The Science of Changing Behavior for Environmental Outcomes:

A Literature Review

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Abstract

While environmental challenges may seem disparate, almost all are unified by a central theme: to achieve positive environmental outcomes, people must act differently. In the past, those hoping to achieve environmental change applied a specific set of levers: rules and regulations, material incentives, and the provision of information. However, these levers are frequently insufficient. The past decades of research in the behavioral and social sciences have pointed towards new directions to meet those environmental ends: addressing barriers, motivations, and social context of the actors whose behavior would need to change as the primary focus for program design. In this review, we identify and describe behavior change interventions that tackle components of five leading environmental challenges: biodiversity conservation, climate mitigation, water management and conservation, waste management, and land management. We review these interventions from three main perspectives: the strength of evidence, their integration of insights from behavioral science, and their integration of insights from social science. We conclude with a framework for understanding how program designers can more effectively integrate behavioral and social sciences into behavior change programming to improve environmental outcomes.

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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.

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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.
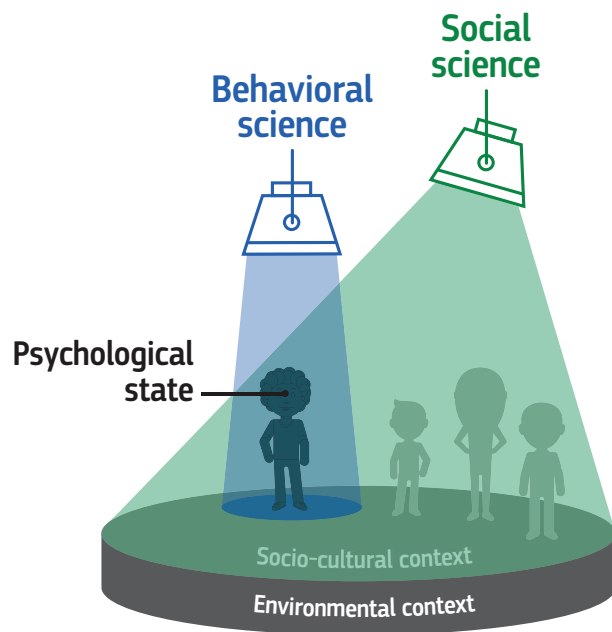

Figure 2. The interaction of behavioral and social science in understanding human behavior. Behavioral science focuses on understanding an actor's psychological state, whereas social science focuses on understanding the socio-cultural context for that actor. Both are necessary for understanding an actor's 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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TOPIC 1:

Biodiversity Conservation

Introduction

Researchers estimate that the rate of biodiversity loss has increased by 1,000 times over pre-human levels. Without intervention, these rates are expected to soon exceed 10,000 times background loss rates (Vos et al., 2015). Direct exploitation, particularly of marine ecosystems, is a significant contributor to these outcomes. Beyond its intrinsic value, biodiversity conservation provides livelihood, security, resiliency, social relation, and health benefits to dependent communities (Millennium Ecosystem Assessment, 2005), including reducing the emergence of zoonotic infectious diseases (Keesing et al., 2010). This section presents a summary and analysis of behavior change interventions that have a direct impact on biodiversity protection and preservation as well as interventions that have indirect but important effects by strengthening the public's engagement with conservation. Specifically, we cover the findings of interventions that target illegal wildlife trade, habitat degradation, and encroachment, as well as those that use various messengers and messages to engage the wider public best.

Analysis Highlights

- Many interventions aiming to protect biodiversity require difficult levels of individual coordination and cooperation. These are strong candidates for norm-shifting campaigns, which operate within the social fabric of the target community. Indeed, the evidence base identifies these interventions to be particularly effective.

- Social norm interventions increase the social cost of not adopting the target behavior, whereas other levers of change (e.g., choice architecture, regulation, or incentives) reduce the cost of adopting the new behavior. Using these levers in combination is likely to ease a community's shift to a novel behavior.

- The evaluations of biodiversity interventions heavily rely on pre-post comparison, significantly weakening the strength of evidence. More advanced evaluation techniques, which may involve randomization or greater reliance on econometrics, are required to build a strong understanding of what works to encourage biodiversity conservation.

- Biodiversity interventions largely focus on single actors in the system, especially suppliers. However, there are many other important actors, including those demanding wildlife products. Interventions would improve by addressing the behavioral system cohesively, shifting the supply and demand behaviors together.

Poaching & Wild Meat Consumption

Around the world, poaching and wild meat consumption continue to put pressure on many species (both flora and fauna), some to the risk of extinction. Rosewood, elephants, rhinos, pangolins, reptiles, eels, and big cats are currently among the most vulnerable species and represent the most seized wildlife in recent years (UNODC, 2020). This section comments on effective interventions to combat behaviors such as wildlife poaching, harvesting, and trade in addition to consuming and selling wild meat.

Reducing poaching: Social norms, incentives, and appealing to local values

In South-East Asia, poaching is generally practiced by a small-subgroup within a community (Rao et al., 2010). However, the behavior is tacitly endorsed by the wider community who expresses indifference to the practice,

resulting in minimal social pressure on poachers to stop. WWF Thailand and Thailand's Department of National Parks ran a community outreach program aimed at reducing poaching in and around the Kuiburi National Park (Steinmetz et al., 2014). Program designers identified six psychosocial factors known to influence behavior: trust, public support, motivation, ethics, self-efficacy, and confidence. Based on these findings, they built a program to create the opportunity for the wider community to organize and collectively express that poaching was detrimental to their livelihoods and that they had the power to act against it. Activities included four years (from 2008 to 20011) of village meetings, school games, musical performances, and education workshops across 24 villages. By 2011, poaching pressure had dropped by a factor of four across the park, with five of the six focal species increasing in abundance across monitoring sites. Just as importantly, by the conclusion of the intervention, 90.5% of the community supported wildlife recovery. Community member's top reason for the decline in poaching was park outreach rather than patrolling. Through the collective action of their outreach events, the program created a new norm within the community of poaching being seen negatively, providing a social rather than formal determent.

Interventions can also highlight how a community can directly benefit from conservation efforts and then use these benefits to establish new patterns of behavior. In Namibia, for example, the 'Rhino Rangers' program stands as a model of community-based conservation through supporting wildlife-related livelihoods and self-efficacy resulting from their stewardship of rhinos. The program supports local communities in choosing rhino custodians from within their communities and then trains and equips these 'rangers' to carry out rhino monitoring (Muntifering et al., 2015). The positions became high social status, and in the span between 2012 and 2018, the number of rhino rangers jumped from 18 to 62. Rhino sightings are at a record high of 918 separate events, and in just five years, poaching has declined by 83% (Muntifering & Rhino Pride Campaign, 2019). A similar program in Madagascar creates social pressure against poaching by empowering local communities to establish their own salaried park ranger positions with the ability to fine poachers and to collect those fines and pay them back directly to the community (Randriamanampisoa & Adams, 2015).

Where creating new roles and incentive structures may be impractical, another way of discouraging the illegal harvest of wildlife is to simply institute conservation rules that act as incentives themselves while avoiding the common presupposition of human-wildlife "conflict." Along Guatemala's Hawaii beach, turtle eggs make for an important source of subsistence and help locals supplement their incomes and diet—still, overharvesting poses a real threat to the many turtle species in the area. In partnership with local hotels, the NGO ARCAS introduced a community engagement scheme that sought to encourage the sustainable harvesting of turtle eggs to address those concerns (Muccio, 2015). Though the scheme bans egg collection for most turtle species, it explicitly allows for the harvest of Olive Ridley turtles, as long as egg collectors who donate at least 20% of the harvested eggs to hatcheries. As it is in the community's interest to continue harvesting turtle eggs in the future, members assist in enforcing the donation scheme. Since the scheme was introduced, the number of eggs rescued nationally has increased from 60,000 in 2003 to 270,000 in 2015, with the number of turtles nesting on Hawaii beach doubling.

Reducing wild meat consumption: Incentives, social norms, and appealing to local values

Norm shifting strategies can be combined with other behavior change levers, such as incentives. This can be seen in a Brazilian amazon campaign which aimed to reduce the consumption of bushmeat by encouraging the substitution of bushmeat for domestic meats, like chicken (Chaves et al., 2017). Researchers randomly selected and assigned 157 households to one of three treatments that included a combination of different behavioral strategies: public information (e.g., visual media, mass media, giveaways, church visits, print media), community engagement strategies (e.g., door to door visits, commitments/pledges, cooking courses), and economic incentives (discount coupons for chicken in the intervention condition and coupons for cleaning products as the control condition). The researchers compared the effects of a community engagement strategy in which people received public information, community engagement strategies, and chicken discount coupons; a coupon strategy in which people received discount coupons for chicken and public information; and a control in which people received public information and discount coupons for cleaning products. The researchers found that information or incentives

alone were not enough to change people's norms and influence behavior: though coupons had increased chicken consumption, the uptake in chicken had not translated to a reduction in wild meat consumption. In contrast, households who were in the community engagement treatment reducing their bushmeat consumption by 62%. For the material incentive to be effective, households first had to understand and feel socially pressured to adopt the new norm in addition to feeling able to cook domestic meats successfully.

Across several countries, bushmeat consumption is embedded deeply into the socio-cultural context. Morsello et al. (2015) found that the best predictor of bushmeat consumption in Brazil and Colombia is its social and cultural value, rather than economic value. In these communities, bushmeat consumption is tied to local beliefs and social norms and suggests the importance of understanding the greater socio-cultural context in which individuals choose this behavior. A study in Ethiopia and Tanzania further examined the gender dynamics around bushmeat hunting and consumption. In this case, researchers found that women reinforce men's hunting routines with praise and encouragement, which drive men's hunting behavior (Lowassa et al., 2012). In the Republic of Congo, bushmeat is perceived as "natural, tasty, and healthy," and the perception that bushmeat is high status can underpin the social dynamic where not providing bushmeat is seen as a social slight or an indicator of low status (Chausson et al., 2019). Similar status benefits of consuming illegal wildlife have been documented through qualitative interviews in Vietnam (Drury, 2009).

Beyond field experiments, simulated interactions, such as themed behavioral games, can allow for observation of how participants understand and discuss the complex social dynamics in wildlife conservation. We find an example of this in the Republic of Congo, where a team of researchers gathered 150 Congolese bushmeat hunters from 10 villages to play a repeated common pool resource game, where each person's payoff depended on the actions of others (Marrocoli et al., 2018). In the game, individuals made decisions about the time they allocated to either hunting or farming under three different conditions: i) without communicating with other group members, ii) with communication, or iii) with communication and a self-monitoring system (i.e., a system where resource use and group trends are recorded and shown to individual players). The researchers found that the combination of communication and self-monitoring led to both a decrease in hunting rates and an increase in the returns from their common-pool resource. In fact, when individuals both self-monitored and communicated with each other in the game, it reduced the likelihood of them choosing to spend time on hunting over-farming by 43%. Such games can serve a dual purpose: first, they can provide program designers with critical insight into the social context, allowing for later interventions to be better tailored to that context; and second, they can serve as a key intervention component themselves, demonstrating to members of a community the dynamics at play in their socio-ecological system, and leading them to share beliefs about others' behavior that they might otherwise keep private (Thulin, 2020).

Anti-poaching and anti-bushmeat programs are often described as addressing "human-wildlife conflicts." However, anthropologists have noted that the framing of these interactions tends to reinforce the perception of conservation as a zero-sum competition over limited resources—one where either humans or non-human species must ultimately end up on top (Cassidy, 2012). However, when the interests of the broader community are brought to the forefront, the dynamic is rarely, in fact, zero-sum. The community may well benefit from the protection of their resources. This situation is far more consistent with the framework of "human-animal relations," emphasizing that the well-being of humans, animals, landscape, and climate are always already inter-related.

Helping communities realize alternative livelihoods is an often-celebrated method for behavior change. However, unlike the interventions illustrated above that are grounded in the conservation efforts of local communities, sometimes alternative livelihood schemes fail to serve as beneficial substitutes to the problematic behaviors we are trying to address or make large assumptions about the motivations for adopting a different livelihood. Alternative livelihoods are not just about financial gains or resiliency but instead confer social and cultural changes to everyday practices (Wright et al., 2016). For example, a scheme in Tanzania aimed to reduce wild meat consumption by increasing the availability of chickens (Knueppel et al., 2009). Unfortunately, though the intervention was successful in increasing the availability of chicken meat, a decrease in bushmeat consumption did not follow. Likewise, an

intervention in Gabon, the Congo, and Cameroon found mixed success in disincentivizing bushmeat consumption through encouraging cane rat farming ('farmed' wild meat). In the author's words: "The Gabonese [were] not naturally livestock rearers, and even less rearers of wildlife" (Wicander & Coad, 2014, p.28)—selling livestock was therefore not a simple or autonomous economic activity for the Gabonese, nor was it for the Congolese. Implementors were also fighting against cultural norms whereby the rearing of 'mini-livestock,' things like rabbit, chickens, or cane rat, is seen as an activity for women. All of the program's participants dropped cane rat rearing within the year following the project's completion. Cameroonians, on the other hand, were far more receptive to the intervention because bushmeat was less readily available and so they had previous experiences rearing chicken and rabbit. The rearing of cane rats required only small modifications to an already established system (Wicander & Coad, 2014).

Tackling the Demand for Exotic Pets

Though efforts to curb wildlife crime primarily focus on illegal wildlife consumption, the illegal pet trade stands as a significant threat to conservation efforts. Between 2014 and 2015, the website 'www.exoticpetmatch.com' allowed members of the public to be 'matched' with their ideal exotic pet. After answering a set of questions, potential buyers were presented with their ideal pet and information about that pet, before being prompted to rate the likelihood with which they would buy the animal. Buyers either received information about dietary requirements, potential zoonotic diseases, animal welfare, the legality of owning such a pet, or the consequences of purchasing on the species' long-term survival. The study found that disease or legality information could reduce the interest in purchasing by 39%. Information on welfare and conservation impacts was comparable to giving buyers the animal's dietary requirements, having no statistical effect. Despite focusing on intentions, the results raise key points for investigations in future campaigns to reduce the purchasing of exotic pets (Moorhouse et al., 2017).

Preventing illegal wildlife trade: Social norms and expectations

Interventions to address wildlife conservation have also worked by targeting different actors throughout the social system. For example, poachers are only one part of a larger system supporting the illegal use of wildlife. As a result, TRAFFIC recruited traditional medicine practitioners to publicly pledge to refrain from using rhino horn (Offord-Woolley, 2017; TRAFFIC, 2015). By socially 'binding' these practitioners to their commitments, as well as to making the new norm more visible in the practitioner community, the program has already led to a measurable reduction in the use of illegal wildlife products. Unfortunately, work remains to understand and shape the demand for rhino horn at the client level. For their client users, demand is almost exclusively driven by the behavior of their peers, unaffected by any campaign or behavioral intervention on intermediaries like traditional medicine practitioners or local leaders (Vu et al., 2020). Many do not trust the implementers of such demand-reduction interventions—something that careful qualitative and quantitative studies could help address and alleviate.

Norm shifting programs can also be augmented with supporting technological solutions. After a successful social marketing campaign in Laos that shifted community norms around the illegal hunting of tigers, state officials introduced a wildlife crime reporting hotline. In the six months when the hotline was operational, state officials

received 250 citizen calls that led to 22 arrests (Saypanya et al., 2013). In Tanzania, researchers and Tanzania's Wildlife Tourism Department created and broadcast a 25-episode radio drama called Temboni ('the voice of the elephant'). Temboni's protagonists would face issues of illegal hunting and wild meat consumption, getting either rewarded or punished depending on their actions related to the topic of the episode (Veríssimo et al., 2018). However, due to limited radio penetration in the region, the implementation challenges of the intervention highlight the difficulties in delivering mass media campaigns, particularly when that intervention relies on creating common knowledge around norms.

Preventing poaching: The limitations of incentives and rules and regulations

The strategies described above, including the changing of norms, giving community members the capacity to act on their values, and providing alternative livelihoods, fundamentally work because they work *with* rather than *against* the will of the community. They diverge from the zero-sum framing of human-wildlife conflict. This can be contrasted with the common policy intervention of bans on wildlife trade, which can often show the opposite dynamic. Interviews with those living within and near protected areas in southern Africa found that bans negatively affect those most impoverished. This financial loss cascaded into a psychological loss of well-being. Respondents reported feeling that the regulations humanized animals, while *de*-humanizing actual people. This feeling of outrage made respondents even angrier with local restrictions, making them even less interested in complying (Strong & Silva, 2020). These results highlight the need to qualitatively understand the needs of a community before developing an intervention, whether it be a ban or a community-based program. Bans alone are unlikely to address the socio-ecological factors that drive wildlife consumption and can even be counterproductive when that context is accounted for. Instead, the behaviorally and socially informed strategies above, perhaps accompanied by a ban when supported by the local community, is far better positioned to drive actual changes in behavior.

Overfishing

Fishing is a primary source of food and income for millions around the world. Coastal fishing communities, in particular, rely on sustainable fish stocks, yet many of the world's fisheries are at risk of overfishing and degraded marine ecosystems. This section covers interventions that increase sustainable fishing behaviors.

Reducing overfishing: Social norms

As part of a global fisheries program, from 2010 to 2012, the NGO Rare worked with local leaders to run a social marketing campaign that aimed to reduce destructive fishing inside the Dongzhaigang National Nature Reserve in China. Simultaneously, the campaign implemented a community co-management committee and trained the monitoring teams on patrolling the area and enforcing fishing bans. Over the period of the campaign, the proportion of fisheries who believed that destructive fishing should be illegal increased from 48 to 82%. Further, the percentage of those who had ever reported an infraction more than tripled, growing from 9 to 30% (Butler et al., 2013). Rare also partnered with the World Wildlife Fund to launch a campaign around Mongolia's Onon River to increase catch-and-release practices for taimen. By creating fishing clubs among fishers, boosting a sense of belonging, and training on sustainable fishing practices, there was a greater awareness and new norms around fishing laws. In the first two years of the campaign, the taimen population had grown by 48.7% (Tully, 2018).

More recently, Rare worked with local partners to encourage local communities from three countries to develop and comply with community-based territorial use rights systems for fishing coupled with no-take marine reserves known as TURF reserves. Campaign leaders recognized that these reserves were the crucial foundation for realizing behavior change and socio-economic benefits. Rare's team launched (and are still active today) social marketing campaigns across 41 sites in Brazil, Indonesia, and the Philippines. They used these campaigns to create new social norms that reinforce fishers' compliance with TURFs. Compared with pre-intervention levels, communities in all three countries significantly increased their support for sustainable fishing practices and have reduced overfishing

behaviors. These results suggest that these communities not only developed new social norms around expected fishing practices but that these new norms drive and maintain sustainable practices even prior to realizing the long-term benefits livelihood benefits (McDonald et al., 2020). Ecological surveys indicate a mean fish biomass increase in the campaign reserves of 390% and a 110% increase in the surrounding waters over six years (Alimi et al., 2018).

Other reviews of community-managed resources further support the benefits of this type of approach. The community-based management of Brazil's Juruá River saw the world's largest scaled freshwater fish (*Arapaima gigas*) dramatically rebound from an average of 9.2 fish in open-access lakes to 304.8 in community-protected ones (Campos-Silva & Peres, 2016). A review of three ethnographies of fishing communities in the Philippines identified various ways in which social complexity affected marine conservation and protected areas. Without understanding the different motivations and barriers of fishers, campaigns can create unfair access to participation and resources (Fabinyi et al., 2010). Other work in the Philippines reinforces the importance of working with local people to determine how institutions like a fisheries management group can incorporate real participation across those in a low power position in the community. Participatory processes must be mindful of local power dynamics and ensure that all feel involved and consulted in decisions to build investment in new programs or rules (Eder, 2010).

When norms already exist, some interventions have focused on reminding key actors to comply with them. Researchers in Tasmania tested whether timely messages might be used to increase regulation compliance in a simulated laboratory setting (Mackay et al., 2019). They presented university students with a common-pool resource game where some players were given information about other people's behavior: 'According to last year's data, the average fisher chose to catch only one (1) fish.' Compared with participants who did not receive the information, those students that had received the descriptive norm message were 10% more likely to comply with the 'maximum catch' rule imposed by the game (two fish maximum). Another finding from this study was that the reminder was far more effective if paired with weak deterrents (5% chance of having your catch inspected) compared with strong deterrents (20% chance of having your catch inspected). Interestingly, while this effect was true of risk-averse individuals, risk-seeking ones were more responsive to deterrents and less to the social nudge.

Reducing overfishing: Decision aids

Interventions that reframe choices—in tandem with social marketing campaigns—have also been effective in curbing overfishing. Decision aids, for example, are cheap and efficient tools that can be distributed and that significantly simplify choices for decision-makers. In the Bahamas, for instance, Rare ran a behavior change campaign from 2009 to 2010, where they also provided fishers with a tool to easily measure the tail size of spiny lobsters (Green, Williamson, et al., 2019). The goal was to prevent fishers from harvesting immature lobsters and allow the spiny lobster population to grow. After the 'Size Matters' campaign was put in place, one of the biggest processors in the Bahamas recorded close to zero undersized lobster for the first time in over 40 years. In 2018, the spiny lobster fishery in the Bahamas received Marine Council Stewardship certification—a testament to the campaign's durability.

Similar size gauges have also made an appearance in Tasmania, where the Inland Fisheries Service distributed a special ruler to measure Tasmanian trout. There are several short and playful messages to gauge size along the ruler, starting with "It may be to size but do you really want it?" at the legal minimum size (220 mm) to "Not bad!" "Impressive!" "Worth bragging about!" and "Officially a monster!" Tasmania also encourages fishers to release undersized fish with the slogan, 'Gently put the little ones back' (Mackay et al., 2018). While these decision aids appear promising from a design perspective, to date, neither researchers nor government has evaluated their effectiveness.

Deforestation & Habitat Degradation

As populations expand, so do human settlements that encroach on forests and other habitats. Deforestation may occur due to natural resource extraction or clearing land for development or agriculture. This section explores interventions designed to change behavior to reduce deforestation and habitat degradation.

Preventing deforestation: Limits of incentives

For decades, a common intervention for slowing deforestation has been the Payments for Ecosystem Services (PES) scheme: a market mechanism by which those damaging an ecosystem are incentivized to shift their behavior, often by those harmed by that damage. While PES schemes have been deployed in various geographic, social, and environmental contexts, there is still much debate as to their effect and cost-effectiveness (see Pattanayak et al., 2010; or Romero et al., 2013).

In Uganda, for example, a PES scheme was successful in reducing deforestation rates on privately-owned lands (Jayachandran et al., 2017). Keeping forests intact reduces atmospheric CO_2 and increases biodiversity, which is an important source of income for Uganda's tourism sector; but these schemes recognize that individual landowners personally gain much more from chopping down those forests for timber or agriculture. To match the value of keeping the forest intact with the individual material value of clearing it, researchers offered landowners yearly payments of 70,000 Ugandan shillings per hectare of conserved forest. After two years, they found that tree cover decline had slowed in those villages where well-calibrated PES schemes were offered. Comparing 61 control villages to 60 villages where forest owners received PES payments, the team found that deforestation rates were almost 4.9% slower in those communities that received payment from 9.1% of tree cover disappearing to 4.2%. In terms of the social cost of carbon emissions, the program's benefits were estimated at more than 2.4 times its cost, although this result is highly dependent on the particular social discount rate assumed.

Although widely deemed a success, the PES scheme above also demonstrates the possible social consequences. While the program had been efficient in encouraging forest owners to reduce their tree-cutting (often to clear land for agriculture or to collect timber and charcoal), it also led owners to stop allowing poorer neighbors to gather firewood or building materials. Though conservationists might rejoice at the 4.9% change in deforestation, a critical eye would identify the missing social costs of the program. Because the evaluation failed to account for the socio-ecological context, the welfare of the low-power neighbors was neither accounted for nor compensated. This resulted in not only an inequitable distribution of burdens but also an incomplete tally of the cost of the program.

Another cause for concern is the possible 'rebound effect' of such schemes. In Cambodia, a team of researchers examined how PES schemes might crowd-out the intrinsic motivation that people have to protect the environment. This crowding out might occur if households previously identified intrinsic value in forest resources, but by framing those resources in monetary terms, those administering the scheme may undermine that original motivation. To test this, researchers compared survey responses of households who were currently enrolled in a PES scheme to the responses of matched controls (Chervier et al., 2019). They found that, while the PES scheme did increase the value that participants placed on forest resources, this value was money-related as oppose to subsistence-based. They also found that those who emphasized money-related benefits more strongly were also more likely to report that they would stop conserving if the program ended.

Recent work in geography and political ecology similarly notes that purely market-based approaches like the PES model can modify human ways of relating to nature, to the detriment of conservation goals. A suggested alternative might be to frame conservation as joyful and sustaining, instead of as a burdensome activity that requires compensation (Singh, 2015).

