Available online at www.sciencedirect.com

SciVerse ScienceDirect

journal homepage: www.elsevier.com/locate/envsci

Opening up knowledge systems for better responses to global environmental change

Sarah Cornell[a,1,*], *Frans Berkhout*[b], *Willemijn Tuinstra*[c,d], *J. David Tàbara*[e], *Jill Jäger*[f], *Ilan Chabay*[g], *Bert de Wit*[c], *Richard Langlais*[h], *David Mills*[i], *Peter Moll*[j], *Ilona M. Otto*[k], *Arthur Petersen*[b,c], *Christian Pohl*[l], *Lorrae van Kerkhoff*[m]

[a] *Stockholm Resilience Centre, Stockholm University, SE-106 91 Stockholm, Sweden*
[b] *Institute for Environmental Studies (IVM) and Amsterdam Global Change Institute, VU University Amsterdam, 1081 HV Amsterdam, The Netherlands*
[c] *PBL Netherlands Environmental Assessment Agency, PO Box 30314, 2500 GH, The Hague, The Netherlands*
[d] *Open University The Netherlands, School of Science, PO Box 2960, 6401 DL Heerlen, The Netherlands*
[e] *Institut de Ciència i Tecnologia Ambientals, Universitat Autònoma de Barcelona, Campus UAB, 08193 Cerdanyola del Vallès, Spain*
[f] *Initiative on Science and Technology for Sustainability, Arbeiterstrandbadstrasse 61, A-1210 Vienna, Austria*
[g] *Helmholtz Alliance ENERGY-Trans on Sustainability and Social Compatibility of Future Energy Infrastructure, Department of Social Science and Technology Assessment, University of Stuttgart, Germany*
[h] *NORDREGIO, Box 1658, SE-111 86 Stockholm, Sweden*
[i] *CEFAS, Pakefield Road, Lowestoft, Suffolk NR33 0HT, UK*
[j] *Science Development/Dr. Peter Moll, Hagenauerstr. 30, 42107 Wuppertal, Germany*
[k] *Potsdam Institute for Climate Impact Research (PIK), Telegrafenberg A51/0.34, 14412 Potsdam, Germany*
[l] *Network for Transdisciplinary Research (td-net), Schwarztorstrasse 9, 3007 Bern, Switzerland*
[m] *Fenner School of Environment and Society, The Australian National University, Canberra ACT 0200, Australia*

ARTICLE INFO

Article history:
Received 17 January 2012
Received in revised form
24 September 2012
Accepted 12 November 2012
Published on line 16 January 2013

Keywords:
Sustainability science
Knowledge democracy
Knowledge systems
Mode 2 science

ABSTRACT

Linking knowledge with action for effective societal responses to persistent problems of unsustainability requires transformed, more open knowledge systems. Drawing on a broad range of academic and practitioner experience, we outline a vision for the coordination and organization of knowledge systems that are better suited to the complex challenges of sustainability than the ones currently in place. This transformation includes inter alia: societal agenda setting, collective problem framing, a plurality of perspectives, integrative research processes, new norms for handling dissent and controversy, better treatment of uncertainty and of diversity of values, extended peer review, broader and more transparent metrics for evaluation, effective dialog processes, and stakeholder participation. We set out institutional and individual roadmaps for achieving this vision, calling for well-designed, properly resourced, longitudinal, international learning programs.

* *Corresponding author at*: Stockholm Resilience Centre, Stockholm University, SE-10691 Stockholm, Sweden. Tel.: +46 8 674 70 70; fax: +46 8 674 70 20.
E-mail address: sarah.cornell@stockholmresilience.su.se (S. Cornell).
[1] Formerly at the School of Earth Sciences, University of Bristol, Bristol BS8 1RJ, UK.
1462-9011/$ – see front matter
http://dx.doi.org/10.1016/j.envsci.2012.11.008

1. Introduction: open science for sustainability

The broad goal of sustainable development is to meet the needs of current and future generations. Supporting this goal requires both the production of knowledge and also close attention to the nature of the processes involved in the generation and validation of knowledge claims. Scientific knowledge has played a vital role in framing the global problems of unsustainability, and there is strong consensus that it also plays a critical role in informing societal responses to these problems, driving substantial research investment and scientific effort worldwide. Yet to a large extent, old knowledge systems are still being deployed for these new emerging social and environmental challenges. This means that urgent knowledge needs are not well met, resources risk being dissipated, and vital skills and capacities are either not developed or not adequately supported. Here, we identify how structures and processes at the interfaces between issue identification, the production and the use of knowledge could be changed to promote a more engaged and reflexive role for science in a 'knowledge democracy' (a concept explored in in't Veld, 2010) that is more oriented toward sustainability in the face of accelerating global social-environmental change. This article draws on work carried out in the European Science Foundation/COST Frontiers of Science Forward Look '*Responses to Environmental and Societal Challenges for our Unstable Earth*' (RESCUE; www.esf.org/rescue, 2009–2011). It is based on discussions of the international Working Group charged with reviewing the current state of interactions and addressing improved approaches at the interface between science and policy, communication and outreach.

