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Editorial

What is climate risk management?

The journal *Climate Risk Management* seeks to publish original scientific contributions, state-of-the-art reviews and reports of practical experience on all aspects of the assessment and management of climate risks, and on the production and use of climate and climate-related information in decision and policy making from the near- to long-term.

What is climate risk management?

Climate risk management is a process for incorporating knowledge and information about climate-related events, trends, forecasts and projections into decision making to increase or maintain benefits and reduce potential harm or losses. It is a multidisciplinary activity that calls for an integrated consideration of socioeconomic and environmental issues. Successful translation of climate information into action requires three essential elements (Cash et al., 2003; Meinke et al., 2006): salience, credibility and legitimacy. Salience relates to the relevance of the information to the needs of decision makers, its consistency with existing procedures and decision protocols and timeliness of delivery. Credibility involves the perceived quality of the information in terms of its accuracy and reliability. Legitimacy refers to the perception that the information and its delivery are unbiased, respectful of user values and beliefs and fair in the treatment of other views and interests. An additional element includes joint responsibility and accountability for providing and using products that lead to plausible, defensible, accessible, and actionable decisions (Asrar et al., 2013).

Goddard et al. (2010) and Asrar et al. (2013) note that while efforts toward the interpretation and tailoring of climate forecasts can improve the quality and usability of the information there is often a mismatch between the information provided and the information needed. This is also the case for climate change projections. Climate information providers do not always understand the needs of users or that the nature and purpose of predictions or projections, for example, may not be fully appreciated. Information providers may not understand the types and volume of information that decision makers can act on, not be aware that climate is likely to be only one factor within the users' decision framework, and not appreciate the institutional setting in which decision making takes place. Providers need to be able to articulate the opportunities and limitations of the information being offered and offer a credible demonstration of its usefulness and benefit to key socioeconomic and environmental sectors. Moreover, decision makers should be aware that in some cases the desired type, accuracy and precision of the information may not be scientifically feasible now or in the future. This situation is due to limitations in our data, knowledge and models, and the inherent uncertainty in the climate system. This, together with an early and ongoing dialogue between decision makers and climate knowledge and information developers, will ensure appropriate and effective use of climate information to anticipate and reduce risks.

The journal begins its publishing history when terms such as risk assessment and decision analysis are increasingly part of the discussion about how increasingly complex society can better cope with climate variability and change. National and international climate programs increasingly recommend risk analysis as a component of planning for climate variability (Intergovernmental Panel on Climate Change, 2012; U.S. National Research Council, 2010a,b; Morgan et al., 2009; and the U.K. Climate Impacts Program, in Willows and Connell, 2003). Kunreuther et al. (2013) asserted that "risk and uncertainty...form the essential lens through which the entire issue must be viewed" (p. 448). Jones and Preston (2011) wrote that "risk management stands as the most appropriate overarching framework for assessing climate change adaptation" (p. 305). Climate risk management has become a key plank in the UN Framework Convention of Climate Change (UNFCCC) adaptation program, especially through its "loss and damage" applications area (see: http://unfccc.int/adaptation/workstreams/loss_and_damage/items/6056.php).

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In broad terms, the interaction of climate and society poses both resources and risks. A ''risk management'' approach invokes the theories, principles, and practices of risk analysis as an aid to decision making and as a guide to reducing expected losses.

The defining characteristic of risk is the combination of uncertainty about events and their consequences. Risk analysis is aimed at reducing, or at least specifying, the uncertainty so that better decisions can be made. The practice of climate risk management is already extensive—the orchardist contemplating the potential for an overnight frost, or the engineer calculating the effective height of a new sea wall—as is the variety of tools available to decision-makers facing climate risks. A risk management approach to climate problems can also signify certain analytical approaches, including particular attention to the probability of both events and consequences, the framing of response choices along a spectrum of possible outcomes, and targeted efforts to reduce uncertainty or at least to handle better the irreducible uncertainties in climate decision-making. Thus a risk management approach also invokes the techniques of decision analysis and decision support, including rubrics for judging preferred policies, or choices that offer the least potential for loss.

