TOPIC 3:

Water Conservation & Management

Chapter 3 of 5 from:

The Science of Changing Behavior for Environmental Outcomes:

A Literature Review

STAP SCIENTIFIC AND TECHNICAL ADVISORY PANEL
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rare CENTER FOR BEHAVIOR & THE ENVIRONMENT

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Introduction

Introduction

The environmental challenges facing us are striking. Whether it is the threat of the sixth mass extinction or global climate change, these challenges can seem fundamentally intractable. What links nearly all present environmental problems is their root cause: human behavior (Foley et al., 2005; IPCC, 2018). Yet this cause also presents a solution: to address these challenges, humans must act differently (Schultz, 2011). In other words, environmental problems are behavioral problems, and environmental solutions must also be behavioral solutions. Whenever one approaches developing an environmental program, what they are doing is developing a behavior change program (Cowling, 2014).

Behavior Change Levers for the Environment

Even when not explicitly identified, changing behaviors have long been at the core of delivering environmental programs. Historically, there have been three main levers pulled for changing behavior: shifting material incentives, promulgating rules and regulations, and providing information to actors.

Shifting material incentives involves increasing or decreasing the costs, time, or effort for doing a behavior. This lever has its roots in neoclassical economics, where an actor is assumed to respond to only the material incentives for engaging or not engaging in a specific behavior. Standard methods for shifting incentives include enforcing penalties for non-compliance with rules, providing rewards for positive behavior, or making a target behavior materially easier, such as removing time friction or promoting substitute actions.

Passing rules and regulations that promote or restrict a behavior is perhaps the most commonly used strategy for achieving environmental outcomes. Rules and material incentives often work together, but each can exist without the other. For example, a seller might offer an incentive to purchase a product without any legal requirement. Similarly, laws and rules can be passed without their enforcement shifting the material incentives. Even without enforcement, rules can shift behavior due to people having a general preference to conform to rules even without positive or negative sanctions (Funk, 2007) or where rules convey factual or social information (Sunstein, 1996).

Figure 1. Rare's Levers of Behavior Change Framework (Rare, 2020)

Providing actors with information has also been a common tactic in traditional environmental programming, including explaining what the desired behavior is, why it is important, and how to engage in it. Informational programs implicitly assume something similar to the information deficit model; the lack of change in someone's behavior is assumed to be because they do not know key information, rather than psychological or socio-contextual factors (Burgess et al., 1998).

While these levers can be successful at changing behavior, they have also been well-documented as generally insufficient for changing behavior on their own (Cinner, 2018). Environmental behavior change program designers have recently expanded their toolkit to include a more comprehensive set of levers for shifting behavior and achieving environmental outcomes. These levers are choice architecture, emotional appeals, and social influences. These three novel levers, along with the three traditional levers, represent the Behavioral Lever Framework for categorizing behavioral interventions in the environmental field (Rare, 2020).

Using choice architecture means constructing an actor's choice environment without changing the value of said actor's underlying options. This lever deviates from the more traditional levers by not assuming that actors are solely

influenced by their rational deliberation, but also how a choice is presented to them. There are many ways in which a designer might construct the choice environment. These include prominent strategies such as directing attention by increasing salient features or changing what outcome occurs by default, using timely moments to prompt action, and providing decision aids that encourage short- or long-term decision making.

Emotional appeals function differently by changing how an actor feels about a set of options. Humans like to believe that they deliberate over all of their decisions, yet emotions often drive our decisions. Emotional appeals can include messaging that makes the behavior feel consistent with the target actor's core identities and values or encourage the actor to experience a particular emotion known to result in a particular behavioral pattern.

Finally, leveraging an actor's social networks and influences is an effective behavior change strategy. Social influence strategies involve understanding how an actor relates to others in their social system, including those with power and prestige, and leveraging these dynamics to support changes in the actor's behavior. Changing behavior in this way often includes social learning, making behavior more observable, or shifting social norms by changing an actor's expectations for what others in their reference network are doing or think is right or wrong.

These novel strategies complete the six levers of the Behavior Levers framework. These levers provide a typology for categorizing the majority of existing behavior change interventions, often delivered in combination rather than isolation.[1]

The logic, ethics, and effectiveness of behavior change programming across these levers have been an intense subject of research. This work has mainly been conducted from the behavioral science perspective, which focuses on the cognitive processes affecting how individuals make decisions, and the social science perspective, which focuses on how social structures shape an actor's capacity and interest in adopting a behavior.

The Behavioral Science Perspective

While there are many different definitions of behavioral science, we focus on the systematic study of human judgment and decision making. This research has been conducted by those working in several fields but is most commonly associated with psychology and behavioral economics. This perspective tends to take the individual actor as the central unit for analysis and understanding behavior.

The roots of what is now commonly known as behavioral science can be traced to rational choice models in neoclassical economics and the inability of those models to account for the decisions people often make. These systematic deviations from rational choice models are known as biases, which result from people applying cognitive heuristics to solve real-world decision problems (Tversky & Kahneman, 1974).

Research in this field focuses on the decision processes that affect how an actor is making a particular decision. These processes are often described as falling into two broad and simplified categories. The first mode is quick and automatic and is more likely to be driven by an emotional reaction. The second mode of thinking more closely approximates rational choice models. This way of thinking is often slow and deliberate, and the decision-maker is generally conscious of this mode. These two groups of processes are often labeled as System 1 and System 2 (Stanovich & West, 2000). Research in the behavioral sciences primarily focuses on documenting the mechanisms underpinning System 1.

Researchers have documented a host of deviations from rational choice models in decision making and the cognitive processes underpinning them. The most extensive set of this work has been conducted in contexts where people face some risky decision, where an outcome could end up going better or worse than their current state.

1 For a more exhaustive list of the strategies in each of lever category, refer to Rare, 2020.

One pattern is loss aversion, where people feel a loss more strongly than a similarly sized gain. Another is risk aversion, where people prefer a sure thing over a risky proposition, even when the risky proposition is likely to return even more. A third is ambiguity aversion, where people prefer to choose options where they know the likelihood of the different outcomes, even when they are guaranteed to do worse. Many of these findings have been replicated frequently and cross-culturally (Ruggeri et al., 2020).

This research has also documented an effect called status quo bias, a general tendency for people to keep doing what they have previously done, even when not in their best interest (Kahneman et al., 1991). This bias describes how habitual behaviors persist but also why it is difficult to form new habits that are inconsistent with one's previous status-quo.

While behavioral science researchers generally take the individual as their unit of analysis, this does not mean researchers ignore social influences. A large body of work on social preferences has documented how people—unlike what would be predicted by a selfish economic model—care deeply about what those in their social network do, believe, and receive. While early research attempted to identify universal social preferences (Fehr & Schmidt, 1999), these social influences differ dramatically across cultural contexts (Henrich et al., 2005). Behavioral scientists now primarily focus on the cognitive mechanisms that result in a particular pattern of behavior within a social context. For example, social norms describe where an individual's actions are influenced by their beliefs of what others are doing and what others think they should be doing (Bicchieri, 2016). The fact that these expectations may be different for different social groups, and different for individuals having different reference networks within a social group, allows for the varied social preferences we see among people of different social groups.

