
ELSEVIER
Volume 17 Numbers 3–4 August/October 2007
ISSN 0959-3780
Global Environmental Change
HUMAN AND POLICY DIMENSIONS
Editors:
Neil Adger, Katrina Brown & Mike Hulme
University of East Anglia, UK

Available online at www.sciencedirect.com
ScienceDirect
ELSEVIER
Global Environmental Change 17 (2007) 349–364
Global Environmental Change
www.elsevier.com/locate/gloenvcha

Linking vulnerability, adaptation, and resilience science to practice: Pathways, players, and partnerships☆

Coleen Vogel[a,*], Susanne C. Moser[b], Roger E. Kasperson[c], Geoffrey D. Dabelko[d]

[a]*School of Geography, Archaeology and Environmental Studies, University of the Witwatersrand, Private Bag 3, 2050, South Africa*
[b]*Institute for the Study of Society and Environment, National Center for Atmospheric Research, P.O. Box 3000, Boulder, CO 80307, USA*
[c]*George Perkins Marsh Institute, Clark University, 950 Main St., Worcester, MA 01610, USA*
[d]*Woodrow Wilson International Center for Scholars, One Woodrow Wilson Plaza, 1300 Pennsylvania Avenue, NW Washington, DC, USA*

Received 7 June 2006; received in revised form 3 May 2007; accepted 13 May 2007

Abstract

Vulnerability, adaptation and resilience are concepts that are finding increasing currency in several fields of research as well as in various policy and practitioner communities engaged in global environmental change science, climate change, sustainability science, disaster risk-reduction and famine interventions. As scientists and practitioners increasingly work together in this arena a number of questions are emerging: What is credible, salient and legitimate knowledge, how is this knowledge generated and how is it used in decision making? Drawing on important science in this field, and including a case study from southern Africa, we suggest an alternative mode of interaction to the usual one-way interaction between science and practice often used. In this alternative approach, different experts, risk-bearers, and local communities are involved and knowledge and practice is contested, co-produced and reflected upon. Despite some successes in the use and negotiation of such knowledge for 'real' world issues, a number of problems persist that require further investigation including the difficulties of developing consensus on the methodologies used by a range of stakeholders usually across a wide region (as the case study of southern Africa shows, particularly in determining and identifying vulnerable groups, sectors, and systems); slow delivery of products that could enhance resilience to change that reflects not only a lack of data, and need for scientific credibility, but also the time-consuming process of coming to a negotiated understanding in science–practice interactions and, finally, the need to clarify the role of 'external' agencies, stakeholders, and scientists at the outset of the dialogue process and subsequent interactions. Such factors, we argue, all hinder the use of vulnerability and resilience 'knowledge' that is being generated and will require much more detailed investigation by both producers and users of such knowledge.

Keywords: Vulnerability; Adaptation; Resilience; Science–practice interface; Knowledge systems; Communication; Southern Africa; Vulnerability assessment

1. Introduction

Climate-related catastrophes, such as the 2003 floods and heat waves in Europe, the 2005 hurricanes in the USA, Mexico and Cuba, and the persistent droughts and floods in Africa, Australia and Asia, as well as non-climatic high-impact events such as the 2004 Asian tsunami and the 2005 earthquake in Pakistan hold a mirror up to the world showing its continued exposure to destructive natural forces. Maybe more importantly, they also focus attention to the deep-seated patterns of underlying social

☆This paper was part of the IHDP (The International Human Dimensions Programme on Global Environmental Change, www.ihdp.org) effort to consolidate and provide an update on the science of vulnerability, adaptation and resilience as used by the global environmental change community (see Global Environmental Change Special Issue 16(3) (2006), Resilience, Vulnerability, and Adaptation: A Cross-Cutting Theme of the International Human Dimensions Programme on Global Environmental Change). Definitions and scientific advances in the use of these terms used in various fields are described in this issue.

*Corresponding author.
E-mail address: coleen.vogel@wits.ac.za (C. Vogel).

0959-3780/$ - see front matter © 2007 Published by Elsevier Ltd.
doi:10.1016/j.gloenvcha.2007.05.002

vulnerability and limited coping capacity that make these natural forces so devastating. All of these examples, usually starkly portrayed via the media, bring to light the daily, real and complex interactions of vulnerability, adaptation and resilience, terms that scientists are grappling with in the global environmental change (GEC) and related scientific communities. They typically produce not just calls for better warning systems and improved scientific forecasting capabilities (although they are needed, too), but increase the demand from the public and policy-makers for useful scientific information that could help ameliorate the situations of those most at risk.

As the real-world need and demand for actionable information on vulnerability, adaptation and resilience grows, many scientists in this expanding community have been drawn into this area of research through an interest in disasters, hunger and famine; others through an interest in global change. Many of them claim to produce policy-relevant or "useful" information. Meanwhile, extensive research—including the social study of science and of science policy—has emerged over the past two decades or more to examine the social contract between science and society, explore and improve the science–policy or (more generally) science–practice interface, and make specific recommendations on how to improve communication and interaction between these two worlds. Frequently, the attempt to produce "useful" science occurs separately from this study of the science–practice interface. Maybe not surprisingly then, policy-makers and managers often indicate that they do not receive the information they need, scientists are frustrated when their information is not being used, and ultimately, communities remain vulnerable in the face of extreme events and environmental changes.

In this paper, we examine the literature on science–practice interactions for useful insights that could inform a more effective exchange between researchers and potential information users of this field of science. In Section 2 below, we first examine the nature of the challenge of scientists and practitioners working together, especially highlighting the challenges that the knowledge–action interaction produces for both the scientific enterprise and for practice. We point to the need for improved communication and engagement, and highlight the specific challenges that arise for such interaction in the field due to the multiple disciplinary origins from which our knowledge base has emerged. In Section 3, we illustrate the challenges and the instances of success of scientists working together with practitioners on such issues in a case of a series of vulnerability assessments conducted in southern Africa. Finally, in Section 4, we offer some conclusions and suggestions for further exploration (through research and trial on the ground) in the hope that many in the global environmental change and hazards communities become better prepared for practical engagement in real-world problem-solving.

2. Challenges and opportunities of working at the science–practice interface of vulnerability, adaptation and resilience

2.1. Pathways to sustainability—does it matter what we mean by vulnerability, adaptation and resilience?

Modern day vulnerability, adaptation and resilience science is rooted in several decades of multidisciplinary research under a range of paradigms, theories, and methodologies. Vulnerability, adaptation and resilience first became widely used in several assessments of environmental change (e.g. Timmerman, 1981, and more recent reflections in Kates et al., 2001). More recently such concepts are re-emerging and receiving renewed attention in discussions linked to global environmental change (see, e.g. Berkes et al., 2003; Gallopín, 2006; Thomalla et al., 2006). Some experts in this field consider vulnerability, adaptation and resilience through the lens of climate change, where the vulnerability approach is a modification of earlier work that focussed on climate change impacts (this approach is best exemplified in the IPCC and UNFCCC (e.g. Adger, 1999, 2003; Downing and Patwardhan, 2003; Huq and Reid, 2004; Brooks et al., 2005). Others use a political-ecology and sustainability perspective to examine vulnerability and resilience, in particular, in the context of a variety of global changes (e.g. Watts and Bohle, 1993; Bohle et al., 1994; Kasperson and Kasperson, 2001; Berkes et al., 2003; Turner et al., 2003a, b; Ogunseitan, 2003; Folke et al., 2005). Others emphasise a social justice perspective (e.g. Adger, 1999, 2003; Adger et al., 2003; Dow et al., 2006) while yet others approach vulnerability and enhanced resilience to change from a disaster risk-reduction orientation (e.g. Thomalla et al., 2006; Bankoff et al., 2004; Wisner, 1993; Wisner et al., 2003, see also the RADIX web site, www.radixonline.org).

At the same time that the focus on vulnerability, adaptation and resilience has become central to the scientific debate in the global change community (including climate change scientists) and in the disaster-risk reduction community, there has also been a growing interest from the practitioner community (including, for example, a focus on various vulnerability assessment methodologies etc.), who have been seeking ways to understand such approaches and concepts to better inform humanitarian interventions (e.g. RHVP, 2006; see also www.wahenga.net). The range of approaches to understanding these concepts has enriched our understanding of the complex dynamics that produce vulnerability and adaptive capacity, but it also brings with it a variety of challenges, particularly in the application and use of these concepts in practice. Dilley and Boudreau (2001), for example, argue that vulnerability has become a term of art for assessment methods in several contexts, not just disaster or risk management. In the context of food security, for example, the term 'vulnerability' has assumed a variety of connotations (e.g., Longhurst, 1994; Alwang et al., 2001; Fussel, 2004) a situation that Dilley and

Boudreau (2001) argue has often been an impediment to food security interventions. Here, vulnerability is usually defined in relation to an outcome such as hunger. This definition may preclude employing the concept for the more specific task of evaluating the susceptibility of a population to explicitly identified exogenous events or shocks that could lead to these outcomes. Differences in understanding of 'vulnerability' also exist between climate impact assessors and hazard researchers. Subtle differences in the understanding of concepts such as 'resilience', 'coping capacity', and 'adaptation' are frequently lost in the course of a growing multidisciplinary discourse (Thomalla et al., 2006).

Clearly, the multidisciplinary nature of research in this growing field is not unique in having to face such linguistic, paradigmatic, theoretical and methodological tensions, and they are not necessarily negative (Miller, 2001). Rather, the range of insights that has enriched this field and the slow and mutual transformation that disciplinary approaches are experiencing as a result of learning from each other is deepening our scientific understanding. We argue here, however, that depending on the approach used to examine vulnerability, adaptation, and resilience, some opportunities for intervention will open and others close. As we will show in our case study of vulnerability assessments in southern Africa, involving practitioners from the outset in the research design, problem definition or framing, choice of approaches, negotiation of credible and legitimate knowledge systems (including 'expert knowledge' and 'local knowledge'), and communication and involvement with relevant stakeholders helps make this choice consciously rather than by default. Despite the complexities and transaction costs incurred, such early and ongoing engagement will shape the science and application opportunities (Steinberg, 2005).

2.2. Conceptualising the science–practice interface: metaphors and implications

So what usually happens when scientific and policy-makers or practitioners interact on issues related to vulnerability, adaptation and resilience? What happens when practitioners ask for guidance from the scientific community? Answers to these questions typically uncover metaphors that are used to describe the interactions at the science–practice interface. They inadvertently reveal assumptions and biases about that interaction. They also hopefully challenge—at a deeper level—a rethinking of the very nature of the practice-oriented scientific enterprise.

