] As noted above, the way that bills are generated and distributed means that each bill covers the 31-day period prior to its generation. This means that consumption in an August bill, for example, covers a month-long period which lies mostly in July and partly in August - but all of which lies after the consumption period covered by the July bill. Thus, our outcome data is water consumption for each household *during a two-month period since they received the intervention bill*. For the bulk of our analysis, we will report results on the average post-intervention water consumption, i.e. the mean of August and September 2014 billed consumption.

We rely throughout on water consumption in the previous wet or rainy season as our main measure of counterfactual water consumption, i.e. a measure of how much water the households in our experimental sample would have consumed, absent an intervention. The rainy season runs from May through November in Costa Rica, and thus covers both our implementation and post-intervention periods. We use this in preference to using the previous months of consumption in 2014 because several of them would fall in the dry season, when water use patterns are likely to have been quite different from those in the post-intervention months for which we have data.

Table 1 compares baseline water consumption in our 4 intervention (3 treatment and one control group) arms to check for the validity of our randomization. As it shows, there was no significant difference in baseline water consumption (which we measure baseline consumption using all available data on water consumption in 2013[10]) between households in any of our treatment groups and the control group. We have also computed year-on-year increase in water consumption between the two months prior to the intervention and the corresponding two months of the previous year, and find no significant differences. After confirming that our treatment and control groups are identical with respect to past water consumption, we turn to the measurement of the impact of our interventions.

VI: Results

Result 1: Treatment groups reduce water consumption more than the control group.

Table 2 shows the differences between average post-intervention water consumption (i.e. the average of August 2014 Billed Consumption and September 2014 Billed Consumption) and the average water

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[9] As discussed above, the system of billing in Belén means that the exact dates of each billing cycle (and thus the precise timing of water consumption which the bill is based on) vary by postal route. For simplicity, we refer in this paper and tables to the water consumption on which the bill for month X is based "Month X Billed Consumption", noting that it in fact refers to the consumption over a 31-day period prior to the generation of the bill for Month X.

[10] Note that the municipality did not have data for December 2013. We have therefore used January-November 2013 and December 2012-November 2013 as our "baseline period" for the purposes of the randomization check.

consumption in the rainy season of 2013 (i.e. the average of water consumption between May and November 2013), by treatment status. We use the rainy season of 2013 as our measure of "pre-intervention" water consumption to ensure that seasonal factors, which have large effects on water use, are minimized. This ought to ensure that differences in pre- and post-intervention water consumption are not driven mainly by seasonality, which is possible if we were to use, e.g., the two months immediately prior to the intervention or the full prior year consumption data. **Figure 6** gives a graphical representation of this information.

Average water consumption in Treatment households declined by more than in Control households for each of the three Treatments, although the difference-in-differences is only significant for the Neighborhood Norms and Plan-Making interventions. In general, we can see that both control and treatment households' average monthly water consumption in August-September 2014 was less than their average monthly water consumption in the corresponding season of the previous year. However, the decline in consumption is much larger for households in the Treatment group.

Result 2: Neighborhood comparison reduces water use by between 3.5 percent and 5.6 percent of control group consumption, but city comparison has no significant effect on water consumption.

Table 3 presents our central regression results. We regress post-period water consumption on treatment status and control for baseline water consumption. Reading across the first row, we see that relative to the control group, the Neighborhood Comparison Treatment reduces water consumption by between 0.98 and 1.47 cubic meters per household, or between 3.7 percent and 5.6 percent of water consumption for the control group over the same period. In contrast, there is no evidence that the City Comparison reduced water consumption significantly in any specification.

As discussed earlier, we use baseline consumption measures from either only the rainy season of 2013, the rainy season of 2013 and the pre-intervention rainy season months of 2014, or the monthly consumption for 2013 as a whole. While the choice of control does affect the size of our coefficients, they are consistently negative and statistically significant.

Result 3: Plan-making reduces water use by between 3.4 percent and 5.5 percent of control group water consumption.

Reading across the third row of **Table 3**, we see that relative to the control group, the Plan-making treatment reduces water consumption by between 0.90 and 1.46 cubic meters per household, or between 3.4 percent and 5.5 percent of water consumption for the control group over the same period. As with the Neighborhood Comparison, the choice of baseline consumption measure affects the size of our coefficients, but not their sign or significance: they are consistently negative and statistically significant.

Result 4: Pooled data confirms the effectiveness of neighborhood comparison and plan-making.

