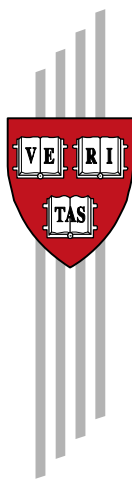


Integrating Science and Practice for the Mitigation of Natural Disasters: Barriers, Bridges, Propositions

Juergen Weichselgartner

CID Graduate Student and Postdoctoral Fellow
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Abstract

An immense enlargement of both the natural hazards literature and practical disaster mitigation efforts has not reversed the upward trend in disaster losses. The paradox of concurrent increases raises questions about knowledge and approaches used in hazard management. Is the knowledge base inadequate despite the increasing research effort, or is it that existing knowledge is not applied or not used in an effective way? The study examines how twenty scientific assessments from the knowledge domains of vulnerability and resilience are carried out and attempts to uncover what gaps and barriers in the science-policy-practice interface limit the use of research-based knowledge. In addressing the question of “What influence do scientific assessments have on decision makers in the practical disaster mitigation arena?,” a number of linkages between specific vulnerability and assessment determinants as well as factors—functional, structural, and social—are identified that inhibit the production of applied knowledge. It is the quality of these relations that determines the grade of influence of research-based knowledge on action. Factors that aggravate greater coherence among and between actors and arenas typically occur when knowledge is transferred through the traditional pipeline mode in which scientists set the research agenda, do the research, and then transfer the results to potential users. It is suggested to avoid discipline-based non-collective knowledge production, which inevitably generalizes, decontextualizes, and reduces much of what is important about the character of vulnerability and resilience, and to engage in the co-production of knowledge through the close interaction of producers and users, hence building a “knowledge-action system.”

Keywords: knowledge, science-practice interface, science-policy interface, hazard research, vulnerability, resilience

JEL Codes: D8, D80, D83, Q0

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It is available at <http://www.cid.harvard.edu/cidwp/grad/021.htm>. Comments are welcome and may be directed to the author, Juergen Weichselgartner, at juergen.weichselgartner@gmail.com.

Juergen Weichselgartner was a Post-doctoral Research Fellow in the Sustainability Science Program at the Center for International Development at Harvard University in 2006. He has a long-standing interest in the interactions of coupled human-environment systems and conducted research on risk perception, disaster management, social vulnerability, and systems theory in various European and Asian countries. Weichselgartner studied geography, political science, and ethnology in Heidelberg, Malta, Santander, and Bonn (MS 1997) and completed his Ph.D. research (2001) at Bonn University with a system-theoretical analysis of the social discussion of natural risks. He has worked at Tokyo University (NENV), the International Institute for Applied Systems Analysis (IIASA), the University of Bonn (GERG), and the University of Cantabria (CITIMAC). Weichselgartner is a recipient of the Ph.D. Prize of the Franzke'sche Foundation Berlin, a Feodor Lynen Fellowship from the Alexander von Humboldt Foundation (AvH), two research fellowships from the Japan Society for the Promotion of Science (JSPS), and an ERASMUS and two Marie Curie Fellowships from the European Commission. Following his work at CID, he was appointed Senior Science Coordinator and Deputy Executive Officer of the IGBP/IHDP joint core project LOICZ (Land-Ocean Interactions in the Coastal Zone).

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The Sustainability Science Program at Harvard's Center for International Development seeks to advance basic understanding of the dynamics of human-environment systems; to facilitate the design, implementation, and evaluation of practical interventions that promote sustainability in particular places and contexts; and to improve linkages between relevant research and innovation communities on the one hand, and relevant policy and management communities on the other. See <http://www.cid.harvard.edu/sustsci>.

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1 Introduction

Coupled human-environment systems are undergoing rapid changes and therefore are committed to adapting to changing conditions. This makes the understanding of response mechanisms—and hence the state of vulnerability and resilience—one of the most important issues for society in general and for science in particular. Research in the fields of natural hazards, ecology, and global environmental change demonstrate that potential losses are determined not by exposure to hazards alone but also reside in the vulnerability and resilience of the society (or system) experiencing such hazards (Burton et al. 1978; Kasperson et al. 1995; Gunderson and Holling 2002). This recognition led to questions regarding the understanding of impacts on and responses of the affected society or its functions. During the last decade, an abundant literature has addressed the complex set of processes, factors, causes, and agents involved in the analysis of vulnerability and resilience (Dikau and Weichselgartner 2005; Janssen et al. 2006). Hence, new insights have been gained and researchers have developed different conceptual frameworks for analysis, as well as techniques and tools for assessment (Turner et al. 2003; Birkmann 2006).

Today, natural hazard management includes many scientists and practitioners from various fields, special research programs and institutes, numerous journals, advanced technology, private companies, and NGOs; in short, it includes a huge variety of knowledge systems and resources. At the same time, great natural disasters set new records again in 2005, and the trend towards higher and higher losses continues (Munich Re Group 2006, Fig. 1). This paradox of concurrent increases in economic loss and in disaster-related research, precisely expressed by White et al. (2001) as “*knowing better and losing even more,*” raises questions about the efficiency of approaches and tools used in hazard assessment and/or disaster mitigation. This in turn raises the possibility that progress is being blocked by fundamental conceptual barriers, in addition to profound changes in environmental and social processes, neither of which are adequately being addressed (Weichselgartner and Sendzimir 2004). A recent prominent example is Hurricane Katrina, after which it was argued that the broad sequence of decisions reflects a long-term pattern of societal response to hazard events: reducing consequences to relatively frequent events while increasing vulnerability to very large and rare events (Kates et al. 2006).

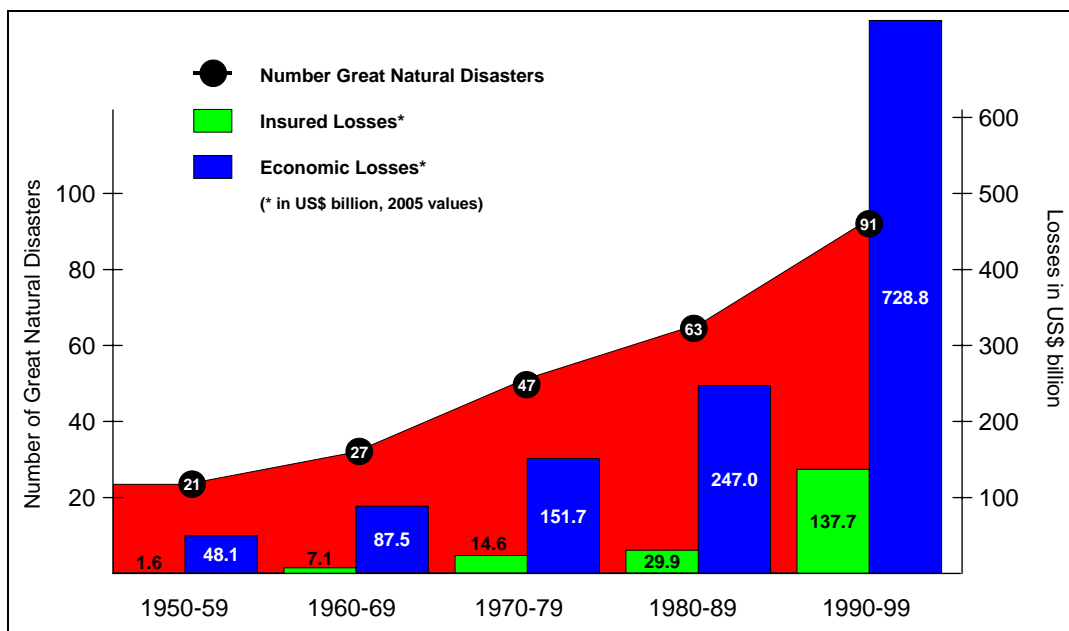


Fig. 1: Great natural disasters and economic losses (data: Munich Re Group 2006, own graphic)

