

COMMENTARY:

From global change science to action with social sciences

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US efforts to integrate social and biophysical sciences to address the issue of global change exist within a wider movement to understand global change as a societal challenge and to inform policy. Insights from the social sciences can help transform global change research into action.

Systematic identification, characterization and prioritization of the greatest and most urgent risks we face from global change, along with the appropriate responses, are scientific and societal grand challenges. A central issue confronting national and international research programs is the need to understand linked biophysical and social processes of change, and to do so in a way that supports societal responses to this change. This requires integrating the full range of disciplinary perspectives and contributions from across the global change research enterprise.

Approaches to this integration have their lineage in a broad intellectual movement at least three decades in the making. Mooney and colleagues¹ offer a fascinating historical perspective on the deepening connection between the social and biophysical sciences in US and international global change research programs. The growth of this movement has paralleled the growth in understanding of the causes and consequences of climate change, as the important questions have evolved from global-scale enquiries, predominantly based in physical science, to place-based, often socio-ecological and socio-economic questions about what drives these changes, what is at risk, and how we might respond.

This evolution has given rise to integrated bodies of knowledge such as the 'sustainability', 'vulnerability' and 'adaptation' sciences²⁻⁴ that share a number of common dimensions: they are problem focused, with research situated within specific human decision contexts; they are interdisciplinary, in that they embrace multiple theoretical and methodological means of exploring an issue or question; and they are transdisciplinary, in that scientists

and practitioners co-design and co-produce applicable research within an environment of sustained engagement. This integration is reflected in recent IPCC reports⁵, the coalescence of multiple international research programs into Future Earth⁶ and in national research efforts in countries such as Australia, the UK and Germany. The most recent *World Social Science Report*⁷ is entirely focused on the need for a social science framing of global environmental change and sustainability, aimed directly at mobilizing a fully integrated global change science around policy and action, as argued by Hackmann *et al.*⁸.

This intellectual current is also reflected in the most recent decadal strategic plan of the US Global Change Research Program (USGCRP)⁹. The USGCRP coordinates global change research across the US government, and its strategic plan, for the first time, articulates an explicit vision of basic research in continuous dialogue with critical society-facing functions (Fig. 1). The existing knowledge-base supports engagement and communication with diverse publics, informs planning and policy, and is synthesized in sustained assessment processes that both support decision-making and identify the next generation of research questions. The plan has been praised for its nuanced understanding of how research can support and be supported by considerations of use, but concerns have also been raised about the practical challenges of implementing such a program¹⁰⁻¹².

The USGCRP decadal plan recognizes the need to integrate contributions from across the breadth of the social science disciplines — for example, economists, geographers, demographers, sociologists, cognitive scientists, anthropologists and

psychologists, among many others — into its future work. This is because it is people and their communities, institutions and governments, who are at the centre of the three main aspects of the global change challenge: that is, humans are the drivers of, are affected by, and have the capacity to respond to global change⁸. Crucially, the plan recognizes that social science research is both an important part of the integrated knowledge-base for understanding the causes and consequences of global change, and can also identify the principles that will help put this knowledge to work for society.

Social science research has historically informed global change science in the US, beginning with a focus on human dimensions research topics, such as understanding land-use change and the development of integrated assessment models. There is certainly much work still to do to move from an understanding of immediate global change drivers, such as land transformation and greenhouse gas emissions, to a deeper insight into underlying causes, such as the behaviours and interactions of individuals, communities, markets, nations and all types of institutions. A fundamental challenge is bringing together the research work in the biophysical and social sciences communities through coequal intellectual partnerships.

An interesting new direction, however, is the mainstreaming of this second role of the social sciences, that is, in elucidating the processes that turn knowledge into action. A central advance is a new understanding of how effective, science-based decision-support for global change-related problems rests on the collaboration and dialogue between scientists (of all disciplines) and practitioners, aimed at producing

knowledge that is practically relevant, usable, credible, legitimate and actionable. This is driven home in a number of recent reports^{13–15} and developed in a few forward-looking government programs such as the US National Oceanic and Atmospheric Administration (NOAA) Climate and Societal Interactions Program¹⁶, which includes the NOAA Regional Integrated Sciences and Assessments centres and the National Integrated Drought Information System. As this kind of collaboration represents a social process, it can benefit from social science expertise to design, develop and maintain the process over time and deliver improved societal benefits.

This new emphasis, explicitly acknowledged within the USGCRP strategic plan, is timely as there is a growing demand for programs assisting in the co-production of scientific information usable in specific place- and sector-based decision contexts. For example, recent US federal policy¹⁷, combined with growing state, local and private sector attention, has established an emerging mandate for climate preparedness and climate adaptation planning.

However, some questions remain. What new emphases in social science research are needed to advance the co-production of decision-relevant science in practice? In what areas do we most urgently need these kinds of social science contributions? What are the most promising practical opportunities to integrate these contributions into global change research over the next decade? A strategy is clearly needed, informed by a logical framework and a set of guiding principles.