Preventing deforestation: Incentives, social norms, and appealing to local values

Behaviorally-informed approaches are in the ideal position to suggest complements to traditional PES strategies or to suggest alternative means of getting forest conservation to 'stick.' For example, one study in Mexico used social marketing tactics to change norms and persuade landowners to register for PES schemes (Green et al., 2013). Working with a local partner, Pronatura Veracruz, Rare ran a pride campaign whereby posters and billboards displayed a specific call to action for the community: Certifica tu Tesoro or 'Register your treasure.' This message, along with a unique theme song, appeared in radio and television stations as well as schools. The campaign also included a community visit to a local bird observatory where individuals could directly observe the species that the program wanted to conserve: the peregrine falcon. Once there was sufficient buy-in in the community, Rare turned to making adoption as easy as possible. They organized a series of meetings to teach landowners how to register their land with the scheme and encouraged participants to share their experience with others. The campaign ran from May 2009 to July 2010. In that time, 14 landowners decided to sign-up and protect what amounted to 1584 hectares of land, more than three times the predicted 500. A survey of households in the area revealed that before the campaign only 36% of landowners understood deforestation as a threat to local ecosystems. After the campaign, that proportion rose to 63%. A new norm had been created in the community, one that encouraged PES adoption without the need for implementers to increase payment amounts.

Similarly, Andersson et al. (2018) investigated the motivation of forest users from Bolivia, Indonesia, Peru, Tanzania, and Uganda to participate in this type of scheme to reduce forest harvesting on communal land through a framed field experiment. By testing a series of different hypothetical PES schemes, the researchers found that making a payment conditional on having achieved a low harvest rate was more effective than simply allowing participants to communicate. However, once the scheme was removed, simulating the common reality of most schemes' conclusion, those groups who had the opportunity to communicate rather than be financially incentivized conserved the greatest amount. Trust among the community was also a significant predictor of the maintenance of conservation efforts post-PES. Andersson et al. suggest that "policy actors may be able to increase PES program effectiveness on forest commons by promoting interventions that facilitate interpersonal communication among forest users, and by prioritizing implementation in contexts where users enjoy high levels of trust" (p.133).

Other than direct payments, a successful approach to reducing deforestation has been to incentivize sustainable behaviors by providing resources that directly address the cause of deforestation. For example, the Health in Harmony initiative in Indonesia provides individuals with healthcare and training in organic farming practices; in exchange, participants hand in their logging equipment (Karak, 2020). Over 13 years, the program has led to a 90% decrease in logging, a 67% decrease in infant mortality, and 52,000 acres of secondary forest regeneration. The true accomplishment of the program, however, was how it was able to address both the cause of logging and replace the behavior permanently through intensive co-design with the community stakeholders. By consulting communities about what they needed to protect the forests of Gunung Paung National Park, Health in Harmony recognized that the real cause of illegal logging was the high cost of healthcare for villagers. Instead of providing extra cash, the initiative therefore provides villagers with affordable healthcare. At the same time, Health in Harmony also teaches communities how to maintain both their livelihood and the rainforest around them—ensuring that the change is not only meaningful but permanent.

Rare adopted a similar approach in the Gansu Province of China, using a social marketing campaign to promote the use of fuel-efficient stoves as a way to reduce deforestation in the area (Dewan et al., 2013). Since most of the illegal logging in the area was tied to the low-efficiency of firewood stoves—rather than simply providing cash to delay forest harvest, the campaign promoted the use of newer, more efficient stoves. After 2.5 years, 43% of the treated population adopted fuel-efficient stoves; and for those households that had adopted fuel-efficient stoves, wood consumption and gathering time expectedly decreased by 40% and 38%, respectively. At the forest level, the intervention led to a 24% reduction in the number of newly felled trees in those areas where fuel-efficient stoves were adopted by more than half of the community.

Reducing habitat degradation: Social norms

Beyond PES schemes, some interventions have applied various social norm-based strategies to promote conservation on private lands. Byerly et al. (2019) ran an intervention with Maple producers in Vermont, USA, aiming to encourage participation in a conservation program called the Bird-Friendly Maple Project. In this program, participants acknowledge and adapt their practices to make bird habitat protection a priority. After sending a variety of solicitation letters to participants, the researchers realized that they had not fully understood existing norms in the area. The researchers predicted that sharing a descriptive norm of what other farmers were doing would increase participation (i.e., "Many of your fellow sugar makers are part of the program"), but this instead slightly decreased interest in the program. For Maple producers who did not directly know anyone participating in the Bird-Friendly Maple Project, this norm message conflicted with their reality of seeing very few sugar makers participating. As a result, they were less likely to feel compelled to sign up.

Norm messaging was also found ineffective in a study by (Metcalf et al., 2018), where Pennsylvanian landowners received mailers that asked them to conserve their riparian land. The intervention tested two things: first, whether micro-targeting landowners based on a model predicting their likelihood of participating would increase uptake relative to farmers randomly selected; and second, whether normative messaging would further boost interest in the program. Those selected through micro-targeting were significantly more likely to take a follow-up survey about land conservation as compared to those who were not micro-targeted (20% vs. 12%). However, the inclusion of the normative appeal that "most landowners like you invest in riparian buffers" had a small effect, and only on randomly selected landowners. While micro-targeting was a successful strategy and interesting for future application, both studies demonstrate how norm messaging can be ineffective when inconsistent with observed practices, and how actors rarely rely on a single source for normative signals (Prentice & Paluck, 2020).

Engaging with Conservation

While addressing overfishing, deforestation, and habitat degradation help to overcome direct threats biodiversity, increasing fundraising and relationships to nature can also have indirect benefits. In this section, we focus on social marketing campaigns, fundraising campaigns, and communication strategies that have helped to create regular and safer interactions with wildlife.

Promoting conservation messaging and fundraising: Social norms and appealing to local values

While many of the interventions targeting biodiversity conservation work with different communities, geographies, and even problem areas, many of these efforts were successful because they apply similar overarching strategies— particularly when it comes to social marketing. For example, Rare's deforestation interventions in Mexico and China both centered their campaigns around flagship species—peregrine falcons in Mexico (Green et al., 2013), and the golden snub-nosed monkey in China. In 2015, Rare published an analysis of 64 of its social marketing campaigns and found that those centered around a recognizable, mascot species had 21% higher adoption of target behaviors (Hayden & Dills, 2015). And in 2018 Rare published a meta-analysis of 84 social marketing campaigns across 18 countries and concluded there was an increase in knowledge, attitudes, interpersonal communication, behavior intention, and behavior indicators from an average of 16.1 to 25.0 percentage points following the campaigns (Green et al., 2019).

Pairing conservation messaging with specific species is a common strategy in the field, and not just to engage actors in point-of-origin countries. To improve this messaging, researchers have tested a number of attributes. Unlike with human beneficiaries, people appear to be no more likely to donate when there is a single identifiable animal beneficiary rather than a group. Yet there is a significant increase in donations when a campaign highlights flagship over non-flagship species (Thomas-Walters & Raihani, 2017). There is also evidence that highlighting the anthropogenic cause of a species' plight leads to more engagement (Bulte et al., 2005). In an interesting nuance,

fundraising campaigns featuring flagship species appear to increase the *probability* of someone donating, but highlighting the human causes of species decline or publicly recognizing donors for their contributions leads to increased donation *amounts* (Shreedhar & Mourato, 2019). Another common strategy employed by NGOs is to use celebrities as campaign messengers. While celebrities do tend to increase engagement with a campaign, they have the negative side effect of reducing people's recollection of the campaign's specific messages (Duthie et al., 2017).

Building new interactions with nature: Appealing to values

Regular interactions with nature can also drive engagement. A 2018 study found that people who experience nature as part of their daily routine were more connected to nature and more likely to act in ways that protect and support biodiversity conservation efforts (Prévot et al., 2018; Whitburn et al., 2020; Zaradic et al., 2009). For those for whom nature is more difficult to access, researchers increasingly suggest that practitioners recruit mobile technologies and augmented reality software (e.g., *iNaturalist, Seek*, and *Pokemon Go*) as a means of facilitating interactions with nature (Bamesberger, 2020; Colléony et al., 2019; Dorward et al., 2017). Of course, there are other limitations to the accessibility of different technologies, and practitioners should also be mindful of how such software ascribes to a Western valuation of nature (Altrudi, 2020).

Stick to the Path: Protecting Protected Areas

Off-trail hiking in National parks is an example of how 'recreational' activities can damage even those areas that are otherwise protected from more traditional sources of harm. In Washington DC's Chesapeake and Ohio National Historical Parks, authorities tested the efficacy of different strategies (and their combination) in the hope of reducing the problem (Hockett et al., 2017). They tested a combination of the following strategies: i) signs that made visitors aware of their impact on the park), ii) symbolic "no hiking" signs across informal trails, iii) placing leaf litter and branches along initial sections of informal trails, iv) restoring and fencing selected trails, and v) placing trail stewards at trailheads that personally communicate the information that was on trailhead signs. Of all these tactics, they found that the contact with trail stewards had been most effective in reducing visitor reports of off-trail hiking from 70.3% to 43.0%. Direct observations of specific problem areas saw a reduction in off-trail hiking from 25.9% to 6.5% after the addition of trailhead signs, and further to 2.0% when trail stewards delivered the message. Renaturalizing parts of the path (i.e., placing leaves and branches to cover informal trails) was also effective—bringing self-reports of off-trail hiking from 70.3% to 60.2%, and 58.6% in the case of those parts that were fenced off. By providing visitors with salient reminders of their impact on the park, increasing the effort needed stray from the path, and having contact with key messengers, this intervention demonstrates how to address a range of different motivations and barriers for behavior change.

People's interest in getting close to wildlife can put both wildlife and people at risk if people fail to act appropriately. National parks are a setting where people are eager to explore the natural world and even encounter rare animals they would not see at home. A study by Abrams et al. (2020) tested ways parks could reduce wildlife-caused injuries to visitors through different park communication messages in four U.S. national parks. Typically, parks highlight the importance of wildlife protection, but this intervention explored whether focusing on the visitor

experience could make a difference instead. At three of the four parks, campaigns that promoted the visitor's experience led to fewer visitors putting themselves an unsafe distance to wildlife. Due to the number of national parks and protected areas worldwide, further research on visitor behavior would be valuable in honing these messages. For example, a landmark study by Robert Cialdini and colleagues (2006) aiming to dissuade visitors from taking petrified wood from an Arizona park tested various social norm messages. They found emphasizing the prevalence of the undesired behavior (i.e., stealing petrified wood) backfired in increasing the behavior, whereas focusing on social disapproval of the behavior decreased undesired behavior.

Finally, it is important to consider that the amount of interactions that a community has with nature does not directly translate to more connectedness. For example, when an intervention's target population is wholly dependent on natural resources, they have less positive feelings of connectedness with nature (Marczak & Sorokowski, 2018). This is also true for people for whom interactions with wildlife and human-wildlife conflict are frequent. One strategy is to promote the benefits of having different species within a community's territory, as well as to highlight those specific actions that people can take to avoid conflicts with said species (Slagle et al., 2013).

Analysis

Overall, the behavioral interventions for biodiversity conservation have a lot in common. Whether it is to combat poaching, overfishing, illegal logging, or engage more people with conservation activities, most of the published evidence relies on social influences. More specifically, social interventions work to spread information and shift norms in communities that live in (or around) protected zones. These interventions highlight the positive externalities that can arise from a community's relationship with nature. By building a sense of self- and collective-efficacy in target populations, biodiversity interventions align community expectations with new, sustainable behaviors.

Review of the strength of the evidence

Behavioral solutions for biodiversity form a cluster around geographies where there are the greatest threats to natural resources and wildlife. Many insights are strong and promising for future interventions. However, interventions on illegal wildlife trade or deforestation focus mainly on the supply side of protecting endangered fauna and flora. Very few interventions address Western populations or the demand side of resource depletion (Wallen & Daut, 2018; Chaves et al., 2017; Moorhouse et al., 2017; TRAFFIC, 2015).

Conversely, studies that focus on actors' engagement with conservation are restricted to western Europe. Future studies could explore how related insights might apply to campaigns in other countries and contexts, mainly testing local communities' sense of connectedness with nature and wildlife (Prévot et al., 2018; Whitburn et al., 2020). Many modern conservation campaigns focus on reconnecting people with nature, and evaluations of such efforts could be implemented at scale (e.g., Barrera-Hernández et al., 2020; Richardson et al., 2016).

It is further important to consider the methodological limitations that may undermine the validity and generalizability of interventions' results. Most of the reported results on poaching, overfishing, and deforestation stem from quasi-experimental evaluations. These are often pre-post studies, where behaviors are compared before and after an intervention happens. The results show a measure of the change in the field but often without an appropriate control or the randomization of the intervention's delivery. Therefore, there is an unfortunate lack of *internal* validity in this evidence-base, particularly for interventions that rely on the social marketing work of NGOs.[2] Exceptions do exist (e.g., Byerly et al., 2019; Chaves et al., 2017; Jayachandran et al., 2017), but the real result of behavior change interventions that focus on poaching, overfishing, and deforestation could be smaller or non-significant if appropriate controls or randomization were in place.

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2   A recent review on the impact of over 280 wildlife demand-reduction campaigns found that 85% of these were led by NGOs. Only 43 of those had attempted an evaluation of their impact, and only 5 made direct observation of changes in behavior as an outcome metric (Veríssimo and Wan 2018).

Fortunately, most interventions are tested directly in a natural field setting with real-world behavior change outcomes. Field studies provide a high degree of ecological *validity*, and we can be confident that the results apply to the behaviors we seek to change. The reverse is true for the smaller set of online or laboratory-run studies in the overfishing and conservation engagement sections (e.g., Duthie et al., 2017; Mary Mackay et al., 2019; Shreedhar & Mourato, 2019). These interventions provide tight controls of internal validity but often require many more assumptions to conclude that the same effect would occur in a real-world (or even offline) context.

Review of the application of behavioral science

Social influences are the most common behavior lever applied to biodiversity conservation interventions. Most interventions find that individual decision-making is highly dependent on the decisions of others. As a result, solutions aim to create norms or make existing norms more salient in target communities and ensure that a majority of the community conforms to these norms.

Behavioral scientists often think of social norms as collective patterns of behavior that result from people conforming to others' beliefs and expectations (Bicchieri, 2016). This tendency to conform is deeply rooted in humans' unique evolutionary history (Henrich & Boyd, 1998). Norms define behaviors that are appropriate in a community and define the socio-ecological boundaries of that community (Hogg & Reid, 2006; Young, 2015). Interventions that successfully create or modify existing social norms inherently leverage our evolved preferences for conformity, and the accompanying social emotions, such as pride, admiration, envy, and shame (Fessler & Haley, 2003).

The real benefit of leveraging social norms is that they become self-enforcing once a community expects a given set of behaviors. This is unlike rules and regulations, which require formal and dedicated enforcement (Nyborg et al., 2016). Interventions focusing on shifting norms tend to move through three behavioral science-informed phases: generating collective demand, coordinating a shift in behavior, and strengthening that norm (Thulin, 2020). Generating collective demand involves encouraging actors to recognize the positive outcomes of their actions and noticing that everyone else recognizes these outcomes as well. For example, community activities like games, parades, or other convenings bring together large groups of community members to engage with the challenge (e.g., Dewan et al., 2013; Green et al., 2013). These community gatherings allow participants to test their new beliefs and expectations, making them confident that others have a similar perspective (Prentice & Paluck, 2020). Generating collective demand for change is critical but insufficient for behavior change because people prefer to conform to what others are doing. The second phase of change is a coordinated shift in behavior, where the community changes as a group. Activities like public pledges help to signal this shift (e.g., Chaves et al., 2017; Steinmetz et al., 2014; TRAFFIC, 2015). Finally, for the new norm to be stable, members of the community need to believe that their conformity to the norm will be observable. Activities such as community patrols reinforce norms and punish transgressors (e.g., McDonald et al., 2020; Muntifering et al., 2015).

Given these conditions, norm-based interventions can have significant and durable impacts; it is the community, not practitioners, that maintains behavior change (Chudek & Henrich, 2011). Unfortunately, norm-based interventions are rarely monitored for extended periods after implementers leave. There is evidence that some programs are durable when norm change is paired with other behavioral levers. For example, Rare's Size Matters campaign and ARCAS' egg harvesting scheme both combine social influences with choice architecture to reinforce social expectations and make conservation behaviors simpler. Both interventions have been shown to be effective and durable (over ten years in the Bahamas case). They also highlight that these solutions must communicate the benefits of behavior change to the community, signal expected behavior change by others, and make the new behavior unambiguous and straightforward (in these cases via the use of decision aids and categorical rules; see, Yoeli & Rand, 2020).

Review of the application of social science

Compared with the other topic areas, interventions on biodiversity conservation take the most care in understanding communities' cultural norms and values. Pride campaigns, for example, rely on social marketing tactics that are

unique to each of Rare's target communities (Butler et al., 2013; Dewan et al., 2013; Green et al., 2013; McDonald et al., 2020). The Kuiburi National Park program on poaching reduction (Steinmetz et al., 2014), Laotian authorities' work on tiger poaching (Saypanya et al., 2013), and ARCAS' efforts in Guatemala on turtle egg harvesting (Muccio, 2015) are also strong examples of developing customized campaigns. With these strengths, there are a few major weaknesses of biodiversity interventions. They need to target both supply and demand reduction for wildlife products, develop a more nuanced set of interventions for different groups within communities, and be more proactive in incorporating community voices during program development.

Similar to the process described in the behavioral science application section above, social scientists have identified similar themes in social norm adoption. While values themselves may be deeply internalized early in development, how a value is expressed in a particular context is far more socially mailable (Lincoln & Ardoin, 2016; Stern, 2000). It is at precisely this level that successful norm change interventions in this section tend to operate. Rather than attempting to change deeply held values, they change the way the perception of a behavior is socially constructed such that a behavior is seen as consistent (or inconsistent with those values), and therefore deserving of positive or negative social sanction.

The social norm processes highlighted in the interventions in this section implicitly rely on an understanding that social context is not a static environmental influence, but rather a dynamic cause and product of human behavior. Social science reveals that these dynamic change processes are often non-linear, with "tipping point" inflections (Granovetter, 1978; Schelling, 1978). Understanding these non-linear dynamics gives greater insight into the total impact of a program, as it must account for not only the direct effect of an intervention, but also the social multiplier. While some work in this space attempts to estimate a generalizable tipping point for social change (Centola et al., 2018), it is important to recognize that the distribution of individual thresholds for change, as well as the configuration of the social network has a significant effect on where the emergent community tipping point might be, and indeed whether any tipping point exists at all (Bentley et al., 2014; Novak, 2020). While the measurement of these individual thresholds is in its infancy (Bicchieri, 2016), it presents significant applied value for biodiversity conservation programming.

We find very few efforts targeted at the demand side of illegal wildlife trafficking behaviors (cf. Chaves et al., 2017; Moorhouse et al., 2017; TRAFFIC, 2015). Even those that do have this focus could benefit from a better understanding of the socio-ecological dynamics and variables that drive demand. For example, though TRAFFIC's intervention on rhino horn demand targeted traditional medicine practitioners (a proximate demand actor), the end-user might not be deterred by such efforts. Those using traditional medicine seem to be unaffected by what traditional medicine experts say and almost entirely driven by their network of peers (Vu et al., 2020). Unless interventions target every practitioner or change the underlying norms within the community, practitioners still providing these treatments will have a business. A systematic approach that examines the full supply and demand system might be more successful.

The second area that we find biodiversity conservation interventions lacking is in recognizing social complexity. An otherwise well-designed behavior change intervention can fail without incorporating insights from the socio-ecological system. Practitioners should aim to disaggregate existing norms relative to biodiversity conservation and identify specific social variables. For example, researchers in Tanzania and Ethiopia have found that targeting men in the fight against bushmeat hunting is interconnected with women's behavior. Men were motivated to hunt by women's encouragement, and women benefitted from the material and symbolic rewards of men's hunting outings (Lowassa et al., 2012, p. 628). In Brazil and Colombia, the best predictor of bushmeat consumption is its association with cultural identity, particularly for urban consumers (Morsello et al., 2015). Our analysis reveals little effort in addressing these more nuanced beliefs and behaviors.

Beyond norms and gender roles, different identities in a community may also lead to unforeseen effects of interventions. For instance, one study showed older Filipino men prefer low-risk, low-return fisheries, while younger

fishers prefer high-risk, high-return activities, which are tied to illegal fishing practices (Fabinyi et al., 2010). These two groups diverge in their willingness to participate in marine conservation efforts, which then results in disparate impact for these two groups. A failure to attend to complexity can lead to inaccurate targeting, unfair outcomes, and heterogeneity of needs that are largely left unaddressed.

Similarly, though some behavioral efforts to reduce wild meat consumption have been effective (Chaves et al., 2017), others have failed because they misinterpreted community needs and capacity (Knueppel et al., 2009; Wicander & Coad, 2014). We highlight Health in Harmony's approach as a model of how this can be achieved. Through their 'Radical Listening' approach, they ask communities what a 'thank you' for engaging in conservation would be. These responses allowed them to target the drivers of biodiversity loss at the source (Karak, 2020). Community members told the NGO that they engaged in illegal logging largely to pay for expensive medical care, so Health in Harmony subsidized healthcare. For loggers, who instead sought alternative livelihoods, Health in Harmony offered sustainable farming training in exchange for no more logging. A deeper understanding of the socio-ecological context underlying unsustainable behavior is an overlooked but crucial tool in the behavior change toolbox. Even so, interventions should aim to help communities build local capacity in addressing their challenges once NGOs and other authorities leave.

Moreover, alternative livelihood projects (ALPs) have had mixed outcomes in terms of their effectiveness in conservation programs (Wright et al., 2016). Program designers assume ALPs will work because they will reduce the need to exploit a given resource, that one ALP will work for all members of a community, or that one individual's success with modifying their livelihood will lead to scaling up within the community. In reality, the adoption of alternative livelihoods is much more complicated by social and economic context. Alternative livelihoods are not just promoting financial security but sometimes very different skills, interests, traditions, or expectations. For a household to substitute or replace one type of income for another, that substitute must meet the same needs and goals (whether they be economic, social, cultural, etc.) as the original. The cases with cane rat farming help to demonstrate when and where this is effective. In Gabon and the Congo, cane rat farming would have required significant training in raising small animals as well as changes to social and cultural norms, whereas farmers in Cameroon had pre-existing experience with small animals. As a result, cane rat farming was more successfully adopted in a place where there were already the skills and norms to support it (Wicander & Coad, 2014). In other cases, alternative livelihoods become a complementary rather than substitute source of income when they are introduced, which may still benefit overall household resilience, yet not be the goal of the program (Wright et al., 2016).

Additionally, members of a community, with different identities, statuses, have differing ability and willingness to adopt a new livelihood (Wright et al., 2016). Some people may see ALPs as proactive or innovative opportunities where they are coping mechanisms for others. The ability to scale ALPs is also dependent on external forces such as population growth or market shifts that could make some activities more or less attractive. Ultimately, designers will be most successful in implementing ALPs if they are based on locally-determined needs and fully recognize the socio-ecological system in which they operate (Wright et al., 2016). The Health in Harmony and Rhino Rangers cases are strong examples of successful projects that did intentional research into local interests (Muntifering et al., 2015; Muccio, 2015).

Finally, biodiversity conservation practitioners often pride themselves on their engagement with local communities and environmental outcomes yet fail to address inequitable power dynamics. PES schemes are inherently tied to land tenure, for instance, and thus may provide disproportionate benefits to those already in positions of power (Knox et al., 2011; Robinson et al., 2018). Social norm-based interventions also fundamentally rely on a powerful group, usually a majority, placing social pressure on those in a less powerful position. The threat of social sanctions is inherent to the effectiveness of any such intervention (Bicchieri, 2016; Chudek & Henrich, 2011). This dynamic can result in inequitable outcomes, particularly if those in lower status positions are not involved in designing the behavioral solution (e.g., Eder, 2010). Applying more social science methodology and concepts in intervention design could start to address these issues. Practitioners should also be mindful that communities may feel alienated

by conservation efforts (Cassidy, 2012). Traditional models of conservation have often prioritized endangered species' survival over human wellbeing and livelihoods (e.g., Barbora, 2017; Jalais, 2005). Here the Rhino Rangers program, community conservation on the Juruá River, and Madagascar's efforts to reduce ploughshare tortoise poaching exist as counterexamples. All of these programs alleviate concerns by both empowering communities to maintain and benefit from their conservation efforts (Campos-Silva & Peres, 2016; Muntifering et al., 2015; Randriamanampisoa & Adams, 2015).

Further Readings

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Climate Mitigation

Introduction

Climate change mitigation refers to human intervention to either reduce sources of greenhouse gas emissions (GHGs) or enhance sinks that absorb these emissions (IPCC, 2014). Numerous comprehensive assessments of the climate system conclude that increasing concentrations of anthropogenic GHGs have been the primary driver of global warming since the mid-20th century (IPCC, 2014; UNEP, 2017). Transportation, energy consumption, and food present some of the most significant opportunities to change human behavior to reduce carbon emissions (Williamson et al., 2018). As a result, this topic includes interventions that encourage shared or alternative transport methods, reduced and green energy usage, and low-carbon or plant-rich diet options.