Since an immense enlargement of both the literature in the domains of natural hazards, vulnerability, and resilience and practical disaster mitigation efforts have not reversed the upward trend in losses, the use of knowledge in hazards management comes to the foreground. How does hazard-related research-based knowledge relate to the evidently growing toll of losses? Is human knowledge and understanding of the causes of the losses inadequate despite the increasing research effort, or is it that existing knowledge is not applied or not used in an effective fashion?

Obviously, there are gaps between what is known about natural hazards and disaster mitigation, on the one hand, and how research findings are translated into policies and programs, on the other hand (Mileti 1999). White et al. (2001) examined four possible explanations for the situation in which more is lost while more is known: (1) knowledge continues to be flawed by areas of ignorance; (2) knowledge is available but not used effectively; (3) knowledge is used effectively but takes a long time to have effect; and (4) knowledge is used effectively in some respects but is overwhelmed by increases in vulnerability and in population, wealth, and poverty. After reviewing recent progress in coping with natural hazards, the authors offer two concluding observations in this context. The first is that better appraisal is needed of the actual results at community and other levels of applying the best available knowledge in the best possible way. The second is that there is a need to build upon past achievements in creating more understanding of natural hazards, by better integration of the knowledge into the wider efforts directed at sustainable development. Complementing these findings, Weichselgartner and Obersteiner (2002) argue that the continuing increase of losses from natural disasters is less a consequence of insufficient knowledge but of unsatisfactory transformation of existing knowledge into practical applications, and, hence, “internal” factors of disaster-related science and policy are also responsible for the inability to stem or reverse the upward trend in disaster damage.

Given the situation that less effort has been made to improve the existing gap between scientists (the knowledge-producers) and practitioners (the knowledge-users), this study focuses on the influence of scientific assessments on decision making in the practical disaster mitigation arena and the barriers that inhibit the involvement of users in the design of assessments, i.e., the co-production of knowledge. Hazard management, specifically the domains of vulnerability and resilience, is context but not focus of the study.

2 Study Objectives

By comparatively analyzing twenty scientific assessments from the knowledge domains of vulnerability and resilience, the study addresses the question of “*How appropriate and influential is the research-based knowledge to support decision making for vulnerability reduction and building resilience?*” to provide some empirical evidence for successes and failures in co-producing knowledge. The aim is to survey the knowledge base to identify gaps and bridges in the science-policy-practice interface (SPPI) and to support efforts for vulnerability reduction and building resilience. Analyzing the influence of vulnerability/resilience assessments requires a certain understanding of social-ecological systems, of the immediate activities taking place on local level (proximate causes), and of the underlying driving forces and fundamental societal processes (root causes). The same applies with regard to knowledge systems and the modes of knowledge transfer. Much about what makes some assessments more influential than others seems to be associated with the *process* by which they are developed, rather than just the *product* itself. According to a study on global environmental assessments (Mitchell et al. 2006), assessments are better conceptualized as social processes rather than published products. An assessment’s formal output—scientific article, report, model or forecast—is only one visible indicator of a larger social process. Thus, focusing exclusively on the content, framing, or components of an assessment can never fully discover the real source of its influence (or non-influence, respectively).

Ideally, the analysis of the influence of vulnerability assessments should take into account all determinants of this larger social process, ranging from vulnerability-determining factors to the assessment process and its impacts on disaster management practice. As illustrated in the conceptual framework elaborated (Fig. 2), an analysis of vulnerability assessments and their influence is a challenging endeavor, requiring a great amount of resources. However, this said, the author’s intention is neither to specify factors for conducting vulnerability analyses nor to critique nor to promote specific frameworks or methods. Rather, his premise is that analyzing case study results can bring some light to the clouded interpretation of barriers and bridges in the SPPI and thus support collaboration between scientists and practitioners in the field of disaster mitigation.