For the inexperienced, there frequently is an expectation that 'bridging' the science–practice 'gap' or 'gulf' is a fairly straightforward, unidirectional, and a simple process. Traditionally, the link between science and practice has been viewed as a linear process in which a set of scientifically vetted and legitimised findings are moved from the 'research sphere' to the 'policy sphere' (for some excellent critiques, see Devereux, 2003; Ellis, 2003; Jasanoff, 2003; Court and Young, 2003; Crewe and Young, 2002; Nowotny, 2003; Moll and Zander, 2006; Karl et al., 2007).

Those studying these interactions challenge our traditional notions of a simple, unidirectional message delivery or transfer. They question the claim that there is a clear divide between researchers and practitioners or users, and they contest that the exchange is merely a matter of transferring specialty knowledge to various target groups. They call into question the notion that science is transferred directly to policy with little or no interaction between user and producer groups (e.g. Ellis, 2003). What is emerging from this growing literature instead is a more complex and dynamic view of the activity and actions that are undertaken by those engaged in the science–practice interface. This view emphasises a 'two-way' process that is shaped by multiple relations and reservoirs of knowledge, and a host of intermediaries and policy-brokers. Rather than being a simple linear process, there is instead a very complex set of engagements and relationships that develop over time. Thus, instead of needing 'bridges' or 'highways of connectivity,' it may be more appropriate to envision 'complex labyrinths of communication and engagement.' The interactions may more adequately be described as 'spider webs' of connectivity and exchange in which there are nodes and complex linkages, with old actors disappearing and new ones entering (Kasperson, 2005).

Thus a strong agreement is emerging that replaces the traditional paradigm of linear knowledge transfer to practitioners. It is built upon the aforementioned efforts to assist in negotiating between science and the practice communities. This newer paradigm describes that interface between science and practice as a *complex terrain that it is best described* as a *multi-level system of governance and knowledge production* among a range of actors engaged in understanding and managing environment–society interactions (e.g. Cash and Moser, 2000; Cash et al., 2002a, b; Cash et al., 2006).

Interestingly, when scientists and practitioners begin working together—through whatever type of networks, with or without intermediary, boundary-spanning institutions—both the science and the practice change, and sometimes in unexpected or unintended ways. For example, practitioners and policy-makers become more than mere recipients of scientific knowledge but begin to help configure research agendas focussing on vulnerability, adaptation and resilience. Such outcomes can, however, blur the 'traditional' roles of scientist and practitioners, as the producer, user, and brokering roles become more fluid and less compartmentalised. Knowledge thus flows in many directions and the distinction between 'pure' and 'applied' or Modes I and II science can no longer be clearly made (Gibbons, 1999; Gibbons et al., 1994; Nowotny et al., 2001; Jasanoff, 2003; Nowotny, 2003; Owens, 2005; Moll and Zander, 2006). Consequently, the more traditional modes of scientific accountability (e.g. peer review) also require scrutiny:

> Unlike the 'pipeline model', in which science [in this case GEC science focussing on vulnerability, resilience and adaptation] generated by independent research institutions eventually reaches industry and government, Notwotny et al. propose the concept of 'socially robust knowledge' as the solution to problems of conflicts and uncertainty. Contextualization, in their view, is the key to producing science for public ends. Science that draws strength from its socially-detached position is too frail to meet the pressures placed upon it by contemporary societies. Instead, they imagine forms of knowledge that would gain robustness from their very embeddedness in society. The problem, of course, is how to institutionalize polycentric, interactive, and multipartite processes of knowledge-making within institutions that have worked for decades at keeping expert knowledge away from the vagaries of populism and politics (Jasanoff, 2003, 235, parentheses added).

The 'types of architecture' that may be required for effective science–practice engagement may, therefore, involve different types of networks and institutional arrangements that demand detailed understanding (e.g., Douglas, 1986; Weigerich, 2001a, b; Karl et al., 2007). As Ellis (2003) neatly summarises, these networks comprise various types of links that are embedded in wider contexts including policy communities (Pross, 1986), policy streams (e.g. Kingdon, 1984), advocacy coalitions (e.g. Sabatier and Jenkins-Smith, 1999), and epistemic communities (e.g., Haas, 1991, 1992).

Depending on the institutional context, these architectures can be quite stable or in flux over the duration of an interaction or policy process. For example, loss of institutional memory, clarity of roles, influx of new ideas, changes in the political saliency of the topics under investigation and so on, will all influence the quality of interactions, the stability of relationships, and the degree of success achieved among those involved. Policy and practitioner brokers can play critical roles as intermediaries in framing policy choices and interpreting assessments for the decision-maker in such complex terrains (e.g., Cash, 2001; Cash and Moser, 2000; Mitchell et al., 2006; Farrell and Jäger, 2006). As a result, substantial scientific and practical interest has grown in "boundary organisations" that can form a communication link and provide information brokering services between the science and practice worlds (e.g. Guston, 2001; Fujimura, 1992, Gieryn, 1999; Miller, 2001; Lemos and Morehouse, 2005; Jacobs et al., 2005; Niederberger, 2005; van Kerkhoff, 2005; van Kerkhoff and Lebel, 2006).

The political context in which the interactions and communication is embedded can also strongly shape the science–practice interface (see, e.g. French and Geldermann, 2005). Researchers are sometimes concerned that this political context challenges the integrity of the scientific process (e.g. through a politically motivated selection of participants, or areas for research included or excluded). Of course, the research exercise itself is a political and institutionalised process shaped by the support for and production of research, questions over the initial 'agenda setting' and framing of the problem, and the final negotiation and implementation. In the negotiation of the nature of the problem and in the implementation process, the power relations among actors are often sharply brought into focus (Clay and Schaffer, 1984; van Kerkhoff and Lebel, 2006). Vulnerability to food security provides a good example. The use and interventions designed to reduce food insecurity are made more complex by decisions on the role of food imports on local food economies, types of food used for aid such as genetically modified foods, and governments' political motivations at the time (e.g., food crisis in the southern African region [Ellis, 2003; Marsland, 2004]). When scientists neglect—even if unintentionally—the political and strategic nature of scientific knowledge, and the political context in which it is produced, they can be faced with uncomfortable and challenging situations for whose navigation many are ill-equipped. This suggests that education, training, and capacity building in relevant skills for scientists working at the practice interface could prove very useful.

Where the science–practice interaction is not taken seriously or carefully designed, a number of disconnections can emerge that frustrate otherwise well-meaning measures to reduce vulnerability and enhance resilience: the scientific output is more likely to be mismatched to user requirements, i.e. not what practitioners need; it may not be delivered in time or in appropriate formats; those interacting do not communicate well; scientists feel their credibility is negatively affected by collaborating with practitioners; stakeholders do not feel their legitimate concerns are addressed; and so on. Thus, although there is a growing body of knowledge on vulnerability, adaptation and resilience, and a variety of pressing application opportunities for that knowledge, all too often still silos of knowledge get produced that fail to help make systems and communities more robust to extremes and to change.

Communication is the means and indeed the very foundation for engagement between the worlds of science and practice. It is also sadly often relegated to an afterthought of scientific practice. Other times scientists dismiss this communication and dialogue role as not their job. It is thus entirely possible that entire volumes of potentially valuable knowledge—such as the Intergovernmental Panel on Climate Change's Working Group II reports that focus on vulnerability and adaptation to climate change—can remain largely untapped by the practitioner community. The next section describes some of the challenges and opportunities involved in effective communication between scientists and practitioners in more detail.

2.3. Communication links at the science–practice interface: Challenges and opportunities

Communication plays a central role in any effort to improve the science–practice interface. Virtually, everything in the interaction between these two worlds comes down to *what is communicated, how and when, through what channels or in what fora, for what purpose, by whom* and *for whom.* More fundamentally, communication touches on *the relationship between those engaged in the dialogue* and *their level of mutual understanding of (institutional) cultures, (professional) codes of conduct, modes of operation, information needs, decision contexts, including pressures, constraints, capacities*, and so on.[1] While communication typically does not easily or directly translate information into policy or action, we argue that science has little chance to enter into decision-making or inform action at all when communication is poor or nonexistent.

Our discussion here focuses on communication between science and two different practice communities, both relevant to, and interdependent in, the reduction of vulnerability and enhancement of adaptive capacity: the policy- and decision-making communities on the one hand and the broader public on the other. Both are rather amorphous and not necessarily clearly separated from the world of science. To illustrate our arguments, we use examples of actions and policy-related communication that affect the three dimensions of adaptations commonly distinguished: those that reduce a person's or system's sensitivity to risk, alter exposure, and/or increase the resilience or coping capacity (e.g. Adger et al., 2005a).

2.3.1. Science–practitioner communication in the context of policy-making and management

In the first context of policy- and decision-making practitioners,[2] science can play a number of roles (Fig. 1), ranging from assisting in problem identification and definition, to aiding in the search for and framing the response options and solutions, to the implementation and finally the evaluation of policy- or management options (Moser, 2004a, b; Lemmons and Brown, 1995). As Fig. 1 suggests, we conceive of the policy- or decision-making process as cyclical, iterative, and ongoing; thus scientific input can occur at any or all stages, and to be most effective should be equally ongoing, even if the type of impact differs from stage to stage.[3]

Importantly, the temporal and spatial scales of the research and policy processes are not the same. Thus, "effective input of science in policy could be enhanced by taking into account the differences in temporal and spatial scales. Different moments in time require different types of knowledge and different modes of communication" (Inter-American Institute for Global Change Research (IAI), 2005). Each stage in the decision-making process depicted in Fig. 1 has its own requirements in terms of how and when data or analyses are communicated, at what level of detail, and from whom to whom. Each stage also requires some degree of negotiation between the two sides. For example, if a water resource manager not yet cognisant of climate change first becomes aware of climate change, he or she may require some basic education. Communication at that point would need to illustrate at a relatively general level how climate change relates to water resources and why it is important to take climate change into account in water management (see, e.g. Miller and Yates, 2005). Beyond the initial stage of getting someone's attention, the communication requirements become more specific. As that same water resource manager decides about supply and/or flood management at very specific times in the water year calendar, scientific information two weeks after the decision point—even if very interesting, regionally specific, and relevant—is no longer helpful (e.g. Jones et al., 1999; Pulwarty and Melis, 2001; Pulwarty, 2003; Miles et al., 2006). If valuable information is offered in ways that do not easily integrate into decision-making procedures or are difficult to understand and interpret, managers may decide to ignore even the most valuable information (e.g. Hall and Paradice, 2005; Morss et al., 2005). Similarly, if relevant management information or policy choices are framed in ways that simply cannot garner political and public support (e.g. because the frame does not mobilise concern, does not suggest a sense of urgency, or goes counter to deeply held values of the decision-makers), they may well fail to enter the policy debate or decision-making process (e.g. Ogunseitan, 2000,2003; Schreurs et al., 2001 Giampietro, 1997; Pielke, 1997; Gerhard, 1994).