Analysis Highlights

- Many target actors already value and intend to engage in climate mitigation behaviors, but their behavior does not follow. Interventions that employ choice architecture to draw attention and use saliency are particularly relevant and effective in this context. These solutions help actors to align their values, intentions, and actions.

- Climate mitigation interventions tend to neglect infrastructural constraints. While an actor may be motivated to pursue sustainable transportation or green energy solutions, the infrastructure and resources must also exist (e.g., available transit routes, restaurants that offer plant-rich dishes) for them to change their behavior.

- Differences within groups of target actors translate to variable effectiveness of behavioral interventions. This is clearest for social comparison and framing interventions where the motivations and responses to climate mitigation are different for different genders, value sets, or socioeconomic statuses. Designing for these differences is key to broad effectiveness.

Transportation

With growing urban populations and increased mobility, more people are relying on personal and public transport to get to their destinations. This creates significant opportunities for either many more vehicles on the road or increasingly efficient and low-carbon transport options. The behavior change interventions in this section target the adoption of these greener transport options.

Increasing carpooling and public transit: Planning, commitment, and timely moments

Highlighting transport information and encouraging the deliberate planning of car trips has been demonstrated to be quite effective in reducing car usage (Bamberg, 2002; Eriksson et al., 2008; Jakobsson et al., 2002). Pairing these commitments mechanisms with non-monetary incentives such as free public transportation has also been successful (Bachman & Katzev, 1982; Fujii & Taniguchi, 2006; Katzev & Bachman, 1982; Thøgersen, 2009). In Germany, a 2006 study found that by offering habitual drivers a free public transportation 'try-out' period, municipalities could effectively decrease car use, particularly when pairing this free 'try-out' with a personal commitment from users (Matthies et al., 2006). In Japan, a review of interventions that rely on travel feedback to encourage non-automotive travel found that these programs were particularly successful when participants had to make a personalized behavior plan (Fujii & Taniguchi, 2006). In fact, across the ten travel feedback programs that

Fujii and Taniguchi review, they found that such interventions reduced car use by 18%, increased public transport by 50%, reducing participants' overall CO_2 emissions by about 19%.

Another way of ensuring that intentions translate into action is to use personal commitments in conjunction with descriptive norms. In a Canadian field experiment, researchers paired a commitment to reduce vehicle use with norm information that informed research participants of others' successful efforts to reduce their vehicle use (Kormos et al., 2014). Compared to participants who received no such message, those who did receive a message reduced their vehicle use by approximately five times. Interestingly, norms messaging decreased private vehicle commutes, but not non-commuting trips—likely because, as others have suggested (Eriksson et al., 2008), normative interventions have a stronger pull on habitual choices (like people's daily commutes). Likewise, for many, the commuting trips were much easier to do via public transport than less habitual, non-commuting trips.

Unfortunately, not all interventions using personalized travel plans have been successful. For example, while the above studies do offer significant positive results, often these are small or limited to those drivers that already intend to reduce their car usage (e.g., Eriksson et al., 2008; Matthies et al., 2006). There is also some evidence that this approach may backfire, leading some drivers to reduce their environmental conscientiousness (Tertoolen et al., 1998). A series of interventions led by Kristal and Whillans (2020) found that neither sending letters, emails, offering a 1-week free bus trial, sending follow up letters, or emailing personalized travel plans to drivers had any effect in reducing car commutes. They also highlight the various barriers that planning and nudging may not have overcome. These include the relationship between driving and perceived autonomy in the United-States and the fact that drivers may simply not want to talk with employees they do not know. Most important, however, is that the target behavior may not have been consistent with individuals' self-interest—a core, yet often overlooked, principle of nudging.

It is important to consider both refinements and alternatives to the above interventions. One strategy has been to target participants in moments of transitions, such as moving homes (Verplanken & Roy, 2016). For example, a study on university employees in the UK found that if a person who is concerned about the environment moves house, they become less likely to use a car to commute than environmentally concerned non-movers (Verplanken et al., 2008). Designers have leveraged this insight for program development, finding interventions to be particularly effective right after the actor moves between towns (Bamberg, 2006). Receiving information on the new town's bus system, personalized travel plans to access shopping areas, and a free 1-day ticket to use the bus led to 47% uptake of public transpiration, as compared to 18% in the control (see also, Dai et al., 2014).

Studies of transportation patterns across demographics reveal how difficult it is to design a single intervention to address the needs of a diverse set us users. For carpooling behavior, for example, there are very different needs across age groups as well as gender. Older people are risk-averse and care more about nearby meeting points, vehicle condition, knowing other riders, and alternative backup transportation plans. Women are most concerned about safety and cost (Wilkowska et al., 2014). For personal car use, once again, gender trends prevail. Due to differing social roles, men tend to travel primarily for reasons related to work, where women travel according to their role as caretakers in the family. Men's trips are shorter and direct, where women's are longer and involve more stops, known as "trip chaining." As a result, both genders have quite different transportation needs, often requiring differing interventions to address (Root & Schintler, 2003).

Promoting alternative and efficient transport: Social norms and appealing to values

Instead of appealing to convenience and new habits, messaging campaigns that reframe transport options or leverage social influences are also effective at reducing car use. In 2007, Beale and Bonsall attempted to use marketing materials to address an overly negative public perception of the bus system in Leeds, UK. After their first campaign, they found that the marketing materials had encouraged bus use among those users who already took the bus: people who already liked taking the bus and women. Men, on the other hand, significantly *decreased*

their use of public transport, as did infrequent users and people who already disliked the bus. To address this, the researchers launched a second campaign where they reframed their message for those people who did not usually travel by bus. The second campaign acknowledged that the car was probably the first choice for some trips, but that the bus could also be more convenient for other trips. While the first campaign had seen a reduction of bus usage in men, the second led to a significant increase for men and recent bus users. This message aligned better with some people's perception of public transport and therefore was more successful in changing behavior for the target population (Beale & Bonsall, 2007).

In Malmo, Sweden, municipal officials also made behavior more personal in their campaign to encourage bike use (Hörlén et al., 2008). Building off its main slogan, "No ridiculous car trips," the campaign asked residents to submit written accounts of when that had driven unnecessarily to a location. The city also gave small gifts to cyclists as a thank you for choosing to bike and brought awareness to the convenience and speed of cycling by having cyclists time routes around the city. A year after the campaign, 75% of residents still reported they remembered the campaign's message, and 15% reported a change in their driving behavior. The city of Malmo saw an increase in the number of cyclists, and 12,000 residents made fewer short trips by car. The combination of strategies here was effective in reinforcing positive attitudes around biking.

Beyond decreasing car usage, interventions as simple as 'reframing' the metric used to measure a car's efficiency could be applied to encourage consumers to purchase more energy-efficient vehicles. In the United States, where the fuel-efficiency of a vehicle is conveyed via the 'miles per gallon' unit (MPG), a reasonable alternative would be to use gallons per 100 miles (GPM). Where MPG allows people to estimate the range of their vehicle on a full tank of gas, GPMs are better at conveying the quantity of gas used for a given trip (Larrick & Soll, 2008). Further, MPG does not offer a linear measure of fuel efficiency as it does for range, since the metric has to be converted. For example, replacing a car that gets 12 MPG with one that gets 14 MPG saves more fuel than replacing a car that gets 28 MPG for one that gets 40 MPG over the same distance (p.1593). Testing this directly, Larrick and Soll presented survey respondents with one of two scenarios: i) a choice between replacing 100 vehicles that get 15 MPG with vehicles that get 19 MPG, or replacing 100 vehicles that get 34 MPG with vehicles that get 44 MPG; or ii) replace 100 vehicles that get 6.67 GPM with vehicles that get 5.26 GPM, or replace 100 vehicles that get 2.94 GPM with vehicles that get 2.27 GPM. In the first scenario, only 25% of respondents chose the first option, which offers relatively lesser MPG gains but that reduces fuel consumption considerably. In the second scenario, 64% percent of respondents chose option one—an increase of 39%. GPM appears to make fuel-consumption easier to understand, explicit, and allows consumers to easily estimate cost-savings relative their gas usage.

Alternatively, rather than reframing the metric that leads to problem behaviors, practitioners can reframe problem behaviors themselves, such as encouraging more efficient use of the car. Bolderdijk et al. (2013), for example, found that marketing campaigns often promote energy conservation using economic rather than environmental arguments, but people much prefer to see themselves as 'green' rather than 'greedy' (Bolderdijk et al., 2013, p.2). Using this to inform a field experiment, the team tested four different sandwich-board messages to encourage US drivers to collect a free tire-check coupon while refueling: an environmental one, an economic one, a safety appeal, or a neutral, control message. Over the span of 22 observation days, Bolderdijk et al. found that drivers took significantly fewer coupons after seeing the economic message (0 percent) as compared to the environmental one (8.7 percent). In a similar study, Yeomans and Herberich (2014) conducted a field experiment at a US gas station where they looked at six different interventions to combat 'tire-pressure neglect' of drivers with low tire pressure. These interventions leveraged various combinations of information and social norms, paired with monetary incentives and social pressure. Out of these combinations, the study found that the impact of social norm messages (i.e., telling customers that 70% of people drove with under-pressurized tires) greatly depended on the accompanying incentive. When paired with social norms, monetary incentives (like waiving the pump fee) decreased the likelihood that someone would inflate their tires, but pairing the norm with an attendant's offer to help reliably increased this likelihood. While the perceived benefits of inflation may still have been too low for people to do it on their own, the added social pressure of a personal request was able to drive behavior change.

Encouraging the adoption of electric vehicles: Social norms and reducing uncertainty

In contexts where personal vehicle-use is necessary, entrenched, or required, encouraging consumers to adopt plug-in electric vehicles (EVs) allows drivers to maintain their autonomy while offering benefits to the wider community, such as reducing CO_2 emissions and air pollution. Still, many psychological and social barriers stand in the way of mass EV adoption. Around the world, high costs, range anxiety, and lack of vehicle choice are commonly associated with lower intentions to switch from internal combustion vehicles to electric ones (Egbue & Long, 2012; Kim et al., 2017; Park et al., 2018). There are also concerns as to the charging infrastructure and energy-efficiency of EVs, particularly when the electricity generated to power them still relies on fossil fuels (Degirmenci & Breitner, 2017; Egbue et al., 2017).

Regional and cultural differences determine how much target actors weigh the above concerns: in China, for example, consumers are less resistant to non-hybrid, plug-in EVs when compared to an American audience (Helveston et al., 2015). Chinese consumers are often first-time buyers and have no previous experiences with either type of vehicle; however, they do have experience with plug-in electric bikes. An inexpensive and far-reaching public train system also allows Chinese consumers to be less reliant on their personal vehicles when wanting to travel long distances. Air pollution is also an important difference between markets: the higher the particulate matter ($PM_{2.5}$) concentration in Chinese cities, the higher the sales volume of plug-in EVs (Guo et al., 2020).

While far from exhaustive, the above serve to highlight the concerns that policies seeking to increase EV adoption should target. Policy-makers have also found that providing benefits to EV drivers could encourage adoption: incentives like bus or transit lane access, toll-free parking or road access, as well as improving EV-relevant infrastructure all contribute to higher EV adoption rates (for review, see Hardman, 2019). Alternatively, behavior change practitioners may use behavioral levers to sway consumer decisions. In Italy's northeast region, most material barriers to EV adoption are low, yet uptake remains stagnant. Researchers have found that making future cost-savings more salient increases the likelihood of someone choosing an EV over an internal combustion alternative (DellaValle & Zubaryeva, 2019). They also found, however, that providing participants with a descriptive norm[3] relative to EV purchasing in their region did not significantly encourage EV choice—likely because the adoption rate was too low to meaningfully change people's perception of the norm. A similar study in Germany corroborates this result: descriptive norms about EV use in their region did not significantly influence EV acceptance, but injunctive norms did (Barth et al., 2016). When asked directly, participants responded that cost and environmental benefits were mostly driving their acceptance of EVs. Yet, survey results suggest that people are significantly influenced by both what they perceive others would approve of and what they perceive others would choose themselves (see also, Axsen et al., 2013; Cherchi, 2017; Thulin & Rakhimov, 2019). In a stated-choice experiment in Nepal, researchers chose to denote the air pollution impact of different kinds of motorcycles using injunctive messaging (i.e., smiley faces for electric motorcycles and sad faces for internal combustion ones). Compared to a group where such messaging was not used, 8.3% more participants said they would purchase an electric motorcycle over an internal combustion one (Filippini et al., 2020).

As with many 'green' decisions, social norms have the potential to be powerful tools for change for EV adoption. And while there remains little testing of behavioral interventions to increase EV adoption in low-income countries, evidence suggests such approaches are likely to be successful. Al Mamun et al. (2019), for example, reports that social norms are likely to be key in encouraging EV adoption in Malaysia. Researchers have made similar claims regarding the EV market in India (Khurana et al., 2020). If practitioners can identify and encourage early adopters to

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3   Several nations and subnational governments distribute visually distinct license plates to EV owners: the United Kingdom, Norway, California in the US, and the provinces of Quebec and Ontario in Canada. No formal evaluation of their impact on consumer choice has been conducted, as they are mainly used for law-enforcement to identify those cars that get access to certain transportation benefits, but the increasing number of 'green' license plates is likely to make more salient the increasing number of EVs on our roads. In other words, green license plates serve as a dynamic norms message, particularly for 'hard-to-distinguish' vehicle models.

interact with non-adopters and serve as social proof, interventions utilizing social norms are likely to become a good strategy in developing markets (e.g., Seebauer, 2015).

Another encouraging area of investigation is in altering the point-of-purchase itself, such as factors that may reduce EV adoption when consumers interact with the seller. For example, researchers have found that even in Nordic countries where EV adoption is high relative to the rest of the world, car dealers were often dismissive of EVs, misinformed customers, or neglected EVs as options altogether (Zarazua de Rubens et al., 2018). This had a significant impact on buyers who rely on dealers' knowledge and recommendations to make 'informed' decisions about EVs. A similar study in Ontario, Canada, found that a lack of EVs on-site for consumers to test was a significant barrier to adoption (Matthews et al., 2017). The decision to purchase a vehicle is a significant one, and so the provision of reliable information and ability for consumers to validate this information (through a test drive) should be an important component of any behavior change strategy. The relevance of these findings is likely to extend beyond Europe or North America, yet there is yet no published evidence of interventions being deployed that target these barriers specifically.

Energy

In addition to transportation, energy use is one of the biggest contributors to greenhouse gases, both in the source and amount of energy we consume. This section offers evidence of interventions that have aimed to change behavior to increase green energy consumption and energy conservation.

Increasing green energy and energy efficiency: Defaults

One particularly effective way to increase energy conservation has been to leverage the 'default effect.' Put simply, the default effect refers to the phenomena whereby pre-selecting options for decision-makers makes them more likely to adopt and stick with that option. As a result, behavior change intervention designers have started using defaults to affect energy use: for example, by making energy conservation schemes the norm when selecting utility plans. An intervention seeking to increase green energy consumption for 40,000 German consumers did this by swapping the typical 'opting-in' policy on green energy contracts to one where consumers were automatically enrolled unless they 'opted-out' (Ebeling & Lotz, 2015). Though the green contracts were more expensive, the new 'opt-out' condition led to ten times more subscriptions: 7.2 percent in the opt-in condition and 69.1 percent in the opt-out condition. In the United-States, a similar approach was used to encourage the adoption of time-based utility pricing (Fowlie et al., 2017). While those who had to actively opt-in to the time-varying policy typically reduced energy by 25%, only 20% of customers actively chose to do so. By comparison, over 90% of customers in the opt-out condition remained in the time-based policy, although they only reduced their energy demand by 10% during peak periods. Due to the larger number of people affected by the opt-out condition, the impact and savings generated by the policy proved much greater, even with the smaller average amount of energy reduction.

Outside of households, researchers are also using defaults in buildings and offices. The OECD launched a randomized controlled trial at their offices and found that a 1˚C decrease in the default thermostat setting (from 20˚C to 19˚C) led to a reduction in the occupant-chosen settings by 0.38˚C on average (Brown et al., 2013). Importantly, this was not the case if the decrease was larger (from 20˚C to 17˚C), suggesting that if the change was large enough to be noticeable and/or uncomfortable, people would increase the temperature themselves. This raises concerns about ensuring a default setting meets people's needs and preferences.

Leveraging defaults in a way that truly preserves people's freedom of choice is a constant debate amongst social and behavioral scientists (Smith et al., 2013). While there are cases where defaults align with individuals' stated preferences (e.g., using energy-efficient lightbulbs; see Dinner et al., 2011), there are many cases where they do not. For example, in Ebeling and Lotz's study on green energy defaults, 100% of people who actively choose 'green' energy in the opt-in treatment were able to recall their decision. In the opt-out treatment, however, this number

dropped to 84.13%. Similarly, only 60% of respondents who did not swap out of the American time-based pricing policy could demonstrate that they effectively understood the electricity rates they were paying, as compared to 85% of those who actively opted-in (Fowlie et al., 2017).

Most recently, a study by Ghesla et al. (2020) found that defaults disproportionately affect lower-income relative to higher-income households. Four years after a Swiss utility company had implemented green contracts as defaults, residents with lower incomes, less education, and who did not own property were less likely than others to have opted-out of the green default policy. As a result, low-income households were paying more than they would prefer to for green energy, while high-income households were typically paying less than they were willing to for green energy. Even higher-income households who were interested and able to pay for greener contracts did not know enough about how to switch away from the default. Given the effectiveness and durability of defaults, 75 percent of these households still had the default green contract four years after the intervention, ensuring the durability of the unintended inequitable outcome.

Increasing energy conservation: Appealing to values

As we have seen previously, the use of defaults is one way of swaying consumer's decisions. Reframing or recontextualizing choices is another way. Where defaults rely on people passively going with the pre-selected choice, framing allows behavior change intervention designers to encourage active choices in situations where a default is less practical, or when the saliency of specific information could better inform consumer decisions. For example, a study by Asensio and Delmas (2016) found that reframing US households' energy conservation efforts relative to their impact on human health (for example, reducing the risk of asthma or lung cancer) engendered long-lasting energy savings of around 8-10%. For families with children, the health frame was even more effective (Omar I. Asensio & Delmas, 2015). A study by Permana et al. (2015) further nuances understandings of family energy use through gender differences. Regardless of a husband and wife's income, when women are in control of energy consumption, usage tends to be lower due to their greater concern with household expenses. Accounting for this, energy interventions might focus on increasing women's energy consumption decision making power, or by targeting men as inefficient consumers.

In Germany, a survey study highlights how framing energy-saving behaviors in terms of their CO_2 emissions may also spill over to other climate-friendly behaviors (Steinhorst et al., 2015). Presenting the impact of unique behaviors (like installing energy-efficient light bulbs, or reducing dryer use) as either cost-saving (in €) or CO_2 saving, Steinhorst et al. found that the environmental framing uniquely encouraged spillover behaviors by making people's pro-environmental goals salient, which then activated a general personal norm for climate-friendly behaviors (see also, Spence et al., 2014). Where both environmental and monetary framings had a positive impact on energy saving intentions, only the environmental framing—through its effects on people's personal norms and perceptions of self-efficacy - affected other climate-friendly intentions.

Similarly, affixing energy-efficiency labels to appliances in stores reminds consumers to think long-term when buying washers, dryers, dishwashers, etc. In the UK, labels with information on total lifetime running cost (in addition to the more 'ambiguous' EU labels and kWh per year) led to the sale of washer-dryer appliances that were 0.7% more efficient on average than those bought in control stores without the label (Behavioural Insights Team (BIT), 2014). There was no effect on washing machines or tumble dryers individually, though, likely because their lifetime energy consumption was far smaller and less salient than for a combined washer-dryer.

An important aspect to consider when framing messages like energy-labels is that not every label is created equal, and different people respond to these labels in different ways. For example, in European audiences, energy efficiency scales and labels that use letters rather than numbers are generally better understood and lead to more energy-efficient purchasing (London Economics, 2015). The evidence also suggests that the impact of a label's design is greatest for those who consider energy efficiency of low importance by making it simpler and more salient

for those who would otherwise not take on the effort. Successful framing interventions must consider the needs they are meeting (beyond just providing more information), the underlying motivations of their target actors, and how best to deliver a message to make it most salient and relevant (Banerjee & Solomon, 2003).

Increasing energy conservation: Social norms and comparison

Beyond changes to the decision-making context and framing, social comparison is also a powerful tool for changing energy behavior. For example, by comparing the energy use of one group of households to another, practitioners create the ideal setting in which social expectations encourage energy-saving behavior.

In collaboration with the software company Opower, Allcott and Rogers (2014) studied the effect of providing consumers with Home Energy Report where information about their energy usage was compared with their neighbors' energy usage. With a sample size of over six million customers, they found that those who received comparative information over many months reduced their energy use by 1-2% (Allcott, 2011) and that these effects persisted over four to five years, as long as the information was provided continuously on a monthly basis (Allcott & Rogers, 2014). A more recent study found that using Home Energy Reports in conjunction with timely, salient comparisons (e.g., when energy demands peak) could increase these energy savings even further from 2-4% to 7% (Brandon et al., 2019).

Giving Feedback, Getting Energy Savings

Beyond monthly home energy reports, smart meters have increasingly become a way that households can get real-time feedback about their energy usage. Several studies have found creative methods of delivering this information to people while also learning insights about maximizing user engagement (Buchanan et al., 2015). For example, home energy displays can pair personal energy use information with social comparative or normative information (Kaaukauskas et al., 2017). A two-year study of residential energy consumption found that normative feedback was effective at reducing household energy use (De Dominicis et al., 2019). Energy feedback can also be customized in the way that the amount of energy is conveyed, such as using numerical or visual, ambient feedback. A Dutch study compared whether giving the number of watts consumed was more or less effective than a lamp that would change color according to energy consumption. The lamp condition led to a 21% decrease in energy use and was also easier to understand than the numerical feedback (Maan et al., 2011). Overall, feedback interventions perform best when they also engage users in a compelling way.

Looking to social influences beyond just comparison, a team of researchers looked at how leveraging reputation could alter participation in energy demand response programs in California (Yoeli et al., 2013). They offered 1400 homeowners to opt-in to the program via a sign-up sheet with two randomized conditions. One required residents to write their name and address on the public sheet (i.e., making individual conservation choices observable), whereas in the other condition, participants used an anonymous code. After just a few days, the difference in participation was significant: participation was nearly three times higher if neighbors could identify who had opted-in rather than being anonymous. The researchers found that this effect was greatest for those whose reputation in

the community mattered most: residents of apartment buildings (compared to those in houses), and homeowners (compared to renters). This intervention was also much more effective than a monetary incentive of $25 to sign up for the program, with researchers estimating that they would have needed to offer the equivalent of $174 per resident to have the same effect. This study showed the importance of observable decisions that have real consequences for yourself and others (see also, Griskevicius et al., 2010).

The direct observability of green choices further makes an evolving norm more salient. For example, solar panels are observable features of buildings and their presence in a residential neighborhood can lead to more residents adopting solar as an energy source (Müller & Rode, 2013), as well as serving as a type of *social proof* for those individuals still unsure about the technology (Rai & Robinson, 2013). Solarize, a campaign to boost solar energy in the US, identified the importance of social proof and observability as key to solar adoption. The campaign used a multi-faceted approach with a foundation of community outreach in which local ambassadors would help to educate and encourage residents about solar energy (Gillingham & Bollinger, 2017). Solarize also tackled the high upfront cost of adopting solar energy as well as customer inertia by recruiting local government and solar contractors to support the community-led campaign. They bundled purchases between neighbors and received discounts from vetted suppliers. Solarize also mitigated the effect of status-quo bias through a time-bound discount campaign, making people feel that the time to act was limited and actively encouraging the choice to go solar.

As these examples demonstrate, most interventions that leverage descriptive norms to compare energy-users are from programs in high-income countries: the United States (e.g., Ayres et al., 2013; Brandon et al., 2017; D. L. Costa & Kahn, 2013; List et al., 2017), Europe (Behavioural Insights Team, 2011; Kandul et al., 2020; OECD, 2017), and Australia (Hurlstone et al., 2014). However, these programs have been expanded to South Africa and India as well. In Cape Town, for example, Ideas42 ran an intervention examining the use of inter-floor comparisons to reduce energy use in a large, non-residential office building (Klege et al., 2018, 2018). They found that by recording half-hourly meter readings from different floors and using this to create a weekly competition between them, energy use could be lowered by an average of 9% compared to floors with no competition. Adding 'floor advocates' who were directly responsible for turning off or asking others to turn off appliances increased savings to 14%, a remarkable finding given that most social comparison interventions see reductions of between 1% and 7%. Moreover, the effect remained durable over a period of 5 months—durability made all the more surprising after accounting for the fact that workers were not paying for their energy use (but see also, Bator et al., 2019).