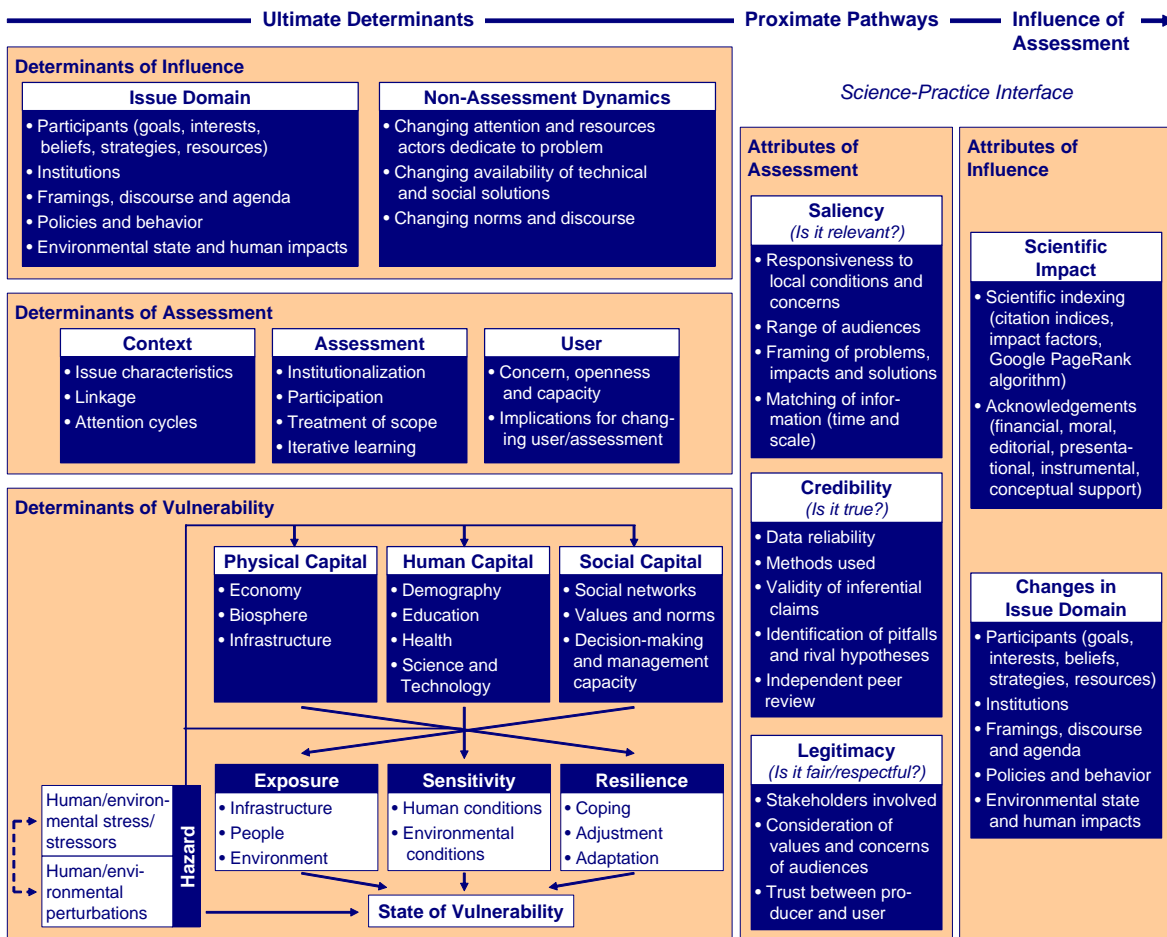


Fig. 2: Elements of a conceptual framework for analyzing the influence of vulnerability assessments (own graphic)

Given the availability of time and work force for the study, the work focuses on the identification of potential linkages between specific vulnerability and assessment determinants and failure and success in bridging the SPPI. The vulnerability framework developed by the Research and Assessment Systems for Sustainability Program (Turner et al. 2003) serves as a basis for the determinants of vulnerability. In determining factors of knowledge transfer and influence, the study builds on research undertaken by the Science, Environment and Development Group at Harvard University’s Center for International Development (Mitchell et al. 2006, see also: <http://www.ksg.harvard.edu/sed>). Of particular interest for this study

is the finding that saliency, credibility, and legitimacy are critical attributes of an assessment about which audiences make judgments, and which determine whether they will change their thoughts, decisions, and behavior.

Having outlined background and objectives, the next section gives a brief rationale concerning the data collection process. In section four, main characteristics and qualities of each case study analyzed are described. Results of the questionnaire survey are presented in section five. By cross-correlating different case study characteristics, patterns in vulnerability assessments that explain success and failures in knowledge transfer are discussed. Based on the case study publications and the empirical findings of the questionnaire survey, barriers and bridges in the disaster-related SPPI are examined in section six. The final section summarizes the findings and concludes with suggestions that may be usefully considered by those concerned with improving linkages between research-based knowledge and action to achieve—or, at least, move towards—reduction of natural disaster impacts.

Note that this study should be considered as preliminary and explanatory, certainly not as exhaustive and definitive. On the basis of a small sample, the investigation attempts to grasp how scientific assessments are carried out and to uncover what limits the co-production of knowledge. As a result of time constraints, both the literature review and questionnaire sample are restricted. A more comprehensive study would be needed to analyze and determine the full range and quality of linkages between specific vulnerability and assessment determinants and failure and success in bridging the science-practice interface.

3 Data Collection

3.1 Case Study Search

The overall goal of the study was to investigate the interface between the science developed in vulnerability/resilience assessments and the actions put into practice by those people in positions to implement that research-based knowledge in mitigating natural disasters. Consequently, assessment selection was made on breadth rather than on depth so as not to limit the study to a bias from a particular subset of assessments, whether by region, hazard type, or publication method. In-depth analyses of vulnerability studies are provided by the VARIP partnership team.

Most research results in the knowledge domains of vulnerability and resilience are published in journals. The *Hollis Catalog* of the Harvard University Libraries, *Google Scholar* and the *Social Science Citation Index* (SSCI) were used to identify published material for the meta-analysis. The latter is provided by the Institute of Scientific Information; the *Hollis Catalog* contains over nine million records for more than fifteen million publications in all kind of formats. Identification of literature was based on a keyword-based search across these databases. Keywords that were combined with vulnerability and resilience used to retrieve papers for the two knowledge domains included: natural hazard, hazards, assessment, assessing, evaluation, coping, response, case study, and disaster. Seminal papers that are referred to frequently by key scholars publishing on vulnerability and resilience complemented the keyword-based search.

The acquired dataset has a number of potential shortcomings that introduce bias for particular streams of research. Most significantly, the non-English literature is largely excluded due to the database and keywords used for the literature search. Since the database covers mostly journal papers, particular book chapters and reports might have been missed as they are not included in the SSCI. Moreover, the concepts of vulnerability and resilience have developed over time, and have been used in various ways. As a result, relevant documents are sometimes published in a “non-scientific” form and/or medium or for internal use only. Such documents were not retrieved, nor were ones that did not contain or use the keywords. Additionally, interesting and valuable studies were excluded because their assessment was carried out in locations where identification and contact of potential knowledge-users was considered difficult (e.g.,

extreme rural areas and regions with restricted information available in the Internet). The limitation of these factors was partly balanced by including certain documents in place of others to broaden the set of case studies.

A second issue was time constraints. Available time to conduct the study limited the sample size of case studies and the amount of knowledge-users included in the questionnaire survey. Knowing that a more comprehensive sample would have improved the quality and informational value of the study, the author believes that the dataset is usable to provide some empirical evidence on the characteristics of scientific assessments and their influence on decision makers and thus adds some value to the VARIP core project.

3.2 Case Study Selection

To provide scope to this research exploration, given the potentially huge database, a number of limiting decisions were made. Each document that was retrieved by keyword-based search was checked manually regarding its suitability for the study. Criteria for the initial selection were publication date, hazard type, and assessment mode and scale. The decision to include or exclude a paper was based on the information provided in the title, abstract, and date of the publication. A first selection was made by the date the document was published. Assuming that newer publications contain more valuable information for knowledge-users, priority was given to documents over the last eight years. This period allows the analysis of whether there are differences in influence between recently published papers and documents already published some years ago. A second criterion was that the paper refers to natural hazards. Studies that focused exclusively on ecological vulnerability or resilience (e.g., animals and plants) or on infrastructure (e.g., buildings and facilities) were excluded. For the remaining publications in the area of natural hazards, a third criterion was that a somewhat concrete assessment was carried out. This study focuses on the influence of research-based knowledge on practice, and this necessitates that the case studies examined have at least a pretense of specific or practical application. Thus, publications that were purely analytical or theoretical were not included. Fourth, it was expected that assessments on local and regional levels would provide more valuable information concerning the identification of successes and failures in the SPPI than national or global assessments. With the exception of Dennis Mileti's "Disaster by Design," national and global assessments were excluded.