A practical framework

Key links between scientific research and decision-making in the context of global change are described in Fig. 2. This practical framework not only emphasizes decision-support products — such as scenarios of future change, indicator systems for monitoring and early warning, and quantitative valuation of economic impacts — but also the critical role of effective decision-support processes, such as participation mechanisms that bring scientists and practitioners into close collaboration¹³. Social science research identifies those processes by analysing social interactions within given decision contexts and by informing the development of networks and communities of practice to transmit information in multiple directions among knowledge producers, decision-makers and other key stakeholders.

Social scientists have developed specific knowledge about participatory scientific inquiry and decision-making

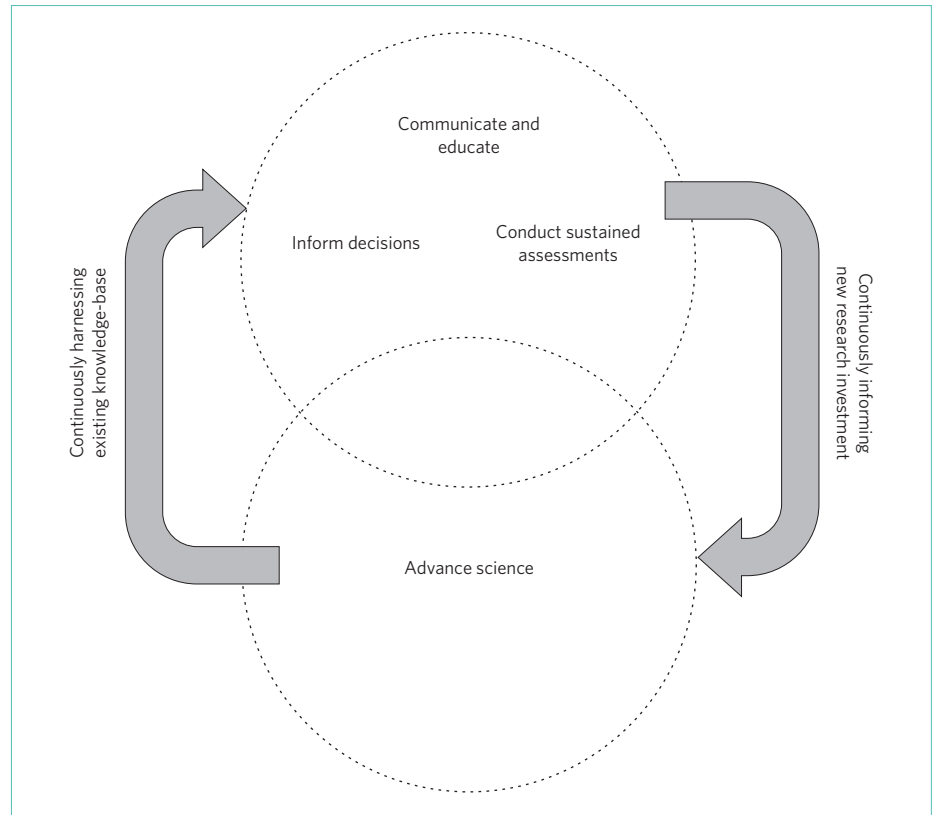


Figure 1 | The four goals of the *National Global Change Research Plan 2012-2021* (ref. 9). Fundamental scientific research within the US Global Change Research Program is in continuous dialogue with the decision-support, outreach and engagement, and assessment arms of the Program. This dialogue serves to operationalize the evolving scientific knowledge-base to meet pressing national needs for responding to global change. It also helps to guide strategic new investments in research.

at the individual, group, community and institutional levels, which should be used to inform global change responses, including how best to integrate scientific information into those decisions. Examples include experimenting with alternative decision-making approaches such as robust decision-making¹⁸; implementing, documenting and assessing public participation methods and protocols to support science-based decisions¹⁹; highlighting successful case studies of indigenous knowledge integration in global change decision-making contexts²⁰; and leveraging new research into networks that connect knowledge and practice²¹.

A better understanding of how to produce and use decision-relevant knowledge must overcome the lack of coordinated, large-scale data prevalent across other areas of human dimensions research. Although data that describe social and planning processes exist across multiple geographic and institutional scales, these data are not always in easily accessible formats or repositories. Greater access to, transparency of, and coordination of data

collection will support closer integration within and between the sciences to move scientific knowledge into action. Moving beyond individual knowledge producers and users, we need to understand decision-support processes in the aggregate. We should identify typologies of users, develop comparative studies of decision processes across contexts and scales, and rigorously evaluate the success of such processes²².