In India, a randomized control trial found that peer comparisons were effective in reducing household energy use by 7% (Sudarshan, 2017). The intervention identified high-energy users as the individuals most influenced by the comparison but that pairing the comparison with monetary incentives (i.e., rewarding or punishing households depending on their ranking) eliminated rather than augmented the intervention's effectiveness. Given that participants already did not trust their government and utility providers, Sudarshan speculates that the monetary incentive may be interpreted as an attempt of the utility to benefit rather than to support consumers or the environment.

It is important to note that social comparison interventions are vulnerable to what researchers call 'the boomerang effect.' Schultz et al. also demonstrated this effect in a 2007 study where they found that although a social comparison intervention had decreased energy consumption on average, it had only truly worked for households that were above the average level of energy usage. In fact, not only did the intervention not work for households already using less energy, it actually *increased* their consumption to be more closely aligned with others' behavior.

Food

A third category of carbon-emitting behaviors relates to food consumption, particularly of meat, such as beef. Diet and food choices contribute a large portion of greenhouse gas emissions and are also a growing reason for deforestation and the production of monocultures. Interventions in this section focus on eating less meat and choosing more plant-rich options.

Promoting plant-rich diets: Increasing saliency and appealing to values

Behavioral interventions on food choices focus on encouraging the selection of lower-carbon food options—oftentimes by discouraging meat consumption and encouraging vegetarian alternatives. These interventions primarily encourage vegetarian choices via choice architecture efforts that increase the salience of vegetarian menu options by changing their order (Kurz, 2018), increase the relative quantity of these options versus non-vegetarian ones (Garnett et al., 2019), or make meatless options the default (Campbell-Arvai et al., 2014; Campbell-Arvai & Arvai, 2015).

A study by Bacon and Krpan (2018) looked at the ways in which changing the way that vegetarian options are presented on a menu could sway consumers purchasing of vegetarian meals. In an online experiment, Bacon and Krpan presented participants with four different menus: i) one where all dishes were presented the same way (the control), ii) one where the vegetarian dish came 'recommended by the chef,' iii) one where vegetarian dishes had more appealing descriptions, and iv) one where vegetarian dishes were shown separately in their own' section.' They found that those menus that 'recommended' or tastefully described vegetarian dishes increased the likelihood that these would be ordered by infrequent vegetarian eaters, but that they also decreased the likelihood of vegetarian orders for frequent vegetarian eaters by around 65.3%. Separating vegetarian dishes had no impact on infrequent vegetarian eaters, but it did decrease the likelihood of ordering for frequent vegetarian eaters by 57.8%.

Self-identity and past behaviors (i.e., the frequency with which one has vegetarian food) were important factors in the online menu experiment. As another form of the boomerang effect, describing or recommending vegetarian options backfired for those vegetarian eaters already doing the recommended behavior, even reducing their intentions to eat vegetarian again in the future (Bacon & Krpan, 2018). On the other hand, the menu changes were highly effective for non-vegetarians—the description and recommendation menus increased the likelihood by roughly 108% of these participants choosing a vegetarian dish. Additional studies by Bacon et al. (2018) and Vennard et al. (2018) on labels for vegetarian food demonstrated that describing plant-rich options with words about their cuisine or ingredients (e.g., 'field-grown,' 'Cuban black bean soup') signaled something more appetizing than descriptions that highlighted what the dishes lacked (e.g., 'meat-free,' 'low-fat').

Reframing meat dish options relative to their CO_2 emissions might also be an effective way of encouraging a more vegetarian diet. A lab experiment looked at the effect on sales of high-emissions foods (e.g., beef soup) of adding food labels that described the energy used to make the product in lightbulb minutes (Camilleri et al., 2019). Compared to participants who were shown no such label, those who did purchase 50% fewer high-emissions products. By making the environmental impact of meat (or milk, see Thøgersen et al., 2012) salient and simple to understand, the intervention reframes the choice of consumers in a way that makes decisions about more than just price and taste.

Social scientists examining food choices and decisions describe them as deeply tied to people's social, personal, and cultural values and less to feelings of urgency around climate change. Eating is further a pleasurable activity and often a social one, especially during major events and traditions. As a result, there may be a wide range of motivations and barriers to consider, some of which are outside of an individual's control (Macdiarmid et al., 2016). It is important to recognize that the barriers to reducing meat consumptions differ across social positions. Those experiencing these barriers most acutely include men, rural residents, and those with low education (Pohjolainen

et al., 2015). However, researchers also find that being exposed to non-meat consumption lowers the perception of the strength of these barriers. This suggests that interventions that encourage trial, such as offering vegetarian dishes in cafeterias, which is therefore expected to increase adoption in other settings. Being exposed to others eating non-meat meals is expected to have similar effects.

Promoting plant-rich diets: Social norms

Finally, as with the section on transportation and energy conservation, the use of social norms is likely to be a very effective tool in encouraging a healthier and more sustainable diet (Higgs et al., 2019). There is recent evidence that bringing attention to the way a norm is changing—rather than the current norm itself—might have a greater impact on people's food choices.

Sparkman and Walton (2017) ran an experiment where they compared the impact of providing information on a *dynamic norm*, i.e., the trend of how people's behavior is changing over time, versus a static one, i.e., people currently behave. When café customers were told that '30% of Americans make an effort to limit their meat consumption', 17% of customers chose the meatless option. In contrast, customers told that 'in the last five years, 30% of Americans have now *started* to make an effort to limit their meat consumption' led to 34% of people ordering a meatless lunch. Further work on the subject has identified that dynamic norms are particularly effective when consumers feel 'connected' with those consumers who form the norm (Sparkman et al., 2020). The use of dynamic norms is especially relevant for situations where only a minority of people doing the desired behavior, as simply disclosing the static norm that the behavior is rare is likely to lead to a boomerang effect (Mortensen et al., 2019; Sparkman & Walton, 2019).

Analysis

Climate scientists around the world are demanding immediate action on greenhouse gas emissions. Research into what can encourage climate mitigating behaviors is needed now more than ever. The behavior change literature focuses on situations where decisions are made at the individual level and could create a significant impact if realized at scale.

Review of the strength of the evidence

For transportation interventions, personal planning and goal setting appear to be the norm for promoting public transportation use or carpooling. These interventions are primarily correlational and exploratory with lower internal validity, but they have valuable insights for future campaigns and programs. For example, interventions appear to be most effective when people have to develop their own personalized travel plans (as opposed to someone else providing them) and when target actors are going through moments of transitions that offer opportunities for habit disruption and formation. For EV adoption or encouraging energy-efficient driving, we instead find the literature mainly evaluating the effect of social norms messaging.

For energy interventions, the use of choice architecture through defaults and social influences through social comparison and observability are consistently effective. In cases of social comparison, however, it is important to keep the *boomerang effect* in mind: salient norms can lead to different behavior for energy users above and below the norm. Message framings around health and environmental impacts of energy also appear to be effective. One particularly successful framing is making salient the environmental cost of appliances, products, or high-energy behaviors during use or at the time of purchase.

This was also true for interventions that are designed to encourage a more vegetarian, sustainable diet. Choice architecture has helped to increase the salience and availability of vegetarian options and highlight the ecological cost of meat through solutions like adding labels. While there has been some research on food choices and social

messaging, the evidence-base remains biased towards choice architecture and menu design. There is a need for more research on the impact of these interventions among their different actors, particularly those who already identify as vegetarian or vegan. For example, several studies showed that interventions were most effective for people who did not already have plant-rich diets but had a rebound effect for people already eating less meat (Bacon & Krpan, 2018).

Unlike transportation interventions, energy and food interventions have been tested and replicated through experiments that establish clear and consistent links between interventions and target behaviors. They vary in their ecological validity, with interventions taking place in naturalistic conditions, lab studies, and online experiments. Most of the research in this section can be thought of as trying to replicate or extend the findings of earlier interventions, although there is less diversity among food interventions. Their impact was thus directly tied to their ability to scale behavioral and social theories to new contexts and change people's norms and expectations.

Most studies lacked any measurement of durability beyond the intervention period, but social comparison interventions showed durable results up to five years into the future. There is also a lack of geographic spread in the interventions. Almost all interventions that encourage climate mitigation behavior have taken place in high-income countries in the United States, western Europe, or Japan. There is a clear lack of research in low and middle-income countries and contexts. The few studies that have explored these settings have provided particularly insightful results.

Review of the application of behavioral science

A recurring problem regarding climate mitigation efforts is that people's intentions, attitudes, or values do not always align with their actions. Behavioral scientists refer to this as the intention-action gap (or attitude-behavior gap or value action gap; see Blake, 1999). It is a phenomenon that is particularly rampant in the environmental field; people generally want to reduce their CO_2 emissions, but they take no action to do it (Flynn et al., 2009; Kollmuss & Agyeman, 2002; Lane & Potter, 2007).

There are several explanations for the intention-action gap. Studies often find that consumers blame their lack of knowledge regarding the actions they can and should take (Kennedy et al., 2009). Also, 'being green' necessitates more time, money, and space in our lives than what we perceive is generally available (Young et al., 2010). Interventions that make 'green' choices easier or those that cater to our cognitive biases are some of the most effective at encouraging climate mitigation behaviors. For example, interventions that rely on the default effect are effective because they leverage our tendency towards going with the current option (e.g., Brown et al., 2013; Campbell-Arvai et al., 2014; Ebeling & Lotz, 2015).

Similarly, labeling interventions (e.g., Behavioural Insights Team (BIT), 2014; Camilleri et al., 2019; London Economics, 2015; OECD, 2017)) work because people focus on a small set of salient variables when making decisions (i.e., we satisfice[4] rather than optimize our choices). By increasing the saliency of the information that we would otherwise ignore, green labels make it easier for decision-makers to align intention with action. Moreover, interventions that ease decision-makers' ability to follow-through on public transport commitments (Bamberg, 2006; Matthies et al., 2006; Thøgersen, 2009) or make more salient the health-impacts of electricity production have been effective (Omar I. Asensio & Delmas, 2015; Omar Isaac Asensio & Delmas, 2016). Intervention designers should seek to make intended choices simple, clear, and easy while considering the behavioral biases that support behavior change.

In cases where people do not have set intentions, social norms can help to promote target behaviors. Norms that align with desired behaviors increase the potential for social and reputational benefits (e.g., recognition, pride),

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4 Satisficing is based in the theory that humans do not possess infinite computational ability. Instead, we have a finite and biologically-'bound' cognitive capacity (Simon, 1956). Because of this, human decision-makers only have the capacity to consider and pay attention to a limited set of information when making decisions. We do not optimize each and every one of our choices (as a supercomputer might). We satisfice (combining satisfy and suffice) among options with a limited set of criteria that our brain uses when making decisions.

which can compel people to make 'greener' decisions. Conversely, social pressure (e.g., guilt, shame, etc.) can motivate people to avoid unsustainable behaviors. For example, norms can mean someone is recognized in their community for installing solar panels or judged for keeping the air conditioning on all day. People's inherent desire to conform becomes a highly powerful motivator when a community's average behavior is made visible and explicit (Allcott, 2011; Brandon et al., 2019; Kandul et al., 2020). This motivation is even stronger when our own behavior is also made visible to the community (e.g., Griskevicius et al., 2010; Müller & Rode, 2013; Yoeli et al., 2013). Finally, intervention designers should be mindful of the boomerang effect that drives well-performing households to consume more electricity, consumers to avoid purchasing EVs, or vegetarians to revert to meat: people tend to center their behavior on visible norms, regardless of their position relative to that norm. The use of injunctive or dynamic norms over purely descriptive ones may avoid or alleviate such effects (e.g., Barth et al., 2016; Sparkman & Walton, 2017).

Review of the application of social science

The application of behavioral insights has become prevalent in the fight against climate change, but there is less emphasis on integrating insights about the wider socio-ecological system. We highlight four main areas where intervention designers could do more to understand local contexts and dynamics in their intervention design.

The first involves a more systemic approach to behavior change. Many of the environmental problems illustrated in this section are structural with complex chains of actors (e.g., transportation, energy consumption, meat-eating). Yet, the current focus of climate mitigation interventions is on the behavior of individuals within the established system. For example, personalized travel plans and commitments may help some individuals use more public transportation (Fujii & Taniguchi, 2006; Matthies et al., 2006). A more impactful approach could be to address the socio-cultural barriers and norms to bus or train use (Kristal & Whillans, 2020). Additionally, Kormos et al., (2014) find that a normative messaging approach leads to a decrease in commuting trips but has no impact on non-commuting, task-specific trips. One program that emerged as engaging a number of actors and interests is the Solarize initiative (Gillingham & Bollinger, 2017). It targeted the behaviors of various actors in the system, including local government to provide symbolic and material support, local suppliers to provide discounted rates, and local organizers to provide community capacity building. This approach exemplifies behavior change that focuses on both the enabling social environment as well as the behavior of the direct actor.

The second area of improvement involves the homogeneous treatment of target actors. There is little acknowledgment of their varied needs, motivations, and social positions as related to climate mitigation behaviors. Yet, we know that different groups of people can react very differently to these interventions. Social analyses provide valuable insight into how homogenous messaging interventions may fail to address the diverse needs of heterogeneous actors. For example, a review of travel behavior in Europe and North America found that women were far more likely than men to take on the gendered role of caring for family and home. As a result, they often make less direct, multi-destination trips that do not occur on major transportation routes (Root & Schintler, 2003). In contrast, men's trips revolve around commutes to and from work on central routes. A personalized travel plan can only go so far in encouraging the use of public transport if said transport is geared only mainly to serve 'commuters. Additionally, besides Filippini et al.'s (2020) efforts to promote electric motorcycles in Nepal, we found no behavior change efforts exploring more informal, fuel-efficient transport options found in many parts of the world (e.g., *autos* in India, *bodas* in East Africa, and motorcycle taxis in Central America and Southeast Asia). These offer alternative solutions to transportation systems where highways are less common (Vermeiren et al., 2015) and improve the sustainability and access to urban transportation (Evans et al., 2018). More behavioral and social scientists should explore the potential of three-wheeled and two-wheeled vehicle electrification efforts.

Beale & Bonsall's (2007) social marketing campaign on bus use is a unique example of how identifying and addressing social differences can determine behavior change. Their first intervention identified that general marketing materials mostly encouraged women and frequent bus riders. In their second iteration, they tried

messaging that described buses as more convenient and logical than cars for specific types of trips, which appealed to men and infrequent bus riders. Where their first campaign had seen a reduction in bus usage by men, the second one led to an increase in bus riding, even though it appealed less to women. Practitioners should also be mindful of the diverging needs and perceptions of different cultural groups when attempting to replicate such interventions outside western Europe or North America (see, for example, Van et al., 2014, on the role that perceptions of public transport systems being 'chaotic' and 'unorderly' might play in Asia).

For energy interventions, providing eco-feedback through social comparison (Allcott, 2011; Jachimowicz et al., 2018) produces significantly different responses depending on the target population's culture (Ma et al., 2017). Social scientists have identified how gender and age shape the energy needs of decision-makers (Root & Schintler, 2003; Wilkowska et al., 2014). In Indonesia, for example, husband-wife household dynamics affect how much energy a household uses. When women control decisions about energy consumption in a household, energy consumption is lower than when men make decisions (Permana et al., 2015). Because women tend to be more cautious about household expenditures than men, gender becomes an essential consideration for intervention design. However, none of the interventions we reviewed target men specifically to reduce energy usage, emphasize the cost of energy-use to women, or try to empower women to make household energy decisions. There are few studies that have addressed gender but as part of a larger appeal to families, such as how individuals with children react more strongly to a general health frame (Omar I. Asensio & Delmas, 2015).

Third, we find that many interventions do not incorporate an explicit analysis of the relationship between the intervention target and the intervening institution. A failure to investigate these factors can lead to unintended consequences. For example, Sudarshan (2017) found that pairing social comparisons with monetary incentives to reduce energy usage nullified the former's effect. This was not due to some psychological bias but rather the specific relationship between Indian consumers and the government's electricity providers. Consumers' lack of trust in the implementer resulted in them seeing comparison-driven discounts as a way to disguise price surges in the future. Intervention designers should be mindful of the relationship between the actor and implementer to prevent potential backfire effects and support more equitable interventions.

Finally, ethical behavioral interventions should strive to prioritize target actors' goals and interests. Many climate mitigation behaviors ultimately come at a cost for consumers. For example, carpooling to work may reduce workers' autonomy because they are now bound to others' schedules (Kristal & Whillans, 2020) or feel a loss of liberty without their vehicle. In the U.S., driving and its associated institutions of suburban living, highway diners, and a car-centric popular culture emphasize individual freedom above everything else (Seiler, 2012). The adoption of plant-based diets also contradicts many personal and cultural values around eating meat. Plant-rich dishes still suffer from a stereotype of creating a less pleasurable or enjoyable eating experience (Macdiarmid et al., 2016) as well as a social judgment from meat eaters (MacInnis & Hodson, 2017). Behaviors like carpooling and choosing vegetarian dishes exist within a complex socio-ecological system and could burden those trying these for the first time unless practitioners address existing norms and values.

There can also be real financial costs for low-income and less-educated individuals if their interests and needs are missing from an intervention's design. For example, Ghesla et al. (2020) examined how green energy defaults in Switzerland disproportionately affect the poor by signing them up for more expensive energy contracts without their full awareness. Four years after the implementation, residents with lower incomes, less education, and who did not own property still had the expensive, default energy contract. While these residents had the choice to select a different contract, they found it difficult to do or did not know how to switch. Practitioners should not equate the existence and perception of options and need to ensure that people's free choice and personal autonomy are truly maintained.

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TOPIC 3:

Water Conservation & Management

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

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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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TOPIC 4:

Waste Management

Introduction

As human populations grow, so do the waste we produce. Current estimates of per capita per day waste generation are .74kg on average but can range from .11-4.54 kg depending on the country. As countries industrialize and urbanize, they generate more waste, with high-income countries being the largest waste producers. Waste management is one of the most critical services that towns and cities provide to their residents and are increasingly adding operations to manage both recyclable and compostable materials. Recycled materials represent about 16% of waste streams in low-income countries and 50% in high-income countries (Kaza et al., 2018). Plastic pollution has received significant recent attention due to its increasing presence in natural habitats, especially in oceans. It is estimated that plastic production has doubled every 11 years since 1950 and that there are 580,000 pieces per square kilometer in oceans (Law, 2017; Wilcox et al., 2015). The low rates of recycling, reusing, and properly disposing of waste also are problems around the globe in household and public settings. This topic covers three main areas of waste management: household waste, consumer waste, and public waste.

Analysis Highlights

- Many of the target actors for behavioral interventions already value and intend to reduce their waste and engage in recycling. Here we see a gap between intention and action, similar to that observed in *Topic 2: Climate Mitigation*. Effective and efficient interventions therefore include altering the architecture of the choice environment to make salient what choice would be consistent with their existing values and intentions, rather than attempting to change underlying motivations.

- Many of the most effective interventions for shifting waste management behaviors involve influencing habits. This can include interrupting existing habits to encourage reflection on other values or intentions or building new habits where the behavior reduces waste. This is consistent with the point above, where these interventions are effective precisely because they are consistent with existing values.

- The interventions covered in this section generally focus on altering the choice architecture and largely neglect other structural elements that would provide substantive support for engaging in the target behavior. While these changes are themselves behavioral, they involve changing the behavior of actors elsewhere in the system to make adopting better waste management practices materially easier for the target actor.

Household Waste

While waste management has many facets, targeting household waste offers significant promise in terms of scalable, adaptable solutions. These are behavioral interventions that focus on the waste management choices made by individuals in private at home (such as recycling and food waste), as well as those that reduce sources of waste coming into the household.

Reducing waste: Providing salient reminders and decision aids

Choice architecture interventions operate by changing the decision-making context, often in how choices are presented, framed, or prompted. Many interventions on waste management offer solutions that target those choices that people make out of habit. For example, an intervention in the UK was successful in increasing the

amount of collected food waste (from a compost bin rather than a trash bin) by 29.74% simply by placing stickers on people's trash bins that said, "No Food Waste Please" (Shearer et al., 2017). A simple solution that, with a cost of just 0.35£ per household, maintained its effectiveness for over four months.

Similarly, the Netherlands Nutrition Centre engineered a straightforward solution to another pervasive, but related problem: making too much food. The 'Eetmaatje' Measuring Cup, developed in partnership with the Dutch Creative Brands Group, aims to reduce food waste in Dutch households by making salient the exact quantities of rice or pasta need to feed different numbers of people (van Dooren et al., 2020). If used as intended, the cup has the potential to reduce food wastage by approximately 6% for pasta and 21% for rice. Between 2014 and 2019, 1.6 million free Eetmaatje cups were distributed to Dutch households. Of those provided with the cup, 77–87% reported that it helped them waste less pasta, with 50-80% stating that they used the cup most times that they prepared meals (van Dooren et al., 2020). The cup simplified choice for consumers through a nudge that helped make healthy and environmentally-friendly portion sizes salient and easy to achieve. Likely tied to more than just the Eetmaatje cup (though up to 7.9 million households could feasibly own one), the Netherlands has nonetheless witnessed a remarkable decrease in the amount of food waste: 0.73 kg of pasta and 1.45 kg of rice per person, between 2010 and 2019.

Prompts or reminders are tools that encourage behaviors that are different from those we perform habitually. Sometimes even just bringing attention to a decision can significantly impact the amount of waste we produce. Liebig and Rommel (2014), acknowledging that German households are often burdened by large amounts of unwanted junk mail, ran an intervention that encouraged people to attach "No junk mail" stickers onto their mailboxes. In the first of two treatments, researchers placed 'unattached' stickers inside people's mailboxes; in the second, they attached the stickers outsides of people's mailboxes, but only halfway stuck on. Because these stickers were only halfway stuck, the duo hypothesized that it would force consumers to actively decide between removing or fully attaching them (as opposed to being able to simply ignore it). Comparing the two treatments, Liebig and Rommel found that more than 21% of households in the forced-choice condition attached the "No junk mail," 5% more than if stickers were simply placed in mailboxes. Pairing these stickers with personalized messages and rewards for attaching them, as the team tested in a follow-up study, further increased sticker uptake and placement (Rommel et al., 2015).

Reducing waste: Social norms and comparison

The use of social norms can also be an effective way to promote green behaviors, particularly when people simply see the 'green' option as less attractive. There are several examples from Europe that demonstrate how people change in response to social pressure. In Poland, comparing the recycling performance of one's neighborhood relative to the national average had great success in encouraging households' willingness to pay for recycling services—particularly among those households that rarely recycled (Czajkowski et al., 2019). In Norway, a similar approach found that comparing individual performance to one's neighborhood increased recycling by 2% (Milford et al., 2015). In Sweden, the provision of leaflets highlighting descriptive norms to a 26% increase in food waste collection that sustained itself for eight months after the intervention (Linder et al., 2018). And in England, comparing the food waste of one's street with one's neighborhoods increased by 2.8% the likelihood that residents would put their food waste or compost bins out for collection (Nomura et al., 2011).

Social norms interventions are efficient and scalable in a variety of scenarios. They are, however, quite dependent on the ease with which the behavior of those in your reference network can easily be observed (Biccheri et al., 2020; Prentice & Paluck, 2020). Using mailbox stickers again as an illustrative example, Hamann et al. (2015) found that simply making existing anti-junk mail stickers more *salient* to neighbors by making them more visually obvious made those neighbors more likely to place the anti-junk stickers themselves. They also found that augmenting those stickers with a normative message that, as citizens, they should "engage in environmental protection and attach the accompanying anti-ads sticker to their mailbox" further boosted the effect. This demonstrates the critical nature of

not just providing vague messages about behavioral frequency but highlighting the real behavior of those engaging in the target practice in the relevant reference network.

Alternatively, intervention designers have found that public commitments, in combination with other tactics, can increase recycling. A study by Burn & Oskamp (1986) compared the effects of persuasive communication, public commitment, or a combination of the two to increase recycling rates in a Californian city. The results showed that 41% of households who received any of the treatments recycled at least once in the six weeks following the intervention as compared to 11% in the control condition. Another study compared signing a public pledge to recycle, receiving weekly feedback on pounds of recycled material, and receiving both interventions. The group who only committed did not change their behavior at all, whereas those who received feedback recycled 25% more. However, those who both committed to recycle more and received feedback recycled 40% more, demonstrating the importance of a multi-faceted approach (De Leon & Fuqua, 1995).

Reducing waste: Material incentives, social norms, and appealing to values

Finally, material and contextual constraints affect people's ability to properly reduce waste by means of recycling or composting. In an experiment in Peru, Chong et al. (2015) found no matter how recycling was framed, residents did not want to keep recyclables in their house because of the space it took and the fear that it would attract insects. Moreover, the separation of recyclables from general waste was generally associated with unofficial workers that residents stigmatized as 'scavengers.' For these reasons, simply providing residents with recycling bins was much more effective than any kind of messaging, be it information on environmental or social benefits, social comparisons, social sanctions, rule and regulation concerns, and reminders. This intervention made recycling more materially more convenient, reducing the time and effort required to perform the target behavior (for European example, see also Bernstad, 2014).