The final selection was made to obtain a set of case studies with a broad range across geographic location, hazard type, and recognition of the publication. Recognition was measured by means of the *Social Science Citation Index* (SSCI) recording the number of times the given report is cited; wider public impact was evaluated by the number of *Google* hits each publication title earned. Using *Google* English, measurement took place between 19 and 21 May, 2006. Taking into account the time available for conducting the study, twenty case studies—seventeen journal articles, one report, one book chapter, and one book—were chosen for meeting the criteria of breadth, time and source of publication, and the potential for relevance to practitioners (Appendix A). Case studies were located in Africa, North America, South America, Asia, Europe, and Australia. For each publication, an analysis sheet was prepared in which information on the author(s), address, title, study location, hazard type, assessment scale, data used, actors involved, research funds, publisher information, SSCI and *Google* hits, main findings, suggestions given, causes of vulnerability/resilience identified, and—if mentioned—barriers and bridges in the SPPI was saved.

To evaluate the influence of the case studies, two questionnaires were designed: one for case study producers and one for potential users of the case study (Appendix C and D). Both questionnaires start with a question regarding the use of information sources and are followed by more specific questions concerning the assessment. The questionnaire for the case study authors is designed to ask questions regarding the research process, the intended audience, dissemination of findings, and the science-practice interface. The questions are followed by multiple choice answers in order to better quantify the responses,

but space is left for elaboration and comments, and several questions were open ended. The questionnaire for potential users includes questions about the usefulness, scope, and real or future impact of the case study publication. As with the producer questionnaire, questions are a combination of multiple choice and open ended questions, with an emphasis on probing into the underlying bases of response.

The authors of each case study were contacted and invited to participate in the study. After establishing contact, the questionnaires were emailed and the authors returned the questionnaires via email as well, with follow up occurring over the telephone or email. Almost exclusively, the case study producers contacted were eager to participate and readily responded with completed questionnaires. In total, sixty-four people authored the twenty case studies selected. Forty-seven authors were contacted and forty of them participated in the study (85.1 % response rate). The rest could not be contacted because authors had died or contact details could not be identified. One author was excluded due to his participation in the VARIP project.

Identifying and contacting potential users of each assessment was more difficult. A case study user was defined as a person in a position to put the ideas and knowledge in each report into practice, whether in the context of the government, a non-governmental organization, or a private company. It was not necessary that a potential user had heard of the report, as this would have severely limited the pool of practitioners. In fact, it was a central question of the study to see how wide the impact of a given assessment was and to determine whether there might be a problem of propagation of knowledge from one sphere to another. A few potential users were identified through the assessments themselves. For example, if a government institution was involved in funding or formulating a report, that institution could likely be considered a potential user. In most cases, however, users were identified by researching the region for which the study was performed and identifying key policy makers in areas of land management, natural hazard planning, emergency planning and response, and other areas specific to each assessment. For each assessment, a strong effort was made to identify a variety of potential users from different levels of government, non-governmental institutions, and other areas.

Once identified, potential users were contacted first by telephone, if the number was available. They were asked to participate in the study, and if they agreed, an email was sent with a cover letter containing details on the study, together with the relevant scientific publication and the questionnaire developed for potential users. When reached by telephone, most potential users were interested in the study and willing to participate. However, it was difficult to contact a significant number of potential users by telephone because their numbers could not be found, or because secretaries and answering machines put up an impassable blockade. In some cases, people did not receive the documents because of SPAM filters. Additionally, as users were located all around the globe, the time change was occasionally a (surmountable) obstacle. In two cases—the case studies in Vietnam and the Philippines (No. 1 and 17)—even with the support of the authors, only one user replied. Thus, the latter case was dismissed in the cross-correlation calculations.

After emailing the questionnaires, the response rate from potential users was disappointingly but not unexpectedly low (42.3 % response rate). Reminder emails and follow up telephone calls were sometimes performed up to ten times for a single potential user. In some cases, understandable delays occurred as potential users were caught up in dealing with current natural disasters in their part of the world. After much follow-up, fifty-two completed questionnaires were received. However, though expected, it is worth noting that those potential users who agreed to participate and followed through with reading the relevant assessment and filling out the questionnaire were those, for the most part, who were already the most interested in the intersection of science and practice, and usually were those for whom the identified assessment was the most relevant. In general, the more often a potential practitioner was used to dealing with scientific worlds, the more eager they were to participate in the study. In total, forty case study producers and fifty-two potential users participated in the survey (Appendix B).

4 Case Study Analysis

4.1 Characteristics of Publications

In total, twenty case studies were analyzed, which were authored by sixty-four people; forty-two of them are male and twenty-two are female (Table 1). The number of authors of a publication ranges from one to eleven authors. Seven publications are single-authored and thirteen are multi-authored. Among multi-authored publications, four have two authors, three have three authors, and the other six have more than four authors. Publication dates of the case studies range from 1998 to 2005 with one unpublished book chapter that would later be published in late 2006. This publication was excluded in the measurement of recognition. Regarding wider public impact as measured by the number of *Google* hits each publication earned, results range from no hits to 10,800 for Mileti's book. Concerning scientific recognition, SSCI varies from zero to sixty-four. On the basis of these two factors, publications were grouped in three recognition classes with four assessments in the highly-recognized group, six in the medium, and nine in the low-recognition class.

Case study assessments were carried out for locations in the following countries: Australia, Canada, East Caribbean Islands (including Antigua and Barbuda, Bahamas, Barbados, Dominica, Grenada, Jamaica, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, and Trinidad and Tobago), Egypt, Germany, India, Mexico, Pakistan, Peru, Philippines, USA, and Vietnam. With twelve case studies, North and South America are represented above average. Four assessments are made in Asia, followed by Oceania with two, and Africa and Europe with one each. Consequently, case studies in developed countries are slightly overweighted. Using the World Bank's country classification which is based on Gross National Income per capita in 2005, twelve case studies are in high-income countries, five in middle-income (both lower and upper middle), and three in low-income countries.

Regarding hazard type, twelve case studies refer to a single hazard and eight to multiple hazards. The following hazard sources are assessed: climate change (impacts include changes in varying rainfall regimes and soil moisture budgets, potential increases in the frequency and intensity of hurricanes, and changes in regional and local sea levels and patterns of wave action), earthquake, flash flood, flood, globalization (i.e., liberalization of agricultural trade and supporting policies), market fluctuation, sea level rise (impacts include inundation, erosion, saltwater intrusion, increased soil salinity, changes of coastal ecosystem, and loss of productivity), storm, storm surge, tsunami, and wildfire. Assessments with composite indices include the following additional hazard sources: chemical release, drought, hail, hurricane, snowstorms, temperature extremes, and tornado. Hence, landslide and volcano hazards are missing, resulting in an overweight of atmospheric hazards. Altogether, the case study sample includes fourteen local assessments (city, community, district level), five regional (state, province, county level), and one national assessment (USA).