Incorporating climate risk analysis into adaptive planning

A wide range of decision and planning tools, strategies, and support systems take on some of the attributes of risk management, or include at least a place-holder for risk analysis, and many of these are conceptualized as one form or another of the iterative ''planning model,'' usually conceptualized as a cycle of: assess, plan, implement, evaluate and re-plan. Versions of that model that incorporate climate risk management (Willows and Connell, 2003; NRC, 2010a) recognize iterative risk analysis as a step in decision-making in which risk analysis can inform public policy (Hultman et al., 2010). A compilation of those versions, shown in Fig. 1, starts, as most do, with problem definition, followed by the gathering and application of climate science in its many forms of knowledge and information. Next the risk assessment process is illustrated as an iterative process within an iterative model, to capture the value of multiple approaches to decision structuring. Carefully constructed climate risk assessments can then inform decision support systems that feed into the choice, implementation, and monitoring common to the policy process. Short-circuits from the choice and appraisal process reflect the need sometimes to revisit problem definition, climate indicators, or decision criteria before making choices. In this way climate risk management is subsumed in planning and decision-making, and lends itself to decision support as proposed in the Intergovernmental Panel on Climate Change's forthcoming fifth assessment report, Working Group II, chapter 2: ''Foundations for Decision Making.''

So how might analysts and practitioners incorporate risk and decision analysis into the adaptive planning cycle model? Public policy and planning is not always risk-focused, but where it may profitably take on risk management techniques, it can draw on useful approaches and tools developed over the last several decades (Morgan and Henrion, 1990; Greenberg et al., 2012; Klinke and Renn, 2002). These range widely, from cultural (Douglas and Wildavsky, 1982) and psychological (Tversky and Kahneman, 1974) approaches, to engineering (Starr, 1969) and natural science (see Kates, 1978 for an early overview). The body of applicable knowledge is most clearly discernible in the formal methods of risk analysis and management, entraining a well-codified set of theories and methods (Scholz et al., 2011) that can contribute to climate adaptation thinking and practice, along with other approaches.

Kunreuther et al. (2013) reviewed strengths and weaknesses of risk and decision analysis methods (e.g., expected utility, risk aversion, and robust decisions) in dealing with climate change, pointing especially to the challenges of decision analysis when probabilities of future events are very uncertain. In that case analysts can turn to methods that do not require probability distributions yet still help decision makers avoid the biggest losses, such as scenario analysis. Dow et al. (2013) offered a more general climate risk management model that falls somewhere in between the iterative planning model and classical decision analysis. Their proposed ''risk-based approach'' starts not with likely events but with a qualitative explication of risk tolerance, or vulnerability, mapped against a descriptive framing of probability and consequence, a version of Klinke and Renn's (2011) generalized model of society's ''risk-handling processes'' (p. 273).

Formal approaches and tools for risk and decision analysis are similar, though not always applied jointly. Risk analysis focuses on pinning down uncertain events and their consequences, and decision analysis is a prescriptive approach that identifies optimal, efficient, or at least satisfactory decisions, given uncertainty and the utilities of outcomes. Such methods are often viewed as yielding a single, ''best'' answer, but when risk analysis and decision analysis are combined, the explicit treatment of uncertainty, if properly carried through the analysis, yields more nuanced answers rather than a single best outcome. Indeed, decision analysis can be designed to tolerate outcomes that are less-than-optimal, including satisficing decisions (e.g., decisions that are ''good enough'' for the time being and given what the decision maker knows and the range of choices available), risk-aversion (e.g., minimized regret instead of maximized utility), and robust decisions (usually a portfolio approach likely to perform satisfactorily over a range of future states, rather than a single state of the world).

Much of the value of risk and decision analysis comes not from definitive solutions but from the process of sorting out the decision context, risks, choices, options, and decision criteria; that is, getting the material together in order to conduct a formal decision analysis or simply to better inform decision makers (Hofmann et al., 2011; Jones and Preston, 2011). The effort is valuable especially for expanding the range of options considered, a theme that developed in early natural hazards research as it became evident that hazard reduction policy tended to pursue a narrow roster of options (e.g., levees for flood loss reduction) from the much larger range of theoretically-feasible options (Burton et al., 1993). This is where case studies of local knowledge, scenario approaches, and risk analysis can combine to enrich our repertoire of climate responses.