Table 4 pools the data for the months of August and September 2013 and 2014, giving us two post-intervention and two pre-intervention observations on each household in the sample, and runs a classic difference-in-differences estimator. The coefficient of interest is now the post-intervention consumption

interaction between treatment group and the post-period dummy variable. This is negative and statistically significant, for both the Neighborhood Comparison and Plan-Making interventions, as in Table 3. The point estimates suggest an effect size of around 4-5 percent of monthly water consumption for both interventions.

The average 4-5 percent reduction found across all estimations for the "Neighborhood Comparison" and the "Plan-Making" treatments can be used for a rough cost-benefit analysis of one the treatments being expended to all the individually-metered households in the municipality. Based on the monthly average water consumption and the current water rates, our results suggest that the monthly water savings (from the household perspective) in monetary terms could be estimated from ¢1.4 million *colones* (US$2,600) to ¢2.8 million *colones* (US$5,200). Given the additional costs to implement the treatments (essentially the cost of printing out the stickers or postcards, which was approximately US$ 400), our experiment would produce a benefit/cost ratio varying from 6.5 to 13 times, justifying its expansion to the entire municipality. In terms of water conserved, our results indicate that, on average, in Belén, approximately 6,720 cubic meters of water could be preserved each month. This amount is equivalent to 87,300 baths, 94,080 washing machine loads, 188,000 showers and 222,000 dishwasher loads.[11] Moreover, this decrease in water consumption can forestall the advent of substantial water shortages in Belén's near future.

Result 5: Plan-making appears to be most effective for low-consumption households, and neighborhood comparison intervention may be most effective for high-consumption households.

Finally, **Table 5** presents an analysis of potential heterogeneous effects across subgroups, based on dividing group by their initial consumption during the May-November 2013 rainy season. Understanding heterogeneous effects can help to more cost-effectively target to subgroups that are most responsive and avoiding wasting money (and political capital) sending information to non-responsive subgroups or subgroups that may react in ways contrary to the policy objective (Ferraro and Miranda 2013). The first column simply replicates Model 2, from Table 3, showing the effects of each treatment on average consumption in August and September 2014, while controlling for consumption during the rainy season.

Columns II and III use the same regression model, but limit the observations to those who were below and above median consumption during the 2013 rainy season, respectively. Our results show that effects tend to be stronger when examining individuals with above consumption across all three treatment arms, without taking into account significance level. The Neighborhood Comparison intervention for the above median consumption households nearly doubles the average effect for the whole city, while the Plan-Making treatment is relatively more effective when applied to households with below median consumption. This suggests that policy makers may benefit from targeting interventions to specific household subsets in order to achieve the maximum effect.

Columns IV-VIII further divide household by quintiles, and separately analyze each subset. Again, we see that effect sizes are largest for household with initially high consumption, although the effect sizes are not significant. However, we also see that, for each treatment arm, the lowest quintile of households saw the second largest decrease in consumption. We continue to see slightly larger effects from the Plan-

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[11] http://www.unitedutilities.com/Metered-customers.aspx

Making intervention in the low initial consumption households (it is the most effective treatment for households whose initial consumption was in the first quintile) while the Neighborhood Comparison Treatment comparison treatment is most effective in the fifth quintile, albeit not significantly due to higher standard errors and lower sample size.

The heterogeneous effects across households show some interesting (but weak) patterns. There are several mechanisms that could plausibly explain these patterns. Members of households with low initial consumption may already be motivated to save water and taking some steps (maybe due to higher financial constraints) to reduce water consumption. For these households, the planning prompt may be most effective because it assists in translating those intentions into concrete actions. Households with high initial consumption may not realize that their current consumption is substantially higher than their neighbors, or may not be conscious of their water consumption at all, such that there is no current intention to reduce their consumption levels. For this population, the Neighborhood Comparison intervention may have created an intention to reduce water consumption.

To summarize our results, we apply interventions based on behavioral economics to a setting where they have hitherto scarcely been utilized – local government functions in a developing country – with promising findings. In keeping with the literature on the use of such interventions from developed country settings, we find that giving individuals feedback on their outcomes relative to that of their peers has measurable effects on water consumption, and that comparisons to more proximate peer groups are more effective. We also find that a Plan-Making intervention that prompts people to set their own goals for water conservation, and make plans about how to achieve these goals, has similar effects on water use as the more effective of our "peer comparison" interventions. Both interventions attain comparable results, although driven by distinctive consumer sub-groups.

VII: Key Contributions and Policy Relevance

This study is perhaps the first to apply behavioral economics to water use in a developing country and to do so in the setting of a municipality or other local government in a developing country. It is significant for two related reasons.