Another characteristic analyzed is the assessment's capability to integrate multiple-scale, science-practice, and social-physical aspects. When grouped according to the degree of integration, four case studies are considered to highly integrate these factors (at least two out of the three factors), ten assessments did it partly (at least one and the others partly), and six case studies showed little integration (only one or less out of three). Sixteen out of the twenty publications acknowledge funding sources.

Table 1: Case study characteristics

No.	Date	Journal / Publisher	No. of Authors	Hazard Type	Location of Assessment	Country's Income Status	Scale of Assessment	Recognition of Assessment	Integration of Assessment
1	1999	World Development	1	Climate change, storm	Vietnam	Low	Local	High	Medium
2	2005	Mitigation and Adaptation Strategies for Global Change	2	Tropical cyclones, storm surges	Australia	High	Local	Medium	Low
3	1999	Disasters	2	Flood	Canada	High	Local	Medium	Low
4	2002	Environmental Hazards	2	Earthquake	USA	High	Local	Low	Low
5	1998	Mitigation and Adaptation Strategies for Global Change	10	Storm, flood	USA	High	Local	Medium	Medium
6	2005	Environmental Hazards	1	Fire	USA	High	Local	Low	Medium
7	2000	Annals of the Association of American Geographers	3	Multiple	USA	High	Regional	Medium	Medium
8	1999	Environmental Monitoring and Assessment	4	Sea level rise	Egypt	Medium	Local	Medium	Low
9	2004	Cities	1	Fire	Australia	High	Local	Low	Medium
10	2002	Natural Hazards Review	1	Earthquake	Peru	Medium	Regional	Low	Low
11	2004	Marine Policy	3	Sea level rise	East Caribbean Islands	Medium	Regional	Low	Medium
12	2003	Global Environmental Change	5	Climate change, market fluctuations	Mexico	Medium	Local	High	Medium
13	2003	Environmental Hazards	1	Flood	Pakistan	Low	Local	Low	Medium
14	2004	Global Environmental Change	11	Climate change, globalization	India	Low	Local	High	High
15	2002	Natural Hazards Review	1	Multiple	USA	High	Regional	Low	Medium
16	2004	Coastal Management	2	Earthquake, tsunami	USA	High	Local	Low	High
17	2002	Mitigation and Adaptation Strategies for Global Change	1	Flood	Philippines	Medium	Local	Low	Low
18	2003	German Committee for Disaster Reduction	9	Flood	Germany	High	Regional	Medium	High
19	1999	Joseph Henry Press	1	Multiple	USA	High	National	High	High
20	2006	Elsevier	3	Sea level rise, flood, surges	USA	High	Regional	N.A.	Medium

4.2 *Qualities of Vulnerability and Resilience*

The knowledge domains of vulnerability and resilience, by virtue of their character which brings together the physical environment, society, and the man-made infrastructure in a dynamic way, inevitably pose difficulties for discipline-based research, in general, and single-authored knowledge production, in particular. The case study review regarding causes, drivers, characteristics, and consequences of vulnerability documents that vulnerability is: (1) multidimensional (economic, social, political, institutional, cultural, spatial, temporal, historical dimensions, among other), (2) socially divergent (individually, between and among social groups), (3) dynamic (causes and conditions vary in time), (4) interactive (causes and parameters modify each other), and (5) scale dependent. In contrast, much of what is important about the character of vulnerability and resilience tends to be lost by the generalizing, decontextualizing, and reductionist tendencies of single-discipline research, single-hazard approaches, single-scale focus, and concentration on either social or physical aspects.

Single-disciplinary and single-author knowledge are, by necessity, reductionist in nature and capture only part of the causes, conditions, and impacts of vulnerability and resilience. Particularly in the risk-related

domain, the epistemological divide between engineering and the natural sciences, on one side, and the social sciences on the other side, obstructs a more comprehensive picture (Jasanoff 1993). Likewise, what interdisciplinary knowledge exists is often generalized rather than specific and decontextualized rather than locally embedded. Though often claiming to have universal applicability, single-disciplinary and single-author assessments still require exterior inputs from other disciplines in order to properly address the dynamic and multi-layered nature of vulnerability and resilience. Additional input is needed from non-research-based knowledge in order to tackle practical issues of suitability and feasibility of concrete vulnerability reduction and disaster mitigation measures.

Today, there is broad agreement that more integrative assessments are needed. However, less consensus exists on *what* needs to be integrated and *how* that integration should be accomplished. Suggestions range from the integration of scope, research methods, and scale to disciplines and stakeholder involvement. In recent years, two interrelated trends of integration have received particular attention: first, an increasing interest in structuring assessments to better integrate science and practice. And second, an increasing effort to identify, assess, and integrate social and geophysical linkages across multiple scales. As a result of the before-mentioned characteristics, an adequate assessment requires integration across all these dimensions of vulnerability and resilience, respectively. Although convincing arguments for the importance of scale in global change research exist (Wilbanks and Kates 1999), only a fifth of the case studies analyzed attempt to integrate practical elements and consider socioeconomic and geophysical aspects across spatial scales.

Existing or potentially vulnerable populations are often institutionally and economically invisible, but their participation in vulnerability assessments is crucial if these assessments are to be useful for decision makers. Although an increasing number of vulnerability assessments aim to be explicitly stakeholder driven, however, the subject of social vulnerability, i.e., vulnerable populations, is rather a study object that is assessed than an equal stakeholder that is integrated in the knowledge production process. Interestingly, for the case study that thoroughly integrated the people into the assessment (interviews, participant observation, and group discussions to assess the differential impacts of floods among the street children, the urban poor, and residents of wealthy neighborhoods in Metro Manila) none of the contacted users returned a filled-in questionnaire.

Another feature of vulnerability and resilience is the lack of a universal definition: “Since different intellectual traditions use the terms in different, sometimes incompatible, ways, they emerge as strongly related but unclear in the precise nature of their relationships” (Gallopín 2006: 293). If care is not used, the author concludes, the field of human dimensions research can become epistemologically very messy. The case study analysis supports this concern. All assessments operate with their own characterization of key terms. While the individual use of the vulnerability and resilience concepts is scientifically problematic, it is not clear whether or not the absence of common definitions poses an obstacle for decision makers to apply the concepts. On the contrary, a diversity of definitions and approaches might be even necessary in order to address the full complexity of the vulnerability and resilience concepts. However, universal standards would certainly facilitate and support the practical application.