Behavioral science insights have recently been deliberately incorporated into behavior change program design, including at the bilateral, national, and regional levels of government and non-government entities (Whitehead et al., 2019). Many applications of behavioral science have been to design a choice environment to nudge people to perform behaviors in their interest (Thaler & Sunstein, 2009). Nudges are intended to be consistent with libertarian paternalism, where each person's actual choices are not restricted, but their environment is designed to encourage a particular behavior. Nudges are often subtle changes, such as shifting the default offering or making one choice more salient. However, nudges represent only one area of the application of behavioral science to behavior change. Other applications of behavioral science incorporate rich insights from the program's target actors. They also often involve shifting entrenched social norms, such as encouraging the adoption of toilets (Ashraf et al., 2020), reducing female genital cutting (Evans et al., 2019), or encouraging treatment adherence to painful drug regimens like those used to treat tuberculosis (Yoeli et al., 2019). This latter set of interventions differs from traditional uses of nudges by addressing actors as members of a community rather than narrowly as individuals, being more overt about the intervention itself, and often targeting socially constructed practices.

In summary, the behavioral science perspective has studied how individuals make decisions, concentrating on the ways human behavior deviates from the predictions of rational choice models. The field has documented various biases that result from people relying on cognitive heuristics for making decisions, many of which are the result of quick, implicit, and sometimes emotional processes rather than slow deliberation. While this work analyzes decisions from the perspective of the individual, it also investigates social influences, showing how people process their social environment and then apply it to their choices. This work has recently been adopted into behavior change program design across various institutions and levels of decision-makers, sometimes within the framework of nudges and larger-scale behavior change campaigns that often target more entrenched behaviors.

The Social Science Perspective

While there is no single definition of social science, in this review, we take it to be the study of the relationship between social structure and decision making. The fields most associated with this research include anthropology, sociology, political science, and human geography.

This perspective recognizes that individuals do not make their decisions in a vacuum. Instead, social science puts social structure into primary focus. This includes how that social structure defines an individual's social identities and social roles, as well as how an individual's actions can feedback into shaping the social structure for themselves and the network in which they are embedded. From this perspective, this feedback system of socially defined identities and roles create the foundation for individuals to make choices (Popitz, 1972). While identity is often thought of as how individuals see *themselves*, the social sciences point to an even more critical component: the bidirectional relationship between how others perceive an individual and how that individual behaves. Common identities and accompanying roles addressed in the social sciences include gender, race, ethnicity, socio-economic status, and various culturally specific positions of power through prestige and authority. Both formal rules, such as laws, and informal rules, such as social norms, can dictate directly and indirectly how individuals of certain identities can or must behave, with that behavior then feeding back into socially defining those same rules (Hechter et al., 1990).

It is important to note that an individual can rarely, if ever, be reduced down to a single identity. For example, an individual might be both a woman and of a particular ethnicity. Their sum identity is reflected in the intersection of these various identities (Crenshaw, 1989). Understanding what intersections an individual inhabits is critical for understanding their behavior, as the social rules governing their actions apply differently for different intersections. For example, while women might generally be given minimal autonomy to make farming decisions, older women might have significantly more independence, pointing to the possible importance of the intersection of age and gender in understanding an individual's ability to act (Carr & Owusu-Daaku, 2016). There are various combinations of identities, and researchers have cautioned against the essentialization of an individual through a particular identity.

Much of the research in the social sciences has focused on how these various instances of social difference affect how a social group may restrict or enable agency through different forms of rules, and how those rules are socially constructed. Agency can be defined as the ability to make decisions to achieve one's current and future goals (Petesch et al., 2018). Indeed, agency is not distributed equally across populations; marginalized and lower-status groups experience less agency and decision-making power in society. This further results in groups having different abilities to make changes in their own lives or affect broader social systems. Some of these effects may be obvious on first observation, such as only men allowed in a particular space. Others may be far more subtle but can have major implications for behavior change. For example, female farmers in South Africa have less autonomy in setting their schedules, meaning they cannot make time to listen to scheduled radio broadcasts for agricultural forecasts (Archer, 2003). While research into the relations between different identity groups often focuses on where they "result in contradictory interests, imperatives and expectations" (O'Shaughnessy & Krogman, 2011), differing social groups may also mutually reinforce each other in complementary ways. For example, in eastern African bushmeat hunting, women reinforce hunting by men through encouragement and praise, plus benefit from their successes (Lowassa et al., 2012).

Scientists across the social and environmental sciences have been expanding the models we use that incorporate agency by going beyond individual actions to include strategic, political, and collective agency. This also aligns with shifts away from purely rational-actor models or Integrated Assessment Models that rely on narrow assumptions about human behavior. Such concepts help researchers explain and operationalize the influences humans can have on transforming systems, such as those required for global environmental change. For example, groups with greater agency tend to be those with greater wealth and those contributing more greenhouse gas emissions in daily activities. This has implications for how designers and scientists perceive leverage points within a system to change existing structures (Otto et al., 2020).

While different forms of relations exist, social scientists have found power between individuals of different social roles to be a particularly strong explanatory force for understanding human behavior. While analyzing these power dynamics within a community can be a fruitful lens, social scientists have also frequently applied this lens to the wider social system outside a given community. This often includes power dynamics between the behavior change implementer, such as a government agency, and those impacted by it. A social science lens can shed light

on phenomena such as why communities surrounding natural reserves area may refuse to comply with hunting regulations (Strong & Silva, 2020), or why someone might comply with an intervention designed to preserve free choice, even when the individual would not otherwise wish to comply (White, 2013).

Social scientists recognize that individuals are not just subject to social structures, but that they *constitute* those social structures as well. This creates feedback loops where one actor's behavior makes up another's social context. This can result in systems-level emergent properties, where the behavior of each individual can fundamentally only be understood by taking into account the behavior of the other actors in the system. This includes social tipping points, where changes among a minority can result in rapid group-wide changes in beliefs or behavior (Granovetter, 1978; Schelling, 1978). This work has been extended to understand how behavior adoption diffuses through social networks, in which each individual adopts a behavior only when a sufficient set of surrounding connected others do the same (Centola & Macy, 2007).

Taking this social-systems viewpoint often highlights the unintended consequences of a behavior change intervention that an individual-focused standpoint might miss. For example, interventions might have achieved their intended behavioral and environmental impacts but had negative impacts as well. Social scientists have pointed to unintended effects of strengthening bureaucracies (Ferguson, 1994), creating informal lines of employment such as interpreters and fixers (Jeffrey, 2010), or even undermining traditional authority structures (Beall, 2010). Understanding the totality of consequences has implications for how social scientists approach program assessment. They focus not only on the behavioral and environmental outputs but also on assessing any social impacts, intended or not, positive or negative, that may result.

The social sciences present a unique opportunity to evaluate the ethics of behavior change programming. One common but ethically questionable element of behavior change programming is its often top-down nature, where local stakeholders have no input into the programs they experience. As a result, programs can fail to recognize local communities' rights or simply be ineffective. A designer's lack of local knowledge results in a program being ill-suited for its target actors (Hansen, 2018). Because of their rich focus on the various identities among target actors, the social sciences have raised ethical concerns over the equitable distribution of a program's costs and benefits. While programs are often evaluated by estimating the average treatment effect for the entire population, the social sciences have focused on disaggregating these results to reveal disparate impacts.

Social scientists have further found justification to criticize the ethical nature of "nudge" style behavioral interventions, which are often invisible to target actors. Designers of this style of intervention often argue that their solutions preserve free choice and are not coercive. However, social scientists have pointed out that those subject to these interventions find a lack of disclosure to violate their autonomy, whether or not the designer finds it free-choice-preserving (White, 2013). Social scientists have also identified that these interventions rarely change the root structures of systems and problems they seek to address, even when they account for the social system in which they are deployed (Feitsma, 2018).