These problems of appropriately matching scientific information with decision situations and needs may seem trivial, yet they are all too often ignored (McNie and Elizabeth, 2007; Sarewitz and Pielke, 2007). Among the best strategies to match better scientific information with practitioners' actual information needs is to find out what exactly a practitioner *does* and what decisions are pending (rather than asking what kind of information he or she may *want* or *need*) (Altalo, 2005). In the case of a detailed analysis of vulnerability or adaptive capacity, for example, it helps little to offer the results to a local decision-maker to inform her actions if the results suggest intervention at higher levels of governance (e.g. Demeritt and Langdon, 2004).[4] Of course, many such problems can be avoided or minimised if scientists or information providers (e.g., extension agents) and decision-makers can build trustful

[1]This broad conceptualization differs from the fairly common notion that communication simply means the conveyance of technical information.

[2]For the purposes of this very truncated discussion, we make no explicit distinction between policy-makers in the public realm and decision-makers and (resource) managers in the private sectors. At the same time, we recognise that the types of decisions they make differ, and scientists may feel differently about interacting with one group versus the other.

[3]Science is depicted here as if it were the central and only input into the decision-making process, which, of course, is not the case. We simply focus here on the relevant interaction between science and decision-making, fully aware that there are other, and frequently competing forms of information and input into that process.

[4]For further discussion of cross-scale challenges in the science-practice interaction see Cash and Moser (2000), Cash et al. (2006), Adger, Arnell and Tompkins (2005b), and Wilbanks (2002).

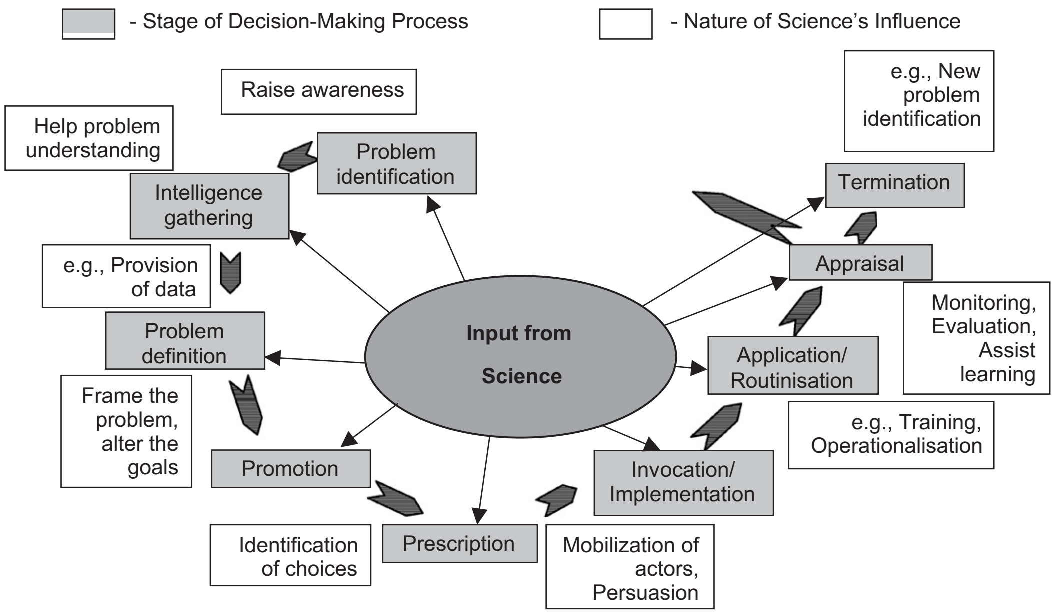

Fig. 1. Scientific input at various stages of the decision-making process and the nature of science's influence. *Source*: Adapted from Clark (2002) using insights from Mitchell et al. (2006).

relationships and mutual understanding of capacities and needs over time (e.g., Cash, 2001; Cash et al., 2002b; Earle and Cvetkovich, 1995). Typically, such trust grows over time—with those involved typically having benevolent attitudes and plenty of social skills and experience—in a jargon-free, non-condescending communication environment, as both sides increase their mutual understanding of each others' language, institutional culture, the standards and expectations of professional conduct, and the larger decision context. This element of trust building has been key in the case of southern Africa, as we will describe below, where various members of consortia working on vulnerability assessments have grown to trust each other and have begun shaping the problem and assessment methods in a collaborative spirit. Clearly, there and in other contexts, trust is not an expendable ingredient, or one that can be handled lightly. As numerous studies in the risk literature have shown, trust can very easily be lost and, when that happens, is difficult to rebuild (e.g., Slovic, 1993; Cvetkovich et al., 2002; Poortinga and Pidgeon, 2004). Thus, great care needs to be given to this aspect of the interaction.

Challenges in communication across the science/policy/practice interface are also common. First, building effective communications is time-consuming, and much of the necessary relationship-building that makes this communication effective occurs in the background, is not glamorous, and is certainly not directly rewarded, and at times is penalised in some scientific circles (e.g., Chappell and Hartz, 1998; Jacobson et al., 2004). This lengthy process is exacerbated by the fact that scientists tend to lack specific training in (non-scientific) communication while practitioners or media representatives frequently lack certain technical expertise (Kyvik, 2005; Gregory and Miller, 1998; Weigold, 2001). Even when "language" barriers can be breached, scientists and practitioners have precious few opportunities for regular face to face interaction that can facilitate trust-building (Dabelko, 2005).

Second, while many in the scientific community hope that their research is relevant and some conduct research that is use-inspired (Stokes, 1997), traditional "applied science" tends to have less prestige and rewards than "pure" curiosity-driven basic science (Moll and Zander, 2006). Third, achieving the balance between credibility and salience is not a trivial undertaking, as decision-makers frequently have high expectations as to how soon decision-specific information can be made available. Meanwhile, many scientists want to err on the side of caution and uncertainty by first vetting their findings in the peer review process (Van der Vink, 1997; Blockstein, 2002; Cash et al., 2002b). Fourth, scientists and practitioners can have very different notions of what constitutes 'legitimate' knowledge. Scientists frequently assume that knowledge that has emerged from a rigorous process of data gathering, hypothesis testing, empirical or model verification, and peer-review is the 'truth' (or at least a superior truth) because of the 'expert' nature of scientific knowledge and, therefore, ready for transfer to and use by end-users. To practitioners, legitimacy may be derived from considering and addressing key stakeholders' values and concerns and inclusion of non-scientific knowledges.[5] These differences

[5]Differently 'constructed' knowledges, contestations between 'scientific/expert' and local or indigenous knowledge (itself highly contested), have been a subject of interest for many years and are growing in importance as many different knowledge holders seek to engage in the science-practice interface.

need to be carefully addressed so as not to undermine successful science–practice interactions. And finally, many scientists strongly object to, or at least resist, closeness to the world of politics for professional and ethical reasons (e.g. McNeely, 1999; Brooks, 2001; Freyfogle and Newton, 2002).

Taking these reasons together, it is not surprising that only a small percentage of scientists do the yeoman's share of communicating to non-scientific practitioners in the policy/management world and the public directly (e.g. The Wellcome Trust, 2000; Jensen, 2005). Institutional and attitudinal changes are required to improve this situation, and in some cases (especially in large projects where funds are sufficient), it may be advisable to have a communications specialist involved (requiring dedicated funding for this responsibility). In addition, more social science research is needed to measure the effectiveness and outcomes of direct science–practitioner and boundary organisation-mediated communication.

2.3.2. Communication with the lay public

Policy- and decision-makers in the public and private sectors are clearly important players in any effort to reduce vulnerability or increase a community's adaptive capacity and resilience to the synergistic impacts of environmental and socio-economic global changes (O'Brien and Leichenko, 2000; O'Brien et al., 2004). But neither will such policy actions occur, nor will the implementation take place, without public support or consent, and in many cases active participation by individuals and communities. This requires at least some understanding of the issues at hand, if maybe not deep knowledge. Moreover, individual action is fostered and/or constrained by the policies implemented at higher levels and also influenced by communication coming from governmental and scientific sources (or other mediating channels) as we highlight in the cases from southern Africa below. In fact, communication with non-scientists can be viewed as a form of adaptive capacity building that enhances resiliency to the impacts of climate change (Adger et al., 2005b, p. 79; Moser and Luganda, 2006). It is thus critical to also examine the role of communication in the context of this second cohort of the practice community: with the lay public (Moser, 2004b).

A vast body of literature, developed in numerous disciplines and interdisciplinary fields, has contributed to our understanding of how the lay public does and does not pick up, process, understand, and act on information about environmental risks (see, e.g. Slovic, 2000; Dietz and Stern, 2002; Cox, 2006), how their perceptions and mental models are shaped and change, and what effect certain forms of communication have on behaviour.[6] Much of this communication between science and the public is mediated by the news media, and as such is subject to the political-economic imperatives of the media enterprise and the media's filter on "newsworthiness" (e.g. stories that have drama, emotional appeal, novelty, and human interest). Many scientists are not accustomed or trained to present their findings in ways that appeal to reporters, and, in fact, resist having their work "sensationalised" to fit the media's (public's) taste.

On the other hand, insights from communication studies should be of significant interest to those who grapple with how to alert, inform, motivate, mobilise, and support effectively public action on global change risks. Many scientists are increasingly frustrated that these risks (which are difficult to perceive, understand, and—for now—directly experience) have not generated a sufficient sense of urgency among lay publics (see, e.g. Biodiversity Project, 1998; Moser and Dilling, 2004). Classic examples include climate change and the loss of biodiversity (and related ecosystem services), both of which are highly likely—for the vast majority of the world's population—to increase vulnerability and reduce adaptive capacity (IPCC, 2001; Millennium Ecosystem Assessment, 2005).

While the public tends to perceive such global change problems as real, underway, and sufficiently established by science, many people are still unclear about causes and solutions, and—generally—do not view the issues as immediate, urgent, or amenable to personal or collective action (e.g., Immerwahr, 1999). In the case of natural disasters, lay people frequently view such events as "acts of God" and thus also not amenable to personal or policy intervention. Once an immediate threat is averted or past and "normal life" reestablished, both the periodic extremes and the gradual long-term changes get placed far below the more pressing daily concerns of food, jobs, safety, health care, and education.