5 Questionnaire Survey

5.1 Knowledge-producers

Almost half of the authors (47.5 %) formulated their research questions for the assessment without input from internal or external colleagues. Out of those researchers who included other people in the design of the research, more than three-quarters (76.2 %) consulted internal and external colleagues. The remaining 23.8 % integrated only internal ones. Regarding frequently used sources for obtaining information, almost all assessment producers regularly use scientific sources (92.5 %), followed by governmental (57.5 %)

and non-governmental sources (42.5 %). About a third of the producers frequently draw on internal information sources, personal communication, and the media. With regard to rarely or never used information sources, the media ranks top (35 %) followed by communication (27.5 %) and internal sources (25 %). When asked about the most influential and critical information sources for the assessment, half of the producers refer to surveys, fieldwork and communication, 47.5 % to statistics, census and maps, and 45 % to scientific literature. Only about a tenth of the producers consider modeling and non-scientific resources as relevant.

For two-thirds of the producers, policy makers and practitioners were the intended audience for the assessment. More than the half (57.5 %) considered science as the primary audience and only a quarter regarded non-governmental, public and private organizations as potential users for their assessment. If the purpose of the assessment would have been an action plan for practitioner use, 35 % of the producers would have changed their assessment to include the application of theory and clear recommendations. A quarter would make changes regarding data and method and 22.5 % would change the focus, audience and/or the medium. Only 17.5 % consider the involvement of stakeholders and 10 % the alteration of style as a way to increase the practical use of the assessment. 12.5 % of the assessment producers would not make any changes.

Almost two-thirds (62.5 %) of the producers said that the research was disseminated in form of a report, 50 % mentioned scientific papers, and 40 % disseminated it through symposia and meetings. Only 20 % used the media, Internet, public material, and lectures to disseminate their study. When asked for their opinion whether the assessment addresses the needs of users or not, 37.5 % of the producers answered “No” and 62.5 % “Yes.” Altogether, half of the responders think that the assessment is relevant for decision makers in local governments. Almost the same amount (47.5 %) considers the assessment as relevant for agencies and practitioners. Only 17.5 % and 12.5 % of the producers, respectively, have the opinion that their assessment is relevant for science and the general public, private sector, media, or NGOs.

Regarding the influence of the study, 45 % of the producers are not aware of any impact whereas 55 % believe that it caused changes. Out of those who are aware of impacts, more than two-thirds (77.3 %) affirm that it caused behavioral changes (i.e., concrete actions were taken as a result of the study, such as new laws), and for 36.4 % the study caused changes of the attitude (i.e., awareness and belief). Almost one-third (31.8 %) are aware of impacts on science and 22.7 % thought that their study caused procedural changes (i.e., methodology and processes were altered). Almost half of the producers (47.5 %) believe that their study had impact on science but not on practice. More than a third (35 %) consider their study to influence the reader’s belief and thus will have impact in the future. 27.5 % believe that it has only limited impact on both science and practice and 7.5 % are not able to evaluate the influence.

With regard to conflicts among actors and institutions in the science-practice interface, almost half (47.5 %) of assessment producers has the opinion that differences in objectives, needs, scope, and priorities are the main sources of conflict. For 32.5 % of producers, divergent institutional settings and standards are causes for inadequate interactions; for 27.5 %, differences in language, a lack of understanding, and mistrust are responsible. One-fifth sees no conflicts or other conflicts that cannot be classified into a specific group. When asked how knowledge transfer at the SPPI could be improved, more than half (57.5 %) responded that the best way would be through more collaboration, trust, and/or outreach. 15 % of the producers noted that efforts in training, education, and/or language could enhance knowledge transfer; 12.5 % pointed out that some kind of “brokers” or intermediary bodies could lead to improvements. Only 7.5 % proposed reward application as a possible means to facilitate knowledge transfer between science and practice.

5.2 *Knowledge-users*

Governmental (71.2 %) and internal sources (65.4 %) are the most frequently used information sources for the knowledge users interviewed. While almost all assessment producers regularly use scientific sources (92.5 %), only half of the decision makers in policy and practice do so. With regard to rarely or never used information sources, the media ranks top (32.7 %) followed by non-governmental sources (19.2 %) and scientific sources (17.3 %). When asked about the most influential and critical information sources for their work, half of the potential users responded that media and governmental sources are most important, followed by non-scientific literature (42.3 %) and scientific sources (38.5 %). Unsurprisingly, the Internet (7.8 %) and field work and surveys (19.2 %) are the least influential information sources for decision makers.

Regarding awareness, over half (51.9 %) of the potential users did not know at all about the specific assessment about which we contacted them. A few had heard that something was going on (9.5 %); 13.5 % knew about the assessment but did not know the assessment report, and 5.8 % knew the report but hadn't read it. Only 13.5 % were aware of both assessment and report and even less (5.8 %) were involved in the assessment. When asked about the influence of the assessment report, many users replied that they did or will talk about it within their organization (69.2 %), that they did or will consider the findings in the future (48.1 %), and that they did or will use the report to convince other people (42.3 %), respectively. About a quarter answered that the assessment will influence their beliefs (26.9 %). Almost the same number of users replied that the report's findings did not or will not influence their actions (25 %).

With regard to the relevance of the assessment, almost half of the users (46.2 %) stated that the report addresses some of their needs. For one-tenth the report is not relevant at all, nearly one-quarter (23.1 %) mentioned that it doesn't address their needs but they see the strength of it. Almost one-third (32.7 %) consider the assessment's findings as relevant, compared to only 1.9 % who did not. 44 % of the users who answered the question "What should the assessment have addressed to be more relevant and useful?" stated that changes in scope (different, broader, and/or more specific) would improve the saliency of the assessment, followed by 32 % who suggested clearer and/or better recommendations.

In contrast, both the perceived credibility and legitimacy of the assessments are very high. 78.8 % of the potential users consider the assessments as accurate and technically sound (compared to 21.2 % who do not), and 82.7 % believe that they are respectful of stakeholders and unbiased (compared to 17.3 % who do not). Main reasons for considering an assessment as not credible are missing or ignoring certain aspects of the issue (36.4 %), a somehow too qualitative and/or theoretical approach, and a weak method and/or insufficient data (both 27.3 %). According to the potential users interviewed, credibility of those assessments can be improved by in-area research and/or applying it to a different location (35 %), by improving data, information sources, and methodology (25 %), and by involving stakeholders and a better linkage to actions (10 %). Reasons for a perceived lack in legitimacy of the assessment are excluded stakeholders and a biased view ignoring certain aspects (both 44 %). Consequently, 57.1 % of the users recommended improving data and/or information sources, followed by integrating stakeholders and local knowledge (28.6 %). For some users an integration of governmental policy and a better understanding of the "real world" would improve the legitimacy of assessments (14.3 %).

5.3 *Characteristics and Correlations*

The followings section points to some observations that come into view when grouping the received questionnaires into specific classes. In particular, cross-covariance between factors illuminates some interesting patterns in the SPPI of vulnerability and resilience. For instance, by grouping the answers from assessment producers by gender and number of authors, some characteristics attract attention. For

instance, single-authored publications mainly draw on scientific literature (71.4 % compared to 39.4 % of multi-authored publications) and use significantly less data (14.3 % compared to 54.5 % of multi-authored publications) and models as information sources. Moreover, the regular use of non-governmental information sources is three times higher for authors of multi-authored assessments than for single-authored ones. The latter also disseminated their findings to a higher degree only through the publication analyzed (28.6 % compared to 3 % of multi-authored publications).