In summary, the social science perspective focuses on the actor as both the product and creator of their social context, rather than as an individual. This view recognizes the importance of the various social identities that an actor might have and how those identities dictate their position in the social system that defines their ability to adopt a behavior. By analyzing this system as a whole, a social science perspective can identify various ways in which actors might influence each other. These include power, allowing some to restrict the choices of others, or reinforcement, where some support others' ability to act. In the context of behavior change programming, this view can provide a critical lens on how powerful organizations, such as governments or NGOs, may, sometimes inadvertently, coerce target actors into compliance, which is ethically dubious. By looking at the total social system, this view recognizes the commonly inequitable distribution of costs and benefits from behavior change programming, often tying those inequalities to existing inequalities in the social system.

Review Focus and Scope

Presented this way, behavioral science and social science may appear quite different. However, both disciplines aim to explain human behavior and interaction. Instead of seeing them as fundamentally different, we argue that behavioral science and social science are best understood as two levels of analysis that exist on a spectrum (See Figure 2). This spectrum ranges from the most cognitive explanations of decisions existing entirely within the individual to the most abstract descriptions of social interaction focused solely on the system in which those individuals are embedded. Many sub-disciplines exist closer to the middle of this spectrum, blending these two perspectives, such as social psychology, cultural psychology, cognitive anthropology, and network analysis. By embracing this entire spectrum of behavioral and social science, we better understand human behavior as a whole.

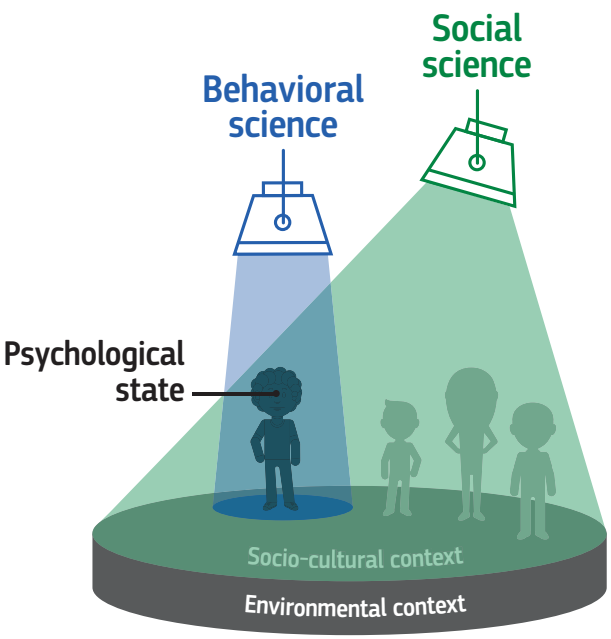

Figure 2. The interaction of behavioral and social science in understanding human behavior. Behavioral science focuses on understanding an actor's psychological state, whereas social science focuses on understanding the socio-cultural context for that actor. Both are necessary for understanding an actor's behavior within a given environmental context. Changes to the socio-cultural context, environmental context, or actor's behavior create feedback loops with one another.

In this review, we aim to identify how these perspectives can be applied to understand existing behavior change interventions designed to address biodiversity conservation, climate mitigation, water management and conservation, waste management, and land management. For each of these topic areas, we review empirical evidence for behavior change programs targeting behaviors in each of these areas. We include evidence that provides empirical analysis on the effect of interventions designed to change these behaviors, as well as evidence for the psychological, material, and socio-cultural barriers and motivations for their adoption. This includes evidence from the behavioral and social sciences, as well as non-disciplinary evaluations, and consists of both qualitative and quantitative analysis across a variety of measurement paradigms.

We then provide an analysis of that evidence in three areas. First, we review the evidence's strength for changes in the target behavior, including the internal validity, external validity, and geographic spread of the interventions. Then, we identify behavioral science insights demonstrated in the interventions or gaps in the intervention logic that behavioral science may elucidate. Last, we similarly identify social science insights in the interventions, including insights to help identify opportunities and gaps. After conducting this analysis for the five topic areas, we provide an overall summary of these analyses to identify trends across the environmental field. We conclude by proposing a framework for understanding how behavioral and social sciences can most effectively integrate into behavior change programming to improve environmental outcomes further.

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Water Conservation & Management

- Water Conservation
- Water Management Agreements

Introduction

Water is integral, even essential, to most social domains—economic, political, religious, and leisure (Strang, 2004). Nearly 80% of humans experience high threats to their water security (Vörösmarty et al., 2010). These water systems are under threat from both climate change generally and population growth and development directly (Bates et al., 2008; United Nations, 2009). A recent call by the Agricultural & Applied Economics Association highlighted the crucial need to utilize behavioral insights to aid in water management efforts (Ferraro et al., 2017). In this section, we review behavior change approaches to freshwater management and conservation: the distribution of water and associated costs and benefits across upstream and downstream actors as well as conserving water resources within households.

Analysis Highlights

- For water conservation, the most common behavior change strategy is social norm messaging. Water conservation is generally private, so norm messaging is particularly effective at changing social beliefs at the household level. Even so, while cost-effective, the observed effects are small. Norm messages that better account for the social reference networks of different populations will likely be more effective.
- Behavior change interventions to promote water agreements tend to heavily rely on lab contexts, which fail to incorporate many complex, social realities. While these results may give insight into a particular component of decision making, they systematically neglect critical and structural forces such as land tenure.
- Unlike interventions commonly found in biodiversity conservation, many water management interventions are overwhelmingly top-down in their design. A more participatory and community-based approach could better incorporate existing cultural practices and institutions to support changes in behavior.

Water Conservation

Individuals and households use fresh water for many daily activities, including drinking, washing, and personal hygiene. Farmers also need water to irrigate their crops. This section covers interventions that seek to decrease water use.

Increasing municipal water conservation: Social norms and comparison

Of the many studies that seek to change behaviors related to water conservation, perhaps the most seminal is Goldstein, Cialdini, and Griskevicius' (2008) study on the reuse of towels in hotels. To reduce the quantity of water used in washing towels, the experimenters presented hotel guests with either a reminder that reusing one's towel was beneficial for the environment, or with a descriptive norm message advising guests that the majority of their peers reuse their towels. The research team found that using a norm message of what others were doing was more effective than a standard environmental message at reducing towel use by 9%. This effect was even stronger if the descriptive norm related directly to a guest's specific hotel room, by almost 12% (see also, Reese et al., 2014). Since this study was published, many others on towel reuse for water conservation have followed. Effective

interventions have combined injunctive and descriptive[5] norms in a message (P. W. Schultz et al., 2008), elicited reciprocity through describing how the hotel had pre-committed the proceeds from towel reuse to an environmental fund (Goldstein et al., 2011), and encouraged guests to publicly state their support for towel reuse at different moments during their stay (Baca-Motes et al., 2013; Terrier & Marfaing, 2015a, 2015b). While research on hotel water conservation is just one context, these studies nonetheless stand as a microcosm of the various behavior change interventions in water management.