The implications of these findings are tremendous: If individuals are to be involved in mitigating and adapting to climate and other global changes, the problems need to be meaningful and relevant; people need help to understand both causes and solutions; communicators must—despite uncertainty—create a sense of appropriate urgency (but not irrational fear); and they must enable and empower people to act in sustainable ways and support relevant public policy (see also Uzzell, 2004; Vlek and Steg, 2004). As Stone (1989, 281) put it, "difficult conditions become problems only when people come to see them as amenable to human action." Importantly, scientists and other communicators must avoid (or abandon) the assumption that better information and understanding alone will lead to such environment-friendly behaviour or policy support (McKenzie-Mohr and Smith, 1999; National Research Council, 2002; Gardner and Stern, 2002).

[6]The literature is too vast to cite even just a representative sample here. Readers are directed to studies in environmental sociology; cognitive, environmental, eco-, and political psychology; behavioural geography; behavioural economics and economic psychology; (mass) communication and media studies; (social) marketing; and various interdisciplinary fields, such as studies of risk perception and communication, or that of the public understanding of science.

A clear understanding of habits, barriers, identities, and pragmatic support needs, as well as institutions, laws, and social norms that constrain or facilitate certain behaviours, must accompany any effort that seeks to use communication in support of individual and collective behaviour change (Moser and Dilling, 2006).

Rather than having experts convey specialised knowledge to a non-expert audience, and focusing on how to best "get the message across," the alternative communication model is considerably more "democratic," mutual, and interactive (e.g. Communication and Cognition, 1996; Servaes et al., 1996; Mcleod et al., 1999). Borrowing from the notion and practice of "participatory communication" (The Rockefeller Foundation, 1997; Gray-Felder, 1999; Figueroa et al., 2002), this model suggests that experts and lay individuals are equally involved in a dialogue over challenging issues, together defining problems and solutions, not aiming at persuasion but empowerment, not at individual behaviour change, but shifts in social norms, policies, and culture (Figueroa et al., 2002). Very similar arguments were already detailed in the US National Conference on Risk Communication in 1989 (see NRC, 1989), and by other risk scholars (e.g. Fischhoff 1995, 1989).

It is difficult to see how vulnerability can be reduced and adaptive capacity increased without such active involvement of those most directly concerned. As the example from southern Africa below shows, until dialogue and a greater understanding of the context in which policy, science, practitioners, and other stakeholders became part of vulnerability assessment, useful interventions can be delayed and the pace of the much-needed intervention retarded.

Various tools or methodologies are currently being used as 'communication entry points' into a wider dialogue between science and practice on vulnerabilities to changes in the southern African region. The case for southern Africa is illustrative as it shows the evolution of complex interactions between science and the world of policy and practice and demonstrates how knowledge production develops through co-production. Initially configured around rather simple modes of communication (e.g. roundtables and workshops) a number of rather complex interactions, consequences, responses, and outcomes have resulted that in turn have begun to drive, shape, and reconfigure the engagement process. Institutional alliances have become challenged, modes of knowledge production have moved from simple institutional interactions to more polycentric modes of interaction (Jasanoff, 2003; Cash et al., 2004) and a range of interesting cleavages in institutional arrangements have emerged as new questions and challenges to traditional and acceptable methods are being revealed.

3. Multiple players, multiple knowledge systems: an example from Southern Africa

Several vulnerability assessments have recently been undertaken in the southern African region to inform current policy and humanitarian interventions in the region.[7] Achievement of the Millennium Development Goals, a major set of development targets agreed on by all member states of the UN in 2000 at the Millennium Summit, is core to livelihood and ecosystem 'health' in southern Africa. Southern Africa is one of the only regions in the world, however, facing chronic, recurrent food insecurity and persistent threats of famine (Devereux, 2000; Devereux and Maxwell, 2001) and one where the number of extreme poor has arguably risen in the last few years as compared with other regions of the world (e.g. Asia) where it has decreased (Sachs, 2005).

Southern Africa is also a region that clearly illustrates how multiple users and producers of knowledge have been brought together to address a persistent vulnerability crisis in the region characterised by repeated calls for humanitarian appeals for food and other resources. Different 'spaces' for knowledge interaction on vulnerability, adaptation and resilience have been created (including expert and lay knowledge interaction, universal and contextual and technical and cultural interactions) through the formation of vulnerability assessment committees (VACs) and a regional vulnerability assessment committee (Maunder, 2005; Owens, 2005; Maunder and Wiggins, 2007). The 'players', in this case, were drawn together by the 'food and humanitarian crisis', heightened in 2001, but still persisting in the region. Such interactions, while successful in some instances, as highlighted below, have also raised some frustrations: an inability to fully comprehend the dimensions of the 'problem', including the multiple causes of the crisis; the inability to fully capture this multiple causation in shaping the crisis; a failure to come to an understanding of the political context in which the evidence to inform interventions that would reduce vulnerability was and is still currently embedded and the quality of the derived evidence to inform interventions in the region and the limited engagement of civil society participation including the non-governmental (NGO) and civil society organisations and sectors (CSOs) (e.g. Tschirley et al., 2004; Drimie and Misselhorn, 2005; Wiggins, 2005).

In the case at hand, we can begin to analyse the role of interactions around applied and conceptual knowledge production on vulnerability, adaptation and resilience, and assess how that knowledge was used in practical applications and also, in turn, fed back into the knowledge production. The analysis of this case study begins to answer the call made by Owens (2005, 290) for "… more research into and at the 'boundary', where a number of issues… are under-theorised, and [where] there is considerable scope for careful empirical research in a variety of

[7]Much of the discussion here is based on a number of reviews (e.g. Darcy and Hofmann, 2003; Tschirley et al., 2004; Mock, 2005a, b; Jere, 2005a, b; SADC-FANR-RVAC, 2005; Tango International, 2005a, b; Maunder, 2005) of the vulnerability assessment process that was commissioned by the Southern African Development Community: Food, Agriculture and Natural Resources, Regional Vulnerability Assessment Committee (SADC-FANR RVAC).

policy contexts.'' By positioning such knowledge into the context of the humanitarian crisis in southern Africa, some degree of practical robustness in our understanding of vulnerability and adaptation is gained, but as we show below, the emerging problems of how to institutionalise and sustain such interactions, that Jasanoff calls ''poly-centric, interactive, and multiple processes of knowledge making'' away from the vagaries of populism and politics, we suggest remain central challenges in the science–practice interaction in the region (Jasanoff, 2003, p. 235). Such challenges in this case can, and often do, frustrate interventions that are ultimately designed to increase the robustness and resilience in highly vulnerable communities.

3.1. Some background to the southern African case

Chronic and persistent vulnerability prevails in southern Africa. In 2002/2003, for example, the severe drought in southern Africa contributed to food shortages for an estimated 14 million people (Oxfam, 2002; House of Commons, 2002–03). This chronic situation is the product of a number of factors besides climate variability, including the growing spread of HIV/AIDS, weakened and eroded social safety nets, weakened capacity, and poor governance (Boudreau and Holleman, 2002; De Waal and Whiteside, 2003; Benson and Clay, 2004; Drimie, 2004; Marsland, 2004). A situation of below-normal rainfall for two to three agricultural seasons aggravated conditions in many parts of the region. As a result of this growing crisis, the UN issued an appeal for US$611 million to address the crisis in the Southern Africa Development Community or SADC region (Lesotho, Malawi, Swaziland, Zambia, Zimbabwe and Mozambique) in July, 2002 (SARPN, 2004; House of Commons, 2002–03). Many thus call the vulnerability crisis a chronic situation, triggered by droughts and food insecurity but aggravated by other 'livelihood' factors mentioned above (e.g. Maunder, 2005; Maunder and Wiggins, 2007).

Prompted by this growing crisis, the Kariba High Level Vulnerability Assessment Technical Consultation (Kariba SADC Regional Vulnerability Assessment Committee or RVAC) brought together over 100 technical early warning and food security professionals from the region in September 2000 (Mock, 2005a; Jackson et al., 2006) to find improved, and where possible, integrated ways, of targeting interventions and reducing vulnerability in the region. The meeting highlighted a number of scientific approaches to livelihood and vulnerability assessments. The Food, Agriculture and Natural Resources Directorate (FANR) of SADC established a number of multi-agency VACs. Their mandate was to use vulnerability assessments for the purposes of food security planning (Jere, 2005b). The importance of these vulnerability assessments to inform better interventions cannot be overstated for the region and they are receiving heightened attention at the level of SADC, from local governments as well as from various institutions, donor agencies, and humanitarian organisations worldwide (e.g. FAO (Food and Agricultural Organisation)/FIVIMS (Food Insecurity and Vulnerability Information and Mapping Systems), FEWSNET (Famine and Early Warning System Network), the WFP (World Food Programme) and DFID (Department of Foreign International Development, UK).

3.2. Successes, problems, and 'food for further thought'

The detailed vulnerability assessments undertaken by the VACs and RVAC throughout the SADC region (e.g. in August 2002, December 2002, May/June 2003 and May 2004 and currently ongoing) highlight several successes in the science–practice interaction. Recent assessment of the VACs concluded that a number of positive attributes have been associated with their activities (e.g. Marsland, 2004; Tschirley et al., 2004; Maunder, 2005; Tango International Inc, 2005a, b). They have, for example, enabled each of the countries in which they have been established to create a forum for all relevant stakeholders to come together and learn more about and better understand vulnerability issues; to provide a key information source for the humanitarian assistance community to respond to complex emergencies; and to create the opportunity to influence policies related to emergency and poverty responses.

What is clear from such science–practice interactions has been the enhanced understanding of the actual crisis in the region. This understanding has been 'informed by the context' in which the science/policy/practice engagement has occurred (what Gibbons, Nowtony and others refer to as the 'embeddedness' and 'social contextualisation' of the interactions). This enhanced understanding of the problem at hand has been the product of multiple knowledge interactions—for example, scientists and consultants discovering the inadequacy of some vulnerability methods and frameworks used to address the multiple complexities of the various vulnerability contexts in the region. Through these interactions, participants uncovered the multi-dimensional, complex nature of food insecurity and vulnerability in the region—not easily addressed by the simpler intervention models used by practitioners or common in the scientific literature.