When asked if they are aware of any impacts of the assessments, 71.4 % of the authors of single-authored papers (compared to 39.4 % of authors of multi-authored publications) said that they are not aware of impacts. Nevertheless, 100 % of those who are aware of impacts believe that the assessment caused behavioral changes. In contrast, 60.6 % of the authors of multi-authored publications are aware of impacts and only one-fourth of them believe that they caused behavioral changes. 42.9 % of the authors of individual papers evaluate the influence of their assessment as limited both on science and practice, and only 14.3 % of them believe that it had impact on science but not on practice. Only one-fourth of the authors of jointly written publications evaluated the influence of their assessment as limited, but more than half (54.5 %) believe that it influenced science but not practice.

No significant differences exist between male and female authors. Divergence can be only observed regarding the conflicts between science and practice, as well as with regard to suggestions to improve them. Only 36 % of the male authors but 66.7 % of the female see existing conflicts in divergent objectives, needs, scope, and priorities between scientists and practitioners. When asked how the knowledge transfer between the two arenas can be improved, both male and female authors mostly suggested through collaboration, trust, and outreach. However, male authors mentioned a variety of improvement measures, ranging from more application of science, better training, and education to reward application and the use of intermediary bodies. Interestingly, female authors do not consider the application of science and rewards as possible options to improve the science-practice interface.

Considerable differences are also visible when grouping the case studies according to their recognition. In particular, the amount of people involved in formulating the research questions seems to have various correlations. The number of cases in which only the author(s) prepared the research is significantly higher for low-recognized publications (77.8 % as compared to 54.5 % for highly recognized publications), for assessments with little integration (66.7 % compared to 46.7 % for highly integrated assessments), and for countries with a low-income status (77.8 % compared to 33.3 % for developed countries). It is assumed that the involvement of external people leads to more integrated assessments, resulting in a higher recognition. Authors in developing countries seem to have more difficulties in incorporating other scientists and stakeholders into their research.

Less surprising is the finding that authors of highly recognized (72.2 %) and single-authored (85.7 %) publications largely regard scientists as their main audience. Great divergence, however, exists regarding the question of whether or not the assessment addresses the need of users. While 45.5 % of the authors of highly recognized documents believe that their assessment is relevant for science, none of the authors of poorly recognized publications believe so. On the other hand, 77.8 % of the latter consider their assessment as relevant for agencies and practitioners, compared to only 9.1 % of the authors of well-recognized publications.

These findings lead to the conclusion that the producers of highly recognized case studies estimate the assessment's scientific quality and relevance somehow appropriate, whereas single authors tend to overestimate the relevance. Only 14.3 % believe that the assessment is not relevant (as compared to 42.4 % of multi-authored assessments), and 85.7 % of those who believe that it is relevant consider agencies and practitioners as the most important users (as compared to 39.4 % of multi-authored assessments). This is supported by the fact that authors of highly integrated assessments consider different

audiences as potential users for their findings, whereas most of the authors of poorly integrated studies believe that their assessment addresses the need of agencies and practitioners (77.8 %) and local governments (88.9 %). None of them thought that it addresses the need of science, the public, nor the private sector.

Authors of publications that are highly recognized use statistical, graphical, and census data to a higher degree (63.6 %) than the average (47.5 %). No huge differences exist regarding the use of information sources, although authors of well-known papers use media sources less often than their colleagues of lowly recognized case studies. Divergent opinions are visible when asked for changes to improve the practical use of the publication. Almost half of the authors of highly recognized studies would change the method and/or data basis, but only one-tenth of the authors of less-known publications would make such changes. In contrast, the latter would improve their case studies mostly through the application of theory and clear recommendations (44.4 % compared to 27.3 %). Moreover, these authors disseminated their findings significantly less often by means of reports than authors of well-known case studies (44.4 % compared to 81.8 %).

Another difference exists when asked how the authors evaluate the influence of their publication. Most of the authors of well-recognized case studies (81.8 %) answered that it had impact on science, but not on practice; only 9.1 % believe that it had only limited impact on both science and practice. Almost half of the authors of less-recognized publications, in contrast, claimed influence on both science and practice. Furthermore, only 22.2 % of them have the opinion that their assessment had scientific impact, but no impact on practice. Between both groups no significant differences exist regarding conflicts and improvements of knowledge transfer at the science-practice interface.

By asking the question *“Is the assessment structured in a way to integrate science and practice, social and geophysical factors, and multiple scales?”*, case studies were grouped according to their capability of integration into three classes: high, medium, low. Concerning this characteristic, it was already mentioned that authors of hardly integrated assessments mostly formulated their research questions without input from internal or external people. When asked about the intended audience for the assessment, a surprisingly high amount of authors of both highly and poorly integrated assessments named policy makers and practitioners as their primary target group (80 % and 78.8 %, respectively). While highly integrated assessments are doubtlessly of high relevance for policy and practice, one possible explanation for the high response of poorly integrative case studies might be the fact that such assessments are very place and case-specific and thus, local decision makers are considered to be the primary users.

Moreover, authors of assessments with a high degree of integration use a variety of information sources, whereas less integrated assessments use primarily one specific source. The highest discrepancy exists regarding the regular use of governmental information sources: 60 % of the former authors but only 22.2 % of the latter use them regularly. For more than half of the authors of highly integrated assessments conflicts at the science practice interface are due to different objectives, needs, scope, and priorities as well as institutional settings and standards. In contrast, authors of less integrated assessments hardly cite these factors, but rather point mainly to differences in understanding, language, and mistrust. Another apparent divergence was already mentioned earlier. Concerning the assessment’s utility for users, almost all authors of poorly integrated assessments believe that their study addresses the need of agencies, practitioners, and local governments. No single author considered it as practical for science and the public and private sector.

As regards to single and multi-hazard assessments, no surprising differences between both groups are apparent. Authors of multiple hazard assessments use governmental information sources more regularly and media sources more rarely than authors of single-hazard assessments. Not astonishing is also the fact that the latter would make fewer changes in data and methods used in order to make their study more

usable for practitioners than their colleagues of multi-hazard assessments. Evidently, for single-hazard assessments data is more accessible and well-established methods are more frequently in use. However, more authors of multi-hazard assessments disseminated their findings through reports, media, and the Internet. Moreover, they considered to a lesser degree agencies and practitioners as primary users for their study than authors of single-hazard assessments. On the other hand, only 16.7 % of the latter are aware of rational or attitudinal changes their assessment caused, compared to 60 % of the authors of multi-hazard assessment. Considering the fact that single-hazard assessments are quite common today, this finding is also not surprising.