On a much greater scale, municipalities and utility-providers also face the dilemma of reducing water usage while maintaining constituent's freedom of choice—and many have done so successfully using the behavioral and social tools presented above. For example, an intervention in California with over 40,000 households tested the use of injunctive norms as a means of encouraging people to conserve water (Bhanot, 2018). In partnership with water utilities, WaterSmart Software sent households an email containing an explicit, social judgment of their household's water use compared to their neighbors. This judgment was signaled with either a smiley, neutral, or frowny face, depending on their water use relative to similar homes. Comparing this to personalized information on water conservation, they found that the injunctive norm led to greater water conservation, an average effect of 2.5 gallons per day, at a trivial cost and without restricting choice. There has since been evidence that combining descriptive and injunctive norms may alleviate boomerang effects (i.e., households below the norm increasing their water usage; P. W. Schultz et al., 2014), and direct comparisons of normative messaging versus the simple provision of information (i.e., tips on water usage) demonstrate that successful behavior change requires more than targeting consumers' information deficits (Seyranian et al., 2015).

Using dynamic norms to shift water use

There has been recent interest in finding ways to shift people's perception of norms to the future, not just the present. An intervention at Stanford University's residence halls compared the use of static norms (what people are doing now) against dynamic norms (how people's behavior is changing over time) to see which type of messaging was most effective at decreasing water consumption for laundry. Presenting each message via labels directly placed on washing machines, the research team found that dynamic norms reduced water usage by 28.5%, compared with 9.7% for those who saw the static norm sticker (Sparkman & Walton, 2017). For this reason, dynamic norms have been a growing area of research in application to several topics, including increasing the consumption of plant-based foods to reducing the use of disposable cups (Loschelder et al., 2019; Sparkman & Walton, 2017).

Social comparison through rankings is a direct and salient way of positioning people relative to their community's water use average (see Topic 2 on *Climate Mitigation*, for examples in the energy sector)—something that would not be easily observable otherwise. WaterSmart delivers injunctive peer comparison (i.e., the use of smiley or

5 Injunctive norms are collectively held beliefs about what behaviors others in a group approve or disapprove of. In other words, what do your peers find acceptable or unacceptable. Descriptive norms, on the other hand, relate to collectively held beliefs about what behaviors are typically performed (or not performed). They rely on empirical expectations, that is, descriptive norms are based your beliefs about your peers' behavior.

frowny faces on water bills), but uniquely descriptive comparisons have been very effective too. During a drought from 2006-2007 in Georgia in the United States, officials increased water conservation for a group of over 100,000 US households by sending different types of information and normative messages (Bernedo et al., 2014; Ferraro & Miranda, 2013; Ferraro & Price, 2013). These included technical messages with tips on water conservation, within-person comparison to their past usage, and social norm messages comparing usage to that of neighbors. Compared to those households that received nothing, all interventions increased water conservation behavior, but the social norms message was most effective and persistent. In the first year of the intervention, the norm message led to a 4.8% decrease in water use, a much stronger effect than the within-person comparison message (2.7%). Additionally, although its effect had decreased by around 50% within a year of the intervention, the response to the strong norms message remained detectable and relevant for four years (increasing to six years if we only consider residents who had not moved households). This is a strikingly durable result given that the nudge amounted to just one comparison message. The effect of the comparison to past usage messages, on the other hand, was undetectable within a year.

Similar interventions have been successful in California, but also highlighting how visible rankings could lead to counterproductive boomerang effects depending on how they were paired with injunctive messages (Bhanot, 2017; Brent et al., 2015; Mitchell et al., 2013; P. W. Schultz et al., 2019). Another intervention in Costa Rica, which presented comparisons between neighborhoods rather than individuals, was successful in decreasing water use (Datta et al., 2015). A study in Colombia used water reports with three different components: a social comparison to similar households and an associated rating (descriptive and injunctive norm), environmental implications of their usage, and the option to opt-out of water use feedback. The results indicate a 6.8 percent decrease in water use for targeted households and also a 5.8 percent decrease for the first six months after the intervention for non-targeted households, suggesting spillover effects (Jaime Torres & Carlsson, 2018). In Tokyo, Japan, community rankings were found to be effective (Otaki et al., 2017). However, they also found that Japanese users found peer comparisons to be an invasion of privacy. As an alternative, they found that a combination with injunctive messaging (red or yellow droplet icons when water-use increases) and historical self-comparisons significantly decreased water use without resorting to peer comparisons (Otaki et al., 2019).

Many city governments and local councils face significant threats to water availability. To address the potential water shortage in the city of Bogotá, Colombia, the municipal government implemented an awareness-raising strategy that backfired, initially increasing water consumption. After refining their approach, they identified the principles of social rewards and punishment, saliency, and education as key for reducing usage. They accomplished this by publishing community comparisons, drawing on important religious icons, celebrating local people who had creative water conservation strategies, and also publicly naming those who had high water consumption. After launching the various components of the program, water usage was reduced by 13.8%. Furthermore, the interventions established a new social norm of water conservation that persisted ten years after the initial set of interventions ceased (World Bank, 2014).

The city of Cape Town in South Africa developed a series of interventions between 2015 and 2017 in which authorities delivered social comparison letters that threatened punishment to those households that were consuming water in excess (with a physical water-management device). Municipalities also published lists identifying the top 100 water users by street that the media then shared as part of "Named and Shamed' or "Cape Town's water wasters" campaigns. The treatment generated a consistent 3% reduction in water use for the highest users and a 6% reduction overall. This reduction amounted to savings of over 1.1kl per household per month (Brick & Visser, 2018). When offering to publicly recognize households that reduced consumption by at least 10%, the research team also found that the promise of social recognition was particularly effective at inducing water usage reductions in the wealthiest households (Brick et al., 2017). The nudges fighting against Cape Town's Day Zero illustrated perhaps one of the biggest lessons on the use of social norms: recognizing the heterogeneity in households allows practitioners to target those households for which a particular intervention might be most appropriate and cost-effective.

South Africa has an especially long-standing and complicated history with water rights, and this case emphasizes the importance of understanding this socio-ecological context in intervention design. The apartheid government established pre-paid water meters to control the ANC's township base, and they remained after 1994 when public utilities were privatized, ostensibly to control a scarce resource (von Schnitzler, 2016). Citizens' relationships with the meters have only worsened in recent times, with the police brought in to enforce compliance. Popular attempts to access water, a public good that is increasingly private, are now struggles over "rights to the city" (Anand, 2017; Björkman, 2015), with a rising call for renationalization of municipal water supply worldwide.

Beyond local politics, social researchers have found that gender and within-household norms can strongly shape motivations and behaviors surrounding water conservation. A study in rural China revealed that women consumed twice as much water as men, even though women engage in more water conservation practices. Women were motivated by reducing their water bill, whereas men wanted to mitigate a water shortage. Due to existing social norms, men's main barrier to change was a change in routine, time, and effort, where women's main barrier was a lack of social support (Tong et al., 2017). Moreover, achieving diverse and inclusive participation in water management requires an understanding of local values, cultures, norms, and institutions. Many current approaches for encouraging women to participate in conservation do not incorporate demands on them based on their roles in the home (Singh, 2008). Moreover, a study by Fielding et al. (2012) demonstrates that within-household norms can be powerful drivers of individual behaviors. Interventions must understand this household context to address individual motivations and barriers effectively.

Increasing agricultural water conservation: Social norms and comparisons

Whereas the evidence base on reducing individual or household water conservation is robust, there is far less evidence on how behavioral and social insights might be applied to the agricultural context. The studies that exist show that traditional water conservation measures struggle in their impact and durability.