First, we show that interventions based on behavioral economics are effective at curbing water use. Given that constraints on the ability to increase supply and increasing water stress have made reducing water use a priority for governments across the developing world, the findings of this study are encouraging insofar as they suggest that behavioral economics interventions can usefully supplement the price- and persuasion-based tools currently in use to tackle this issue.

Secondly, and perhaps more importantly, we show that interventions leveraging behavioral economics, which have thus far been restricted either to governmental settings in developed countries or to small NGO-run programs in developing countries, can be implemented and are effective in resource- and technology-constrained settings, such as small municipal governments in the developing world, where they have not been widely used so far.

Insofar as strengthening the capacity of local governments to raise resources and finance the provision of public services to their residents effectively is a key issue in development, we believe that this study has ramifications well beyond the immediate context of water use in Costa Rica and represents a potentially important advance for the study of urban governance and government capacity in the developing world.

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Table 1: Baseline Measures, Treatment vs. Control

Water Consumption in Cubic Meters, m³	Control	Neighborhood Comparison		Municipality Comparison		Planning Postcard	
		Treatment	Difference (C-T)	Treatment	Difference (C-T)	Treatment	Difference (C-T)
Average Monthly Consumption, December 2012 – November 2013, m³	27.38	27.47	-0.09	27.21	0.17	27.85	-0.47
(SE)	(0.58)	(0.69)	(0.90)	(0.50)	(0.77)	(0.65)	(0.87)
n	1312	1287	2599	1287	2599	1274	2586
Average Monthly Consumption, January – November 2013, m³	25.59	25.58	0.02	25.39	0.20	26.01	-0.42
(SE)	(0.54)	(0.64)	(0.84)	(0.47)	(0.72)	(0.61)	(0.81)
n	1312	1287	2599	1287	2599	1274	2586
Average Monthly Consumption, May – November 2013, m³	28.07	28.02	0.05	27.80	0.27	29.09	-1.02
(SE)	(0.60)	(0.76)	(0.97)	(0.58)	(0.84)	(0.71)	(0.93)
n	1339	1321	2660	1309	2648	1304	2643
YOY Increase in Consumption May/June 2012 – May/June 2013, m³	1.25	1.42	-0.16	1.33	-0.07	1.24	0.01
(SE)	(0.06)	(0.11)	(0.13)	(0.09)	(0.10)	(0.10)	(0.11)
n	1324	1299	2623	1293	2617	1282	2606
Notes:							
1. Numbers in parentheses are standard errors							
2. Stars indicate statistical significance: *=p<0.10, **=p<0.05, ***=p<0.01							

Table 2: Differences-in-Difference in Water Consumption

Water Consumption in Cubic Meters, m³		Treatment 1: Neighborhood Comparison	
	ΔControl	**ΔTreatment**	**ΔT-ΔC**
Difference between Average Monthly Post-Treatment Consumption (August - September 2014) and Average Monthly Consumption in Pre-Treatment Rainy Season (May - November 2013)	-0.24	-1.50	-1.26*
(SE)	(0.40)	(0.53)	(0.66)
n	1285	1267	2552
		Treatment 2: Municipality Comparison	
	ΔControl	**ΔTreatment**	**ΔT-ΔC**
Difference between Average Monthly Post-Treatment Consumption (August - September 2014) and Average Monthly Consumption in Pre-Treatment Rainy Season (May - November 2013)	-0.24	-0.93	-0.68
(SE)	(0.40)	(0.44)	(0.60)
n	1285	1261	2546
		Treatment 3: Planning Postcard	
	ΔControl	**ΔTreatment**	**ΔT-ΔC**
Difference between Average Monthly Post-Treatment Consumption (August - September 2014) and Average Monthly Consumption in Pre-Treatment Rainy Season (May - November 2013)	-0.24	-1.52	-1.27**
(SE)	(0.40)	(0.43)	(0.59)
n	1285	1248	2533
Notes: *1. Numbers in parentheses are standard errors* *2. Stars indicate statistical significance: *=p<0.10, **=p<0.05, ***=p<0.01*			