Most of the VACs were initially focused on collecting information and data to provide a deeper understanding of food insecurity, prompted by the apparent food crisis and emergency of 2002. It was soon realised, however, that the humanitarian crisis was, and is, embedded in a socio-economic context that includes the role of macro-economic failures in the region dating back to the 1970s, the liberalisation of domestic markets, and the role that HIV/AIDS plays as it intersects and interacts with food crises (e.g. SADC-FANR, 2003; Marsland, 2004; Wiggins, 2005; Maunder, 2005). Now the focus, in most instances, of vulnerability assessments is on a more nuanced view of vulnerability and the requirements for efforts to build sustainable resilience.

One of the institutional advantages of the consultative process encouraged by the VACs was the ability to include the lessons and insights emerging from the field into the planning and thinking of the design of vulnerability assessments to better capture the unfolding situation in the field. In the December 2002 round of assessments, various countries began to adapt the VACs' original vulnerability assessment approach to better fit their own local realities. Various VACs (e.g. in Mozambique) moved towards a "multi-sectoral" questionnaire using the Rapid Rural Appraisal technique. The focus was still on food security but included additional analyses on issues related to water and sanitation, HIV/AIDS, and agricultural prospects. Developed at the local level, the assessments departed from earlier notions of the vulnerability assessment, by using information for longer-term planning and decision-making that was seen as a priority and relevant by local stakeholders (for more details see Marsland, 2004). The role of stakeholder engagement and consultation thus became key in 'informing' the types of vulnerability information that was collected.

Likewise in the Zimbabwean vulnerability assessment case (Tango International Inc, 2005b), it was realised early on that a focus on food balance sheets and food production was not really capturing the vulnerability that many in the country were and are experiencing (Tango International Inc, 2005b). In the early round of several assessments, the goal was to identify 'food gaps' at national and household levels to better inform food interventions, including a series of 'snapshots' of data on food shortages from field assessments. As with many other cases and country examples, the stresses and risks are driven by multiple causes and as information continued to be exchanged and methodologies debated the focus of the vulnerability assessments began to shift (Marsland, 2004). In this case the VAC process enabled the switch in focus based on the consensus of key stakeholders and motivated by the stakeholders' interest in improving the breadth of VAC data (Tango International Inc, 2005b). The active engagement and interaction of knowledge brokers and stakeholders turned into a particular strength in the vulnerability assessment process: "*the greatest accomplishment of the VAC was to bring the stakeholder community together to begin the process of 'harmonizing' statistical estimates of food aid and discovery of the nature and causes of food insecurity*" (Mock, 2005a, p. 12, emphasis added). In these rounds of interactions not only was knowledge about vulnerability being applied but participants brought about and shared fundamental breakthroughs in the conceptualisation of vulnerability and resilience to the causes of change in the region.

Certain weaknesses have also become apparent, however, in the science–practice engagements around vulnerability in the region. A variety of stakeholders has been involved in the VAC processes. The urgency of the persistent 'food' crisis has meant that those involved are usually drawn from a range of groups including government staff, non-governmental representatives, and scientists. Several scientists in the region are working with various NGOs and humanitarian agencies as field workers, or as consultants to the various organisations. In southern Africa the mode of operation involves building new 'institutional designs' or 'architectures,' such as consortia where scientists, practitioners, and other stakeholders all bring together their respective knowledge systems to assist in assessments, understand better, and manage food insecurity (e.g. FIVIMS-ZA, Food Insecurity and Vulnerability Information Mapping Systems for South Africa, www.sarpn.org.za, RHVP, The Southern African Regional Hunger and Vulnerability Programme, www.rhvp.org or www.wahenga.net and the VACs). Such consortia have enabled information to feed into the vulnerability assessment process, improved the use of methods and data, and have helped to effectively target the outcomes to the most sensible points of intervention. The legitimacy and future sustainability of such institutional arrangements have also been brought under the spotlight.

The production and uses of knowledge via these modes of interaction thus revealed a number of problems. Recent critiques (e.g. Jackson et al. (2006, p. 9) of the vulnerability assessments, for example, list the following challenges, many echoing the issues raised by Nowotny (2003) and Jasanoff (2003) and those highlighted in Section 2.3 on communication flows above:

- Relevant policies are poorly understood by stakeholders, which then limits their use in very applied contexts of heightened vulnerability, reduced resilience, and poor adaptation.
- Definitions and perceptions of vulnerability vary within the region.
- Assessments are critically dependent upon the flow of data between information providers and users.
- While VACs are considered to be among the few forums that co-ordinate information on vulnerability that channel recommendations to governments and collaborating partners, they have not been fully institutionalised. VACs, therefore, exist as informal committees with unclear institutional *roles* and responsibilities and suffer from *ad hoc* financing arrangements (Adapted from Jackson et al., 2006. For more discussion see Jackson et al., 2006, 9 and other relevant publications on the RHVP web site, www.wahenga.net).

While stakeholder engagement at the science–practice interface was useful in some aspects of the process, the downside of such an approach, argued by some, is the 'creation' of a rather loose network as opposed to a formal 'institutionalised process.' While many of the VACs were chaired by government (e.g., the Ministry of Agriculture) the operational sides of the VAC was characterised more by a '…loose alliance of interested organisations' (Jere, 2005b, p. 15). The somewhat loose relation between stakeholders and various agencies has meant that in some cases tensions have arisen between 'information sharing' and a devolution of tasks between partners. The lack of 'leadership' may also have led to the generation of 'false consensus' and a spirit that discouraged dissent (Darcy and Hofmann, 2003). In some assessments of the process in most countries a common frustration with such a loose arrangement was revealed: "The ZIMVAC needs to find an institutional home within the government structure" (Tango International Inc., 2005b, p. 19). The absence of an institutional frame was seen by many as impeding the progress of the VACs. At the local level, as is the case in Mozambique, a more harmonised assessment process with activities of FEWSNET and FIVIMS activities, housed in the facilities of the Technical Secretariat for Food Security and Nutrition (SETSAN), illustrated, for example, how a co-ordinated vulnerability assessment process may be more sustainable. In the wider regional context, however, the science–practice interaction around the VAC experience demonstrated the fractures that exist, and remain, in region-wide coordination (e.g. Drimie and Misselhorn, 2005).

How does one then design a forum or create 'spaces' for such interaction and co-ordination? One of the findings from much of the interaction in the region is that: "… there is currently no formal forum for civil society to engage with SADC at the regional level" on issues of food security (see for example results from a workshop presented by Drimie and Misselhorn, 2005, p. 6). One possible arrangement to overcome these tensions and difficulties is through 'boundary organisations' (e.g., Cash, 2001; Guston, 2001; Miller, 2001). In southern Africa, for example, the UN established a form of a 'boundary organisation' in the Regional Inter-Agency Coordination Support Office (RIACSO), a light model of coordination both within and between country coordination (e.g., between those focusing on food security and those focusing more on health issues and the implementation of the emergency response—e.g. Darcy and Hofmann, 2003). Such an organisation may also help overcome problems of a lack of 'trust' by groups working on behalf of certain donors, may ensure credibility of evidence where various sources of information are gathered. Assessments of several VAC activities also point to continued attempts at integration that all involve a dialogue and engagement across user and producer groups of knowledge:

> More attention needs to be given to district-level audiences and ideally results should be tied to administrative and programming units. Whenever possible, there should be an *interactive analysis that brings together district councils, local government authorities and agencies* such as district and area executive committees…… (Jackson et al., 2006, p. 53, emphasis added).

In summary, the vulnerability assessments in southern Africa provide an example of the science–practice interaction "in action" that is designed to reduce vulnerability to change and climate-driven extreme events in the region. They show both some of the benefits and challenges involved in the attempt to bring together multiple sources of knowledge rooted in the science and action domains. Despite some successes a number of issues persist that require further examination, particularly if such efforts are to made more sustainable and not seen as 'once-off' engagements to support relief efforts. One is the tension between developing consensus on the methodologies used by a range of stakeholders across a wide region (posing particular challenges for comparability and regional integration) when their applicability in local contexts demands idiosyncratic adjustments. Such debate is, however, ultimately healthy and may lead to better methodologies and framings of the problems in the region. Another problem is the slowness of the delivery of products that reflects not only a lack of data, and need for scientific credibility, but also the time-consuming process of coming to negotiated understanding in science–practice interactions and the need to clarify the role of 'external' agencies, stakeholders, and scientists at the outset of the process. Finally, the absence of some form of 'organisational base', or institutional 'frame' as well as clear 'rules of engagement' at the outset of such information exchanges, research activities, and interactions continues to frustrate many operating the VACs, and can inhibit the building of long-standing trusted relationships. Such problems have prompted some (e.g. Maunder, 2005, p. 12) to argue that as the next round of vulnerability assessments proceeds through the Regional Hunger and Vulnerability Programme (RHVP) "major challenges [remain] to the future of the VACs. The current analysis is failing to deepen the understanding of the causes of food security. The overlapping crises remain largely confounded. Consequently, responses continue to address symptoms rather than causes."

4. Conclusions

Linking science to practice, as we try to show in this paper, is not a simple task. It involves a variety of possible pathways and players, but always depends on a spirit of partnership, and perhaps a convergence of interests. The responsibility for making this linkage work is by necessity mutual; it rests on the shoulders of those in both the scientific and practice communities. As Cicerone (2005), President of the US National Academy of Sciences, recently said so aptly, "Science must be useful and science must be used." While we focus in this paper on the perspectives with which we are most familiar—that from the science side, there are misunderstandings and misconceptions about science, practice, and the connection between the two on both sides—there are many practical and logistical reasons for the observed failures and challenges and resistance to making that connection on both sides, as the case of southern Africa shows.

Our examination of "resistance" in this paper leads us to identify a number of areas for further exploration in future deliberations and research on this subject. They are as follows:

Our metaphors for characterizing science–practice interactions are sometimes faulty, sometimes simply insufficient to reflect the complexity of interactions. Discourse in this arena typically evokes the image of "bridges" or "highways" of connectivity between science and practice. In reality, there is almost never a clearly defined route or connection. Rather, something like "spider webs" of interactions lie between science and practice, composed of nodes and a multitude of ephemeral linkages. Frequently, policy brokers and intermediaries traverse these nets, shaping notions of the science that is needed for policy decisions, or of the societal interventions required to reduce vulnerability and to build resilience, and helping to form coalitions of participants required to achieve the reservoirs of support to make things happen. Our language needs to reflect better the dynamics that actually operate.

In these nets, boundary organisations may play a particularly important role, though they may not represent the only institutionalised or less formal process of working at the science–policy interface. Boundary organisations can provide communications and brokerage services and "signal" systems that alert and shape the perceptions of scientists, practitioners, and interested publics. Despite the interest in such organisations, we still know relatively little of where and how they may be important and most effective players in the spider webs of connections.