For example, in India, 53.4% of the land is described as arid or semi-arid with declining water levels—farmers have vested-interest in adopting groundwater conservation measures. An analysis of farmers' attitudes towards groundwater conservation reveals that many other factors are important when producers consider implementing conservation behaviors (Varua et al., 2017). One factor is education level: the higher the educational attainment of farmers, the more likely they are to protect groundwater. Similarly, those who view themselves as 'environmental stewards' tend to be more likely to conserve groundwater. Size of land holdings and off-farm income (i.e., any income that does not directly depend on agriculture) also are a part of farmers' attitudes towards groundwater conservation. Unfortunately, for many producers, the low cost of pumping groundwater continues to motivate use. This is a problem that India also shares with Mexico: both countries have historically suffered from groundwater depletion, yet the financial incentives for farmers have remained misaligned (Scott & Shah, 2004).

In the United States, 99% of the groundwater withdrawn from the High Plains Aquifer is used in agriculture. To try and reduce the amount of water used by producers, many states have adopted a policy of technology conversion: they seek to reduce farmers' water consumption by promoting increased irrigation efficiency, often by subsidizing new technologies. An analysis of Kansas' efforts between 1995 and 2005 highlights how such policies have failed to resolve the issue of groundwater depletion (Pfeiffer & Lin, 2014). By subsidizing the widespread adoption of dropped-nozzle, center pivot systems (versus the traditional center pivot irrigation system), state officials intended to reduce groundwater extraction. Unfortunately, what they witnessed was an increase—as farmers had begun saving water, they had also shifted production towards more water-intensive crops.

Despite these challenges, some promising insights have emerged for future interventions. Farmers have been found to be more likely to conserve water if they feel like the risk of a water crisis is high (e.g., Clark & Finley, 2007; Yazdanpanah et al., 2014). Practitioners could look at strategies that make water shortage risks more credible and salient and leverage feelings of risk-aversion. Alternatively, as 'smart' technologies have begun to spill over into

agriculture, real-time, water-use information may help farmers understand and reduce their consumption (Bell et al., 2015). Pairing irrigation smart meters with social comparisons also holds promise. In France, for example, a randomized controlled trial was run with 200 farmers where everyone was informed of their water use, but 99 of them also received information about other farmers' consumption (Chabé-Ferret et al., 2019). Though the difference in water-usage between the two groups was not significant (a mere 1%), the team identified surprising results: i) the intervention significantly decreased the proportion of farmers who would have used over 80% of the water allocation quota, but ii) the intervention also significantly decreased the proportion of farmers who would not have used water. In essence, a boomerang effect seems to have countered the positive impact of the treatment—an effect that an injunctive norms message may have alleviated.

Increasing municipal water conservation: Key messengers

Highlighting key messengers and shared identities can be effective for creating new norms. In Queensland, Australia, where drinking water is scarce, efforts to promote the use of recycled drinking water have also begun to leverage research-informed insights. For example, a recent study found that using messengers with a shared identity increased participants' acceptance, perceived knowledge, and positive emotions towards recycled drinking water and lowered risk perceptions, particularly for those who shared a superordinate identity such as scientists (T. Schultz & Fielding, 2014). Key messengers can also be valuable for modeling target behavior among those with a shared identity. At the University of California at Santa Cruz, researchers found that having students model shower-taking behavior that conserved water increased the compliance rate of other students to 67% (Aronson & O'Leary, 1982).

Increasing municipal water conservation: Timely reminders and moments

Lastly, where most of the work on household water conservation we review applies social influences, there have been interventions that use timely reminders to drive behavior. An intervention in Perth Australia found that where social comparisons prove ineffective, reminders at key times can work well (Kurz et al., 2005). The team found that water-use reminder labels on showers and appliances led to a 23% decrease in water use. A different example from East Queensland on long-term water consumption discovered that a shared experience or transitional moment might have been motivating to change behavior. The researchers gave information about how to reduce water usage as well as signaled the descriptive norm, which was effective at reducing water usage while the intervention was in-place. The authors speculate that the effectiveness of these interventions was perhaps due to the communities' recent experiences with drought, particularly since 12 months after the intervention ended, consumption shifted back to pre-intervention levels (Fielding et al., 2013). It is important to contrast timely reminders with general informational interventions. While information interventions try to change behavior through changing beliefs, timely reminders make different information salient at the key point of the decision, thereby influencing the decision without necessarily providing any informational value.

Water Management Agreements

While social norms have been shown to be critical for the voluntary conservation of water, individual and household water use has still largely been approached at an individual and household level. However, many water management challenges exist at higher levels than that of the household, which requires cooperation across groups, regions, and even countries. These challenges also highlight key power dynamics generally not present at the household level, where water scarcity, as well as pollution experienced by downstream users, is often determined by the behavior of upstream actors. This section covers interventions that focus on changing upstream and downstream water management through regional agreements or Payment for Ecosystem Services (PES) schemes.

Negotiating water agreements: Limits of incentives

At a regional level, a common source of conflict over water management is the upstream versus downstream placement of agricultural producers. Beyond managing consumption by these different actors, regional authorities

must monitor the many sources of nonpoint source water pollution that can taint water for both the polluter's community and those communities downstream of a shared waterway. This presents a classic case of negative externalities, where the costs of the upstream actor's over-consumption or pollution are borne by those below them. A traditional market-based approach to internalizing those negative externalities are PES schemes that help bring the costs and benefits that individual water uses face in line with the needs of the community.

PES schemes have been criticized for not incorporating socio-ecological factors and local value systems nor inclusive design processes. National or regional water agreements entail discussions of water governance and management that rely on shared valuations and uses of water, which often do not exist or are at odds. For example, PES or PWS (payment for watershed services), tend to focus on bolstering instrumental values such as money rather than more relational values such as interpersonal learning and relationships between people and nature (Bremer et al., 2018). A study by Kwayu et al. (2014) found that PES schemes that focused on farmer participation led to more equitable outcomes for farmers as well as increased participation overall. Hearing farmers' perspectives allows for programs to allocate resources to farmers' real needs, such as access to training and resources. For example, PES schemes can be inaccessible to poor farmers unless the inputs (e.g., fertilizer, technology, etc.) or training on farming techniques are provided. Other studies show that technologies such as customary irrigation systems or the construction of dams and distribution networks are perceived differently by system implementors, regional authorities, and water users (Guillet, 1998; Mosse, 2005).

The results of an artefactual field experiment in Kenya demonstrate the complexity of implementing PES schemes (Jack, 2009). The experimenters asked representatives from 29 different villages to play an investment game, where upstream mover's investment represented land-use decisions, and downstream movers' responses represented a choice of compensation. The experimenters compared the impact of enforcement that encourages downstream compensation for upstream investments versus no enforcement and letting users coordinate on their own—all over multiple rounds of play. Specifically, the enforcement mechanism worked as a fine by subtracting payoffs from downstream users if they did not return an equal compensation amount to the investment of upstream actors.

Women and those with higher education were found to be more likely as downstream users to support the conservation efforts of those upstream, although the underlying cultural reasons for this difference were not investigated. In terms of effect, however, the researchers found that when the weak enforcement was instituted and then removed, upstream users engaged in *even less* water conservation than those for whom no enforcement ever existed. While the enforced PES scheme resulted in increased conservation when it was in effect, it had a backfire effect after it was withdrawn. This can be explained by the psychological phenomena of *crowding out* intrinsic motivation, where an action is no longer seen as intrinsically valuable once it is put into a market frame, even once that market frame is withdrawn. This suggests that schemes that force compliance with sanctions may have unintended side-effects on future compliance. Crowding out effects have also been observed in the farming communities of the Colombian Andes when external funders come in to support water-use infrastructure (Murtinho et al., 2013). There, however, the effect seemed to vary depending on whether communities with water-scarcity issues had received funding after requesting funding (no crowding out), or whether the funding had been unsolicited (crowding out observed). Specifically, communities who sought for project-related funding were more likely to engage in a higher number of scarcity-mitigating efforts than those communities who received unsolicited donations.