Table 3: Effect of Treatments on Average Post-Treatment Water Consumption

Outcome Variable: Average of August and September 2014 Water Consumption, cubic meters, m³	I	II	III	IV	V	VI	VII	VIII
Treatment 1: Neighborhood Comparison, m³	-1.27*	-1.28**	-0.98**	-1.47**	-1.27*	-1.29**	-0.99**	-1.47**
(SE)	(0.67)	(0.60)	(0.50)	(0.58)	(0.67)	(0.60)	(0.49)	(0.58)
Treatment 2: Municipality Comparison, m³	-0.81	-0.81	-0.77	-0.92	-0.82	-0.83	-0.77	-0.92
(SE)	(0.65)	(0.58)	(0.50)	(0.56)	(0.65)	(0.58)	(0.49)	(0.56)
Treatment 3: Planning Postcard, m³	-1.11*	-1.23**	-0.90**	-1.46***	-1.13*	-1.26**	-0.93**	-1.49***
(SE)	(0.64)	(0.59)	(0.46)	(0.57)	(0.64)	(0.59)	(0.46)	(0.57)
Constant	11.40***	7.12***	2.96***	6.09***	8.77***	5.41***	1.42	4.97***
(SE)	(2.13)	(1.89)	(1.12)	(1.71)	(1.97)	(1.75)	(1.25)	(1.59)
August and September 2013 Total Consumption	X				X			
Rainy Season 2013 Total Consumption (May 2013-November 2013), m³		X	X			X	X	
May - June 2014 Total Consumption, m³			X				X	
Average Annual Consumption (December 2012 - November 2013), m³				X				X
Fixed Effects for Billing Date					X	X	X	X
Observations	5126	5061	5061	5061	5126	5061	5061	5061
R-squared	0.41	0.52	0.68	0.56	0.41	0.53	0.69	0.56

Notes:
1. Numbers in parentheses are standard errors
2. Stars indicate statistical significance: *=p<0.10, **=p<0.05, ***=p<0.01

Table 4: Effect of Treatments on Consumption, Repeated HH Observations

Outcome Variable: Average of August and September 2013 and 2014 Water Consumption, cubic meters, m³	I	II
2014 Consumption Dummy	-0.13	-0.13
(SE)	(0.45)	(0.45)
Treatment 1: Neighborhood Comparison	0.10	0.10
(SE)	(0.98)	(0.98)
Treatment 2: Municipality Comparison	-0.20	-0.20
(SE)	(0.83)	(0.83)
Treatment 3: Planning Postcard	0.21	0.21
(SE)	(0.93)	(0.93)
2014 Consumption Dummy x Treatment 1	-1.34*	-1.35*
(SE)	(0.81)	(0.81)
2014 Consumption Dummy x Treatment 2	-0.97	-0.97
(SE)	(0.70)	(0.70)
2014 Consumption Dummy x Treatment 3	-1.28*	-1.28*
(SE)	(0.67)	(0.67)
Constant	26.54***	26.67***
(SE)	(0.57)	(0.58)
Monthly Fixed Effects		X
Observations	20,939	20,939
R-squared	0.00	0.00
Notes: *1. Numbers in parentheses are standard errors* *2. Stars indicate statistical significance: *=p<0.10, **=p<0.05, ***=p<0.01*		

Table 5: Effect of Treatments on Average Post-Treatment Water Consumption, by subgroup

Outcome Variable: Average of August and September 2014 Water Consumption, cubic meters, m³	Full Sample (I)	Below Median Consumption (II)	Above Median Consumption (III)	First Quintile (IV)	Second Quintile (V)	Third Quintile (VI)	Fourth Quintile (VII)	Fifth Quintile (VIII)
Treatment 1: Neighborhood Comparison	-1.28**	-0.38	-2.03*	-0.92	-0.46	-0.65	-0.80	-3.25
(SE)	(0.60)	(0.54)	(1.06)	(0.87)	(0.88)	(0.82)	(1.30)	(2.33)
Treatment 2: Municipality Comparison	-0.81	-0.45	-1.15	-1.30	-0.31	0.14	0.14	-2.62
(SE)	(0.58)	(0.52)	(1.03)	(0.85)	(0.84)	(0.78)	(1.40)	(2.09)
Treatment 3: Planning Postcard	-1.23**	-0.97*	-1.47	-1.53*	-1.23	-0.21	-1.22	-1.88
(SE)	(0.59)	(0.48)	(1.06)	(0.78)	(0.80)	(0.76)	(1.31)	(2.26)
Constant	7.12***	4.59***	10.73***	5.39***	3.51***	-0.21	6.80	12.42
(SE)	(1.89)	(0.59)	(4.61)	(0.94)	(2.19)	(3.04)	(5.28)	(8.75)
Observations	5061	2534	2527	1004	1024	1032	1004	997
R-squared	0.52	0.24	0.40	0.10	0.04	0.06	0.03	0.37

Notes:
1. Numbers in parentheses are standard errors
2. Stars indicate statistical significance: *=p<0.10, **=p<0.05, ***=p<0.01
3. All columns include control for Rainy Season 2013 Total Consumption (May 2013- November 2013).

Figure 6: Change in Average Monthly Water Consumption between Rainy Season 2013 (pre-treatment) and August and September 2014 (post-treatment)

Change in Average Water Consumption, m^3