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Decisionmaking, Transitions, and Resilient Futures

The newly established National Research Council Board on Environmental Change and Society explores insights and research frontiers for understanding coupled human-environment systems.

In early 2010, two major earthquakes hit the Western Hemisphere: a 7.0 magnitude quake southwest of Porte-au-Prince, Haiti (population 9.7 million), and an 8.8 temblor north of Concepción, Chile (population 17.1 million). The death toll in Haiti was over 220,000; that in Chile, fewer than 1,000. This two-orders-of-magnitude difference can be attributed in part to the distances between the epicenters of the quakes and the countries' respective population centers. But the largest part of the difference is the result of the Chilean government's consistent willingness to heed the advice provided by its world-renowned natural and social scientists and engineers—advice that minimized vulnerability with strict building codes and enabled robust emergency response through preparedness planning. Disasters may strike randomly, but the extent of the damage and the speed of and capability for response and rebuilding have nothing to do with luck and everything to do with science.

Not all eventualities for which governments need to plan are natural disasters such as earthquakes, or even very abrupt; many shifts occur so gradually that their consequences may not be felt for some time. Environmental and social changes are happening, and scientific data show that many, from floods and severe storms to droughts and wildfire, are having greater effects than they had in the 20th century. Government agencies are beginning to take action. The U.S. military is trying to anticipate, mitigate, and adapt to the consequences of the environmental changes that are happening right now, and some localities and major cities such as New York, Chicago, Seattle, and Los Angeles are also making preparations. Still, both the military and the cities have questions in the arena of interactions between human and environmental systems that research could help to answer. They and the broader civil society can benefit from existing and future research that identifies potential environmental changes and explores social factors influencing how well planning and responses can limit damages.

One of the biggest challenges confronting society is climate change. Most people consider additional natural science research on climate change to be a wise societal investment. This is because naturally occurring changes such as slight alterations in Earth's orbit have over the eons caused both ice ages and warm periods, with profound implications for life on Earth. If human activities have the potential to interact with natural cycles and bring an end to the relative stability that the climate system has experienced over the past 10,000 years, the potential risks posed by climate change could be large and are thus worth understanding. But what are the risks, and how large might they be? Unfortunately, the amount of warming to which we are already committed because of past emissions and inertia in energy and economic infrastructure makes achievement of the low end of the range of climate change futures almost impossible. Thus, iterative risk management is now being framed as a combination of adaptation (preparing for and responding to changes to which the climate system is already committed over the next several decades) and mitigation (reducing human contributions to climate change), where efforts started now will have significant consequences for the magnitude and nature of climate change and associated impacts after mid-century. Research seeks to understand the risks of different combinations of these approaches, to identify many potential effects and societal consequences, and to clarify where, when, and how likely these consequences are to occur, given different levels and rates of climate change, and how they will interact with other societal and environmental changes.

Energy security is a parallel case involving both natural resources and societal risks. A country dependent on importing energy is vulnerable to supply disruption resulting from international politics or the domestic policies of the exporting countries; expenditures on imports can also negatively affect domestic economic growth. Focusing efforts on developing an apparently abundant domestic source of fuel for electricity generation may provide various forms of "security" in the short term—jobs, economic growth—but may engender unintended consequences that result from uncertain side effects of the new technology. Although these considerations have natural-science and engineering components, the greatest risks are in the social arena: economic ramifications, health effects, or quality-of-life changes, to name but a few. How great an impact might events in these risk categories have?

Risk is usually seen as a function of the consequences of an event, such as loss of life or economic damages, combined with the likelihood of its occurrence. The details of interactions between the natural and social systems of Earth in this time of transition are not predictable with our current level of understanding, but that there are risks involved is undeniable, and that there will be some drastic consequences if and when these events occur is likely. How a nation averts, prepares for, and/or manages risk forms the difference between human loss of life and destroyed infrastructure such as occurred in Haiti, and the minimized loss of life and recovering infrastructure of Chile.

Research in the social sciences, integrated with climate and environmental research, provides insights about consequences and likelihood and the potential effectiveness of different approaches to increase resilience or reduce human contributions to the drivers of change. Social science research contributes to global environmental risk management by projecting the effect of alternative human choices: not predicting the future, but providing "if/then" analyses of the potential consequences of acting or not acting, of alternative economic development pathways, future scenarios of population growth, different technologies, or the aggregate effects of billions of consumer choices made every day. It helps to anticipate vulnerabilities and damaging exposures of environmental and societal change and to identify and plan for potential opportunities that may arise. Drawing on these and other insights, it also contributes significantly to the development of decision-support mechanisms that help decisionmakers with the complex sets of choices that they face.

Informing decisions

The differences between the disasters in Haiti and Chile had to do with preparedness for any disaster or eventuality. Preparedness for environmental changes, either abrupt or gradual, involves one or more series of decisions, any one of which may also have a place in strategies for maximizing agricultural productivity or energy efficiency, for example, even under stationary environmental conditions.

Decisionmaking can be regarded as a process that results in the selection of a course of action among one or more alternative scenarios. Individuals often make decisions unconsciously, based on need, preference, and values; these may be rational or irrational, depending on the balance between emotion and reason engendered by the situation calling for the decision. Societal decisions about policies, public expenditures, and other issues involve additional influences, including complexity that arises from differences in need, perception, and values across individuals, and cultural and other differences across groups. Effective decisionmaking processes enable participants to explore these differences, incorporate information, and iterate to achieve

ROB CARTER, *Metropolis* (excerpt), Animation; 3:00 minutes, 2008.

a common understanding and basis for action.