The effectiveness of incentives can further be shaped by existing norms, as in a case from Mexico on participation in communal litter collection. Offering a collective payment to a village (e.g., to support an annual festival), in fact, reduced participation relative to offering no payments—likely because of a lack of trust in local leaders (Kerr et al., 2012). On the other hand, if payments avoided authorities and went directly to individuals, or if the community had higher rates of trust in their leaders, participation increased. A similar intervention in Tanzania led participants to overwhelmingly express satisfaction when the task was either not rewarded or rewarded with a group donation to the village's school, but not when payments were offered individually. In fact, offering high individual payments led participants to report that they were unhappy with the payment level as well as the communal task they had just performed (Kerr et al., 2012). In both of these scenarios, different social norms led the communities to react very differently to material incentives. Beyond different perceptions of incentives, local contexts also shape how waste is perceived and valued. Whether waste management is seen as women's work in the house, a central city service, or a source of income, understanding what waste means to actors and stakeholders is an important part of intervention design.

Consumer Waste

Outside of the household, individuals create waste through their purchasing behavior. Behavior change interventions on consumer waste focus on point of purchase choices, encouraging a reduction in unnecessary purchases, packaging, and accompanying waste generation.

Reducing plastic bag use: Providing negligible incentives

Every year, the world uses between 500 billion and 1.5 trillion disposable plastic bags (Clapp & Swanston, 2009). Recently, levies, or taxes, have become increasingly prevalent. As of 2017, at least 127 countries had some sort of regulations on plastic bags of varying restriction levels (UNEP, 2018). In England, a £0.05 plastic bag tax was

introduced to try and reduce the use of disposable, single-use plastic bags. Despite the relatively small increase in cost, plastic bag use declined from 57% to 29%, and the use of reusable bags increased (Thomas et al., 2019). The policy became more popular after its introduction, much like it did in Ireland, where it reduced plastic bag usage by over 90% (Convery et al., 2007). Longitudinal analysis revealed that those who increased their support for the plastic bag tax also increased their support for other similar policies to reduce plastic waste.

Portugal also introduced a successful plastic bag tax in 2015 (Martinho et al., 2017). Four months after its implementation, there had already been a 74% reduction in the consumption of plastic bags, combined with a 61% rise in the use of reusable bags. An unintended effect of the tax, however, was that whereas people used to 'recycle' plastic 'grocery' bags as bin liners, they now increased their purchasing of garbage bags by 12% (Martinho et al., 2017)—an effect that had also been observed previously in Wales (Quested, 2013). Moreover, when asked about their opinion of the tax, the majority of people stated that though they agreed with it, they still viewed it as a source of extra revenue for the Portuguese state.

A city-wide $0.05 tax was introduced in Toronto in mid-2009, but the effects were lower than those in Europe (Rivers et al., 2017). Researchers found that the intervention had only increased the use of reusable bags by 3.4%. This was a smaller effect than those observed in other studies. One reason could be the study's difference-in-difference approach, which effectively controlled for country-wide changes in environmental attitudes and preferences. Without that control, the increase was estimated at 22%. The other studies' pre-post analyses may have positively biased what is otherwise a much smaller plastic bag tax effect.

Studies have also explored how the framing of plastic bag taxes could increase or hinder their effectiveness at swaying consumer behavior. For example, Muralidharan and Sheehan (2016) found that the framing to utilize a reusable bag has a significant impact on the choices that consumers made. Specifically, informing shoppers that they would be 'paying a tax' for using plastic bags appeared more effective than encouraging shoppers to "avoid a fee" by utilizing reusable bags. In a similar vein, an intervention in Maryland's Montgomery Country, USA, found a $0.05 plastic bag tax to be almost 40% more effective at reducing the use of plastic bags than a $0.05 bonus for the use of reusable bag early (Homonoff, 2018). In both cases, presenting the tax as a loss was significantly more effective than presenting it as a gain (i.e., the bonus or the fee avoidance). This supports the assertion that the effect of plastic bag taxes is not due to their shift in material incentives, as both a tax and a bonus offer similar monetary effects.

Whereas high-income countries have used plastic bag taxes due to public pressure and growing green norms, low-income countries have instead relied on government-enacted plastic bag bans driven by the direct harm of excessive plastic use (Knoblauch et al., 2018). In 2011, Nepal introduced a municipality-driven ban on plastic bags because of the growing threat that plastic posed for the country's wellbeing (Bishal Bharadwaj, 2016). In Botswana, both a ban and a tax were introduced for bags that fell below 24 microns of thickness (Dikgang & Visser, 2012; Mogomotsi et al., 2019). In 2017, Kenya introduced what is widely seen as one of the strictest plastic bans in the world. But where reusable bag ownership has increased when shopping patterns support it (i.e., in urban centers), a recent survey revealed that this effect was mostly concentrated among low-income or female city residents (for similar effects in China and Malaysia; e.g., He, 2012; Zen et al., 2013). In fact, only around 42% of survey respondents actually brought their own reusable bags when shopping (Omondi & Asari, 2019).

In South Africa, where a plastic bag ban was used in combination with a small levy, researchers initially reported a decrease in the use of plastic bags of around 70% in the first three months (Dikgang et al., 2012a). Unlike the European examples of plastic bag taxes, however, these effects were only short-lived. Though the fee was universal at first, the price for plastic bags soon differed between retailers—hampering the government's efforts. As people became accustomed to paying different amounts for the bags, the initial sense of loss that consumers felt largely faded, and there has since been a true rebound in the consumption of plastic bags as their use per capita steadily

increases (Dikgang et al., 2012b). A more recent study by O'Brien and Thondhlana (2019) finds that this rebound is largely due to the fact that plastic bags remain the most convenient option, in addition to still being widely available and affordable. They suggest making alternatives as appealing—perhaps by providing reusable, environmentally-friendly bags for free (as plastic bags once were) or by not selling carrier plastic bags at the till (i.e., keeping them elsewhere in stores that is less convenient). Tests showed that the plastic bag problem in Delhi, where almost 94% of citizens continued to use bags despite a ban, could be reduced by providing customers with an inexpensive alternative and a cash incentive (Gupta, 2011).

Reducing plastic waste: Social norms

While bans and taxes have become commonplace, social influences offer a complementary tool for reducing waste. For example, an intervention in a Parisian supermarket looked at the effects of asking shoppers to endorse and sign a poster advocating for 'not using plastic bags' (Rubens et al., 2015). The endorsement served as a commitment mechanism, making shoppers 29% less likely to take free plastic bags if they had signed the poster. Alternatively, researchers have leveraged normative messaging. In an exploratory field-study, De Groot et al. (2013) found that injunctive and personal norm messaging could be used in conjunction with informational environmental messages to successfully reduce the use of plastic bags in UK supermarkets.

Variants of the above interventions have also been used for waste issues that go beyond the problem of plastic bags. A study by Schmidt, in 2016, found that public commitments, combined with intention planning, could lead consumers to better plan for grocery shopping and therefore reduce excessive food wastage. Similarly, norms messaging has been found to be effective at reducing the use of disposable plastic water bottles (Santos et al., 2016; van der Linden, 2015), and in encouraging the use of reusable takeaway boxes at restaurants (Dorn & Stöckli, 2018). Importantly for future program design, a norm message appeared to have no effect, whereas direct observation of the norm—i.e., other customers using reusable takeaway boxes—increased the odds of making a similar decision nearly six-fold.

Reducing product waste: Altering the context of the choice

A final grouping of interventions to address consumer waste involves altering the choice context. The way choices are presented to consumers influences both how and why they ascribe value to a given option. For example, priming consumers to think about protecting the environment while shopping has been found to increase the selection of unpackaged groceries relative to packaged ones regardless of a shopper's personal attitude towards the environment (Tate et al., 2014). In a laboratory experiment, Stefansdotter and her colleagues (2016) found that they could nudge potential phone buyers into making greener choices by simply altering the way in which their options were presented. While most vendors typically only present customers with the option to purchase a new phone, the experiment explored the impact of also actively offering customers the option to purchase a used phone (or to simply get one's screen repairs). Where only 4% of customers typically chose to buy a used phone, 29% made that choice when the 'green' alternative of purchasing a used phone was actively offered. For screen repairs, the corresponding percentages were 87% when actively offered, and 67% when not.

Some countries are adding labels to products to prompt consumers to think about their longevity. Across six European countries, the addition of 'lifespan' labels to various products such as suitcases, printers, trousers, sports shoes, coffee makers, washing machines, vacuum cleaners, and smartphones increased the purchase of longer-life products by 13.8% (SIRCOME et al., 2016). Consistent with the labels focusing consumer attention on lifespan, the effectiveness of the labels depended on the perceptions of lifespans for different products. For example, the lifespan labels made a greater difference in suitcase purchases than televisions, given the expected length of use of each.

The way in which 'green' options are labeled also has an impact on consumer choice. For example, using familiar labels to describe eco-friendly disposable dinnerware makes them more appealing to customers with labels like 'no plastic' and 'recyclable.' In contrast, obscure labels such as 'made from agricultural crop byproduct cellulose,'

'cellulose from dedicated crops/organically sourced cellulose,' 'certified biobased,' 'compostable,' and 'uses no trees' were less appealing (Gill et al., 2020). The significance of these labels can also impact how much food we waste. One study found that highlighting that cafeteria waste will be composted can, in fact, backfire and *increase* wastage (Qi & Roe, 2017). If the negative impact that people attribute to waste is reduced, people worry less about wastage. People care about the type of waste that they produce and change their consumption decisions towards what they feel is less destructive.

Public Waste

The last section of waste management focuses on public waste and littering. Waste management in these settings is an important part of keeping public spaces clean and enjoyable for residents as well as reducing pollution in local waterways. These interventions focus on waste management decisions that support people in recycling, reducing waste, or disposing of waste properly in public.

Increasing recycling and decreasing littering: Incentives, decision aids, and prompts

A number of studies highlight the effectiveness of increasing the ease of recycling and disposing of waste properly in public spaces. For example, McCoy et al. (2018) found that by adding and relocating recycling bins to increase their prominence, they could, in fact, increase recycling efficiency by 23% on a university campus (and decrease the number of recyclables in the trash by 13.38%). In another study, providing more bins was as effective as asking people to plan recycling behavior in advance—the former redirecting a habit, the latter interrupting it (Holland et al., 2006). Additionally, placing specialized lids on recycling bins that have the shape of the recyclable items they accept has been found to further sway our decisions towards 'greener alternatives.' A field study found that specialized lids served to both deter non-recyclable items from being placed in the wrong bins and to make more salient those items that should be recycled (Duffy & Verges, 2009). The presence of these lids increased recycling rates by 34% compared to those bins without specialized lids, and the number of bins that contained non-recyclable items was reduced by 95%.

Defaults to Decrease Paper Waste

Paper waste in office and university settings can create both a drain on natural resources and supply budgets. Defaults, one of the core tools of choice architecture, have successfully mitigated paper waste in university settings. A study in computer labs at Rutgers University explored making double-sided printing the default option on computers to save paper. Over the course of three years, the intervention led to a 44% decrease in paper usage from this one setting change, the equivalent of saving 4,650 trees. A Swedish university replicated this intervention and observed a 15% immediate and lasting reduction in paper usage. These solutions are also more effective than a 10% tax on paper products, which has only demonstrated a 2% decrease in paper consumption (Egebark & Ekström, 2016; Sunstein, 2016).

Other visible interventions for reducing waste have taken the form of symbols and prompts in the environment. Guiding pedestrians to waste bins via green footprints printed on the ground has been shown to be effective in both Copenhagen, where it reduced littering by 46% (iNudgeyou, 2012), and in a number of English cities, where littering dropped 15.9% (Keep Britain Tidy, 2015). In China, researchers found that they could reduce littering in a factory by over 20% by placing gold coin decals, a culturally important sign of good fortune, on the shop floor (Wu & Paluck, 2018). This was more effective than previous attempts at rules, reminders, and monetary penalties. The intervention lost its effectiveness if these decals were removed and reintroduced—likely because easily taking the decals away revealed to workers that these were not as meaningful as once thought. At Indian informational technology firms, an intervention to limit unnecessary printing involved posted signs near printers and around the office as reminders. These also invoked an injunctive norm with a sad face to provide a social signal supporting behavior change. The intervention reduced per person daily paper wastage in the firms who received the reminders by 4-6 sheets compared to firms in the control condition (Chakravarty & Mishra, 2019).

Analysis

There are many parallels between interventions that target waste management and those that tackle climate mitigation (see *Topic 2 Climate Mitigation*). One of the biggest trends in this section on waste management is that people's intentions do not match their actions. This gap between intentions and actions also tends to be very context-dependent; the barriers to reducing household waste are often very different from those that we face as consumers or in public settings. Likewise, waste is perceived and experienced very differently in different parts of the world. The challenge for behavior change designers is translating intentions into actions for a wide range of actors.

Review of the strength of the evidence

The most common technique for encouraging improved waste management is the use of material incentives, mainly taxes and bans. In fact, because of the sheer quantity of such interventions, plastic bag taxes and bans dominate the evidence base. The most promising results from such programs come from pre-post comparisons (Convery et al., 2007; Martinho et al., 2017; Thomas et al., 2019), but these have a less robust intervention design. The results from more experimentally-sound evaluations have recently highlighted how the lack of internal validity in such pre-post assessments creates inflated outcome reporting (Rivers et al., 2017). While results from plastic bag tax and ban interventions should be interpreted with caution, small incentives like these help to draw attention to choices otherwise made out of habit, leaving them open to powerful framing effects (e.g., Homonoff, 2018; Muralidharan & Sheehan, 2016). Whether these effects are long-lasting, however, remains a matter of debate (Dikgang et al., 2012a, 2012b; Rivers et al., 2017).

Except for the plastic bag policy interventions (i.e., taxes and bans), interventions to reduce waste are most frequently evaluated with internally-valid experimental methods. Such methods increase our confidence in the strength and significance of their results. Moreover, the majority of evidence is based on field interventions, with a minority coming from lab-based hypothetical choice experiments. Field-based studies provide a high degree of ecological validity, as minimal assumptions are required for inferring whether these insights apply to target behaviors in a natural setting. We thus find reliable and credible results for interventions that leverage social influences (often through normative messaging; e.g., Czajkowski et al., 2019; Nomura et al., 2011) and for those that make waste-reducing choices easier and more salient (Duffy & Verges, 2009; SIRCOME et al., 2016). The use of descriptive norming (where an individual is given feedback about what others are doing and how their behavior compares) has been found to be effective at increasing proper handling of waste in the household (Czajkowski et al., 2019; Linder et al., 2018; Milford et al., 2015; Nomura et al., 2011). While few of these interventions were evaluated for durability across time, those that were evaluated months after first being implemented had a persistent effect (e.g., Hamann et al., 2015). The same is true for choice architecture interventions that subconsciously alter the context of the decision. These interventions are often inexpensive to administer, making them cost-effective even with seemingly low but significant behavior adoption rates. Choice architecture interventions were found to be effective for months

when the cues remained in place (e.g., Egebark & Ekström, 2016; Keep Britain Tidy, 2015; van Dooren et al., 2020), but few evaluate the durability of the effect after those cues were removed.

Interventions in this section are most often from high-income countries, particularly in Europe. We find Northern Europe to be over-represented. Given that these interventions are most frequently carried out by local government authorities, this is likely a reflection of relative policy priorities. These interventions would need to be replicated with a more globally representative population for us to be confident in generalizing their results beyond those geographies and across varying socio-ecological dynamics.

Review of the application of behavioral science

One important phenomenon to consider for waste and pollution is that target actors will most likely face intention-action gaps. People's intentions, attitudes, or values do not always reflect in their actions (Blake, 1999). Even though people claim to want to reduce the waste they create, they do not take steps to do so (Barr, 2006; Chung & Leung, 2007). Our choices relative to waste are often subconscious and guided by habits, and choices that generate more waste are often cheaper, easier, and available. Many of us accept and rely on plastic bags at the grocery store, either by habit or because they represent the fastest option at our disposal.

As a result, social norm interventions work because they make waste decisions about social trends and expectations, not just price and convenience. When told that 'most people do it this way,' decision-makers want to conform. A visible norm in favor of waste-reduction encourages greener decisions by placing a social 'cost' on those behaviors that are outside the norm (Czajkowski et al., 2019; Dorn & Stöckli, 2018; Nomura et al., 2011). Social norms also signal what others expect from you, yet practitioners must be mindful of existing norms as well (Kerr et al., 2012). Public commitments appear to be effective because by committing to waste-reducing actions publicly, consumers now have the added pressure of meeting that commitment in front of other members of their community (e.g., De Leon & Fuqua, 1995; Rubens et al., 2015; Schmidt, 2016).

Additionally, interventions that work with or interrupt habitual decision-making also prove useful because they make waste-reducing decisions active and easy. People will intuitively follow simple prompts that guide them towards making better waste decisions. Examples range from green footprints printed on the ground (iNudgeyou, 2012), to object-shaped waste bin lids (Duffy & Verges, 2009), to easy-to-use measuring cups (van Dooren et al., 2020). These are simple choice architecture efforts that streamline our decisions and make salient the 'recommended' choice. They remove some of the *behavioral friction* that might otherwise widen people's intention-action gap. Intervention designers can also leverage people's status quo bias (i.e., our tendency to stick with current options) to design interventions that 'pre-select' waste-reducing options as defaults (Chakravarty & Mishra, 2019; Egebark & Ekström, 2016).

Where intervention designers may not have the option to enforce defaults or shape the decision context, another effective option has been to actively encourage choices that reflect intentions. Such interventions include prompting a change in behavior through reminders, emphasizing new information (Shearer et al., 2017; SIRCOME et al., 2016), or forcing an active choice (Liebig & Rommel, 2014; Stefansdotter et al., 2016). These are simple yet effective strategies because they pause decision-makers to rethink habits or following the status quo.

Currently, single-use plastic interventions rely on an increase in price to change behavior, yet little research has been done to make choosing the alternative easier and more convenient (Dikgang et al., 2012b; O'Brien & Thondhlana, 2019; Gupta, 2011). Moreover, the tax may have changed how consumers perceive plastic bags, but decision-makers still need to plan to carry a reusable bag with them while shopping, which has its own barriers.

We identified very few behavioral interventions involving air or water pollution as waste, and those have been covered in the *Agricultural Land Management* and *Water Management & Conservation topics* (cf., Duflo et al., 2013).

We suspect this lack of research is due to a failure to apply behaviorally informed approaches to corporate actors, who are perceived as different from consumers or rural producers. However, actors within companies are subjects to the same behavioral influences as demonstrated by multiple waste management interventions in the public context (Chakravarty & Mishra, 2019; Holland et al., 2006; Wu & Paluck, 2018).

Review of the application of social science

Issues surrounding waste, though global, are highly specific to the communities in which practitioners need to intervene. Many of the interventions in this section have visible outcomes that materialize in people's daily lives. This is an advantage for behavior change practitioners, as it allows us to bring behavioral interventions more easily into the physical world (e.g., iNudgeyou, 2012; Keep Britain Tidy, 2015; van Dooren et al., 2020). It also leads many intervention developers to consider more deeply the cultural context in which interventions are deployed and to gain a better understanding of the unique norms and values that can reinforce or impede behavior change efforts. Interventions aimed at encouraging litter pickup, for example, can have very different outcomes based on the socio-cultural context in which they are deployed. In Mexico, rewarding litter collection efforts through communal payments to one's village proved highly ineffective because certain communities do not trust their local leaders. In Tanzania, collective payments overwhelmingly led to workers' satisfaction following litter collection (Kerr et al., 2012).

The heterogeneity of community norms and their effects on people's behavior is integral to the design of behavior change interventions. Wu and Paluck's (2018) golden coin intervention stands out as a case study for how a deep dive into communities' norms can support more tailored solutions. Having identified that Chinese factory workers associated golden coins with fortune and luck, the team endeavored to make littering about more than a simple waste issue by placing decals of golden coins all over a textile factory's floor (Wu & Paluck, 2018). Because of the cultural norms associated with the coins, workers became self-motivated to respect the symbolism and keep the golden coins clear of waste. This was true until the coin decals were removed then reintroduced, and the symbols became less permanent and sacred.

Where the interventions in this section do a great job at swaying consumer behavior, there have been no efforts to target actors further up the supply line (plastic bans notwithstanding). Behavioral and social scientists are uniquely positioned to target the behavior of sellers and producers. Yet, most of the interventions here focused on consumers changing their behaviors within larger market forces. The few interventions that deviate are those that highlight how providing easy and sustainable alternatives to plastic bags may help in lessening the pull of cheap and convenient plastic (e.g., Gupta, 2011; O'Brien & Thondhlana, 2019). We suggest intervention designers focus their efforts on interventions that reduce waste systematically at the source rather than solely encourage waste recycling. This would mean adopting a systems-based approach that considers waste management behaviors throughout the production and consumption lifecycle of waste products.

As a complement, the evidence-base also points to simple 'ease of access' interventions that target systematic changes without much effort. For example, Chong et al., (2015) thought that Peruvians' negative attitudes towards recycling were socially driven (i.e., that recyclers were seen by the community as 'scavengers'), but they also found that for many, the lack of accessible bins was the root of the issue. No matter how many behavior change interventions the team tried (normative appeals, timely reminders, social sanctions), households did not want to keep recyclable waste around the house and risk attracting insects. The bins were a cheap and easy way to alleviate these concerns and encourage recycling. Similarly, on US campuses, simply relocating recycling bins to increase their prominence can lead to effects similar to adding specialized bin lids (Duffy & Verges, 2009; McCoy et al., 2018).

On ethics, waste management interventions remain true to the libertarian paternalism roots of nudging. Most interventions aim to maintain people's freedom of choice, and intervention outcomes are designed to support people's best interests. Only very rarely do we identify problematic and unequal dynamics between implementors and target actors. The main difference we found was between high-income and low-income countries in terms of

plastic bag bans and taxes. As mentioned previously, high-income countries tend to adopt plastic bag taxes (not bans) as an environmentally-friendly reaction to public pressure. In low-income countries, plastic bag bans (not taxes) are imposed as a reaction to the visible and harmful effects of plastic on the environment, regardless of public opinion (Knoblauch et al., 2018). The effect of policymakers' decisions has resulted in restricting the choices of those in low-income countries while preserving the right to choose in the high-income countries, which is a pattern of effective discrimination we find troubling.

Further Readings

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Agricultural Land Management & Climate Adaptation

Introduction

The IPCC estimates that agricultural croplands and pastures account for roughly half of all ice-free land on earth (Arneth & et, 2019). Encouraging the adoption of sustainable farming practices, which enable farmers to meet current production without compromising future production, is therefore likely to be one of the most pressing challenges facing environmentalists this century. Interventions in this topic focus on reducing destructive farming practices and improving resilience as well as protecting and regenerating farmland.

Analysis Highlights

- Shifting agricultural practices presents significant risks, particularly for smallholder farmers. Cognitive biases surrounding risk and ambiguity aversion are particularly relevant to address in the agricultural context. Social proof, which demonstrates how others in the target's reference network have succeeded with the target intervention, presents a uniquely compelling strategy for agricultural extension.

- Farmers are often considered as a homogenous group, and research has shown how this limits interventions' effectiveness. Social differences among farmers put them in different roles and positions of power, which change their ability to access and incorporate agricultural information. It is critical to understand these social differences and how they are expressed in the local context for effective programming.

- Agricultural extension presents unique challenges due to the difficulty and cost of accessing target communities. Programs incorporating information and communications technology (ICT) are particularly attractive. While present schemes tend to focus on how ICTs can best provide practical guidance, new directions might focus on how they can leverage behavioral insights to provide social proof of successful application. While ICTs present uniquely exciting opportunities, we must process their ethical implications. Each farmer's unique position in their socio-ecological context drives their ability to access and benefit from these technologies.

Increasing Sustainable Farming Practices

There is significant pressure on farmers to produce enough food and staple crops to meet the needs of growing populations. As a result, farmers seek out practices that will increase their yields, even to the detriment of their land's future productivity and resilience. Interventions in this section focus on increasing the adoption of sustainable practices, particularly through increasing access to information and reframing messages to farmers.

Increasing sustainable farming practices: Limits and opportunities for information and incentives

Although much work had been done last century looking at the economic and socio-cultural factors that may influence farmers' decisions to adopt sustainable practices, only more recently have psycho-social factors been integrated into developing a deeper understanding of producers' context and choices (Dessart et al., 2019), as well as in designing interventions to make those choices more sustainable (Streletskaya et al., 2020). The most obvious and traditional levers to push for the adoption of new practices—policy change, agricultural extension services, and certifications (e.g., fair trade, organic, Good Agricultural Practices)—are slowly being phased out, or complemented with a new and more profound understanding of the farmers' decision-making (Bernier et al., 2015; Norton &

Alwang, 2020). Additionally, while climate information services have historically focused on what information they have to provide, there has recently been a necessary shift to focus more on the needs and capacities of target actors (Carr et al., 2020). However, even this focus on the needs of target actors is often done too coarsely, merging groups which, due to the social dynamics within a community, have varied capacities and needs.