Meadows et al. (1982) observed that: '*It is better to state your biases than to pretend you don't have any*' (p. xxv). We cannot easily list them all, but we can state that in this Working Group, we had a very diverse set of biases, and we often had to confront our own profound differences in worldview in the course of our discussions. In this article, we try to expose the main areas of debate. In terms of our own initial academic formation, our group had about equal numbers of social scientists and natural scientists, but all of us now work across disciplinary divides, and operate at the interface between science, policy, and wider society. We work with a shared assumption that research is – and should be – expected to have a positive societal impact.

Before we proceed, some initial clarifications are needed. First, we use the word *science* in its broadest sense, to include both the body of knowledge about the world in which we live, and the systematic and accumulative processes of inquiry in pursuit of that knowledge. This meaning encompasses all the academic disciplines of the natural, physical and social sciences. A defining characteristic of this knowledge (and the practices that structure it) is that it traditionally 'belongs' within universities and other specialist knowledge institutions. It is in these particular spaces where procedures are designed to select, generate, document, debate, and ultimately accept or reject what is understood as valid knowledge. In this traditional system, interfaces with other actors in society are oriented toward the post hoc dissemination of this knowledge. There is growing top-down pressure for change in this regard from funders and research policy-makers wanting greater social and economic research impact (e.g., Eynon, 2012), but it has not yet translated into widespread change in practices. Because of this, one of our core focal areas in this article is the institutional aspect of research.

We refer to *knowledge systems* as something broader than science. Knowledge systems are made up of agents, practices and institutions that organize the production, transfer and use of knowledge. Applied to the social goal of sustainability, knowledge systems are '*. . .a network of actors connected by social relationships, formal or informal, that dynamically combine knowing, doing, and learning to bring about specific actions for sustainable development*' (van Kerkhoff and Szlezák, 2010). While science plays a fundamental role in knowledge systems, it is evident that many other actors, institutions and networks also play significant roles (and many researchers of science in society have focused on these actors, e.g., Irwin, 1995; Irwin and Wynne, 1996; Leach et al., 2005). We argue that relationships within knowledge systems shape the flows of knowledge, credibility and power within those systems (cf. Van Kerkhoff and Lebel, 2006; Jasanoff, 2004). We also note that these patterns of relationships are currently undergoing rapid changes. In this fluid context, we need to conceive improved roles for science in contributing to socio-ecologically robust knowledge foundations, decisions and actions toward resolving problems of unsustainability (cf. van Kerkhoff and Szlezák, 2010; O'Brien et al., in this issue). Our starting point is that the challenges of achieving sustainability require radical and deliberate changes in knowledge systems (see Jäger et al., in this issue). In particular, the interactions between scientists and other actors in diverse knowledge systems must be intensified, with scientific practices becoming more oriented toward the societal arenas in which sustainability problems are being tackled. We term this the 'opening up' of knowledge systems (cf. Tàbara and Chabay, in this issue).

We see this process of 'opening up' occurring within an emerging global context that may be characterized as a *knowledge democracy*, where governance is being transformed by the mass creation and availability of knowledge. The concept of the knowledge democracy is comparatively new, and presents theoretical, practical and ethical challenges (in't Veld, 2010). The term highlights the relationship between science and the rest of society, which is currently undergoing profound change in the context of phenomena such as the scientization of politics (see Sörlin, this volume) and the politicization of science (e.g., Weingart, 1999; Leach et al., 2005). Using this term reflects our own stance in favor of democratic ideals in the production and use of knowledge: the quality and validity of knowledge systems for sustainability depend on ensuring plurality, transparency and independence; furthermore, sustainability scientists have a responsibility to collaborate openly in knowledge co-production and its translation to action with other social actors within knowledge systems.

In this paper we envision a way forward, which to a large extent consists of research institutions and individual researchers accepting this responsibility. Present-day science is a huge knowledge-generating system. Is it able to tackle such an enormous challenge with the urgency required?