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Reorienting climate decision making research for smallholder farming systems through decision science

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Research into the social dimensions of climate decision making has proliferated in recent years. This body of work is informed by principles from decision science and addresses questions around when and why people adopt behaviors in response to climate change. The vast majority of this research is based on studies in relatively wealthier populations that are predominantly from industrialized nations, yet those most impacted by climate change are small-scale farmers in areas that also are experiencing the compounding effects of high rates of poverty. In the following article we look at recent findings from decision science to explore why and how research should be reoriented to provide insight into climate related decision making among smallholder farmers in areas with limited infrastructure and few public services.

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Introduction

The majority of research on climate decision making (CDM) has focused on studies and applications in Western industrialized countries often using non-representative and urban samples within those contexts. Even though psychological insights from these populations and contexts are not appropriate analogs for broader populations, the findings are often used in unreflective ways to make broad inferences about people in general [1]. In fact, creating standards and reference models based on a particular population and extending it to other populations can have adverse consequences across a variety of domains, from medicine to public safety [2•]. Conversely, research that factors in sociocultural aspects such as gender, ethnicity, or religion can facilitate scientific advances that result in better predictive and explanatory models [3]. In other words, diversity in the sample population can improve our understanding of behavioral sciences by capturing variation in human thought and action across distinct and divergent contexts [4].

There is an implicit assumption in much of the existing CDM literature that psychological phenomena found to exist within actors from predominantly Western educated industrialized countries like the US, Western Europe, and Australia, can apply to populations worldwide. And yet substantial variation exists among populations in domains associated with fundamental aspects of psychology, motivation, and behavior [5]. Comparative work that includes a more diverse international sample (e.g. across economic development categories) has highlighted that dimensions of CDM, such as perceptions of current and future risk from climate change, can differ between groups of people [6]. Even when cross-cultural comparisons of psychological phenomena are done, these studies often only include wealthier countries. For example, Ruggeri *et al.* [7] showed cross-country replicability of prospect theory, which proposes that people value uncertain gains and losses differently, but only two non-western countries were included, and the samples in all countries were substantially younger and more educated than resident populations. Significant challenges remain in comparing psychological findings across cultural differences [8•], which are particularly important to address for understanding CDM globally.

Here we explore why and how CDM research using a decision science perspective should be extended to include studies in smallholder farming systems that are currently underrepresented in this field. We describe why existing CDM findings are not translatable and then highlight specific areas of research which are needed. Following Orlove *et al.* [9••] we adopt a broad definition of CDM as consisting of decisions by actors that affect or are affected by climate change and that are not explicitly undertaken in relation to the climate. We focus specifically on farmers cultivating small parcels of land who

comprise the vast majority of agricultural production in developing countries, often referred to as smallholder farmers, for three reasons. First, about 79% of the world's poor (approximately 480 million people) live in rural areas [10], and agriculture is their most important income source, making smallholder farmers a key component of the economic lives of many communities. Second, smallholder farmers in the least developed countries in Africa and Asia are poised to be the most impacted by climate change given their locations and the crops they grow [11]. Third, because of the global social and economic importance of agriculture, it has been a central focus of climate risk management and climate adaptation efforts, and so to guide those efforts more effectively around the world, we need to know more about the CDM of smallholder farmers in their various contexts. We focus on individual climate decision making among farmers engaged in unstructured processing of information, as opposed to policy-related or institution-related decision making.

Some of the recent research on CDM from the field of decision science is applicable for smallholder farmers, but in many cases it needs to be reoriented and extended, or enhanced with new studies for three major reasons: (a) The ubiquity of poverty in smallholder systems creates additional uncertainty for decision makers; (b) CDM is bounded by the quality of climate information and communication available to decision makers, which is understudied among smallholder farmers; and (c) CDM is shaped by cultural cognition, particularly the influences of social structures and social norms, which vary greatly across agricultural societies. In the following sections we go into more detail on each of these topics, describing recent research and how it needs to be extended to help us better understand the cognitive dimensions of CDM among smallholder farmers. In the process we illustrate the need to diversify research and models about CDM to include vulnerable populations that current CDM models are not well designed to describe or serve.

Poverty contributes additional uncertainty to climate decision making

There is ample evidence to suggest that poverty can complicate climate decision making but little research exists on this topic among smallholder farmers, many of whom live in a state of poverty. While climate change is itself a significant source of uncertainty that shapes the decision-making environment for smallholder farmers, so too is poverty. Poverty alters the decision-making environment in multiple ways as we expand on below: by constraining some options that are available to decision makers (imposing external bounds), straining attention and processing of information (imposing internal bounds), and influencing risk preferences.