The use of in-person extension services, for example, has long been a staple of agricultural interventions to effect behavior change: extension workers provide easily digestible information for farmers, and in turn, farmers adopt new technologies and practices. Information Communication Technology (ICT) offers the potential to deliver timely and place-specific information to farmers around the world and address more 'upstream' production issues typically left unaddressed by extension services. In Kenya, for example, and ICT intervention found that providing sugarcane farmers with a hotline to report delays in fertilizer delivery reduced such delays by 21.6% (Casaburi et al., 2019). They also found that the simple act of sending text message prompts to perform specific agricultural tasks could improve farmers' yields by 11.5%.—particularly for those farmers with no agronomy training and/or little prior interaction with sugar cane companies. Similarly, researchers in India found that providing farmers with a mobile phone-based, agricultural, consulting service, could result in dramatic increases of average yields of up to 28% for cumin and 8.6% for cotton (Cole & Fernando, 2016). The mobile service provided advice to farmers through a hotline, where they could ask questions and receive responses from agricultural scientists and local extension workers. Interestingly, the researchers also found that farmers were more likely to follow mobile recommendations if others around them also used the service—a finding echoed in a study by Genius et al. (2014) relative to the increased effectiveness of extension services when the concentration of adopters also increases.

Researchers have discovered that many factors tend to interfere with the success of extension workers. For example, farmers often learn by doing, and they do not simply adopt new technologies when shown (Pannell & Claassen, 2020; Ziervogel, 2004). Social networks also influence farmers' uptake of natural resource management practices, such as growing climate-smart crops, intercropping, or rotating crops. Larger networks and the ability for social learning lead to greater adoption, such as having friends, family members, and neighbors farming sustainably. Some suggest that using these strong informal networks as dissemination mechanisms for extension services could be quite effective (Wossen et al., 2013). As we will see in this section, the way in which extension workers frame information has a significant impact on its influence.

Gender is also a critical factor in access to extension services and information on agricultural practices. Traditionally, women have had significantly less access to extension services, and the services they do receive often differ from those of their male counterparts (for review, see Rola-Rubzen et al., 2020). Women tend to have more knowledge about a household's food security, yet have less access to information about practices like climate-smart agriculture (Bernier et al., 2015). Various programs have been evaluated to reduce this gender gap in uptake. For example, providing female farmers with access to dedicated female extension workers has been increasing gender equity (Buehren et al., 2019; Kondylis et al., 2016; Mogues et al., 2019; Shikuku, 2019), but another important and evolving avenue has been to address women's lack of access to extension services via information and communications technologies (ICTs). In Uganda, researchers are exploring both the effect of provisioning extension services through online videos and the effect of having those videos delivered by female extension workers (Lecoutere et al., n.d.; Van Campenhout et al., 2018). Preliminary analyses are finding that ease of access to extension services can increase female farmers' productivity, but much work remains to understand barriers to the access of ICTs, such as asymmetries in mobile phone ownership, as well as the diverging needs for information that women have versus men (e.g., Kansiime et al., 2019).

Gender can further affect women's decision-making power to access the information they need at the right time. Research from Senegal found that women often lacked control over the means of production, resulting in them having no choice but to plant later than men. While men required information on when they ought to plant, women required information on seasonal cessation, an insight only derivable through a nuanced understanding of the overall social dynamics at play (Tall et al., 2014). Similarly, researchers found that in South Africa, while men often preferred

information delivered by radio broadcast, women lacked the power to establish flexible schedules to regularly listen to the radio, and therefore preferred extension agents to deliver information via a "teach-in" (Archer, 2003). Finally, studies across countries in Latin America, Asia, and Africa on agency and demonstrate that gender inequality and domestic violence negatively affect women's ability to innovate in agriculture and sustainably manage resources (Petesch et al., 2018; Petesch, et al., 2018; Kelkar, 2007). Women's agency tends to be higher when they are single, widowed, or acting as head of house (even temporarily) due to men seeking higher-paying work elsewhere (Petesch et al., 2018). These findings stress that we cannot assume that that information provided will be successful if we fail to account for the social context in which it is delivered. There is additional research needed on the best ways to contact women and young people in sharing information on agricultural practices, both in different media and locations (Bernier et al., 2015). We must account for the varied challenges for different segments of the population, and identify what information would best suit their needs, acknowledging that different information may be needed for different populations, and certain information may only be relevant for some segments (Carr & Onzere, 2018).

While this focus on gender is a helpful lens through which to see how designing for the heterogeneous needs of a community is critical, focusing only on gender can itself be overly reductive (Carr et al., 2020). Even within a given community, women's needs for climate information are often diverse, as is their ability to act on the information provided. Instead, a designer must start by understanding *which* social differences shape their ability and interest engaging in the target behavior, which may include but are certainly not limited to gender (Carr et al., 2016). Similarly, we cannot assume that a given individual in a community has only one identity. To truly understand and design for the needs of a community, we must reveal the intersectional identities of the target population, allowing the designer to account for these varied roles and responsibilities (Carr & Owusu-Daaku, 2016).

Understanding these varied identities means not only looking at the individual but also how those identities affect social interactions. Researchers have found that while participatory approaches facilitate an understanding of climate forecasts, how and for whom they are effective can differ depending on the cultural context. For example, researchers have found that Ugandan farmers have varying cultural styles of participation, such as *Kiganda* style, which "favors the consideration of locally relevant issues, indigenous knowledge, empirical observations, and personal experience" (p.135), and *Western*-style, which "facilitates a critical examination of authoritative knowledge, an appreciation for the value of diversity of opinions, … [and] a consideration of pluralistic framing of solutions" (p.135). Researchers found that these styles affected the interpretation of forecasts and the response strategies (Roncoli et al., 2011). Similarly, whether a certain group of people is even *allowed* to participate in informational workshops is culturally determined. Researchers assessing the Climate Forecasting for Agricultural Resources program in Burkina Faso found that social inequities and power dynamics shaped who had access to these spaces (Roncoli et al., 2008). Finally, the likelihood of adopting sustainable or climate-smart practices is strongly tied to community trust and collective action, with the strength of local institutions and collective community power often barriers to change (Bernier et al., 2015).

Increasing sustainable farming practices: Social norms, key messengers, and appealing to values

Farmers' social networks and identities can be leveraged to promote sustainable production. In Kenya, for example, researchers tested the public TV edutainment program on sustainable farming *Shamba-Shape-Up* to increase the adoption of new practices among Kenyan farmers (Areal et al., 2020). Weekly episodes take the viewer to visit selected farmers—people just like the target actor—and discuss the farming challenges they face. Solutions are presented by experts, but the episodes are designed so that that viewer can 'view themselves' as having the same issues, and thus potentially adopting the same solutions as the visited farmer. In doing so, Shamba-Shape-Up (SSU) had significant success in encouraging maize and dairy farmers to implement a greater number of sustainable production practices, regardless of the difficulty. The positive influence of SSU, however, did vary considerably depending on the agricultural practices that were recommended, the level of trust farmers had for TV material, as well as depending on whether the farmer watched the program for learning or for entertainment.

A similar video-based empathy appeal was tried in Vietnam where researchers ran a randomized control trial with 1287 tea cultivators. The study looked at the effect of either i) offering an organic fertilizer subsidy (50% price reduction) at the point of purchase, or ii) first presenting a video of other farmers sharing their experience of adopting organic fertilizer, then offering the fertilizer at full-price. Compared to the control condition, both interventions significantly increased the likelihood of cultivators buying organic fertilizer and the quantity they purchased. However, they differed greatly both in effectiveness and in cost: the video treatment was far less costly but only had about one-third the effect of the price subsidy (Vu et al., 2020). The impact of the video treatment was nearly three times greater for those cultivators who were certified (i.e., tea farmers certified in good agricultural practices) compared with that of the overall sample. Video tutorials and stories are becoming a staple tool to teach and encourage the adoption of sustainable agricultural practices in the developing world. In Africa, for example, the online service 'accessagriculture.org' reaches over 1,200 farmers in around 33 countries. A recent survey of their members highlights that many farmers proactively look for such information on the web and further share this information with their communities (Bentley et al., 2019). Developing and encouraging cost-efficient ways for more technologically sophisticated youth to serve as 'online information brokers' and share videos with their wider communities is an exciting amplifier to existing ICT strategies.

Another successful social intervention involves referrals. Research shows that for farmers who are informed of, or referred to, a training program by participating peers in their community (i.e., farmers who are currently enrolled in a program or have adopted a practice) are more likely to adopt new production practices. For example, in Bangladesh, researchers promoting the adoption of rice production best practices (System for Rice Intensification, or SRI) faced overcoming the complexity of these methods. The research team decided to run their program in two phases: the first would select farmers randomly for training, and the second would recruit farmers via referrals from the first generation of trainees. Compared with farmers selected randomly, referred farmers were 4.2% more likely to adopt SRI. If referrers were rewarded or incentivized for recruiting others, both referrers and referees were 12% more likely to adopt. However, the targeting under incentives appears to be less precise and, therefore, less efficient. Many of the new adopters did not directly benefit from the practice and reverted to their old ways but a year into the program.

In Malawi, Beaman et al. (2020) also explored how network theory could be used to better target producers and increase new technology adoption. After creating community network maps of 200 villages, the researchers leveraged the social structures they identified to select two 'seed' farmers in each community that would be trained on, and asked to disseminate their knowledge of 'pit planting.' They tested four conditions, each applied to a random selection of 50 villages: i) a control using extension agents' local knowledge to select seed farmers, ii) selecting seed farmers using a simpler network contagion model, iii) selecting seed farmers using a more complex network contagion model, and iv) selecting seed farmers using a complex network contagion model built on geographic rather than social links. After two years, the diffusion of pit planting in network-seeded villages was 3.6 percentage points higher than the 3.8% diffusion observed in control villages. The diffusion of pit planting then increased from 3.8% in year two to 7.5% in year three for control villages, and from 7.4% in year two to 11% in year three in those villages selected for complex social network seeding. The results suggest that social network-based seeding serves the critical function of supporting social learning, allowing farmers to learn from multiple people before they themselves adopt the behavior.

The importance of social influences can also manifest in other parts of an intervention, such as the use of social norms and observability to promote compliance with sustainability norms. In one study, Dutch farmers were presented with a sustainability rating specific to their farm, either privately or at a public meeting where they were prompted to publicly commit to adopting specific practices that could improve their score (Lokhorst et al., 2010). The combination of tailored information with public commitments led to a stronger desire to engage in conservation, an increase in the surface area of non-subsidized natural habitat, as well as increased time spent on conservation overall. The intervention affected both subsidized (i.e., land under PES schemes) and non-subsidized conservation, but the effects were stronger for non-subsidized conservation.

In the United-States, Monsanto also tried to leverage social levers to encourage the planting of refuge crops in North Carolina. Through a social marketing campaign, they promoted the stories of individual farmers who had been recognized as exceptional in their refuge planting (Brown, 2018). Farmers who agreed to feature in the promotion received no additional compensation but were featured publicly in Monsanto's campaign. The campaign successfully increased the average probability of planting refuge crops by 12%, particularly among first-time growers. However, it is important to note that this gain was insufficiently large to meaningfully increase compliance with mandated refuge thresholds, and even those farmers who had adopted refuge planting largely abandoned the practice after two years.

Another way to approach to improving behavior change programming would be to adapt those interventions to existing social norms and beliefs. In Alberta, Canada, for example, there is widespread adoption of climate-mitigating agricultural practices despite a large proportion of producers disagreeing with climate change being human-caused. Studying this paradox, researchers found that farmers were embracing these practices not for their 'climate-mitigating' effect, but for their long-term economic benefits, improvements in soil quality, and the value they placed on wildlife and biodiversity (Davidson et al., 2019). Farmers' connectedness to nature also plays an integral part in shaping their motivation to preserve their land. In Australia, feelings of connectedness with nature are likely to influence farmers' decisions to conserve vegetation—as long as farmers also understand the importance of the environmental benefits that vegetation management can provide to the local ecosystem (Gosling & Williams, 2010). Interventions could find much success in 'reframing' the costs or benefits of sustainable practices better reflect the realities, values, and existing perceptions, of one's target actors. For example, emphasizing the possible destruction of a resource is likely to engender more conservation efforts (Messer & Borchers, 2015), but portraying sustainable practices as 'profitable' may not always have the desired effect (see Andrews et al., 2013, on conservation tillage).

As many of these studies demonstrate, local demographics, values, and social norms greatly influence the context in which a behavior occurs. Studies examining factors that influence the uptake of agricultural technologies describe socio-economic, agro-ecological, institutional, informational, perceptional, and technological factors at work. The age, education status, wealth status, development pressure on nearby land, comfort with technology, farm size, and perception of profitability can all play a role and differ in each context (Tey & Brindal, 2012; Meijer et al., 2015). Some of these factors can then affect values and social norms. For example, a study in northwest India showed that lower-caste farmers perceived higher-caste farmers to have more land, status, and ability to pursue different agricultural practices. Their experiences of marginalization, social exclusion, and having less access to land and resources have led farmers to feel less self-efficacy about making changes. The study further identifies three general typologies of farmers based on their outlook and decision-making mindset: fatalistic, passive, and purposive (Singh, Dorward, & Osbahr, 2016). These outlooks suggest links between farmers' perceived agency and agricultural management. Related research on climate adaption and agricultural societies in Niger found that divergent adaptation can occur when one group's adaptive capacity increases and another's decreases based on resource access inequality, which can later lead to farmer cooperation or conflicts (Snorek, Renaud, & Kloos, 2014).

Values and associations between humans and nature can also drive agricultural decisions. An exploration of indigenous values in Hawai'i demonstrates the difference between Western and non-Western worldviews on the environment. In this system, the value of nature is not instrumental or intrinsic but relational, or built through relationships, which challenges notions of separating people and nature. Reciprocity, balance, sacredness, care, rights and responsibilities, and life energy are all core themes in native Hawai'ians belief systems and shape how they approach environmental stewardship (Gould et al., 2019). Similarly, a study of landowners in Uruguay describes their feelings of land stewardship that no not exist separately from other parts of their lives. They have a strong place-based identity rooted in an appreciation of biodiversity, rural work, neighbor relations, ancestral legacies, and traditional lifestyles. As a result, landowners are able to talk holistically about the challenges they face as

social, development, and environmental goals, as in the case of land-use change and access to education. Such understandings encourage designers to look at how local perceptions of land, work, and stewardship are encoded in each context (Cortés-Capano et al., 2020).

Setting the Record Straight

The Great Barrier Reef off the coast of Queensland, Australia, is the world's largest coral reef system and a UNESCO World Heritage site. Excess fertilizer runoff from sugarcane farms into the Great Barrier Reef is one of the main factors impacting its health. In recent decades, the Australian government has tried to encourage farmers to modify their practices through enacting laws and offering economic incentives. Despite these efforts, change has been slow and insufficient. Project Cane Changer and state actors targeted cane sugar producers to change their unsustainable farming practices. The project's slogan, 'Setting the record straight,' aimed to boost the participation, identity, and reputation of farmers for engaging conservation practices that had traditionally been villainized for harming the reef. The program also accredited farmers in Smartcane Best Management Practices (BMP). The program involved 770 landholders and industry stakeholders, incorporated 113 workshops, and over 400 meetings and events. The program led to a ~480% increase in the adoption of BMP throughout active project areas, which translated to more than 49,000 hectares of sugarcane (Pickering et al., 2019).

Increasing sustainable farming practices: addressing cognitive biases and uncertainty

Sometimes, social influences and information are not enough to address the key barriers to adopting sustainable practices. Risk and ambiguity aversion refer to biases towards decisions that are less risky and more well defined. This is relevant for farmers who are likely to choose options that increase the chances of ensuring successful yields. In India, researchers found that farmers who were more risk-averse were more willing to adopt newer, risk-reducing seeds (Ward & Singh, 2015), and in Ghana, we see the same effect with risk-averse aquafarmers' choice of newer, extruded feeds (Crentsil et al., 2018). The level of ambiguity in the information presented to farmers also plays a major role in their decisions to adopt novel practices. In the above Ghanaian study, for instance, aquafarmers' levels of ambiguity aversion were directly linked to their adoption of floating cages—a technology with high fixed costs and more ambiguous returns (Crentsil et al., 2018). The more ambiguity-averse farmers were, the less likely they were to adopt the new technology. Similarly, in Peru, ambiguity relative to possible crop yields appears to reduce farmers' likelihood of planting multiple crop varieties (Warnick et al., 2011).

Practitioners and extension workers might do well to simplify and resolve ambiguous information using familiar, easy-to-use schemes. In Germany, for example, a laboratory experiment with agronomy students tested a 'traffic light' label as a means of simplifying and making more salient the toxicity levels of pesticides (Buchholz et al., 2018). Measuring the students' farming choices in a business simulation game, the researchers running the experiment found that, while a tax on pesticides reduced the application of pesticides by 8.25%, traffic light labeling led to a decrease of 9.52%, demonstrating how information simplification may have a greater effect than financial incentives without the burden of additional taxation.

Another way of approaching the problem of ambiguity aversion is to leverage it to encourage the adoption of practices that disambiguate farming outcomes. A US study on the adoption of genetically modified seeds highlights how this could be the case: they found that farmers were eager to adopt new pest-resistant GM corn varieties if it meant reducing the ambiguity associated with pest damage (Barham et al., 2014). In a framed field experiment in Costa Rica, Alpizar et al. (2011) explored the role that risk and ambiguity aversion plays in modulating farmers' adaptation decisions relative to potential natural disasters and making crops more resilient to extreme weather events. Over nine rounds of a game, the research team recorded farmers' decisions in a scenario where natural disasters had varying likelihoods of happening and reducing payoffs. At the same time, not-adapting and not-experiencing a disaster were more profitable than adapting. Sometimes the farmers knew the likelihood in advance (a risky decision), and sometimes they did not (an ambiguous decision). As expected, while farmers had varying levels of risk aversion, more farmers chose to adapt as the scenarios go riskier. However, in the condition where the risk of an adverse weather effect was unknown, more farmers chose to adapt overall, regardless of their risk-preference. This suggests that ambiguity relative to future events may be a more powerful motivator for change than risk—at least when the outcomes of adaptation choices are otherwise known. Understanding the impacts of farmers' preferences for risk and ambiguity is a promising, yet underdeveloped, area of research for behavioral interventions.

Nudging Farmers to Fertilize

There have been consistently low agricultural yields in Africa, even as other regions (notably South Asia) have enjoyed dramatic increases in farm productivity. Fertilizers can boost yields when used correctly in areas that have limited soil nutrients. To encourage Kenyan farmers to use fertilizer on their land, researchers and an NGO tested four behavioral interventions comparing the Savings and Fertilizer Initiative (SAFI) to fertilizer subsidies. Farmers either received an NGO visit after crop harvest that offers farmers full-price fertilizer with free delivery (basic SAFI), a visit before crop harvest to select the date of a future date to purchase fertilizer (SAFI with choice of timing), a half-price subsidy on fertilizer and free delivery close to the time of fertilizer application, or a full-price fertilizer and free delivery close to the time of fertilizer application. In the two seasons that the basic SAFI was offered, the program increased fertilizer use by 14 and 18 percentage points, respectively, which represented a 69% increase. The SAFI with ex-ante timing choice increased fertilizer use by 22 percentage points, and the subsidy intervention increased usage by 13 percentage points. While these effects did not last into the next season, the results suggest that offering farmers small, time-limited discounts for fertilizer at critical points in time may substantially increase usage without inducing overuse among farmers who are already using fertilizer (Duflo et al., 2011).

Conserving Land

The protection and regeneration of farmers' land represents another important avenue of research for land management. Interventions in this section include the recruitment of farmers into agri-environmental schemes. This is a practice that is commonplace, often debated, and one whose failings can lead to ambiguous or fully unintended outcomes (Cooper et al., 1997; Ferguson, 1994). The following interventions address the utilization of behavioral and

social insights to i) encourage enrollment into agri-environmental schemes (extensive participation), and ii) ensure the durability of conservation efforts during and after PES schemes end (intensive participation).

Conserving land: aligning incentives with values and preferences

Interventions that 'reframe' decision-makers' choices have become more common, particularly with regards to agri-environmental schemes. For example, an increasing number of studies are finding that the way in which PES information is presented has a significant impact on farmers' adoption of conservation schemes. In Madagascar, Clot et al. surveyed agronomy and economics students to better understand the effects of reframing agri-environmental schemes (2017). Presenting the participants with four different scenarios, researchers measured whether the trust that participants placed in agri-environmental schemes changed depending on if it offered payment versus compensation for conserving one's land, as well as if the scheme was said to be associated with a local versus an international organization. They found that trust was higher for schemes that offered 'compensation' for services rather than 'payments' and that students placed more trust in an agri-environmental scheme administered by an international organization than one run locally. 'Compensation' framing also generated more optimism than 'payment.' A similar survey, this time administered to French farmers, found that the willingness of French farmers' to participate in 'biodiversity conservation' schemes was higher than one described as 'biodiversity offsetting' (Le Coent et al., 2017). This result was mainly driven by farmers who identified as 'organic' farmers—reinforcing the importance of understanding target actors' psycho-social motivators.

Other possible psychosocial factors influencing the adoption of PES schemes include trust and time preferences. Clot & Stanton (2014) measured these two factors through economic games with Ugandan farmers and correlated their findings with household survey data and PES participation. Surprisingly, they found that trust, as measured in experimental games, had no significant role in modulating PES participation. However, farmers' time preferences did make a difference. Those identified as present-biased (who more heavily discounted the future) were 47.7% more likely to also be participating in the PES schemes. Where many programs may try to improve PES adoption through increasing trust between providers and communities, Clot & Stanton's work suggests that payment structures and the time at which payments are distributed may be even more important to consider. In this case, a PES provisioning 30% of its total payment up front and the other 70% via four installments in later years favored present-biased adoption.

Researchers have also examined how and which values shape farmers' and landowners' participation and engagement with conservation programs. While ecosystem services are traditionally seen as providing a series of instrumental functions such as supporting, regulating, and provisioning services, non-instrumental values are also important to many farmers. It's important that designers not assume the relationships between people and nature, but instead, use local socio-cultural interpretations from the perspectives of the target actors (Ellis, Pascual, & Mertz, 2019). For example, a study in the United States identified different types of relationships that farmers consider: farmers and land, farmers and landscape, farmers and communities, land and landscape, and landscape and community. Researchers identified that some conservation programs might align or conflict with existing value systems, leading to more or less successful efforts. Key trends included the importance of farmers feeling agency over their land management decisions, that their expertise is acknowledged and respected, that they can maintain a strong connection to their land, and that they ascribe certain farm aesthetics to 'good' farming. Understanding these relationships may help program designers better meet the needs and goals of farmers and customize activities accordingly (Chapman, Satterfield, & Chan, 2019).

Conserving land: Social norms and key messengers

Beyond optimizing the name of an agri-environmental scheme, key messengers can also boost participation. For example, a study looking at farmers in Spain, Germany, and Switzerland found that these producers were more likely to enroll in identical agri-environmental schemes if they were recommended by a farmer versus if they were recommended by scientists (Villamayor-Tomas et al., 2019). Similarly, the United States Department of Agriculture

(USDA) compared the effects of sending farmers either a standard information letter, a handwritten letter designed to evoke empathy towards the environment written by research assistants on state conservation projects, or a photocopied version of that same handwritten letter to recruit farmers into a Conservation Stewardship Program (Czap et al., 2019). They found that the simple act of sending any letter was enough to double applications to the scheme, a far more cost-effective measure than the alternative financial incentive. When comparing the effects of the different letters, the researchers found that the handwritten letter performed best, and the standard letter second best, although the difference was not statistically significant. However, both letters performed better than a photocopied version of the handwritten letter, which was perceived as disingenuous.

The use of norms can also boost participation. In another intervention by the USDA, farmers were again sent letters encouraging them to participate in agri-environmental schemes (Wallander et al., 2017). Farmers received either a standard reminder letter, a letter emphasizing those farmers who join as 'environmental stewards,' or a letter with the stewardship message and a descriptive norm message informing them of the participation level of their peers. Among farmers who were re-enrolling, they found that all three letters improved participation almost equally. In another study, Coent et al., (2018) found that among French wine producers, injunctive norms (i.e., what farmers believe others think about adopting a PES scheme) were in driving producers' participation choices. Descriptive norms (what farmers believe other farmers will do relative PES scheme adoption) did not.