To assess the feasibility and demand for improved irrigation water supply along the Blue Nile river basin, researchers sought to quantify Sudanese farmers' willingness to trust and compensate their upstream neighbors in Ethiopia for reciprocal use efforts that could ensure improved irrigation downstream (Tesfaye & Brouwer, 2016). Using a choice experiment, the research team evaluated the willingness of farmers to pay for two solutions to improve the irrigation water supply. In the first, farmers' irrigation water supply would be made more secure by enhancing the operation and management of local irrigation channels; in the second, the irrigation water supply would be secured through transboundary cooperation between water users in Sudan and Ethiopia (p. 181). In both cases, the farmers would be

required to pay a higher fee than they already were paying to secure benefits, but the benefits would occur through different means. The international solution could also potentially strengthen transboundary institutional cooperation between the two groups of farmers.

Overall, respondents felt positively about paying more to ensure and increase the water supply in both scenarios. The local scenario was chosen in 50.6% of cases, the international one in 48.7% of cases, and opting out of everything was selected 0.7% of the time. The research team found that the price farmers were willing to pay depended on several factors. These included the frequency of crop irrigation, type of irrigation technology used, and potential increases in irrigation fees. Whether the solution was local or international did not negatively impact the willingness of farmers to pay. Compared to other irrigation solutions, farmers are willing to increase their average fee by US$1.6 per hectare to be allowed to flood their land more often, less than US$1 per hectare to change from flooding irrigation to a more efficient sprinkler system, and US$1.2 per hectare for the transboundary option instead of a local irrigation one.

Whether or when PES or water-use coordination schemes are implemented in a region, implementers have the ability to evaluate the willingness of various actors and groups to participate given the structure of the program (Tesfaye & Brouwer, 2016). Shared use and cooperation efforts are often decided on the basis of political and administrative negotiations. Data on the willingness of producers to cooperate may serve to clarify and reduce the ambiguities associated with a particular payment scheme. Such data may also help to ensure the crucial participation of actors throughout the socio-ecological system (Draper, 2012), which pre-empts avoidable conflicts between water users who judge policies to be 'unfair' or unpopular. By taking the time to understand the psychological and social barriers that may lead water-users to resist an agreement, uncertainties relative to the possible uneven effects of policies would be reduced (Barnes, 2017). Behavioral and social insights have yet to be systematically integrated at the negotiation table—they nonetheless would be useful in shaping long-lasting, behaviorally-informed water management agreements.

In addition, having the ability to evaluate and share water-users' motivations and barriers to engage can better align negotiators' expectations. For example, in the context of Israeli-Palestinian water negotiations, misinterpretations of social factors (e.g., population growth, resource prices, freedom of choice, people's propensity for risk, etc.) have tended to result in delayed negotiations (Fischhendler & Katz, 2013). This suggests that beyond the commonly expected sharing of hydrological data, negotiations would also benefit through the sharing of psycho-social data, helping to resolve one of the commonly most ambiguous components of negotiations. Humans are generally averse to ambiguity, and this can have profound impacts on the outcome of negotiations (Kelsey & le Roux, 2015) regardless of whether they are political negotiators, farmers, or any other actor in a broader water agreement system.

Mianabadi et al. (2015) further analyzed a number of historical and current transboundary water agreements and hypothesized several main reasons for their failure or instability. Out of the 276 shared water basins around the world, 158 of them have no cooperative framework in place, yet even the ones that do have not been successful. Hydrological variability and climate change are two significant factors that affect the demand, quality, and availability of water at a given time, and agreements do not account for these potential changes, which leads to conflict. A lack of comprehensive and unambiguous water laws is also contributing, where states decide to interpret the laws in the ways that benefit them rather than finding common ground. 'Hydro-hegemony' is another challenge, where states or actors with more power end up controlling or restricting water access, setting the terms of agreement in ways that do not work for all parties. Oftentimes this means groups that are marginalized or occupy a lower social status end up receiving fewer benefits. Finally, the authors call out a need for integrated water resources management, which outlines principles of equity, efficiency, and sustainability, and could be useful terms for agreements (Mianabadi et al., 2015).

Negotiating water agreements: Social norms and appealing to values and traditions

In response to the limitations of PES schemes, program designers have built social marketing campaigns designed to shift social norms and increasing cooperation and buy-in for water agreements. In Peru, a local campaign promoted the importance of natural resources, as well as the individual and collective benefits that reciprocal water agreements could have on the community (Martinez et al., 2013). They used billboards ads, posters, t-shirts, baseball caps, magazines, local theater, radio soap operas, and folk songs, all to change the attitudes and knowledge of upstream and downstream users, as well as to encourage direct communication among upstream users. The campaign resulted in water users signing 25 reciprocal water agreements, collectively protecting 362 hectares of threatened habitat in the Quanda micro-watershed. From a differing cultural context, program designers in Scotland found that encouraging sustainable water management among farmers was best accomplished by focusing on social norms rather than conventional enforcement mechanisms (Barnes et al., 2013).

A case study in Bali, Indonesia, provides a compelling example of the value of building upon established socio-ecological dynamics that successfully encourage water management. For centuries, Balinese rice farmers have maintained a coordinated and sustainable water usage strategy without external or centralized enforcement, despite the threat of water scarcity, pests, and disease. An anthropological investigation into this complex socio-ecological system found that these producers had developed a unique system involving terracing, irrigation technology, and religious shrines and temples that serve as meeting places to coordinate farming strategies within the community (Lansing & Miller, 2005). Translating this system into a game-theoretic model, researchers found that the system of Balinese water temples acted as communication hubs, facilitating coordination among farmers that made them more resilient to pests and scarcity issues. Indeed, in situations where the temple system has been abandoned, water scarcity and pest problems are rife. Formalizing local management traditions may be one way for policymakers to reinforce existing social norms while maintaining the capacity for regulation to adapt to changes in water availability (for examples in India, Pakistan, Yemen, and Egypt, see van Steenbergen, 2006)

The idea that water management should rest on value-based, bottom-up rules is common amongst researchers (for review, see Mitchell et al., 2012). Recent work also points to social learning, or learning in and through our interactions with different social and stakeholder groups, as important to encourage water agreements (Ananda et al., 2020; Grassini, 2019; Wehn et al., 2018). Two case studies, one in the Alps of Europe and another in the Mekong river in Asia help to demonstrate the value of social learning. Lebel et al. (2010) suggest that coordination is missing both "horizontally" among different sectors, regions, and nations as well as "vertically" at the policy level (p.340). Social learning can serve to alleviate informational uncertainty, reduce conflicts, and improve synergies within agreements themselves. It also allows relevant decision-makers to consider the behavioral and social factors that may shape stakeholder needs, behaviors, or attitudes. In other words, to go beyond simply acknowledging actors at multiple levels and to learn from them. Inadequate knowledge-sharing between the stakeholders could ultimately undermine water agreements' ability to respond to change and to fairly address the water needs of those they serve.