Communication breakdowns, it is clear, are a central barrier to better coordination and integrations between science and practice. Addressing these communication breakdowns touches on a host of issues: How do we best match scientific information with decision needs? How can the time-consuming and high resource needs required for an informed public be met? What is "legitimate" knowledge for needed decisions and where should that knowledge come from? How may it be validated? How can the incentives be refocused and the communication and outreach capacities of scientists be increased to meet the growing information and knowledge resource demands from practitioners? Over the past several decades, as societies have struggled with these issues, an alternative communication model has emerged from a range of fields to replace the traditional, linear, one-way notions that previously have underlain the science–practice interaction. It is a more democratic model of communication in which different experts, risk-bearers, and local communities all have something to bring to the table. But we have much to learn as to how to do this effectively.

Science—as a social institution—has always been in a position to play a potentially significant role in detecting and defining global environmental problems, framing, and shaping the public and policy debates around them, helping to identify socially and ecologically appropriate solutions, and informing the social learning process. It is for this reason that we see an important emerging possibility for the scientific and practitioner communities to engage, when required, on a number of themes. As this paper has shown, we see important, emerging opportunities for practical engagement with the wider community, particularly in the filed of global environmental change, in working more effectively with those who would enhance the science on such themes, develop and implement policies on the ground that could reduce vulnerability, increase adaptive capacity, and build the resilience of people and the environment in the face of global change.

Acknowledgements

Some of the contents of this paper were first discussed at a workshop organised by the IHDP at a workshop in Arizona in February 2005 on the state of the science of vulnerability, adaptation, and resilience in global environmental change. Several ideas were captured and we acknowledge the useful inputs of the members of the group including Barry Smit, Maureen Woodrow, Aromar Ravi, Emilio Moran, Daniel Sarewitz, and Michael Schoon. We also appreciate comments and inputs from Scott Drimie and Alison Misselhorn on earlier drafts of this paper. The opinions expressed and any remaining oversights remain ours.

References

Adger, W.N., 1999. Social vulnerability to climate change and extremes in coastal Vietnam. World Development 27 (2), 249–269.

Adger, W.N., 2003. Social capital, collective action, and adaptation to climate change. Economic Geography 79 (4), 387–404.

Adger, W.N., Huq, S., Brown, K., Conway, D., Hulme, M., 2003. Adapting to climate change: in the developing world. Progress in Development Studies 3 (3), 179–195.

Adger, W.N., Arnell, N.W., Tompkins, E.L., 2005a. Successful adaptation to climate change across scales. Global Environmental Change 15, 77–86.

Adger, W.N., Arnell, N.W., Tompkins, E.L., 2005b. Adapting to climate change.

Altalo, M., 2005. Don't ask me what I want, ask me what I do. Paper presented at the US Climate Change Science Program Workshop Climate Science in Support of Decisionmaking, November 14–16, Arlington, VA.

Alwang, J., Siegel, P., Jorgenson, S., 2001. Vulnerability: a view from different disciplines. Social Protection Discussion Paper Series No. 115. Washington, DC, World Bank Social Protection Unit.

Bankoff, G., Frerks, G., Hilhorst, D., 2004. Mapping Vulnerability: Disasters, Development and People. Earthscan, London.

Benson, C., Clay, E., 2004. Understanding the Economic and Financial Impacts of Natural Disasters. Disaster Risk Management Series, No. 4. World Bank, Washington, DC.

Berkes, F., Colding, J., Folke, C. (Eds.), 2003. Navigating Social-Ecological Systems: Building Resilience for Complexity and Change. Cambridge University Press, Cambridge, New York.

Biodiversity Project, 1998. Engaging the public on biodiversity: a road map for education and communication strategies. The Biodiversity Project, Madison, WI.

Blockstein, D.E., 2002. How to lose your political virginity while keeping your scientific credibility. BioScience 52 (1), 91–96.

Bohle, H., Downing, T.E., Watts, M., 1994. Climate change and social vulnerability: the sociology and geography of food security. Global Environmental Change 4 (1), 37–48.

Boudreau, T., Holleman, C., 2002. Household Food Security and HIV/AIDS: Exploring the linkages. The Food Economy Group. Available at: 〈http://www.fews.net/resources/gcontent/pdf/1000087.pdf〉.

Brooks, H., 2001. Autonomous science and socially responsive science: A search for resolution. Annual Review and the Energy Environment 26, 29–48.

Brooks, N., Adger, W.N., Kelly, M.K., 2005. The determinants of vulnerability and adaptive capacity at the national level and the implications for adaptation. Global Environmental Change 15, 151–163.

Cash, D.W., Moser, S.C., 2000. Linking local and global scales: designing dynamic assessment and management processes. Global Environmental Change 10, 109–120.

Cash, D.W., 2001. ''In Order to Aid in Diffusing Useful and Practical Information'': Agricultural extension and boundary organizations. Science Technology Human Values 26, 431–453.

Cash, D.W., Clark, W.C., Alcock, F., Dickson, N., Eckley, N., Jäger, J., 2002a. Salience, Credibility, Legitimacy and Boundaries: Linking Research, Assessment and Decision Making. RWP02-046. J.F. Kennedy School of Government, Harvard University, Cambridge, MA.

Cash, D.W., Clark, W.C., Alcock, F., Dickson, N., Eckley, N., Guston, D.H., Jäger, J., Mitchell, R.B., 2002b. Knowledge systems for sustainable development. Proceedings of the National Academy of Sciences 100, 8086–8091.

Cash, D.W., Adger, W.N., Berkes, F., Garden, P., Lebel, L., Olsson, P., Pritchard, L., Young, O., 2006. Scale and cross-scale dynamics: governance and information in a multilevel world. Ecology and Society 11(2), 8. Available at: 〈http://www.ecologyandsociety.org/vol11/iss2/art8/〉.

Chappell, C.R., Hartz, J., 1998. The challenge of communicating science to the public. Chronicle of Higher Education. Available at: 〈http://www.physics.ohio-state.edu/wilkins/writing/Resources/essays/sci_-comm.html〉.

Cicerone, R., 2005. Enhancing the scope and utility of climate science. Keynote address at the US Climate Change Science Program Workshop Climate Science in Support of Decisionmaking, November 14–16, Arlington, VA.

Clark, T.W., 2002. The Policy Process: A Practical Guide for Natural Resource Professionals. Yale University Press, New Haven, CT.

Clay, E.J., Schaffer, B.B., 1984. Room for Manoeuvre: An Exploration of Public Policy in Agricultural and Rural Development. Heinemann Educational Books, London.

Communication and Cognition, 1996. Editorial: Is popularization possible? special issue on popularization of science. The democratization of knowledge in perspective. Communication and Cognition 29 (2), 149–152.

Court, J., Young, J., 2003. Bridging Research and Policy: Insights from 50 Case Studies. ODI Working Paper 213. Overseas Development Institute, London.

Crewe, E., Young, J., 2002. Bridging Research and Policy, Context, Evidence and Links, ODI Working Paper 173. Overseas Development Institute, London.

Cvetkovich, G., Siegrist, M., Murray, R., Tragesser, S., 2002. New information and social trust: asymmetry and perseverance of attributions about hazards managers. Risk Analysis 22 (2), 359–367.

Dabelko, G., 2005. Speaking their language: How to communicate better with policymakers and opinion shapers—and why academics should bother in the first place. International Environmental Agreements: Politics, Law and Economics 15 (4), 381–386.

Darcy, J., Hofmann, C.-A., 2003. According to need? Needs assessment and decision-making in the humanitarian sector. Humanitarian Policy Group (HPG) Report No. 15. Overseas Development Institute, London.

De Waal, A., Whiteside, A., 2003. ''New Variant Famine'': AIDS and Food Crisis in Southern Africa. The Lancet 362, 1234–1237.

Demeritt, D., Langdon, D., 2004. The UK Climate Change Programme and communication with local authorities. Global Environmental Change 14, 325–336.

Devereux, S., Maxwell, S., (Eds.), 2001. Food Security in Sub-Saharan Africa, University of Natal Press, Petermartizburg, South Africa and ITDG Publishing, London.

Devereux, S., 2000. Famine in the twentieth century. Institute of Development Studies, IDS Working Paper, No. 105, IDS, Sussex.

Devereux, S., 2000. Famine in Africa. In: Devereux, S., Maxwell, S. (Eds.), Food Security in Sub-Saharan Africa. Pietermaritzburg. University of Natal Press, South Africa, pp. 117–148.

Devereux, S., 2003. Policy Options for Increasing the Contribution of Social Protection to Food Security, Forum for Food Security in Southern Africa.

Dilley, M., Boudreau, T., 2001. Coming to terms with vulnerability: a critique of the food security definition. Food Policy 26, 229–247.

Douglas, M., 1986. How Institutions Think. Routledge & Kegan Paul, London.

Dow, K., Kasperson, R.E., Bohn, M., 2006. Exploring the social justice implications of adaptation and vulnerability. In: Adger, W.N., et al. (Eds.), Fairness in Adaptation to Climate Change. The MIT Press, Cambridge MA, pp. 79–96.

Downing, T.E., Patwardhan, A., 2003. Vulnerability Assessment for Climate Adaptation. In: Lim, B., Spanger-Siegfried, E. (Eds.), Adaptation Policy Frameworks for Climate Change: Developing Strategies, Policies and Measures. APF Technical Paper 3, New York: United Nations Development Programme, pp.67–89. Available at 〈http://www.undp.org/gef/undp-gef_publications/publications/apf%20technical%20paper03.pdf〉.

Drimie, S., 2004. The underlying causes of the food crisis in southern Africa–Malawi, Mozambique, Zambia and Zimbabwe, Oxfam-Gb Policy Research Paper, HSRC 〈www.sarpn.prg.za〉.

Drimie, S., Misselhorn, 2005. Enhancing civil society participation in SADC food security processes. Conference Report, Look, Listen and Learn Project, Regional Conference, 14–15 November, 2005, SARPN, ODI, FANRPAN.

Earle, T.C., Cvetkovich, G.T., 1995. Social Trust: Toward a Cosmopolitan Society. Praeger, Westport, CT.

Ellis, F., 2003. Human vulnerability and food security: policy implications. Forum for Food Security in Southern Africa, Overseas Development Institute, London. Available at 〈http://www.odi.org.uk/Food-Security-Forum/docs/vulnerability_theme3.pdf〉.