Further exploring these norms, the French Ministry of Agriculture looked at how descriptive norms could be used to sway farmers' intentions to maintain sustainable farming practices even after agri-environmental schemes expire (Kuhfuss, Préget, Thoyer, Hanley, et al., 2016). Compared to a control group, farmers who were told that 80% of their peers intended to renew their PES contract (or that 20% of their peers did not intend to renew) were 18% more likely to report that they were willing to sustain their current sustainable practices. Unfortunately, though promising, this also points to the possible negative impacts of social norms—something that researchers in China had previously observed. If the norm in a community is to maintain conservation efforts, the result is a more durable intervention; if, however, the demographic trend is to reverse course and abandon agri-environmental schemes, that its effect and farmers' re-enrollment are negatively affected (Chen et al., 2009). More work has to be done to replicate these results and to understand the socio-ecological contexts in which highlighting social norms becomes effective for agri-environmental program recruitment, as well as understanding how intense those signals of the relevant norms must be to motivate action.

Conserving land: Incentives and social norms

Social conditions can also inform insights about the friction costs of enrollment (Jack & Jayachandran, 2019) or payment structures that become deterrents of participation. Revisiting the Villamayor-Tomas et al. (2019) study on trusted messengers, the researchers also examined farmers' willingness to adopt schemes depending on: i) whether farmers had to coordinate tree planting with neighboring farmers, ii) the size of an area a farmer lost to tree planting, and iii) how large the payment was for adopting the scheme. While the significant positive effects of payment size and reducing conservation area size were predictable, the team also found that Spanish and German farmers, in particular, were significantly more resistant towards schemes that required coordination (~60% of farmers thought coordinating with neighbors would make planting trees harder, and ~90% thought their neighbors would be uninterested; Villamayor-Tomas et al., 2019).

The incentive structure of an agri-environmental scheme is also an important component of its ultimate success. Some structures may aid in a scheme's deployment, but these do not always translate to better conservation outcomes. In Uganda, for example, many barriers make PES schemes easier to dispense as community-based payments rather than performance-based at an individual level. Yet, evidence suggests that schemes that reward individual performance are likely to lead to stronger conservation outcomes than those that offer payments relative to a community's performance (Gatiso et al., 2018). Conversely, in Colombia, we find that collective payments enhance farmers' social motivations to protect forests by aligning the community's expectations (Moros et al.,

2019)—a norm that might encourage conservation efforts to continue once PESs end. A similar, hypothetical scenario was presented to wine producers in France (Kuhfuss, Préget, Thoyer, & Hanley, 2016). There again, the addition of a collective bonus to an existing PES scheme led to increased expectations of peers' participation and created a pro-environmental social norm that could ultimately translate to a reduction in pesticide-intensive farming practices. This suggests the critical need to evaluate the relevant social dynamics in which a program is deployed to understand how the scheme may interact with that more general context defining social interaction.

Designers need to be further mindful of the ways PES schemes can exacerbate existing inequities. Since poor farmers may not have official land tenure, they may not be eligible to be included in land contracts, making the long term benefits from these payment programs less certain (Corbera et al., 2007; To et al., 2012). Customary land rights are not necessarily recognized by local authorities, and PES benefits are more likely to flow to elites than poor households. Perhaps even more troubling, PES schemes have been linked to the *loss* of traditional tenure rights (Luck et al., 2012), dietary diversity, and cultural practices (Ibarra et al., 2011).

Analysis

With the threats of climate change, water scarcity, and biodiversity collapse looming over the safety of agricultural production, a shift from production-driven farming to sustainable farming is required now more than ever. Farmers need to maintain more resilient crops, meet the world's growing food demands, and ensure that these demands will also be met in the future. Interventions of Agricultural Land Management can be broadly divided into the two groups we highlight above: interventions that focus on farmers' practices (i.e., bringing production techniques more in line with today's sustainability requirements) and interventions that help farmers protect and regenerate the land they live on through agri-environmental schemes (e.g., maintain land buffers, increase tree cover on their lands, etc.).

Review of the strength of the evidence

The literature on agricultural land management efforts is well represented by field evidence. It focuses directly on situations or interventions that farmers face in their day-to-day lives, except for a few artificial laboratory games. We can be quite confident that the results of these studies are ecologically-valid representations of 'real-world' outcomes. They also represent a broad mix of geographies, even though many focus on unique populations. Almost all studies properly randomize their interventions, and many use appropriate control conditions to ensure the internal validity of their results. Nevertheless, it is also worth noting that a good proportion of this literature relies on farmers' responses to hypothetical scenarios; results are likely to correlate with real-world choices, but the strength of these effects might ultimately be overweighed (O'Keefe, 2013).

Interventions that focus on the individual benefits of conservation for farmers, as well as how those benefits are presented, appear to be the most effective at getting farmers to adopt new sustainable practices. In most cases, designing with these benefits in mind also means addressing the unique needs and perspectives of the various groups within and between communities. The evidence points to leveraging social norms and community benefits to maintain these practices. It may be necessary to understand existing norms that may prove a challenge when it comes to the durability of and adherence to behavior change.

While many of these interventions show great promise in inducing long-lasting behavior change, we find that durability is generally not studied across this evidence base (but see, Brown, 2018). Durability may not be a problem for those interventions for agri-environmental schemes, as they usually mandate behavior change for a set number of years. For other behaviors, there is a significant gap in practitioners' ability to infer how many members among their target actors might stick to new and sustainable production practices once an intervention ends. The complementary use of timely prompts and ICT technologies shows great promise in both increasing farmers' production and ensuring that they maintain target behaviors (e.g., Casaburi et al., 2019; Cole & Fernando, 2016). ICT technologies must be active, ongoing, and designed to benefit all members of a community.

Review of the application of behavioral science

Agricultural producers often rely on their intuition and experience to make farming decisions. This way of decision making makes them particularly vulnerable to decision biases and heuristic reasoning. Therefore, we find that many behavior change programs find success mostly due to how they interact with those biases.

The first cognitive bias that is particularly relevant for agricultural decisions is that people are broadly found to be risk-averse when making a decision that involves uncertain but describable gains (Kahneman & Tversky, 1979; Ruggeri et al., 2020). For example, when offered a choice between receiving $5 or playing a game of heads or tails for $10, people prefer to take the less risky $5 option. People prefer to take the less risky option and get $5, even though the options are equivalent mathematically (a 50% chance of $10 is equivalent to $5 for certain). In agriculture, farmers face uncertain information often, such as when making long-term commitments or investment decisions. It becomes important for behavior change designers to be mindful of people's propensity for risk-averse choices when trying to sway farmers towards novel or sustainable production practices. Framing novel techniques as risk-reducing appears to be particularly appealing to farmers on the more risk-averse end of the spectrum: seeds that reduce the risk of crop failure (Ward & Singh, 2015) or animal feed that produces reliable results (Crentsil et al., 2018). Alternatively, interventions could also look at reframing gains as losses when describing new or sustainable practices. Since farmers become risk-seeking when perceiving potential losses (Bocquého et al., 2014; Tversky & Kahneman, 1985), intervention designers could emphasize that farmers would be missing an opportunity by not adopting these practices.

When uncertainty presents itself in a way we cannot describe with precise probabilities, likelihoods, or examples that farmers comprehend, then we cross into the realm of ambiguity aversion. Like risk-aversion, people generally tend to favor known uncertainty (i.e., probabilistic events) over unknown uncertainty (i.e., ambiguity). Ambiguity aversion tends to dominate when it comes to agricultural production decisions. Farmers prefer certainty over risk and risk over ambiguity. This makes it particularly hard for farmers to trust novel production means when they have neither heard of them nor when no one in their community can speak to its success or efficiency. Farmers also tend to suffer from both a confirmation bias (i.e., our tendency to overlook information or experiences in favor of those that support our beliefs) and status quo bias (i.e., our general preference for the current state of affairs). Therefore, intervention designers must find creative ways of reducing the ambiguity associated with novel production techniques (e.g., Buchholz et al., 2018) or to 'sell' these novel techniques as ambiguity-reducing (Barham et al., 2014). We need to be mindful that it is easier for farmers to stick with what they know, even if it has a lower chance of success. A shift in behavior depends on how clear the new solution is.

Social proof helps to resolve ambiguity and risk aversion in addition to supporting social norm change. When facing new and risky decisions, farmers tend to adopt those that they know other farmers have trialed and succeeded in using, which could explain the success of programs like Shamba Shape up (Areal et al., 2020). Similarly, farmers are more likely to adopt new techniques or to sign up for agri-environmental schemes if the recommendation comes from other farmers (Fafchamps et al., 2020; Villamayor-Tomas et al., 2019) or if they know that other farmers have signed up (Cole & Fernando, 2016; Genius et al., 2014; Kuhfuss et al., 2016; Vu et al., 2020). The concept of social proof also helps us understand where and why social norms can be effective at encouraging the adoption of sustainable or conservation-oriented practices. An extensive set of behavioral science research shows that people generally want to conform. And in the context of social learning, this is not an irrational bias (Rendell et al., 2011). When a farming technique is widely adopted, the wisdom of the crowd allows farmers to conclude that "if others are doing it, it must be working." But not everyone in a network is seen as equally worthy of imitation. Therefore, the challenge is to identify who it is that farmers look to for information and to ensure that their observable behavior is in line with the descriptive norms of desired behaviors. If norm conflicts could arise (when messages of what people are doing conflict with what people think is right or wrong), intervention designers can instead use public commitments to signal norm change (Lokhorst et al., 2010), dynamic norm messaging (as seen in *Topics 2 & 3* on *Climate Mitigation* and *Water Management & Conservation*, respectively), or injunctive norms that impart others' expectations relative the adoption of new, more sustainable practices (Coent et al., 2018).

Providing information is a common strategy for driving the adoption of climate-friendly agricultural practices. While only providing information has been criticized as an insufficient behavior change strategy (Cinner, 2018), information can be a critical part of a comprehensive behavior change program. Behavioral scientists have noted that the *timeliness* of information can significantly alter the effectiveness of environmental behavior change interventions (Yoeli et al., 2017). For information to affect choice, it must be salient to the actor at the point of decision making. While a rational actor would have available to them everything they know for every choice, humans only account for beliefs that are top of mind. Therefore, reminders that make salient information at the time of decision making can be particularly useful, even when the actor already knows that information. It is important to note that what information is salient can be incredibly fleeting, perhaps lasting as little as a matter of seconds or minutes. Consistent with this understanding, optimizing the time at which information and reminders are provided has been found effective for driving the adoption of climate-friendly practices through ICT services (Cole & Fernando, 2016). Researchers have extended the importance of precise timeliness to the provision of incentives, finding that offering discounts for fertilizer right after harvest, rather than right before planting, can significantly increase adoption due to farmers' hyperbolic discounting of future gains and losses (Duflo et al., 2011).

Review of the application of social science

While cognitive biases may be generalizable across populations and communities, the socio-ecological settings in which we find agricultural producers are much more distinct and varied. These settings ultimately dictate whether or not efforts to address the above biases will prove effective and whether target actors will engage with practitioners' behavior change efforts.

Looking specifically at gender, social scientists find that the informational needs and agency of male and female producers differ markedly. Many of this section's behavior change interventions fail to acknowledge these diverse needs and experiences. In Senegal, for example, men mostly control the means of production, and women usually sow their crops later than men. Where men may benefit from knowing when to sow their crop, women would benefit from knowing how late into a season they can feasibly plant (Tall et al., 2014). Similarly, in Kenya, where men can focus on 'commercial' production, women tend to focus on production that ensures household food and nutritional security (*Gender and Institutional Aspects of Climate-Smart Agricultural Practices*, 2015). Social structures and traditional gender roles create differential needs for information as well as agency in making decisions. Unfortunately, many interventions choose to reframe the language of extension efforts or production techniques to make them homogeneously more appealing to all genders instead of customizing to each (e.g., Andrews et al., 2013; Clot et al., 2017; Le Coent et al., 2017). Much work remains to identify the different needs of target actors and in finding the best ways to address them (Carr & Onzere, 2018).

Encouragingly, evidence suggests that once the diverse needs of target actors are met, meaningful and sustainable change in agricultural production should ensue. For example, women are generally less aware of community-supported and sustainable practices. Still, once they learn about these practices, they are no less likely to start utilizing them than men (Bernier et al., 2015). Providing extension services and training for women, by women, is thus essential for reducing the gender gap in the adoption of sustainable production practices (e.g., Buehren et al., 2019; Kondylis et al., 2016; Mogues et al., 2019; Shikuku, 2019). Similarly, women who have more decision-making power in the household, due to social or family networks or them acting as head of house while their husbands seek other work, means they have more agency to be agricultural innovators (Petesch et al., 2018).

There is also a need for behavior change practitioners to diversify how they interact with farmers that are less prone to participate in community meetings or that lack access to conventional extension efforts. Edutainment radio or TV shows like Shamba Shape Up are good examples of behavior change efforts that do not require in-person contact and might be more accessible to marginalized members of society (Areal et al., 2020). Even so, edutainment programs implicitly require target actors to be available during the show's broadcast time and to have access to a television or radio. These cannot be taken for granted given different communities' power dynamics (Archer,

2003), and these programs might ultimately not address the unique needs of a heterogenous farming population. Interventions designed to target the behaviors that only individual members of the community have the physical and socio-cultural affordances to engage in cannot be expected to have equitable effects across the community. The only way to build an intervention with equitable outcomes is to understand and account for social difference.

Similarly, practitioners need to pay due diligence to the messengers they leverage to deliver information or more complex behavior change programs. For example, norm messaging would be far better informed through initial exploratory research that identifies the social context and networks where target actors are situated. This would allow intervention designers to then better understand what and whose normative message would be most appealing. A handwritten normative letter, for example, might sound like a good idea until you consider those producers might not trust or value the opinion of the person writing the letter (see letters from research assistants in N. V. Czap et al., 2019 with other farmers' recommendations in Villamayor-Tomas et al., 2019). A more systematic analysis of producers' social networks would provide intervention designers with a better understanding of whom farmers trust as well as the suppliers and other stakeholders with whom they engage.

For example, we know that people with more extensive social networks and those who find themselves living next to novel adopters (of technologies or practices) are more likely also to adopt changes (Beaman et al., 2020; Wossen et al., 2013). Conducting a social network analysis would also ensure that behavior change efforts do not ignore those that are marginalized but hold considerable power (Prell et al., 2009) and better understand community trust dynamics that may aid or impede conservation efforts (e.g., Gatiso et al., 2018; Kuhfuss et al., 2016; Moros et al., 2019; Villamayor-Tomas et al., 2019). We found but one intervention in this topic area that leveraged tools such as social network analysis to better target and understand farmers (Beaman et al., 2020). Modeling existing and ideal networks, as Beaman et al. did, would allow practitioners to bring about change more effectively, as well as ensure that the social environments in which we find producers are amenable to and enable change.

Another reason farmers may be more or less likely to engage could be due to local value and social norm alignment or misalignment with program goals. Many societies perceive relationships between humans and nature to be relational, holistic, and deeply rooted in culture, language, and livelihoods (Ellis, Pascual, & Mertz, 2019; Cortés-Capano et al., 2020; Gould et al., 2019). Ecosystem services and land conservation may have value beyond something instrumental or intrinsic. Local demographics layer on context-specific associations with age, education status, wealth and class, development pressure, comfort with technology, and perceptions of profit in agriculture (Tey & Brindal, 2012; Meijer et al., 2015). Both values and demographic trends can further shape how actors perceive their agency that may drive actors to certain decisions (Singh, Dorward, & Osbahr, 2016; Chapman, Satterfield, & Chan, 2019)

Finally, we want to emphasize the need for behavior change interventions to explore more than just end-user behaviors. While these interventions generally focus on working *within* the existing power structures, we also need to recognize that farmers do not cultivate in a vacuum. The pressures to maintain unsustainable practices stem largely from land ownership arrangements, regulated markets, and the presence or absence of agricultural infrastructure and institutional support (e.g., minimum prices, credit lines, crop insurance, access to seeds, subsidies for adopting sustainable behaviors). For example, a PES scheme that does not take into account land-tenure heterogeneity may end up exacerbating existing social inequalities by only providing payments to landowners (To et al., 2012). Farmers may also be more prone to reject interventions if the means of achieving sustainable change requires investment without a safety net. These interventions may appear risky or ambiguous, even if these changes are good for farmers in the long run. Instead, we find that one particularly promising area of research is to provide farmers with ways to interact with (and even modify) relevant market structures. Having the ability to notify fertilizer suppliers of late deliveries, for example, is crucial since farmers' fertilization windows are both vital and narrow (Casaburi et al., 2019). Similarly, having supplier visits better agree with farmers' crop cycles is an easy change that leads to, in the case of the SAFI program in Kenya, significant behavior adoption (Duflo et al., 2011).

Further Readings

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Concluding Analysis

This review included behavior change interventions across five environmental topic areas: biodiversity conservation, climate mitigation, water management and conservation, waste management, and land management and climate adaptation. In this section, we provide a synthesized analysis of these interventions from three perspectives: the strength of the evidence, the integration of insights from behavioral science, and the integration of insights from social science. We then conclude with a framework for understanding how behavioral and social sciences can be effectively integrated into behavior change programming to improve environmental outcomes further.

Analysis of the Strength of Evidence for Behavior Change Interventions

The strength of evidence for behavior change in the environmental field is varied. We identify four ways where the evidence for behavior change interventions differ in strength:

- Internal validity, or whether interventions show a clear and causal impact;

- Ecological validity, or whether interventions represent the natural context;

- Evaluation of durability, or whether interventions persist over time; and

- Geographic generalizability, or whether interventions can provide supporting evidence for their generalizability across geographies.

Internal Validity

Internal validity describes the extent to which we can confidently attribute changes in outcomes to the intervention. This causal attribution is critical for our ability to determine whether an intervention was effective and critical for making programming recommendations.

The interventions reviewed differed in their degree of internal validity, largely predicted by the environmental problem they were designed to address. Poaching and transportation interventions, in particular, tended to have lower internal validity. This is largely due to their reliance on pre-post comparison without randomization to treatment or other methods for statistical control. We saw a similar pattern with regards to plastic bag taxes and bans in the topic on Waste Management, and as demonstrated in River's et al.'s (2017) analysis of Toronto's plastic bag tax, these techniques can result in large over-estimates of an intervention's effectiveness.

Interventions that focused on sustainable farming practices, engagement in conservation, water conservation, energy conservation, water management, and waste management (minus plastic bag taxes) tended to have a higher degree of internal validity. Interventions in these sections were often evaluated in controlled lab experiments or randomized field experiments, so we are more confident in the average effect of the intervention.

Gaps and Future directions
The common reliance on pre-post evaluations requires the assumption that no other influences would affect the target behavior during the intervention period. That assumption is rarely, if ever, justified. Alternative quasi-experimental designs, such as matched trials and difference-in-difference, provide more robust evidence but are still subject to untestable assumptions.

To increase internal validity, environmental interventions that rely heavily on pre-post metrics for evaluation would benefit from adopting alternative strategies. Randomized controlled trials are not perfect but present the strongest opportunity to evaluate field interventions. They have been widely adopted in the evaluation of development economics interventions (Deaton & Cartwright, 2018). Many of the studies using pre-post evaluation have interventions that are administered to a *group* rather than an *individual*. This means that if such interventions were to be evaluated through randomized trials, they would need to be *cluster* randomized trials. This type requires evaluators to recruit a sufficient number of groups to be confident that changes observed are not just because

certain groups were assigned to certain interventions (Hayes & Moulton, 2017). When cluster randomized trials may be infeasible, intervention designers may consider modern causal inference techniques like synthetic controls (Abadie et al., 2010). Regression discontinuity analysis may also provide more convincing estimates when sufficient pre- and post-intervention data is available (Imbens & Lemieux, 2008).

Ecological validity

Ecological validity describes the degree to which study results can be generalized to real-world behaviors. Studies conducted in the real context of the intervention have the highest degree of ecological validity. Laboratory studies, particularly those involving hypothetical choices, require substantial assumptions to be considered ecologically valid. This form of validity is key for confidently recommending an intervention be adopted.

Studies of behavior change interventions reviewed here largely fall into three categories: those that measure the real target behavior in the field, those that measure the intentions of hypothetical behaviors in the field, and those that occur as laboratory or online experiments (with target population or non-representative populations like university students).

We find that those interventions targeting energy use, waste management, and those trying to promote sustainable farming practices generally observe the target behavior in the natural context. So did interventions on poaching. This results in a high degree of ecological validity, capturing the real motivations of actors as well as their actual socio-ecological context. Many of the studies we reviewed that focused on PES or agri-environmental schemes measured the efficacy of their interventions through hypothetical scenarios or intention surveys. The studies we reviewed that focus on water agreements, and food purchasing decisions often observed the effects of interventions in a simulated laboratory context or online, which offer a low degree of ecological validity.

Gaps and future directions
Topics lack ecological validity if they rely heavily on laboratory studies, hypothetical choices, and samples that do not represent the target actors or the context of interest. Topics supported by artefactual field experiments increase ecological validity by recruiting participants representative of target actors. Framed experiments design studies in terms of the actual environmental challenge, making them more likely to trigger real psychological responses. However, even these framed experiments generally fail to integrate the complex socio-ecological relationships that real participants have with those around them and the target behavior.

Laboratory experiments allow for strong internal validity at a low cost, making them an attractive first step in evaluating a new concept. Similarly, hypothetical and intention-based measures are often valuable indicators that an intervention concept may be worth pursuing. Accessing participants for interventions focused on low-to-middle income contexts is extremely costly. Convenience samples, such as university students, are an attractive substitute. However, when insights derived in these contexts are applied to ecologically valid contexts, their effects are often substantially diminished (DellaVigna & Linos, 2020). While artefactual field experiments and framed experiments provide some degree of ecological validity, they are not as accurate as natural field experiments. Therefore, laboratory techniques, artefactual field experiments, and framed experiments should be seen as lower-cost, initial steps on the way to natural field experiments, rather than sufficient evidence to justify the large-scale implementation of an intervention. Instead, practitioners must develop a comprehensive understanding of the target socio-ecological context to assess the degree to which any laboratory insights would be applicable. Moreover, any field intervention based on those insights must be evaluated before we can be confident in its ecological validity.

Evaluation of durability

Durability refers to the persistent effect of a program. This can mean within the delivery period of a program, determining whether the potency of an intervention declines over time. It can also mean after a program's delivery

concludes, determining the degree to which a change in behavior is stable even without the support of the intervention. The evaluation of durability is critical for determining whether an intervention has achieved its intended outcomes, as well as for calculating an accurate estimate of the total benefit of the program for making further scaling out decisions.

It is important to recognize that assessing the ongoing durability of a program may not always be appropriate. This is dependent on the behavior change logic of the intervention. If an intervention is *only* intended to change a one-time behavior (e.g., encouraging someone to opt in to an environmental behavior), then durability is not a relevant concept. However, if the intervention aims to continue to influence behavior over time (e.g., encouraging compliance with an environmental behavior), then understanding the durability of that change in behavior is critical.

The interventions we reviewed that target energy and household water conservation are relatively unique in their assessment of durability. These programs often monitored their impact relative to controls for years after their initial introduction. This means we can be more confident in the long-term causal effect and benefit of the program. We find that agricultural and wildlife conservation interventions tend to be more mixed, with a sizable minority continuing to monitor the long-term state of community behavior. However, as pre-post interventions are generally not assessed relative to a control, it is difficult to make any claims about whether these changes can be attributed to the intervention. Lastly, we find that few waste programs monitor the durability of their effects other than behaviorally-informed policy interventions such as plastic bag taxes.

Gaps and future directions

We identify two gaps in the evaluation of durability. The first is that a number of interventions that require persistent behavior change are failing to monitor it. Energy and water conservation interventions are the best relative to other topics in measuring durability. This may be due to the availability of administrative records for utility use, whereas other durability assessments require ongoing data collection.

Secondly, while a number of programs collect data suitable for *monitoring* the behavioral state of the target community, they fail to collect data that allow for actual evaluation. This is common because these programs were often originally evaluated through pre-post comparison, with no control available for strong causal inference. While this poses a problem for the initial evaluation of a program (see the internal validity section above), the issue is only compounded as time passes. This is because more and more factors other than the intervention itself may come to influence the outcome variable being monitored for durability. As a result, implementors may mistakenly attribute a durable effect to their intervention when, in fact, the purported result is simply driven by changing higher-order trends.

To build a better evidence base around the durability of behavioral interventions, those designing and funding monitoring and evaluation programs should ensure that the evaluation program continues for as long as the behavior change takes to occur. While this may present up-front costs, the resulting data will be indispensable for decision making when considering whether a program should be scaled out more widely. Designers may consider various forms of remote sensing to reduce the cost of long-term evaluation of durability. Finally, future programs should ensure that long-term durability assessments do not involve merely assessing the state of target actors. Instead, they should also include a robust causal-inference framework to determine the causal impact of the intervention, rather than just general trends.

Geographic generalizability

Interventions are often developed in a particular geographic context. However, the degree to which that intervention can be scaled out to other geographies can be critical for applying the intervention to a range of environmental challenges and contexts.