The importance of dealing with uncertainty is central to research on 'bounded rationality' [12]: the study of how people make decisions despite uncertainty arising from having limited information, attention, and time to make a choice. Even under uncertainty, people often manage to make good-enough decisions, and bounded rationality seeks to explain how conditions external and internal to an individual, influence decisions and their outcomes [13]. Decisions have been characterized as occurring by processes operating at two levels, one based on heuristics that create shortcuts and the other based on more analytical sequential thinking and the use of decision rules [14]. It is suggested that decision processes modeled solely on the analytical mode do not apply well to situations characterized by uncertainty, such as climate related decisions, where people tend to rely more heavily on heuristics [15]. Research on smallholder adaptation to climate change largely assumes rational approaches to decision making that do not fully capture the effects of decision making under uncertainty [16••].

Poverty imposes external limits on bounded rationality by shaping the context within which decisions take place. Structural factors, such as access to education or healthcare for example, can lead to various income and social well-being gaps that can cause some groups to disproportionately experience the effects of climate change [17]. Climate change can be central to conflicts related to environmental pressures involving unequal power dynamics between ethnic groups [18]. These structural factors reside outside the individual smallholder farmer's control but limit the climate adaptation options available to the individual and increase their climate vulnerability [19]. Structural factors can also be compounded by declining institutional support and agricultural policies that limit farmers' adaptive capacity and leave them more vulnerable to environmental shocks [20•]. The combination of the reliance on natural resources for production, low adaptive capacity, and little public support leaves them more exposed to climate change, with diminished options available to address its impacts, vulnerabilities and risks.

In terms of internal bounds on rational decision making, poverty can cause people to focus greater attention on some problems at the expense of others [21]. People have a finite pool of attention or worry [22] and so diminished attention can cause decision makers to miss out on choices that might otherwise alleviate poverty or facilitate climate adaptation. Lacking money (or time) can occupy decision makers' attention and make it difficult to process new information or prepare for future decisions related to climate change adaptation. A study by Mani *et al.* [23] examined cognitive function before and after sugarcane harvest in India, when personal income stress differed, and found that the increased pre-harvest (acute) poverty impedes cognitive performance relative to after harvest

when farmers are effectively wealthier. Similarly, research has found that reducing chronic financial debt through a debt relief program improves cognitive functioning and decision making by decreasing the need for mental accounting that otherwise consumes attentional resources and produces anxiety [24]. The effects of extreme weather events, for example, can contribute to these concerns, sapping attention and preventing farmers from devoting attention to making longer term climate adaptive investments. Smallholder farmers are susceptible to making the same decision errors as anyone else, but because the margin of error is smaller for the poor, their errors can lead to worse consequences [25]. Financial strategies that can help mitigate bad agricultural outcomes, such as crop insurance are less prevalent (and accessible) in lower-income economies [26]. The increased risk of bad outcomes can also capture farmers' attention and negatively impact the decision process in these situations.

Poverty not only imposes particular external and internal limits on bounded rationality, but can also influence an individual's perceptions of risk, which affects how that person responds to climate change. In some instances, poverty lowers the willingness to take risks, such as adopting a water-saving technology that requires an upfront cost but is more cost effective in the long run [27]. The relationship between poverty and risk, however, is not clear. Other research has found that poverty and one's perception of poverty are nearly independent from risk preferences [28]. Factors related to poverty such as social rank, access to resources, and social mobility have a meaningful impact on people's risk preferences, but research is inconclusive whether these factors are associated with more or less risky decisions [29]. The subjectivity of risk likely helps explain why associations with poverty vary. Weber [30] demonstrates that perceived risk from climate change (among a relatively wealthy industrialized population) is both idiosyncratic and inconsistent across individuals. In other words, risk is contextual and depends on individuals' reference points. Despite strong suggestions that connect poverty to risk perceptions and risk management, work that has been done suggests the need for further investigation of climate-related risk perceptions and CDM among smallholder farmers.

Climate change communication is bounded by the quality of and access to information

Communicating about climate change is complex and there has been little research on climate communication among smallholder farmers who have different relationships with climate messengers, lower access to accurate weather and climate information, different types of cognitive biases and different modes of communication. There has been a recent push to bring together diverse stakeholders in ways that strive to reduce expertise hierarchies and co-produce climate science and knowledge [31]. While evidence suggests this mode is effective at creating usable climate information for smallholder farmers, it is unclear how and why co-production works well in certain circumstances and less well in others [32]. There are a number of studies done, mostly in the US and not with farmers, that could shed light on improving climate communication for smallholders if replicated in these contexts.