Farrell, A.E., Jäger, J. (Eds.), 2006. Assessments of Regional and Global Environmental Risks: Designing Processes for the Effective Use of Science in Decisionmaking. Resources for the Future, Washington, DC.

Figueroa, M.E., Kincaid, D.L., Rani, M., Lewis, G., 2002. Communication for social change: an integrated model for measuring the process and its outcomes. Communication for Social Change, Working Paper. Johns Hopkins University, Center for Communication Programs, Baltimore, MD & The Rockefeller Foundation, New York.

Fischhoff, B., 1989. Risk: a guide to controversy. Appendix to National Research Council. Improving Risk Communications. National Academy Press, Washington, DC, pp. 211–319.

Fischhoff, B., 1995. Risk perception and communication unplugged: twenty years of process. Risk Analysis 15, 137–145.

Folke, C., Hahn, T., Ollson, P., Norberg, J., 2005. Adaptive governance of social-ecological systems. Annual Review of Environmental Resources 30, 441–473.

French, S., Geldermann, J., 2005. The varied contexts of environmental decision problems and their implications for decision support. Environmental Science and Policy 8, 378–391.

Freyfogle, E.T., Newton, J.L., 2002. Putting science in its place. Conservation Biology 16 (4), 863–873.

Fujimura, J., 1992. Crafting science: standardized packages, boundary objects, and 'translation'. In: Pickering, A. (Ed.), Science as Culture and Practice. Chicago University Press, Chicago, IL, pp. 168–211.

Fussel, H.-M., 2004. Coevolution of the political and conceptual frameworks for climate change vulnerability assessments. In: Biermann, F., Camp, S., Jacob, K., (Eds.), Proceedings of the 2002 Berlin Conference on the Human Dimensions of Global Environmental Change "Knowledge for the Sustainability Transition. The Challenge for Social Science." Global Governance Project, Amsterdam, The Netherlands, pp. 302–320.

Gallopín, G.C., 2006. Linkages between vulnerability, resilience, and adaptive capacity. Global Environmental Change 16, 293–303.

Gardner, G.T., Stern, P.C., 2002. Environmental Problems and Human Behavior, second edition. Pearson Custom Publishing, Boston, MA.

Gerhard, L.C., 1994. Framing policies on resources and the environment. Geotimes 39, 20–22.

Giampietro, M., 1997. Improving the societal process of decision making for sustainability: the crucial role of mass media in communicating scientific information and framing public debate, Italy.

Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P., Trow, M., 1994. The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies. Sage, London.

Gibbons, M., 1999. Science's new social contract with society. Nature 402, C81–C84.

Gieryn, T.F., 1999. Cultural Boundaries of Science: Credibility on the Line. University of Chicago Press, Chicago, IL.

Gray-Felder, D., 1999. Communication for Social Change: A Position Paper and Conference Report. Johns Hopkins University, Center for Communication Programs, Baltimore, MD and The Rockefeller Foundation, New York.

Gregory, J., Miller, S., 1998. Science in Public: Communication, Culture, and Credibility. Plenum Press, New York.

Guston, D.H., 2001. Boundary organizations in environmental policy and science: an introduction. Science, Technology, and Human Values 26, 87–112.

Haas, E.B., 1991. When Knowledge is Power: Three Models of Change in International Organisations. University of California Press, Berkeley, CA.

Haas, P.M., 1992. Introduction: epistemic communities and international policy coordination. International Organization 46 (1), 1–35.

Hall, D.J., Paradice, D., 2005. Philosophical foundations for a learning-oriented knowledge management system for decision support. Decision Support Systems 39 (3), 445–461.

House of Commons, 2002–03. The Humanitarian Crisis in Southern Africa. Third Report of Session 2002–03. International Development Committee, The Stationery Office Limited, London.

Huq, S., Reid, H., 2004. Mainstreaming adaptation in development. IDS Bulletin 35 (3), 15–21.

Immerwahr, J., 1999. Waiting for a signal: public attitudes toward global warming, the environment and geophysical research. American Geophysical Union. Available at ⟨http://www.ago.org/sci_soc/attitude_study.pdf⟩.

Inter-American Institute for Global Change Research (IAI), 2005. Linking the Science of Environmental Change to Society and Policy: Lessons from Ten Years of Research in the Americas. (Group D on Communicating Science). Workshop report from a meeting in Ubatuba, Brazil, 27 November–2 December, IAI, www.icsu-scope.org.

IPCC, 2001. Climate Change 2001: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the IPCC Third Assessment Report. Cambridge University Press, New York.

Jackson, J., Mkwende, G., Mathule, L., 2006. A rapid appraisal of the predictive performance of the 2005 annual VAC assessments in Lesotho and Malawi, Regional Hunger and Vulnerability Programme. Available at ⟨http://www.wahenga.net⟩.

Jacobs, K., Garfin, G., Lemart, M., 2005. More than just talk: connecting science and decisionmaking. Environment 47 (9), 6–21.

Jacobson, N., Butterill, D., Goering, P., 2004. Organizational factors that influence university-based researchers' engagement in knowledge transfer activities. Science Communication 25, 246–259.

Jasanoff, S., 2003. Technologies of humility: Citizen participation in governing sciene. Minerva 41, 223–244.

Jensen, P., 2005. Who's helping to bring science to the people? Nature 434, 956.

Jere, P., 2005a. Vulnerability Assessment Methodology Review, Namibia Country Report, Commissioned by SADC-FANR-RVAC. PJ Development Consultancy, Lilongwe, Malawi.

Jere, P., 2005b. Vulnerability Assessment Methodology Review, Swaziland Country Report, Commissioned by SADC-FANR-RVAC. PJ Development Consultancy, Lilongwe, Malawi.

Jones, S.A., Fischhoff, B., et al., 1999. Evaluating the science-policy interface for climate change research. Climatic Change 43, 581–599.

Karl, H.A., Susskind, L.E., Wallace, K.H., 2007. A dialogue, not a diatribe: effective integration of science and policy through joint fact finding. Environment 49, 20–34.

Kasperson, J.X., Kasperson, R.E. (Eds.), 2001. Global Environmental Risk. United Nations University Press, Tokyo.

Kasperson, R.E., 2005. Bridging vulnerability science and practice. Paper presented at the Open Meetings of the International Human Dimensions Programme, Bonn, Germany, October 2005.

Kates, R.W., Corell, R., Hall, J.M., Jaeger, C.C., Lowe, I., McCarthy, J.J., Schellnhuber, H.J., Bolin, B., Dickson, N.M., Faucheux, S., Gallopin, G.C., Grubler, G.C., Huntley, B., Jager, J., Hodha, N.S., Kaserpson, R.E., Magobunje, A., Matson, P., Mooney, H., Moore III, B., O'Riordan, T., Svedin, U., 2001. Sustainability science. Science 292, 641–642.

van Kerkhoff, L., Lebel, L., 2006. Linking knowledge and action for sustainable development. Annual Review of Environmental Resources 31, 12.1–12.33.

van Kerkhoff, L., 2005. Integrated research: concepts of connection in environmental science and policy. Environmental Science and Policy 8, 452–463.

Kingdon, J.W., 1984. Agendas, Alternatives, and Public Policies. Harper Collins, New York.

Kyvik, S., 2005. Popular science publishing and contributions to public discourse among university faculty. Science Communication 26, 288–311.

Lemmons, J., Brown, D.A., 1995. The role of science in sustainable development and environmental protection decisionmaking. In: Lemmons, J., Brown, D.A. (Eds.), Sustainable Development: Science, Ethics, and Public Policy. Kluwer Academic Publishers, Dordrecht, pp. 11–38.

Lemos, M.C., Morehouse, B.J., 2005. The co-production of science and policy in integrated climate assessments. Global Environmental Change 15, 57–68.

Longhurst, R., 1994. Conceptual frameworks for linking relief and development. IDS Bulletin 25 (4), 17–23.

Marsland, N., 2004. Development of food security and vulnerability information systems in southern Africa: the experience of Save the Children UK. Available at ⟨http://www.sarpn.org.za⟩.

Maunder, N., 2005. Regional food security policy issues: Challenges and opportunities for civil society engagement. Background paper for the Conference on Enhancing Civil Society Participation in SADC Food Security Processes, SARPN, ODI and FANRPAN, 14–15 November, 2005, Johannesburg.

Maunder, N., Wiggins, S., 2007. Food security in southern Africa: Changing the trend? Review of lessons learnt on recent responses to chronic and transitory hunger and vulnerability. Natural Resources Perspectives, No. 106, ODI.

McKenzie-Mohr, D., Smith, W., 1999. Fostering Sustainable Behavior: An Introduction to Community-Based Social Marketing. New Society Publishers, Gabriola Island, BC.

Mcleod, J.M., Scheufele, D.A., Moy, P., 1999. Community, communication, and participation: the Role of mass media and interpersonal