Building water agreements in the lab: Incentives, social norms, and emotions

The analysis of social systems—and their later translation into useable and reproducible game-theoretic models—is increasingly being used to understand the various levers that can be used to encourage cooperation, and reduce the unsustainable or inequitable use of water resources (Yu et al., 2019). From there, laboratory studies that explicitly test and introduce changes to the various models tend to dominate the evidence-base. These look at social norms, framing, and even socio-ecological restructuring as different ways of alleviating over-extraction in 'commons'-style water use scenarios. Of these, a particularly insightful experiment explored the role of social observability in shaping producers' use of those practices that reduce runoff (Griesinger et al., 2017). In a cooperation game, researchers asked university students to make investment and production decisions as if they were producers trying to maximize production in a situation where pollution was taxed at a group level. Testing a variety of interventions in this scenario (signaling, open communication, community feedback), the team found that giving participants the ability to signal 'green' production choices was the most effective way of reducing pollution and encouraging

the adoption of "green" technologies. Observability meant that those behaving in a cooperating matter could be identified, but also that those non-cooperators could be now be pressured. This led to social influences of pressure and shame bringing self-interest in-line with the community's best interests.

Similarly, another set of laboratory experiments explored how the costs and benefits of 'green' behaviors could be reframed so that upstream farmers adapt their production in a way that benefits both them and those downstream of their production. For example, in a laboratory experiment where upstream producers receive feedback from downstream producers, the framing of pollution-reducing technologies had a significant impact on the rate of adoption by upstream farmers (H. J. Czap et al., 2011). Compared to being told it would be better for their own production, upstream participants invested more in water conservation technology if they were told that adopting better technologies would benefit downstream farmers. On the other hand, if upstream farmers were told that investing in new technologies would be mostly self-serving, receiving negative feedback from downstream producers significantly reduced upstream pollution.

Moreover, a combination of empathy framing and financial incentives—in the right scenario—appears to be more effective than either strategy alone (N. V. Czap et al., 2015). Still, special care should be taken as to the impact of social differences on such interventions. Gender, for example, has marked effects on the target actors' reactions to monetary incentives and the feedback they get from other producers (N. V. Czap et al., 2014). Female participants were more responsive to both fines and empathy nudges compared with male students and were also more likely to share and conserve resources from the start. Beyond gender, intervention designers should also pay attention to contrasts in power over resources (Abbink et al., 2010), and when access to water is highly uncertain or inequitably distributed within a group (Anderies et al., 2013), as both can reduce overall production among those who share water resources. While experimental games allow for the clear causal identification of different motivations, they fail to incorporate many of the real-world complexities of local contexts. For example, games fail to incorporate critical existing power structures, such as a farmers' lack of access to land tenure rights (Figueiredo et al., 2013).

Analysis

While household water use and water management agreements may appear as rather distinct subjects, they share underlying features that are critical for behavior change. Both present a case where what narrowly benefits the individual actor (e.g., over-consumption of water, cheap but ineffective treatment of pollutants, etc.) eventually harms the wider community. We refer to this dynamic as a 'tragedy of the commons' problem (Hardin, 2009). No individual feels personally responsible for the depletion of water resources, and the negative impacts of overuse or pollution are only felt collectively. It is a pervasive problem and ideal for behavioral solutions.

Review of the strength of the evidence

The evidence-base for this section is largely made up of interventions that rely on social influences. These interventions make use of normative messaging or public commitments. Researchers or water utilities are the main implementors who test their effects on water consumption via field studies. The evidence-base is internally valid, clearly linking interventions to their behavioral outcomes, as well as externally valid, because of the field-focused approach.

While we acknowledge these strengths, the evidence on water conservation lacks in its geographical generalizability. The majority of published studies in this section stem from behavior change programs in the United States, mainly California. There are several interventions in Australia, and the rest of the world is represented by single cases of water scarcity. Outside of South Africa (Brick et al., 2017; Brick & Visser, 2018) and Japan (Otaki et al., 2017, 2019), interventions to reduce household water consumption in Africa and Asia are underrepresented. Moreover, normative messaging demonstrates strong potential to maintain engagement over time (e.g., Bernedo et al., 2014; Bhanot, 2018), yet, there remains a clear gap in the literature relative to how these interventions could also be applied beyond household water use to the agricultural or industrial sector.

In contrast, interventions that target cooperative water agreements lack the field-based results and take place in low-income rather than high-income countries. Many interventions test the reliability and efficacy of using norms and framing so that payment schemes and cooperative agreements are more effective. These solutions further highlight the possible crowding-out effects that payment schemes and monetary compensation may engender as well as the complexities of designing efficient systems with strong power dynamics between actors. Empathy frames (particularly those paired with monetary incentives, e.g., H. J. Czap et al., 2011; N. V. Czap et al., 2015) are shown to be effective for increasing cooperation among different water users and in upstream-downstream conflicts. Unfortunately, the evidence on water agreements appears primarily at the level of models, games, and laboratory experiments, and there is a considerable lack of field-testing. Most insights are gleaned from lab experiments, which are internally valid but that lack the ecological validity that real-world testing provides (Jack, 2009; Martinez et al., 2013; and Tesfaye & Brouwer, 2016). There also remains a clear gap in the literature on behavior change with regards to transboundary water management. These cases are complex because they implicate groups with potentially very different needs and interests, rather than just individuals. An important avenue for future research would be to target a diverse range of actors involved in water management and distribution, beyond direct users.

Review of the application of behavioral science

Behavior change interventions for water management focus on social influences that can be used to sway decision-makers towards water-conservation behaviors. Specifically, the interventions reviewed tend to rely on social norms to rank, compare, or inform water users of others' behavior. These strategies aim to make existing water conservation norms more salient, create conformity, and decrease water use by high water users. These interventions have been highly cost-effective in inducing household water conservation, yet their impact is most impressive because of their scale (c.f., Chabé-Ferret et al., 2019). A recent review puts the average effect sizes of norm-derived water management interventions at an average of 4% (Lede & Meleady, 2019). A decrease of 4% in water usage might not mean much at an individual level, but it becomes much more significant if 40,000 other people also decrease their water usage by 4%. Even just a few percentage points can mean the difference between scarcity or depletion, as in the case of South Africa's 'Day Zero' (Brick et al., 2017; Brick & Visser, 2018; Parks et al., 2019).

Social norm strategies can be seen as the "low-hanging fruit" of water reduction interventions (Lede & Meleady, 2019). They are cost-effective, realistic and easily achievable, durable, and can lead to substantial reductions in water demand (Bernedo et al., 2014; Bhanot, 2018; but see, Brandon et al., 2017). With the ever-growing number of 'smart' technologies being incorporated into agriculture, social norms can also easily be used to change producer behaviors all over the world (e.g., Bell et al., 2015; Chabé-Ferret et al., 2019). Nevertheless, it is important to consider the unexpected outcomes of such interventions. Normative comparisons for water management interventions can lead to 'boomerang effects': high water users use less water, but low-water users use more water. Some intervention designers have found that this boomerang effect can be eliminated by pairing the descriptive norm with an injunctive message that informs water users about what others think of their actions and expect them to do (e.g., Allcott, 2011; Ayres et al., 2013; Mitchell et al., 2013; P. W. Schultz et al., 2007, 2014; W. P. Schultz et al., 2008). For example, low-usage households are informed of the current water use norm and also told their community expects and encourages them to stay under it. Unfortunately, injunctive norms themselves are not immune to rebounds. Competitions, for example, can alienate high-water users to such a degree that the resulting increase in their water use counteracts any positive effect of the competition (Bhanot, 2017). Regardless, boomerang effects often stabilize within just a few months (Brent et al., 2015) and have only rarely been shown to nullify an intervention's results.