The framework shown in Fig. 2 helps define where fundamental social science insights can bridge gaps between research investments and the need to inform societal responses to global change. In turn, a number of emerging processes under the new USGCRP strategic plan provide opportunities (natural laboratories) for exploring these ideas in practice. For example, the recent release by the USGCRP of the Third National Climate Assessment (NCA)²³ creates an enormous opportunity to experiment with decision-support processes; evaluate the utility of synthesized information about climate change and its impacts on a regional and

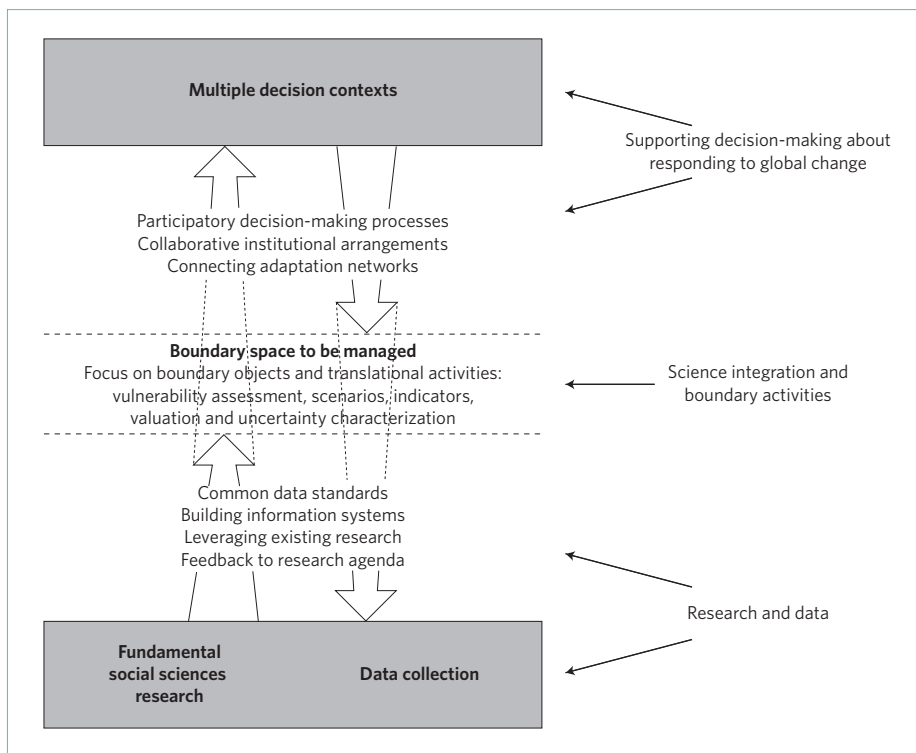


Figure 2 | The conceptual framework for understanding the boundary management, science integration and translational activities that connect the fundamental scientific knowledge-base with the need to support decision-making about responses to global change. This framework identifies bridging activities — such as participatory decision-making processes, the connection of knowledge networks, common data standards and the development of information systems — which offer the most promising near-term opportunities to improve the integration of the social sciences. The framework also highlights the need to focus on boundary activities and identifies those (for example, indicators, scenarios and valuation) that offer the greatest potential for near-term progress given existing efforts and momentum.

sectoral basis; and study the knowledge networks, communities of practice and other institutional arrangements developed around the production and dissemination of the assessment findings. As it covers such topics as coastal vulnerability, climate change and human health, transportation and supply-chain risks, food production vulnerability and the potential loss of critical ecosystem services, the NCA offers the opportunity to systematically bring social science investigators into partnership with governmental regulatory and resource management agencies working to develop adaptation strategies and incorporate climate information into their planning²⁴.

Challenges and opportunities

The implementation of a framework for increased knowledge co-production to support decision-making and responses to global change presents important challenges. Interdisciplinary and transdisciplinary collaborations have significant transaction costs, especially given the fact that norms and vocabularies differ. For example, a social

scientist would start with questions about human behaviour and social processes; planners and policy-makers would start with specific decisions to make and missions to accomplish; neither may easily mesh with studies of physical climate and biological systems. Similarly, Earth system models do not operate across the full range of scales necessary to comprehensively link human behaviour, actions and decisions to their impacts on, and feedbacks with, biophysical and geo-climatic processes.

Although we have emphasized the need for a practical program of knowledge co-production between scientists and stakeholders, this need is bound with an equally critical requirement for a practical program of co-inquiry between biophysical and social scientists. Real progress will require a greater commitment to joint problem-formulation between the disciplines. The nature of problems related to global change risks and responses means social sciences cannot merely be an add-on to research agendas driven only from the biophysical side (or vice versa). Co-framing

of both basic and applied research questions from multiple perspectives is not yet the norm in global change research, but it is essential if we are to move forward to find actionable solutions for the challenging questions raised by global change⁶. Historically, US global change research has focused primarily on the physical climate sciences. Thus, despite investments in environmental social science by a few federal agencies, the internal capacity to develop joint basic and applied research frames that encompass all disciplines needs significant strengthening. In a time of fiscal constraint, the pathway to stronger integration will be through building new partnerships and new communities of research and practice — perhaps by taking greater advantage of the broader international intellectual movement towards integration of all relevant scientific disciplines in global change research. □

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Author contributions

C.P.W. oversaw the project. C.P.W. and S.M. wrote the initial manuscript and oversaw comments and editing. All authors participated in the discussions and contributed comments, edits and intellectual content.

Additional information

All opinions and conclusions expressed here are those of the authors and do not necessarily represent those of any US federal agency.