Aspects of science communication that participatory modes of engagement seek to address relate to the trust and credibility assigned by an individual to both the information and its messenger [33••]. In the U.S., public trust in experts and in climate scientists has been shown to be consequential, as negative affect toward experts makes citizens more likely to deny matters of scientific consensus [34]. Understanding public mistrust in climate scientists is important for designing interventions and communication strategies to improve trust. Subtle changes in climate adaptation framing, such as an emphasis on natural disasters, vulnerability, risk, or environmental justice, varies in effectiveness depending on the messenger, as has been found in the U.K. [35]. But because science belief and denial are mostly studied within narrow cultural and demographic contexts [36], such aspects of climate communication remain unexplored among smallholder farmers.

The credibility of climate information can also be affected by the quality of the data. The World Meteorological Organization estimated that Africa needs an additional 4000–5000 basic meteorological stations in order to make substantial improvements in weather and climate scientific capacity across the continent [37]. As many as 54% of African surface weather stations and 71% of its upper-air weather stations do not report accurate data [38]. Inaccurate forecasts may be rooted in inadequate surface observing networks and technical capacity [39]. The cognitive implication of limited and inaccurate climate information availability for smallholder farmers is that they are forced to rely more on their own mental models (an individual's intuitive perception of the world) and recollection of past climate conditions when making farming decisions about preparing for future climate conditions.

Research from decision science has uncovered cognitive biases that can distort individual's mental models of environmental change — yet there is scant research relating to either farmers or least developed countries. For example, Americans were more likely to think that temperatures were increasing if they were asked on a warm day [40], and to change their reference points for 'normal weather conditions' as the weather extremes become more common and less remarkable [41]. There is little research with smallholder farmers examining

whether such biases also apply to farmers who attend to weather conditions more closely [42••] or whether availability of more climate information would help alleviate the biases. While literature from other fields has illustrated that that farmers in specific contexts have developed traditional ecological knowledge to adapt to climate changes, research is needed on how limited climate data could interact with cognitive biases and heuristics to negatively impact CDM in the face of unprecedented climate change, and how such impacts could be mitigated.

Additional challenges lie in how to communicate about climate change across diverse contexts. There has been relatively little research on effective climate messaging among smallholder farmers yet but recent research from industrialized countries indicates that how you communicate about climate change matters: emotionally salient stimuli can capture individuals' attention [43], fearful messages can lead to apathy and alarming climate-related images can sow mistrust [44], and humor can engage young people [45] and be an important learning device [46]. Many of these findings need to be tested for their generalizability across socio-cultural contexts because responses to emotional stimuli are likely to vary across cultures. Idiosyncrasies in the modes of climate communication, such as through memes or video, also can influence the effectiveness of communicating different aspects of climate change [47].

Social norms shape climate decision making

Social norms are an important driver of CDM and there exists little research on the role of social norms and cultural affiliation and cognition related to climate change outside of the United States. A debate persists about the extent to which climate perceptions and beliefs are related to the bounded rationality of humans (interacting with the complexity of the science of climate change) versus cultural cognition [48]. Cultural cognition posits that individuals use critical reasoning skills to form individual beliefs that are not necessarily true but are loyal to cultural beliefs that exist among those they have close ties to [49]. From a recent meta-analysis, it is not clear whether people reject new information that contradicts their standing beliefs (i.e. directional motivated reasoning) or if people want to form accurate beliefs but are unsure what credible information is (i.e. accuracy-motivated updating) [50•]. It is clear from this body of research however that group identity and affiliation become a central context through which factors like messaging, framing, and heuristics impact CDM.

There is little research on how smallholder farmers' cultural identity influences CDM. The notion of cultural cognition is in many ways unique to the US and fails to acknowledge the inseparability of environmental decisions and culture in other societies. The United States, where most cultural cognition research has taken place, is generally considered to be a highly individualist society, where less than half of Americans think their friends and family have a social norm about taking action on global warming [51]. There is however, significant variation in climate beliefs and the perceived threat of climate change across the world [52]. These beliefs and concerns are less connected to pro-environmental behavior in societies with lower levels of individualism [53]. When applied to more collectivist settings, theories developed and tested in contexts that emphasize individual-level perception, deliberation, and decision making are at risk of underemphasizing collective processes. For example, in the context of smallholding agricultural communities in Sri Lanka, Tozier de la Poterie *et al.* [54] found that most farming decisions are made at the village level, and individual farmers rarely deviate from these community-level cultivation decisions, even when it is in their best interest. This high level of coordination is especially common where livelihood resources are collectively managed, such as within irrigation cooperatives, fisheries, or collectively managed forests [55]. In recognition of this, some scholars have proposed adaptations to traditional theories of risk perception and decision making that more explicitly incorporate the role of social coordination (e.g. Ref. [56]).