There remains a lot to learn about how to tailor normative messages that go beyond standard peer comparisons. Normative beliefs are not static; instead, we can see them as dynamic and responding to changes in behaviors and beliefs within people's social networks (Prentice & Paluck, 2020). Intervention designers will be most effective if they understand the underlying cognitive process for norm belief formation and use techniques that leverage relevant social referents in a given context.

Similarly, much work remains for water management efforts to fully embrace behavioral insights. Best exemplified by a field experiment in Kenya (Jack, 2009), schemes that rely on monetary payment run the risk of crowding-out producers' intrinsic motivation to conserve water. While farmers might have previously conserved to protect the environment or to help others, payment can lead to seeing conservation through a purely monetary framing. This shift in framing means that, after a monetary scheme is withdrawn, farmers may conserve even less than they did before the scheme was put in place. It is therefore crucial for intervention designers who seek durable results to rely on more than money as a motivator, and to understand the broader psychological motivations behind farmers' decisions. People care about their effect on others, and about others' opinions and feedback relative to these choices (H. J. Czap et al., 2011; N. V. Czap et al., 2015). They also care about the social norms that govern their communities. Instead of relying on a narrow, monetary focus, Martinez et al. (2013) appealed to the underlying values and traditions that intrinsically motivate producers to behave in a certain way. Through social marketing that encouraged a norm of cooperation, communities, rather than implementors, came to be the ones reinforcing the motivation for change. This persistence of motivation can make the behavioral shift sustainable after program activities end. Such interventions could be particularly effective (and quickly implemented) in regions where upstream and downstream producers already trust each other (e.g., Tesfaye & Brouwer, 2016).

Review of the application of social science

Many interventions in this section tend to rely on outside institutions for implementation. While this may be appropriate in some contexts, there are other contexts where deploying interventions is more concerning, given certain community dynamics.

Firstly, most of the behavior change efforts for water management target large groups of people, and there is often a lack of granularity in an intervention's treatment of target actors. Normative interventions treat everyone as if they were similarly motivated (e.g., Bernedo et al., 2014; Brandon et al., 2017; Mitchell et al., 2013). At most, intervention designers acknowledge rebound effects that result from targeting a seemingly homogenous group or address it with another similar intervention (Bhanot, 2017; Brent et al., 2015; P. W. Schultz et al., 2014). Some researchers are exploring the role that social identity has on the effectiveness of water management interventions (e.g., Aronson & O'Leary, 1982; T. Schultz & Fielding, 2014) or how household dynamics shape water use behavior (Fielding et al., 2012). Regardless, little research exists to understand how to best appeal to different segments of the population beyond leveraging a messenger's identity.

The norm messaging strategies employed in many water conservation interventions implicitly treat social norms as a static property of the social context. However, this is counter to the social science treatment of norms as the result of the dynamic interplay between people's behavior and their belief about the behavior of others (Veenstra et al., 2018). If this dynamic perspective is adopted, then it becomes critical to understand what threshold each individual has for adoption, and how these thresholds can amass for an emergent adoption tipping point in a community (Granovetter, 1978; Schelling, 1978). Through this understanding, norm-based interventions can be improved by targetting these social tipping points for outsized impact.

These are important considerations, particularly given the heterogeneity of practitioners' intervention targets. For example, in China, studying the social determinants of water conservation practices revealed that women appeared to be more motivated by monetary incentives and household bills. In contrast, men were compelled by concerns of water shortage (Tong et al., 2017). Women and men also react differently to monetary incentives and injunctive messaging in the context of water use coordination (N. V. Czap et al., 2014). This effect would be missed by a narrow analysis focused on water use behavior.

Economic status also has a role to play in people's reactions and participation in behavior change initiatives. In South Africa, a series of behavioral interventions aimed at delaying 'Day Zero' found that offering public recognition for water conservation was particularly effective in reducing wealthier households' water usage (Brick et al.,

2017). Moreover, it is incredibly difficult for conventional water management efforts (i.e., PWS schemes) to work when poorer farmers lack fundamental rights like land tenure (Figueiredo et al., 2013) or when water-use issues are exacerbated by disparities in water access (Anderies et al., 2013). Of the evidence we highlighted in this section, very few studies paid attention to the social differences inherent in their target population. Due to the overrepresentation of laboratory and game-based experiments in the evidence, we would argue that very few of these studies even can capture those core social variables or complexity (Mianabadi et al., 2015).

While a social science analysis of transboundary water agreements treats states as actors themselves, this level of analysis is insufficient for developing behaviorally informed solutions. Transboundary water agreements must overcome a number of major obstacles, including ecological, socio-cultural, institutional and legal, and geopolitical ones (Mianabadi et al., 2015). Their success or failure depends on many interconnected factors involving numerous actors. Moreover, the motivations of state leaders and stakeholders often greatly differ from the 'motivations' or strategic priorities of states. While behavioral interventions could be relevant for encouraging state leaders to uphold certain legislation or participate in negotiations, they are less appropriate for addressing institutional or geopolitical matters at the state level. Moving forward, analyses of transboundary water conflicts would benefit from a behavioral lens that could examine decision-making among state actors.

Secondly, interventions focused on coordination and water management agreements could rely more on existing social structures and local context. In India, for example, many top-down programs seeking to increase local participation are ineffective because they do not integrate traditional social institutions (Singh, 2008). This is especially important for women whose participation may depend on their social roles within a traditional social structure. There is also a case for reconsidering the 'monetary value' that PES and PWS schemes ascribe to natural resources. Although the use of economic games does allow implementers to examine the viability of water-use schemes or render them more palatable (Tesfaye & Brouwer, 2016), people might be better motivated to conserve water based on existing values for land stewardship (Bremer et al., 2018). Emphasizing the monetary value of conservation efforts may also undermine traditional practices and intergenerational learning that have been well-adapted to the needs of the community for generations (Lansing & Miller, 2005). With many calls from experts to maintain and promote local and traditional management practices, a promising approach may be for authorities to learn from and help formalize or tweak existing relationships (Ananda et al., 2020; Grassini, 2019; Mitchell et al., 2012).

Finally, water conservation interventions need to do more than simply influence direct water users; they need to be mindful of the inequalities that they exacerbate within or between communities. Payment schemes can unfairly benefit those with land tenure as well as those with the means to participate in program development (Figueiredo et al., 2013). Researchers often claim human development goals when designing water interventions; yet their failure to incorporate measures of that development nor consult with the local communities on defining 'development' are critical omissions. Water management schemes can also be inaccessible to poor farmers because of the costs associated with unique interventions. For example, in Tanzania, terracing efforts designed to manage irrigation were untenable for farmers because of the costs of this process (Kwayu et al., 2014).

Designing *with* rather than *for* one's target actors may lead to programs better adapted to the communities in which they are deployed. This practice further ensures that systemic factors like poverty are accounted for in an intervention's design. Additionally, interventions designers need to account for the implicit ethical frameworks embedded in their programs. For example, a PWS scheme in which downstream users compensate upstream users assumes a rights framework in which the upstream farmers control water. However, an alternative regulatory framework might assume that upstream farmers instead have an *obligation* to honor the water access rights of downstream farmers, even without compensation. This allocation of rights is often implicit to a program's design but should instead be an explicit choice in program development.

Fortunately, there are already ways practitioners have navigated ethical concerns. The water conservation case from Japan highlights how behavioral interventions can be flexibly adapted to the concerns of target actors. Where people were concerned about privacy, intervention designers used self-based, historical comparisons rather than revealing descriptive information about others' water use (Otaki et al., 2019). We encourage future efforts to take similar care in addressing the unique ethical considerations of different communities and geographies.

Further Readings

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