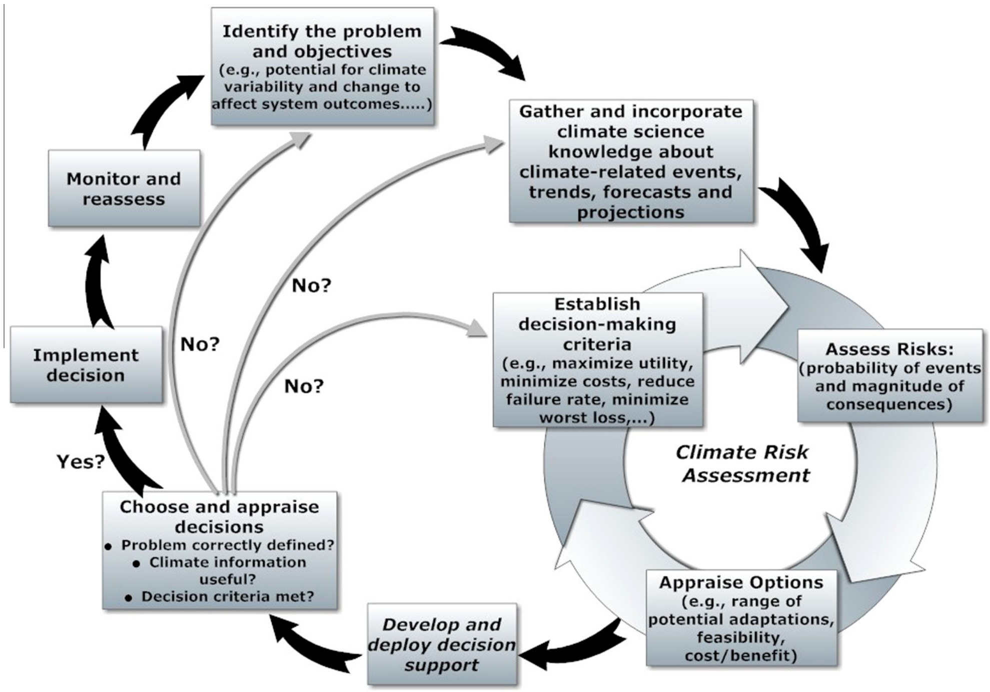

Fig. 1. The climate risk planning cycle. The cycle begins with problem definition followed by the gathering and application of climate science in its many forms of knowledge, including trends, forecasts and projections. This climate knowledge is used in an iterative risk assessment process applying alternative decision criteria and response options. Carefully constructed climate risk assessments can then inform decision support systems that feed into the choice, implementation, and monitoring common to the policy process. Short-circuits from the decision choice and appraisal process reflect the need sometimes to revisit problem definition, climate indicators, or decision criteria before making choices. Adapted from the UK Climate Impacts Programme (Willows and Connell, 2003) and the U.S. National Research Council (2010a).

Risk management in climate adaptation

Risk approaches have appeared in climate impacts research for a couple of decades (Yohe, 2009). But recent assessments point out that formal risk analysis is still rare in climate adaptation studies. Yohe and Schlesinger (1998) applied a risk- and decision-analytic frame in early work on response to sea level rise. Useful integration of risk into planning approaches can be seen in studies of how the Thames Barrier might be adapted as sea level rise and storminess increases the probability of failure (Reeder et al., 2009). A larger literature exists on risk approaches to greenhouse gas mitigation. Lempert and Collins (2007) and Lempert and Groves (2010) bridge this gap by starting with mitigation risk modeling and then applying a "robust decision making" (RDM) approach to water resources planning with potential climate change in mind. Risk and decision analysis is also melded in studies by Hallegatte (2009) and Smith et al. (2011) on the range of adaptation options that make sense under different scenarios of, and uncertainty about, future climate conditions. Smith et al. extend this to "transformative adaptation" under assumptions of very large climate change, which begs the standard question in decision analysis: when to switch from one response posture (e.g., incremental adjustment) to another (e.g., transformative adaptation), a tipping point that might occur sooner or later under different levels of vulnerability and rates of change (Kates et al., 2012).

As *Climate Risk Management* publishes its inaugural issue, the literature applying risk approaches to climate problems in agriculture, fisheries, infrastructure, human health, and other climate-sensitive sectors is growing rapidly. We see risk and decision analysis applied, for example, to species conservation (McDonald-Madden et al., 2011), fisheries (Plagányi et al., 2013), and many types of infrastructure (Chinowsky et al., 2013; Korteling et al., 2013). This first issue reflects that breadth, and touches on many of the elements of a risk approach, including better specification of the probability, magnitude and location of climate events, the propagation of effects through socio-ecological systems, improved assessment of exposure and vulnerability, decision analysis and support, and tests of risk management tools. Articles in this first issue address:

- The conditional probabilities of different climate outcomes in specific geographies associated with variations in ENSO events.
- Production challenges in marine aquaculture given uncertainties about future ocean conditions.
- An end-to-end evaluation of climate risks in sea food supply chains that not only recognizes the different vulnerabilities and adaptabilities at different points in the supply chain, but the interaction of decisions that flow up and down the chain.
- The risks posed by sea level rise in Bangladesh that reveals finer-scale nuances based on geomorphology and land use, which challenges blanket notions of the risk.

- Decision support methods that take fuller advantage of uncertainties in climate projections while simultaneously clarifying risks and decision options, thus easing barriers to the application of probabilistic information to climate adaptation.

With this start, *Climate Risk Management* offers a forum of research and applications aimed at understanding and reducing the risks posed by climate variability and change.

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