We find that among the interventions reviewed, different environmental targets or behavior change strategies tended to be clustered within particular dimensions of geography. For example, interventions on illegal wildlife

trade operate in point-of-origin countries. Habitat degradation interventions operate where threats of ecosystem loss appear most urgent. Interventions focused on improving agricultural practices tend to focus on lower-income countries where agriculture is a primary livelihood. Interventions for water agreements are located near shared water bodies at local, regional, and international scales.

Interventions related to climate change mitigation, agri-environmental scheme adoption, engagement in conservation, and waste management are often located in higher-income countries, even though these topics apply to communities around the world. Across topics, we find that social comparisons and the use of injunctive norms tend to be used more in high-income regions (e.g., Europe and North America). Interventions that strive to create new social norms and empower communities tend to focus on low and middle-income regions (e.g., South East Asia, China, Africa, and South America).

Gaps and future directions

Across topics, interventions that have been scaled out tend to be scaled out to a particular geography. Some intervention types have been conceptually replicated across multiple countries to test the same psychological insights across populations. Even so, those replications are concentrated within particular geographic contexts. It is important to acknowledge that some of these limited geographic scopes are justifiable given the problem. For example, conservation interventions are often focused around the geographies where there are urgent conservation priorities. However, the particular focus of climate and waste management interventions in high-income countries is not similarly justifiable. Researchers have documented that behavioral insights developed among Western, Educated, Industrialized, Rich, and Democratic (WEIRD) samples are rarely generalizable to the majority of humanity (Henrich et al., 2010). Results developed exclusively among WEIRD samples are therefore unreliable for applications in other geographies.

Future interventions should be mindful of adapting studies based on WEIRD populations for non-WEIRD audiences. Behavior change findings that have replicated across geographic and cultural contexts should be prioritized when developing and scaling interventions. Similarly, interventions that work across contexts and share target cultural contexts should be prioritized. We should further elevate developing effective evidence that generalizes across geographies and cultures to the extent possible. It would also be valuable to understand which interventions interact with which features of a socio-ecological context to better understand where certain interventions may be applicable.

Behavioral Science Perspective on Behavior Change Interventions

The behavior change interventions identified in this review rely on a host of behavioral science insights and principles. These include strategies for applying social norms to overcome cooperative dilemmas, reducing risk and ambiguity aversion to adopting novel practices, and overcoming or leveraging cognitive biases to overcome the intention-action gap. Here we analyze the application of these strategies for achieving behavior change and identify new directions for increasing their effectiveness.

Shifting social norms to address cooperative dilemmas

The most common behavioral science-informed strategy for shifting behavior in this review involves social norms. These interventions are most commonly employed when a behavior results in group-wide benefits where the entire group would benefit if everyone complied. There are two main categories of social norm interventions in this review: those focusing on norm messaging, and those focusing on norm *shifting*.

Interventions focusing on norm messaging are most commonly found in household water and energy conservation, household waste reduction, and sustainable agriculture. These interventions rely on the behavioral insight that people tend to like to conform to what those in their social reference group around them are doing. Messaging based on this insight is known as descriptive norm messaging.

Descriptive norm messaging can occur in a variety of ways. The most straightforward method is to broadcast to all members of a group what the average person in that group is doing and what they expect others to do. This style of messaging fails to account for people who respond only to expectations about what their *reference group* is doing. Some interventions attempt to address this by providing more personalized social comparison by informing the target of what those in their immediate area are doing.

One concern with norm messaging is the risk of a boomerang effect. This effect occurs when people who are already engaging in the desired behavior see that they are exceeding the average and then do less of the desired behavior. Many of the interventions in this review have included injunctive norm messaging, which indicates what the community thinks is the right thing to do, as a method for mitigating the boomerang effect.

Interventions employing norm messaging are generally effective and surprisingly durable. However, their average effect is small, usually only shifting behavior an average of low, single-digit percentage points. Behavioral science identifies two related reasons for this small average effect. The first is that for behaviors that are observable, people are more likely to rely on their observations of those whom they care about rather than on abstract statistics reported to them. Secondly, while these strategies can report the state of the norm, people can also hold false beliefs about that norm. Norm messaging interventions do not aim to *change* the norm, meaning that they have little capacity to result in large shifts in group-wide behavior to a new equilibrium.

As an alternative, another set of interventions goes beyond simply messaging to *changing* the underlying norm. We find these interventions most commonly in community-based biodiversity conservation and illegal wildlife trade reduction. The behavioral science of norm change has identified a set of key elements. These include generating collective demand for change by increasing beliefs about desired behavior, coordinating a shift in behavior where everyone agrees to join in the new normative behavior, and strengthening the norm through community-based observation and enforcement. This style of intervention can experience a tipping-point effect, where early adoption may have minimal social influence, but after exceeding a particular threshold, adoption cascades throughout the remainder of the network.

As compared to norm messaging interventions, norm shifting interventions are far more intensive and costly to operate. However, we find that they result in far larger shifts in behavior. Behavioral science theory would also predict norm shifting interventions to be far more stable over time, as they inherently create self-reinforcing mechanisms that maintain the normative behavior even after the intervening party has left.

Reducing perceived risk and ambiguity to promote the adoption of novel practices

When practitioners ask actors to engage in environmentally-friendly practices, they may also be asking them to take on substantial risk. Moreover, these risks can be ambiguous, meaning that the actor may not even know how likely a good or bad outcome may be. In our review, we find that these challenges are particularly relevant in sustainable agriculture where farmers are asked to adopt entirely novel practices that they perceive to threaten their livelihood.

Recognizing these risk aversion-related barriers has a significant impact on programming. In particular, risk aversion has major implications for how extension agents can be most helpful in shifting agricultural practices. Agents need to provide clear and scientifically sound guidance as well as focus specifically on resolving these concerns over risk. One core behavioral science strategy in this review that resolves issues around risk perception is to provide *social proof*, highlighting those who have already succeeded while adopting the novel practice. Social proof is even more effective when those highlighted are in the target's reference network.

We also find creative interventions that reframe risk's relationship with novel practices. Some interventions present novel practices as ways of *reducing* other risks that the actor is already encountering: for example, describing new seeds as a way of reducing the risk of crop failure or using animal feed as a way of producing more consistent results.

Designing choice architecture to bridge the intention-action gap

A number of the behaviors addressed in this review embody what behavioral scientists have coined the *intention-action gap*. For many pro-environmental behaviors, actors desire and intend to engage in them yet fail to ultimately do so. We find this particularly common in those behaviors that are relatively low effort and target households or consumers, such as water and energy conservation and waste reduction.

Behavioral science can shed light on why people might not translate their intentions to action, especially when a behavior seems trivial. People have limited cognitive resources, and low-consequence decisions are often relegated to more implicit forms of decision making. This means those decisions are more vulnerable to decision biases that can lead the actor away from the desired choice.

We have identified various strategies in this review for overcoming the intention-action gap through the application of choice architecture. In these cases, decision biases are either eliminated or magnified to influence decision making. This can explain the effectiveness of green defaults, where a decision-maker retains the ability to choose the less environmentally-friendly option. However, if no choice is made, the green choice is automatically selected. The reason this style of intervention is so effective is also why people were failing to overcome their intention-action gap in the first place. While people might prefer the green option, they are not willing to devote the cognitive resources needed to make that decision actively. By making the green option the default, those cognitive resources are no longer required.

Interventions that exploit the *saliency* of particular information work similarly. For example, simplified labeling that highlights the environmental benefits of choosing a green option allows the actor to fulfill their intention *without* devoting additional cognitive resources to the decision. Salient labels do not shift any material costs or benefits but make it psychologically easier to incorporate the information, thereby nudging the actor into a green choice without restricting their options.

Gaps and future directions

The behavior change interventions identified in this review applied a variety of behavioral science insights. However, we found that very rarely was the problem systematically analyzed to determine *which* behavioral insight would be most applicable to the given situation. Instead, interventions often seemed to be developed either from the perspective that all behavioral science insights might be equally relevant to a given problem or that designers wanted to apply certain behavioral insights to a particular context. However, this review identifies the clear link between particular classes of environmental challenges and interventions: shifting social norms pairs with cooperative dilemmas; risk and ambiguity reduction pairs with adopting novel and costly practices; and choice architecture strategies pair with overcoming the intention-action gap in low-cost decisions. We recommend using a behavioral design approach to design interventions so that program designers will be better able to select behavioral insights best suited for their environmental challenge. A list and analysis of behavior change design approaches can be found in the *Review of Behavior Change Approaches in the accompanying Behavior Change Interventions in Practice* document.

We found that while a variety of behavioral science insights were incorporated into different interventions, few incorporated multiple behavioral science insights into a *single* intervention. We suspect this is due to the involvement of academic partners who may prefer a finding in which a change in behavior can clearly be attributed to a single psychological change. However, this is not the most effective strategy for those hoping to have the largest possible effect on behavior. Instead, multiple behavioral science insights should be leveraged in concert. This would address multiple motivations that an individual actor might have and how different groups of actors may have different motivations.

Environmental behavior change would also benefit from the adoption of recent methodological innovations in the

behavioral sciences. Behavioral scientists have recently begun to adopt various open science practices to build a more accurate understanding of the behavioral science landscape. These include pre-registration, where the study design and analysis plan are posted before administering the study, often with a commitment to publish the findings regardless of the outcome. This is widely practiced in other applied fields, such as medicine and public health (Lindsay, 2018). Unfortunately, pre-registration is rarely found in environmental behavior change studies, including the studies in this review. Pre-registration leads to less bias in published findings and more confidence in the results (DellaVigna & Linos, 2020; Kaplan & Irvin, 2015). Funders could be influential in requiring interventions to pre-register their design and analysis and mandating that researchers post their results.

Social Science Perspective on Behavior Change Interventions

For behavior change to be effective, it is critical to recognize that every behavior occurs in a socio-ecological context. This context shapes the abilities and motivations of the actors we seek to change, who, in turn, dynamically shape their socio-ecological context through their actions. Social scientists have identified a number of broad recommendations to improve behavior change programming: build an enabling socio-ecological system for the direct actor; design for social differences within a target set of actors; and address ethical concerns and intervention power dynamics. In this section, we analyze how interventions in this review incorporated these dimensions and how these dimensions can more broadly improve program effectiveness.

Build an enabling socio-ecological system for the direct actor

We find that the large majority of behavior change interventions exclusively focus on changing the behavior of the actor whose behavior directly contributes to the environmental challenge. Identifying that direct actor and the behaviors they would need to change is an important step. However, we find that interventions commonly make the mistake of maintaining a myopic focus *solely* on those direct actors. This design fails to appreciate the degree to which others affect the direct actor's ability and motivation to engage in the desired behavior.

Influential actors can appear at various levels in the direct actor's social system. For example, when programs fail to address government officials' behavior, these programs also reduce the effectiveness of PES schemes that operate under restrictive land tenure rules (To et al., 2012). We observe the same theme in both marine and terrestrial ecosystem management. Behavior change is more likely to occur when government officials devolve authority to local communities (Alimi et al., 2018; Muntifering et al., 2015). Community members can also create this enabling environment at the local level and apply social pressure to direct actors (Gillingham & Bollinger, 2017; Pickering et al., 2017). This dynamic can even be found in the household where within-family social roles can substantially shape behavior (Fielding et al., 2012; Lowassa et al., 2012).

A traditional method for providing structural support to farmers in an agricultural setting is through extension agents. The role of extension agents has generally been to provide information. However, frequently farmers do not simply lack information (Bernier et al., 2015). Instead, extension agents can most effectively encourage adoption by providing social proof of others' success with new practices and targeting influential members of the community (Kwayu et al., 2014; Wossen et al., 2013). This means that shifting the behavior of the extension agents *themselves* is a behavior change challenge, focusing on their role as social change agents rather than information providers.

The few programs that successfully create an enabling environment for the direct actor take a community-based approach. In studies of marine and terrestrial conservation, the national government, subnational government, local government, and the wider community contribute to fishing sustainably and abstaining from poaching (McDonald et al., 2020; Muntifering et al., 2015). In green energy interventions, the local government, suppliers, and community members support the installation of rooftop solar (Gillingham & Bollinger, 2017). And in sustainable agriculture solutions, the regional government, local government, and community members support runoff reduction practices (Pickering et al., 2017).

Design for social differences within a target set of actors

Social scientists recognize that within a given group of target actors, they may differ dramatically in their identities and social roles. Across the behavior change interventions reviewed, nearly none address that these different identities and social roles present unique barriers and motivations to action and require a segmented approach to reach the entire population.

There are a number of relevant social identities for behavior change across the environmental topics we reviewed. Gender was a commonly identified social difference, with men and women having different motivations to conserve water (Tong et al., 2017), conserve energy (Permana et al., 2015), and partake in bushmeat hunting (Lowassa et al., 2012). These roles are also related to positions of power. For example, women have limited access to participation in water management bodies (Eder, 2010; Singh, 2008) or less ability to choose when to plant crops (Tall et al., 2014). Gender roles also shape patterns of behavior. For instance, women may be unable to control their own time and less able to be available for climate information broadcasts (Archer, 2003). Additionally, women are more commonly expected to serve in the role of the caretaker (Wilkowska et al., 2014).

These social differences are not only relevant for improving program effectiveness; they are critical for ensuring an equitable distribution of program benefits. For example, when a PES scheme fails to deliver benefits to poor farmers because they lack land tenure, this not only results in a less effective program, it entrenches existing social inequalities (Figueiredo et al., 2013; To et al., 2012).

Address ethical concerns and intervention power dynamics

A social science analysis is particularly well-positioned to investigate the power dynamics and ethics involved in implementing behavior change interventions as well as their unintended consequences. We find that behavior change interventions largely fall into two broad categories regarding ethics and power. The first is overt community-based approaches. These strategies tend to rely heavily on leveraging existing social institutions and power for effective change. In some ways, we can celebrate communities taking control of change rather than external actors. However, interventions did not address how community-led solutions may entrench existing power hierarchies.

The second category of interventions largely focuses on changing the choice environment without restricting choice. These strategies are sometimes referred to as 'nudges'; they preserve choice while still moving people in what is seen as the normatively 'correct' direction (Thaler & Sunstein, 2009). However, critics have observed these strategies exploit massive power discrepancies between the implementor and target actors. They substitute the implementor's preferences for those of the target. Even more problematic is that those in poverty must use precious cognitive energy to notice and avoid nudges (Mani et al., 2013). The few disaggregated results in this review demonstrate these troubling effects. For example, default nudges to pay more for green energy are most likely to affect the poor, despite them being the least interested in those contracts (Ghesla et al., 2020). Designers may have good intentions with employing environmental nudges, but they still wield great power when making a decision for those whom the intervention affects.

Finally, evaluations of behavior change interventions tend to solely focus on behavioral outcomes and rarely assess whether any unintended consequences of the intervention may have occurred. This is surprising given a large body of social science literature has found that negative or harmful effects are common in environmental work (e.g., Beall, 2010; Ferguson, 1994; Jeffrey, 2010). We speculate that designers fail to measure unintended side effects because they do not have a robust understanding of the social context to predict them and then do not include those in the program's evaluation design.

Gaps and future directions
Despite some bright spots, we largely find the behavioral interventions in this review lack a social science lens in

program development, implementation, and evaluation. Interventions commonly fail to address a broad system of actors, account for social differences among target actors, or explicitly address power and ethical concerns.

Future behavior change interventions can embrace a number of practices that better address these concerns, both to make programs more effective as well as ethically sound. The first is to ensure that a clear understanding of the socio-cultural context is established *before* a program is designed. Common tools to do so include interviews, focus group discussions, and observation. In addition to these techniques, designers can build intervention with the target actors and stakeholders to ensure their local knowledge is incorporated into any program. Social science researchers have developed innovative techniques for identifying possible relevant stakeholders, such as applying quantitative social network analysis to ensure that all relevant parties are represented (Prell et al., 2009).

To account for social differences among target actors, intervention designers must use their understanding of the social context to determine how actors with different identities interact with the target behavior. These differences should be considered as separate variables to ensure each group's needs are adequately addressed and equitably represented in program design.

Creating an enabling socio-ecological system means treating the various actors as more than targets for behavior change. Instead, effective programming treats the various stakeholders as participants in the development and implementation of the intervention. This can be achieved through sustained multi-stakeholder dialogue (MSD) (Ratner & Smith, 2020). Importantly, MSD implies far more than consolation and advisement. It means collaborative action throughout the intervention lifecycle.

Designers must explicitly grapple with and justify the ethical position of their intervention as a core part of its success metrics. Behavioral interventions without top-down bans and mandates can still have significant unintended consequences. Designers cannot assume that because an intervention is community-driven or preserves free choice that it is inherently ethical. Instead, designers should explicitly propose possible ethical risks and incorporate their risk assessment into their overall program evaluation. This includes reporting disaggregated results across social differences to ensure that a program is delivering program benefits equitably.

These proposed future directions represent significant efforts on the part of program designers, implementers, and evaluators. However, these costs return significant benefits in terms of more successful programs delivered in an ethical manner. Funders can serve a critical role in aligning the incentives of program staff with local communities' interests and needs.

Conceptual Framework for Advancing Social & Behavioral Science Informed Interventions for the Environment

Through our analysis of the behavior change interventions in this review, we identified three main ways to improve the integration of behavioral and social sciences into environmental behavior change programming: learn the socio-ecological context, use well-documented and evidence-based behavioral insights, and engage target actors throughout the socio-ecological system. Designers who adopt these practices will build interventions that are more effective, durable, and consistent with the needs and values of the communities they serve.

Learn the socio-ecological context

Our review of environmental behavior change interventions demonstrated that they consistently do not incorporate an understanding of the relevant socio-ecological context. Moreover, our review of social science findings identified numerous cases in which the failure to address these socio-ecological factors would lead to either ineffective or less effective behavior change interventions.

This context is important for several reasons. Individuals do not make decisions in a vacuum. Their decisions are influenced by their social network who may restrict or support their ability to act. Within a given socio-ecological context, people who take on different identities are afforded different abilities and responsibilities. Without accounting for these social differences, interventions may only address the needs of the most visible actors. This is ineffective at addressing everyone's needs and also inequitable in elevating the needs of a subset of the target population.

As a result, program designers must proactively develop an understanding of the socio-ecological context *before* they develop an intervention. Interventions should be developed from the ground-up to fit the needs of the target population. Previously published literature may provide a good starting point for this information but is unlikely to cover the specific needs of the target population. Instead, intervention developers will need to analyze the behavioral context to identify relevant social dynamics. This can involve a variety of techniques, including observation, focus group discussions, interviews, and surveys. It may also include stakeholder dialogue, which further builds community buy-in for the intervention. Here are several strong examples from biodiversity conservation where program designers incorporated the socio-ecological context:

Conserving Spiny Lobster in the Bahamas (Green et al., 2019)

The program designer conducted surveys, interviews, and observations of community members in local fishing villages. This included fishers but also others in the community who also make up the fishers' reference network. The campaign managers then used the information to create a campaign called "Size Matters." The campaign recognized that fishers were already motivated to reduce their catch of immature lobsters but lacked the support to do so. The campaign provided a simple, easy-to-use measurement tool so fishers could quickly assess whether a lobster was large enough to keep. This campaign resulted in the Bahamas spiny lobster fishery being the first in the Caribbean to receive the Marine Council Stewardship certification.

Establishing Reciprocal Water Agreements in Peru (Martinez et al., 2013)

The campaigners used sociological surveys to develop a program that relied on existing local social norms of reciprocity. They also recognized the low financial status of upstream farmers that limited their ability to participate in the scheme. As a result, farmers received in-kind payments that were consistent with conservation, such as beekeeping equipment and fencing to keep cattle from encroaching on riverbanks. The intervention designer also recognized that the farmers made their decision within the larger social environment of their communities. Social marketing campaigns built social pressure from other community members to create an enabling social environment. The program resulted in farmers signing 25 reciprocal water agreements and the protection of more than 360 hectares of forest.

Protecting Rhinos in Namibia (Muntifering et al., 2015)

The program designers conducted a series of socio-ecological surveys of those living on communal land to identify key aspects of the relevant socio-ecological context. The intervention was then co-developed through a partnership between community members, government representatives, and NGOs. Intervention designers needed to address conventional models of conservation that had created distrust within the community. This resulted in a combination of policy and programming that returned the rights of wildlife management to local rangers and community members (see Ostrom's design principles for effective community property management). Rangers also received all of the resources, tools, and social support they needed to do their jobs effectively. Under this program, the benefits of rhino conservation were retained by the community through tourism revenue, which both relied on and strengthened local values and institutions.

Use well-documented, evidence-based behavioral insights

We identified various applications of behavioral insights throughout our review. Many interventions rely on their preconceived notions and assumptions of target actors' behavioral challenges, motivations, and context. Instead, we encourage a deliberate approach where designers map the barriers and motivations of target actors to evidence-based behavioral insights. This allows for programs to be designed to most efficiently address the needs and decision-making processes of the target actors and their context. Here are several examples from our review of climate mitigation interventions that included robust behavioral insights:

Increasing Enrollment in Green Energy in Germany Through Default Effects (Ebeling & Lotz, 2015)

Program designers identified that green energy is not commonly considered by consumers and that they generally keep their current contract subscriptions. This made the behavioral challenge a clear candidate for changing the default enrollment to green energy, thereby relying on consumers to opt-out rather than opt-in to green energy. This program resulted in a tenfold increase in green energy enrollment.

Reducing Energy Consumption in The United States by Appealing to Existing Values (Asensio & Delmas, 2016)

Program designers identified that the cost savings from energy reduction were insufficient to motivate their target actors. They appealed to actors' existing values of health rather than purely financial incentives with messaging that linked energy use and pollution to childhood asthma and cancer. The program reduced energy consumption by 8% and nearly 20% among households with children. The intervention relied on the behavioral principle of appealing to existing values, resulting in a sustained energy reduction.

Increasing Participation in Energy Reduction Programs in the United States Through Observability (Yoeli et al., 2013)

Program designers identified that reducing energy consumption during peak periods was a public goods problem: everyone was better off reducing their air conditioning usage to stabilize the electric grid, but each individual did better free-riding on the reduction of others. In creating an energy reduction program, designers found that increasing observability increased participation because others would know whether or not each actor participated. They designed an intervention that made sign-ups to the program public rather than private. This led to a threefold increase in participation.

Reducing Energy Consumption in the United States Through Descriptive and Injunctive Norms (Allcott & Rogers, 2014)

These program designers took a different approach to address energy consumption as a public good. They identified norm messaging as a relevant behavioral strategy because people tend to believe others are contributing and that they expect people to do the same. The designers developed an energy report that provided social comparisons between one's energy consumption, similar others, and "efficient neighbors" who consume little energy. They also provided injunctive messaging, giving a smiley face to those who consumed less energy than average. This intervention was able to reduce energy usage by almost 2% across thousands of residents over a multi-year period and at nearly no additional cost.

Engage actors throughout the socio-ecological system

All actors are embedded in a larger socio-ecological system that can enable or restrict their ability to adopt the target behavior. The large majority of behavior change interventions in this review only target the actor whose behavior is directly responsible for the target ecological outcome, rather than those who create the environment to support them. Interventions should be designed to influence not only the behavior of the direct actor but also all the indirect actors elsewhere in the socio-ecological system. This includes treating actors throughout the socio-ecological systems as not only targets for behavior change, but also as active participants in the design and implementation of the intervention through sustained multi-stakeholder dialogue (Ratner and Smith, 2020). Here are two examples from this review that leverage a system of actors:

Increasing Sustainable Sugar Cane Farming in Australia (Pickering et al., 2017)

The program designers recognized that sugar cane farmers existed in a complex agricultural and social system. They developed Project Cane Changer, which aimed to increase the uptake of sustainable behaviors and change the poor reputation of farmers who were perceived to be polluting the Great Barrier Reef. In addition to working with sugar cane farmers directly, the program targeted the behavior of politicians, encouraging them to lend public support to the program to increase positive social pressure for farmers to adopt the target behaviors. After three years of the program, sustainable agricultural accreditation increased by over 300%.

Increasing the Adoption of Rooftop Solar in the United States (Gillingham & Bollinger, 2017)

Program designers identified a variety of psychological and structural barriers reducing the adoption of rooftop solar in the United States. These included solar panels' high upfront cost, the complexity and ambiguity of the decision, and customers' status quo bias of preferring to stay with their current energy source. Solarize overcame these barriers through a multi-level strategy, organizing local government and solar contractors to support a community-led outreach campaign. Solarize worked with vetted suppliers to provide time-sensitive discounts on purchase costs. Local government and community leaders organized to reassure prospective participants in their decision to adopt solar and provide positive social recognition. The implementation of the Solarize program led to the three-fold increase in rooftop solar adoption.

Together, these dimensions can guide designers, program implementers, and funders towards interventions that are more likely to have significant, durable impacts and be supported by the individuals and communities who participate.

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