discussion in local political participation. Political Communication 16 (3), 315–336.
McNeely, J.A., 1999. Strange bedfellows: why science and policy don't mesh and what can be done about it. In: Cracraft, J., Grifo, F.T. (Eds.), The Living Planet in Crisis: Biodiversity, Science and Policy. Columbia University Press, New York.
McNie, L., Elizabeth, C., 2007. Reconciling the supply of scientific information with user demands; an analysis of the problem and review of the literature. Environmental Science and Policy 10, 17–38.
Miles, E.L., Snover, A.K., Whitley Binder, L.C., Sarachik, E.S., Mote, P.W., Matua, N., 2006. An approach to designing a national climate service. PNAS 103 (52), 19616–19623.
Millennium Ecosystem Assessment, 2005. Millennium Ecosystem Assessment Synthesis Report. Island Press, Washington, DC. Available at 〈http://www.millenniumassessment.org/en/index.aspx〉.
Miller, K., Yates, D., 2005. Climate Change and Water Resources: A Primer for Municipal Water Providers. AWWA Research Foundation, Denver, CO.
Miller, C., 2001. Hybrid management: boundary organizations, science policy, and environmental governance in the climate regime. Science, Technology, and Human Values 26 (4), 478–500.
Mitchell, R., Clark, W.C., Cash, D.W., Dickson, N.M. (Eds.), 2006. Global Environmental Assessments: Information and Influence. The MIT Press, Cambridge, MA.
Mock, N., 2005a. Vulnerability Assessment Methodology Review, Lesotho Country Report, Commissioned by SADC-FANR RVAC, SADC.
Mock, N., 2005b. Vulnerability Assessment Methodology Review, Mozambique Country Report, Commissioned by SADC-FANR RVAC, SADC.
Moll, P., Zander, U., 2006. Managing the Interface: From Knowledge to Action in Global Change and Sustainability Science. Oekom Verlag, München.
Morss, R.E., Wilhelmi, O.V., Downton, M.W., Gruntfest, E., 2005. Flood risk, uncertainty, and scientific information for decision making: Lessons from an interdisciplinary project. Bulletin of the American Meteorological Society 86 (11), 1593–1601.
Moser, S.C., Dilling, L., 2004. Making climate hot: communicating the urgency and challenge of global climate change. Environment 46 (10), 32–46.
Moser, S.C., Dilling, L., 2006. Cambridge University Press, Cambridge, UK.
Moser, S.C., Luganda, P., 2006. Talk for a change: communication in support of societal response to climate change. UPDATE: The IHDP Newsletter 1, 17–20.
Moser, S.C., 2004a. The Contextual Importance of Uncertainty in Climate-Sensitive Decision-Making: Toward an Integrative Decision-Centered Screening Tool. NCAR/ESIG Working Paper, Boulder, CO.
Moser, S.C., 2004b. Climate change and the sustainability transition: the role of communication and social change. UPDATE: The IHDP Newsletter 4, 18–19.
National Research Council, 1989. Improving Risk Communication. Committee on Risk Perception and Communication, Commission on Behavioral and Social Sciences and Education and Commission on Physical Sciences, Mathematics, and Applications (CPSMA). National Academy Press, Washington, DC.
National Research Council, 2002. New Tools for Environmental Protection: Education, Information, and Voluntary Measures. National Academy Press, Washington, DC.
Niederberger, A.A., 2005. Science for climate policy change policy-making: applying theory to practice to enhance effectiveness. Climate Change Science and Public Policy 32 (1), 2–16.
Nowotny, H., Scott, P., Gibbons, M., 2001. Re-thinking Science: Knowledge Production in an Age of Uncertainty. Polity Press, Cambridge.
Nowotny, H., 2003. The Potential of Transdisciplinarity, Rethinking Interdisciplinarity. Available at 〈http://www.interdisciplines.org/interdisciplinarity/papers/5〉.
O'Brien, K.L., Leichenko, R., 2000. Double exposure: assessing the impacts of climate change within the context of economic globalization. Global Environmental Change 10, 221–232.
O'Brien, K., Leichenko, R., Kelkar, U., Venema, H., Aandahl, G., Tompkins, H., Javed, A., Bhadwal, S., Barg, S., Nygaard, L., West, J., 2004. Mapping vulnerability to multiple stressors: climate change and globalization in India. Global Environmental Change 14, 303–313.
Ogunseitan, O.A., 2000. Framing vulnerability: global environmental assessments and the African burden of disease. Belfer Center for Science and International Affairs John F. Kennedy School of Government Harvard University, Cambridge, MA.
Ogunseitan, O.A., 2003. Framing environmental change in Africa: cross-scale institutional constraints on progressing from rhetoric to action against vulnerability. Global Environmental Change 13, 101–111.
Owens, S., 2005. Making a difference? Some perspectives on environmental research and policy. Transactions of the Institute of British Geographers 30, 287–292.
Pielke Jr., R.A., 1997. Reframing the US hurricane problem. Society and Natural Resources 10, 485–499.
Poortinga, W., Pidgeon, N.F., 2004. Trust, the asymmetry principle, and the role of prior beliefs. Risk Analysis 24 (6), 1475–1486.
Pross, P., 1986. Group Politics and Public Policy. Oxford University Press, Toronto.
Pulwarty, R.S., Melis, T.S., 2001. Climate extremes and adaptive management on the Colorado River: lessons from the 1997–1998 ENSO event. Journal of Environmental Management 63, 307–324.
Pulwarty, R.S., 2003. Climate and water in the West: science, information and decision-making. Water Resources Update 124, 4–12.
Regional Hunger and Vulnerability Programme, 2006. Review Paper on Community Coping, Vulnerability and Social Protection, Final Version, Feb. 2006. Available at 〈http://www.wahenga.net〉.
Sabatier, P., Jenkins-Smith, H.C., 1999. The advocacy coalition framework: An assessment. In: Sabbatier, P. (Ed.), Theories of the Policy Process. Westview Press, Boulder, CO.
Sachs, J.D., 2005. The End of Poverty: Economic Possibilities for Our Time. The Penguin Press, New York.
SADC-FANR, 2003. Towards identifying Impacts of HIV/AIDS on Food Insecurity in Southern Africa and Implications for Response, findings from Malawi, Zambia and Zimbabwe, SADC-FANR, Zimbabwe.
Sarewitz, D., Pielke Jr., R.A., 2007. The neglected heart of science policy: reconciling supply of and demand for science. Environmental Science and Policy 10, 5–16.
SARPN, Southern African Regional Poverty Network, 2004. Scoping Study Towards DFIDSA's Regional Hunger and Vulnerability Programme, Department for International Development, DFID, prepared by SARPN, Pretoria.
Schreurs, M., Clark, W.C., Dickson, N., Jäger, J., 2001. Issue attention, framing, and actors: an analysis of patterns across arenas. In: Clark, W.C., Jaeger, J., van Eijndhoven, J. (Eds.), Learning to Manage Global Environmental Risks: A Comparative History of Social Responses to Climate Change, Ozone Depletion and Acid Rain. The MIT Press, Cambridge, MA, pp. 349–364.
Servaes, J.T., Jacobson, L., White, S.A., 1996. Participatory Communication for Social Change. Sage Publications, Thousand Oaks, CA.
Slovic, P., 1993. Perceived risk, trust and democracy. Risk Analysis 13 (6), 675–682.
Slovic, P. (Ed.), 2000. The Perception of Risk. Risk Society and Policy Series. Earthscan, London.
Southern African Development Community (SADC), 2005. Strengthening Vulnerability Assessments and Analysis in the SADC Region. SADC Regional Vulnerability Assessment Committee, A five year programme 2005–2009, Gaborone, Botswana.
Steinberg, P., 2005. Is anyone listening? The impact of research on global environmental practice. International Environmental Agreements: Politics, Law and Economics 15 (4), 377–379.
Stokes, D.E., 1997. Pasteur's Quadrant. Brookings Institute, Washington, DC.

Stone, D.A., 1989. Causal stories and the formation of policy agendas. Policy Science Quarterly 104 (2), 281–300.

Tango International Inc., 2005a. Vulnerability assessment methodology review synthesis. Paper commissioned by the Southern African Development Community: Food, Agriculture and Natural Resources, Regional Vulnerability Assessment Committee (SADC-FANR RVAC), Tango (see also: 〈http://www.wahnega.net〉).

Tango International Inc., 2005b. Vulnerability Assessment Methodology Review, Zimbabwe Country Report. Tango (see also: 〈http://www.wahenga.net〉).

The Rockefeller Foundation, 1997. Communication for Social Change: Forging Strategies for the 21st Century. Johns Hopkins University, Center for Communication Programs, Baltimore, MD and The Rockefeller Foundation, New York.

The Wellcome Trust, 2000. Role of Scientists in Public Debate. Research study conducted by MORI for The Wellcome Trust. Available at 〈http://www.wellcome.ac.uk/doc%5Fwtd003429.html〉.

Thomalla, F., Downing, T., Spanger-Siegfried, E., Han, G., Rockstrom, J., 2006. Reducing hazard vulnerability: towards a common approach between disaster risk reduction and climate adaptation. Disasters 30, 39–48.

Timmerman, P., 1981. Vulnerability, resilience and the collapse of society. Environmental Monographs, No.1. Institute for Environmental Studies, University of Toronto, Toronto.

Tschirley, D., Nijhoff, J.J., Arlindo, P., Mwinga, B., Weber, M.T., Jayne, T.S., 2004. Anticipating and responding to drought emergencies in Southern Africa: Lessons from the 2002–2003 Experience. Report prepared for the NEPAD Regional Conference on Successes in African Agriculture, 22–25 November 2004, Nairobi, Kenya.

Turner Jr., B.L., Matson, P.A., McMcarthy, J.J., Corell, R.W., Christenson, L., Eckely, N., Hovelsrud-Broda, G., Kasperson, J.X., Kasperson, R.E., Luers, A., Martello, M.L., Mathieson, R., Naylor, C., Polsky, A., Pulsipher, A., Schiller, A., Selin, H., Tyler, N., 2003a. Illustrating the coupled-human environment systems for vulnerability analysis: three case studies. Proceedings of the National Academy of Sciences 100 (14), 8080–8085.

Turner II., B.L., Kasperson, R.E., Matson, P.A., McCarthy, J.J., Corell, R.W., Christensen, L., Eckley, N., Kasperson, J.X., Luers, A., Martello, M.L., Polsky, C., Pulsipher, A., Schiller, A., 2003b. A framework for vulnerability analysis in sustainability science. Proceedings of the National Academy of Sciences 100, 8074–8079.

Uzzell, D., 2004. From local to global: a case of environmental hyperopia. UPDATE–The IHDP Newsletter 4, 6–7.

Van der Vink, G.E. (Ed.), 1997. Scientifically illiterate vs. politically clueless (Editorial), Science 276, 1175.

Vlek, P., Steg, L., 2004. Solid environmental policy needs valid environmental psychology. UPDATE–The IHDP Newsletter 4, 11–13.

Watts, M.J., Bohle, H.G., 1993. The Space of vulnerability: the causal structure of hunger and famine. Progress in Human Geography 17 (1), 43–67.

Wegerich, K., 2001b. Determining Factors of Local Institutional Change in Countries in Transition. Occasional Paper No. 38. Water Issues Study Group, School of Oriental & African Studies, University of London, London.

Wegericha, K. 2001a. Institutional Change: A Theoretical Approach. Occasional Paper No. 30. Water Issues Study Group, School of Oriental & African Studies, University of London, London.

Weigold, M.F., 2001. Communicating science: a review of the literature. Science Communication 23, 164–193.

Wiggins, S., 2005. Success stories from African agriculture: what are the key elements for success, New Directions for African Agriculture. IDS Bulletin 36 (2), 17–22.

Wilbanks, T.J., 2002. Geographic scaling issues in integrated assessments of climate change. Integrated Assessment 3, 100–114.

Wisner, B., 1993. Disaster vulnerability: geographical scale and existential reality. In: Bohle, H.-G. (Ed.), Worlds of Pain and Hunger. Universität Freiburg, Saarbrücken, Breitenbach, pp. 13–52.

Wisner, B., Blaikie, P., Cannon, T., Davis, I., 2003. At Risk: Natural Hazards, People's Vulnerability and Disasters. Routledge, London, New York.