Kelly Sims Gallagher and John C. Randell point out that important and expensive government programs apparently do not take advantage of what is already known about consumer behavior. The predictive capacity of this existing knowledge also indicates that there is a great deal of value to be gained from integrating research on creating new technologies with research to address the nontechnical barriers to the adoption of those technologies by society. These understandings of individuals' choice behaviors could then be planning inputs for alternative scenarios of futures in which these technologies are deployed to increase national energy security and human well-being.

When decisions must be made that affect groups of people or large segments of society, the process should be conducted within a structured framework that helps the decisionmakers take into account multiple objectives, needs, preferences, and values as well as vulnerabilities, risks, and uncertainties. Such a framework, for energy strategy, is outlined by Joseph Arvai and his coauthors in this issue. Within this decision-support framework, the principles of scenario planning and systems thinking, developed through social science research, are applied to break very complex decisions into smaller, more tractable parts that are not prone to error and bias and are internally consistent. Such a decision-support process leads to more satisfied and better educated decisionmakers as well as a more transparent process in which affected parties place greater trust. A framework of this kind has been used by Michigan State University and is demonstrated in an interactive exhibit at the Marian Koshland Science Museum in Washington, DC, and is being developed for Canada's national energy strategy.

The application of either method calls for some ability to compare values among different choices. In a pure market analysis, this may be possible because the choices can all be valued with a common monetary metric. But as Stephen Polasky and Seth Binder explain, environmental decisionmaking presents challenges because many of the inputs and outcomes cannot easily be measured monetarily because they are market externalities. Most also have strong impacts, because a single one may simultaneously affect multiple environmental and social factors. As these authors note, making decisions about tradeoffs among multiple objectives that society cares about involves making value judgments. There are extant methods for comparing values of market internalities and externalities, and these can be used now in scenario planning. But there is research yet to be done on ways to collect information on the values of the alternatives and on methods for aggregating these values to estimate social net benefits.

Even if there are adequate metrics, it is a fact that decisions and policy have to be made in the context of uncertainties. There will always be more than one possible result of a decision, uncontrollable and uncertain forces may affect the feasibility of implementing a decision, and some of the possibilities are likely to involve a loss, catastrophe, or other undesirable outcome. Uncertainty is not only unavoidable in the absence of prior knowledge of an actual future, it is also a tenet of the scientific process that the eradication of uncertainty is itself inherently a danger. Certainty can lead to complacency and a lack of the questioning that leads to increasing knowledge. It is important to understand which of these is the source of an expert's uncertainty when that expert is asked for advice by policymakers, as well as to have some idea of the degree of uncertainty to which the advice is subject. As Baruch Fischhoff describes, however, it is possible for scientists to communicate more clearly with policymakers about the parameters of uncertainty inherent in the expert advice they are providing, and for policymakers to help experts understand the need for their advice to be couched in terms that allow judgments to be made about the degree of confidence that can be placed in it.

Science for transitions

Going forward, research in behavioral economics, risk communication, governance, decision science, and socioecological interactions will provide new data and information that can inform the processes and strategies described in this group of articles. Some examples of the kinds of questions about global environmental change and its implications that require social science research to answer include:

- How can warning systems for droughts, floods, or severe weather be made more effective?
- How are major environmental hazards and changes linked to humanitarian disasters, political instability, and other security threats? What makes some societies better able to cope than others?
- How can diverse societies, comprising individuals with very different values and risk tolerances, agree on how to place a value on potential impacts, considering economic damages as well as less tangible factors such as cultural or environmental benefits?
- How can limited existing knowledge be best used by decisionmakers? How can they weigh the risks of waiting for more information against the benefits of acting when knowledge is more complete?
- How will different human choices regarding economic development, population, technology, and consumption contribute to different levels and rates of climate change?
- How should risks from high-consequence, low-probability exposures and events be assessed and communicated by scientists to decisionmakers and the public?
- What are the employment and economic effects of "green" stimulus and energy technology policies, including factors that contribute to their success or failure?
- What factors contribute to the development and diffusion of technological innovations? How do technical, institutional, social, economic, and behavioral dynamics accelerate or slow improvements in energy efficiency and the deployment of emerging technologies such as "smart" electrical grids?
- What are the economic, social, and other implications of environmental markets and other approaches for reducing emissions, adapting to change, or national security?

Two recent developments have the potential to advance this research. In the recently released *National Global Change Research Plan 2012–2021: A Strategic Plan for the U. S. Global Change Research Program*, increasing attention is devoted to the interactions of coupled human-environmental systems, understanding the societal consequences of environmental change, and providing information in a fashion that is useful to decisionmakers. This plan is built around four goals: advance science, inform decisions, conduct sustained assessments, and communicate and educate. It specifically calls for increased social science research to achieve these objectives.

The National Academy of Sciences has also taken steps to encourage the research needed to address these issues by establishing the Board on Environmental Change and Society (BECS). The board builds on two decades of work by a predecessor committee on the human dimensions of global environmental change. Its goal is to advance the scientific basis for understanding coupled human-environment systems and to inform transitions needed to improve human well-being in the face of environmental change. By making behavioral, social, economic, and decision sciences research accessible to environmental policy and by integrating social and environmental research, the board seeks to identify potential opportunities, anticipate vulnerabilities and damaging exposures, and inform policies and transitions that contribute to environmental sustainability. With its focus on coupled human-environment systems, innovation and technology deployment, risk and governance, vulnerability and adaptation to environmental change, resilience, and decision support, BECS's scholarly work and publicly accessible products will in the coming years be important resources for policymakers at all levels of government, the private sector, education, and the public. The articles that follow provide examples of the kinds of contributions that BECS can make.

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