TOPIC 5:

Agricultural Land Management & Climate Adaptation

Chapter 5 of 5 from:

The Science of Changing Behavior for Environmental Outcomes:

A Literature Review

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

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Introduction

Introduction

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

Behavior Change Levers for the Environment

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

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

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

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

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

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

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

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

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

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

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

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

The Behavioral Science Perspective

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

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

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

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

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

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

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

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

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

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

The Social Science Perspective

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

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

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

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

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

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

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

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

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

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

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

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

Review Focus and Scope

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

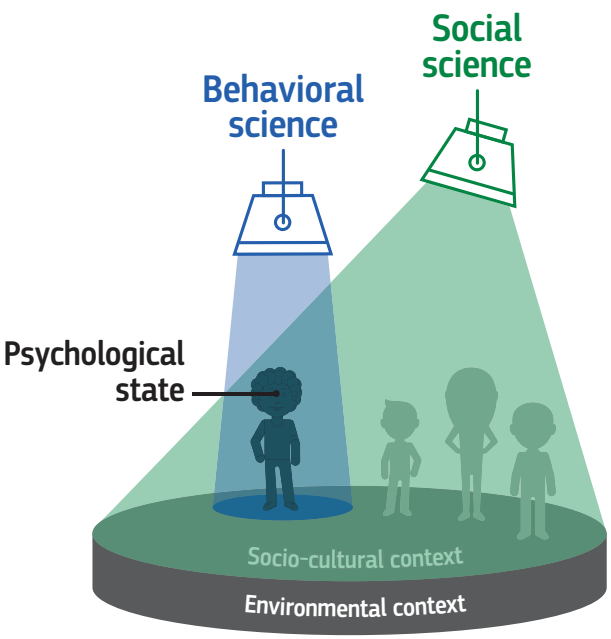

Figure 2. The interaction of behavioral and social science in understanding human behavior. Behavioral science focuses on understanding an actor's psychological state, whereas social science focuses on understanding the socio-cultural context for that actor. Both are necessary for understanding an actor's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

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

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

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Agricultural Land Management & Climate Adaptation

- Increasing Sustainable Farming Practices
- Conserving Land

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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