How can we foster broader and more effective use of climate information to support decision-making in agricultural systems?

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In this presentation I hope to make three specific points. The first one is that in order to understand and foster effective use of climate information in agricultural production, agroecosystems have to be framed as complex social-ecological systems. This conceptual framing has strong implications for the way in which climate information should be produced, communicated and used by the agriculture sector. My second point is that existing institutional arrangements appear insufficient to provide the relevant, credible and actionable knowledge needed to managethe impacts of climate variability and change on agricultural ecosystems. Accordingly, there should be a strong push to establish national and regional “climate services”to supportsectorial decisions on adaptation to climate variability and change,and thus help increase societal resilience to climate. Last, but not least, my third argument is that in agricultural production, as in other climate-sensitive sectors, there has been apredominant focus on predictions of regional climate conditions.The forecast-centric focus has possibly detracted fromproduction and effective use of other kinds of climate information (historical records, diagnostics of recent conditions) that can help to narrow significantly the range of likely outcomes. In the following paragraphs, I expand each of these arguments.

Until recently, research on the use of climate information in agricultural systems has followed a paradigm characterized by unidirectional connections between the natural and human components of agricultural production (i.e., the impacts of climate on physical and monetary outcomes of agriculture). Nevertheless, agroecosystems combine the complexity, nonlinearities and thresholds, time lags, multiplicity of scales, and feedbacks of biophysical interactions in natural ecosystems with the additional intricacies of human decision-making (Dalgaard et al., 2003; Feola and Binder, 2010; Malawska et al., In press).Clearly, agriculture is the human activity mostvulnerable to climate and the most extended land use by humans (Meinke et al., 2006; Sivakumar, 2006). Nevertheless,in many cases, climate is onlyone of many relevant inputs to decisions in this sector. Production of relevant climate information,therefore, requires a multi-disciplinary,integrative understanding of the overall dynamics of the agricultural sector, and of the complex, multidimensional contexts in which adaptation/mitigation decisions are embedded.

The design and communication of usable climate information should be informed by a better understanding of human decisions. For instance, decision-makers have a limited capacity for worrying about issues(Linville and Fischer, 1991). Therefore, concerns about prices of agricultural commodities driven by consumers or competitors halfway around the world (Yu et al., 2013)may completely override consideration of expected local climate. In the light of loss aversion – the fact that “losses loom larger than gains” (Kahneman and Tversky, 1979)– the potentially negative outcomes of acting on an inherently probabilistic forecast will weigh more heavily on decision-makers than equally-likely gains. Humans also have developed “heuristics” to simplify decisions in a complex, uncertain environment. For example, the “availability heuristic” is a way of simplifying frequency estimation problems. To assess the likelihood of an event (say, a drought of a certain magnitude) we sample our own memory for examples. Certain examples may be more easily available to us (e.g., the memory of a recent severe drought) and therefore lead us to overweigh the probability of such an event(Gilboa, 2011). Any diagnostic or prognostic information about climate,therefore, should be accompanied by contextual data on historical frequencies of observed/predicted conditions, as well as information on recent conditions (e.g., climatological spring rainfall *plus* precipitation amounts observed in the last 3-4 years). Finally, well-known human decision biases such as overconfidence and the tendency to seek or give greater weight to information that supports our prior attitudes, beliefs or actions should be taken into account in the design of climate information(Heath and Heath, 2013).

Scientific and technological advances, together with growing awareness of the importance of climate on human endeavors, are creating increased worldwide demand for the production and dissemination of usefuland actionable climate information. Despite major scientific advances in climate science, use of information in decision-making still appears to lag the availability of new knowledge (Baethgen et al., 2009; Kirchhoff et al., 2013). For example, while there are many examples of seasonal forecast use in agriculture, uptake has been slower than anticipated (Ash et al., 2007; Baethgen et al., 2009; Stone and Meinke, 2006). Clearly, progress in climate knowledge must be matched by a better understanding of how climate information and knowledge can support climate-resilient decisions and policy (Harrison et al., 2008; Stainforth et al., 2007).

The seasonal forecasting experience suggests thatearly, iterative communication and partnerships among scientists and stakeholders are the most effective paradigm for increasing the usability of climate information (Dilling and Lemos, 2011). Yet, often it has proven difficult to sustain such a dialog over the time needed to build social capital and trust. A typical research project can support interactions with stakeholders for, at most, 5-6 years. My second argument is that current institutional arrangements are insufficient tosustaintwo-way communication between producers and users of climate information and to overcome institutional, technological and cultural barriers. Consequently, new approaches should be explored.

In response to the increasing demand for actionable climate information, the World Meteorological Organization hasdeveloped the Global Framework for Climate Services (GFCS), that promotes the use of relevant science-based climate information and prediction (High-level taskforce for the Global Framework for Climate Services 2011).Agricultural production and food security are among GFCS priority sectors. “Regional Climate Centers” (RCCs) are important components of the overall WMO GFCS design (Martínez Güingla, 2011). RCCs not only will supply climate information, but alsocan be hubs of a broad network that facilitates dialog and sharing of domain knowledge about climate-sensitive sectors. I submit that the ultimate success of RCCs depends critically on the involvement of a broad disciplinary spectrum of scientists and practitionersable to work at the interface between research and decisions. Innovative partnerships with a range of academic, research and non-governmental organizations and actors from multiple sectors of society will be necessary.

The last point I hope to make is thatadaptation to climate variability and changeshould not be precluded by the uncertainties and imprecision that still afflicts (and will continue to afflict for the foreseeable future!) climate predictions.Non-predictive information has a strong potential to help agricultural decision-makers identify and assess actions that may reduce their vulnerabilities to future climate.For example, a thorough characterization of historical climate variability in a region may help constrain possible outcomes. For short-term (weeks to months) strategic decisions in agriculture, diagnostics of recent climate conditions – various drought indices, remotely-sensed vegetation status, soil moisture and groundwater depth – can narrow considerablythe range of likely outcomes, to the point that forecast information may not be that critical. Changes in decision-making approaches also can help examine the performance of adaptation strategies over a wide range of plausible futures driven by uncertainty about the future state of climate and socio-economic drivers. Strategies that perform sufficiently well across a range of alternative futures can be identified evenwithout accurate and precise predictions of future climate (Dessai et al., 2008). For example, the Robust Decision Making (RDM) approach(Lempert, 2002; Lempert and Groves, 2010) characterizes climate uncertainty with multiple, rather than single, views of the future. Unlike maximization approaches typically used in agricultural decision-making, that identify a single best or highest-ranking option, RDM suggestsa set of reasonable choices that performs reasonably well compared to the alternatives across a wide range of plausible future scenarios.

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