Labels or messages that communicate or reinforce social norms around environmental issues have been effective in developed countries [57] and are most effective when the message is tied to salient group membership [58]. While there may be more opportunities to appeal to climate related social norms given the importance of collectivism in many traditional agrarian societies, we know little about how CDM is influenced by institutional membership and social cohesion in these societies. Evidence suggests that the benefits of institutional participation or community cohesion on agricultural outcomes varies across demographic groups [59,60,61•]. For example, Abate *et al.* [59] found that female farmers and those with smaller landholdings in Ethiopia benefit less from joining farming cooperatives. However, the reasons why such benefits are not evenly distributed are poorly understood. Most of the CDM research is coming from highly industrialized societies where individualism is the dominant cultural norm and these studies fail to explain behavior in societies where collectivism and collectively managed resources are more common.

Conclusions: reorienting climate change decision research for smallholder farmers

In this article we examine contributions to CDM research from the field of decision science and discuss how it might be reoriented to study climate adaptation among smallholder farmers who are experiencing the compounding effects of climate change and poverty. In large part, reorientation is needed because most of this literature

involves research in wealthier populations and samples, mainly in the US, Western Europe, and Australia and does generally not engage diverse populations. Such reorientation, focused on the cognitive processes and psychological factors that can facilitate or limit climate adaptation and adaptive capacity, is a crucial step in figuring out how policymakers can support smallholder farmers adaptation to climate change. If we build CDM theory with only data and studies from urban and wealthy populations, we are missing the full range of variability that will help researchers create more comprehensive theoretical frameworks to understand the full extent of CDM among smallholder farmers.

We offer three recommendations to reorient CDM research to smallholder farmers. First, research is needed on the implications of bounded rationality on climate change adaptation. As climate change worsens and conditions become more extreme, smallholder farmers are presented with additional structural challenges and a higher level of uncertainty than in the past. Research has shown that poverty negatively impacts attention and mental bandwidth, and it is possible that the effects of climate change, such as fluctuation in extreme weather conditions will further sap farmers' attention and potentially inhibit longer term adaptation decisions. It is unclear how the compounding effects of poverty and climate change influence smallholder farmers' willingness to take risks, and how risk-taking impacts climate adaptation.

Second, the decision science oriented CDM literature is largely focused on the politics of climate change beliefs in partisan western environments where the majority of the population has access to an abundance of online media and scientific data rather than in contexts which are characterized by low climate data availability. While much of this problem is structural, there are also cognitive issues related to information access that should be addressed. More research is needed that investigates how to increase the 'usability of climate information' [62] to smallholder farmers such as enhancing the presentation of climate adaptive seed varieties [63] or the presentation of crop insurance mechanisms. At the same time decision scientists might also create space for the inclusion of indigenous knowledge within the current methods for scientific enquiry [64]. Participatory research can counter technoscientific approaches that underemphasize indigenous knowledge [65] and shed light on how smallholder farmers utilize heuristics in CDM.

Third, new studies should investigate how competing group affiliations and collectivist norms impact CDM in less individualist societies. Results from highly individualized societies have less applicability in contexts with high social cohesion and strong commitments to collectivist principles. Research should investigate the extent to which social cohesion might inhibit or enhance climate adaptation and how social norms might be leveraged to support climate adaptation across diverse cultural contexts. This research would build on evidence that descriptive norms, or perceptions of whether others are engaging in a behavior, signal which adaptive behaviors are likely to be effective [66].

Substantial differences in CDM exist across sociocultural dimensions such as gender, age, education, and political orientation [67•]. Overlooking variations in these demographics, or only studying certain cultural groups, risks drawing the wrong conclusions about human behavior [1] and even exacerbating climate related inequalities. These three directions for new research are interlinked and should be studied in a comprehensive way that seeks to contribute to the broader interdisciplinary research program on CDM. More research is needed that focuses on vulnerable populations such as smallholder farmers, considering the large numbers of smallholder farmers whose livelihoods are directly affected by climate change. CDM research remains important in developed economies in order to understand why actors there continue to make decisions that disregard climate impacts. Building up scholarship on CDM among smallholder farmers will help us understand how comprehensive behavioral theories are, and make sure they are valid to the people most immediately impacted by climate change.

Conflict of interest statement

Nothing declared.

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Declaration of Competing Interest

The authors report no declarations of interest.

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