When comparing assessments in developing countries with those undertaken in developed countries, the number of cases in which only the author(s) prepared the research is significantly higher for assessments in countries with a low income status (77.8 % compared to 33.3 %). Authors of assessments undertaken in developing countries more often use internal information sources (66.7 % as compared to 42.9 % and 25 % of countries with middle and high income status) as well as surveys and fieldwork as suppliers of information (77.8 % as compared to 28.6 % and 45.8 % of countries with middle and high income status). Moreover, they don't disseminate their findings in the form of public material, offprint, and lectures (0.0 % as compared to 28.6 % and 25 % of countries with middle and high income status). Explanations could be the limited availability of or access to (public) data and less financial resources to produce public and offprint material. The fact that these authors would primarily make changes in data and method in order to improve the practical use of their study supports this assumption. Given that some of the authors of an assessment undertaken in a developing country are from developed countries, the differences mentioned would be even more significant when considering only authors from developing countries.

Interesting is the finding that one-third of the authors of case studies in low-income countries who believe that their assessment addresses the need of users think that their publication addresses the need of science, but to a lesser degree the need of agencies, practitioners, and local governments. In contrast, only 12.5 % of the authors of publications with assessments in developed countries consider that their study addresses the need of science. The majority holds the view that it is practical for local governments (58.3 %) and agencies and practitioners (66.7 %). When looking at the impacts of the assessment, no author of case studies in developing countries is aware of procedural changes as a consequence of the assessment (compared to 35.7 % of authors of case studies in developed countries), but 60 % are aware of rational changes in awareness (compared to 21.4 %). Moreover, a vast majority of authors believes that the assessments influenced science and not practice (77.8 % compared to 37.5 %). Also interesting is the fact that one-third suggests intermediary bodies and brokers to improve knowledge transfer at the science-practice interface, whereas only 4.2 % of the authors of case studies in developed countries do so.

When grouping the answers of case study producers according to the date of the publication, only a few differences are significant. While the authors' ranking of regularly used information sources is the same, the use of non-scientific information sources generally increased. Authors of "newer" publications frequently use more internal, governmental, and especially non-governmental sources for their work. They also consider to a higher degree scientific literature and data as most influential and critical for scientific assessments and disseminate their findings more often through reports as compared to authors of "older" publications. Not surprisingly, the latter are more aware of scientific impacts their assessment caused, whereas authors of recently published case studies are more aware of changes in perception due to their research.

Interesting observations come also into view when grouping the questionnaires from knowledge-users into specific classes. For instance, there are differences in the use of information sources with respect to the gender of the potential user. Male decision makers to a higher degree frequently use internal sources (70.7 % as compared to 45.5 % of female users) and scientific sources (53.7 % compared to 36.4 %). In contrast, female users in policy and practice frequently use governmental information sources (81.8 % as

compared to 68.3 % of male users), personal communication (81.8 % as compared to 39 %), media sources (72.6 % as compared to 36.6 %), and non-governmental sources (54.5 % as compared to 29.3 %). In general, some male users don't use specific information sources at all, whereas as female users mostly use the existing variety of sources. Consequently, slight differences exist regarding the information considered to be most important. While 41.5 % of the male decision makers affirmed that scientific sources are most critical to their work, only 27.3 % of the female users did. Moreover, 73.2 % of the men stated that they did or will talk about the assessment within their organization (compared to 54.5 % of the women), but only 36.6 % said that they did or will use the report for their work or to refer to it to convince other people (compared to 63.6 % of female users). A slightly higher number of women consider the findings of the assessments as relevant (45.5 % as compared to 29.3 % of male users). More interesting is the fact that significant gender differences exist concerning the credibility of assessments. 66.7 % of female users did not believe in assessments' findings because of weak methodology and/or insufficient data (compared to 0 % of the men), whereas for 42.9 % of the male users the use of too qualitative and/or theoretical approaches were the main reason for a lack of trust in the assessments (compared to only 14.3 % of the women who listed the same reason).

Likewise, divergent views exist between decision makers working in the domain of disaster management (e.g., emergency planning, fire department) and those whose work is not primarily disaster-related (e.g., development planning, health, city council). For example, the former use internal information sources to a lesser degree (54.8 % compared to 81 %) and consider scientific information as more critical to their work (45.2 % as compared to 28.6 %) than decision makers in the non-disaster domain. It also seems that the assessments are more influential to users in the disaster arena. When asked about the influence the assessment did or will have, decision makers working in disaster-related policy and practice affirmed to a higher degree each level of influence, ranging from "talking about" to "influencing my beliefs" and "consider the finding in the future." The assumption is underlined by the fact that almost half (48.4 %) of the users who work is related to disaster management issues consider the assessment's finding as relevant as compared to only 9.5 % of decision makers working in the non-disaster arena. On the contrary, the assessments address to a larger extent the needs of the users not working on disaster management (66.7 % as compared to 32.3 %).

Interesting also are the different views regarding credibility and legitimacy. Although both user groups consider the assessments generally as true and legitimate, divergent opinions exist with regard to reasons of not considering the assessment as true and legitimate and the recommendations to increase both factors. Decision makers in disaster policy consider an assessment as having low credibility if certain aspects were ignored or missed (60 % as compared to 20 % of decision makers in the non-disaster field), and suggest to a higher degree to improve credibility by providing clear recommendations (18.2 % as compared to 0 %). On the other hand, users in the non-disaster arena state more often that the assessment's credibility would be higher if the authors would have chosen more in-area research and/or a different location. Differences with regard to legitimacy are even higher. While for 80 % of the disaster-related decision makers the exclusion of stakeholders is the reason for considering an assessment as illegitimate (compared to 0 % of the users in the non-disaster arena), the use of weak theory, methodology, and recommendations is the main cause cited by those decision makers who are not working directly in disaster management (compared to 0 % of the users in the disaster arena).

Little surprising is the finding that in developing countries twice as many decision makers consider scientific information as most critical to their work and use slightly more often the government and the media as information sources than the users from developed countries. Moreover, decision makers were to a lower degree aware of both the assessment and report: 71.4 % were not aware at all (as compared to 51.4 % of users in developed countries); none of the users in the developing countries read the report before nor was involved in the assessment (in developed countries, 16.2 % of the users read the report and 8.1 % were involved). More interesting is the fact that almost the same number of users from developed

countries state that the assessment did or will influence their beliefs (29.7 %) and will not influence their actions (35.1 %), respectively, but none of the users from developing countries marked these statements. They almost exclusively answered that they will talk about the assessment within their organization (71.4 %) and will use it for their work and refer to it to convince other people (57.1 %). Furthermore, differences exist when an assessment is considered to be not salient. While 42.1 % of the users from developed countries suggest clearer recommendations to improve the saliency of the report, none of the users from developing countries do so. In contrast, half of them suggest the use of “better” methodologies, which none of the users from middle-income countries and only 5.3 % from high-income countries recommend. Also when considering legitimacy, it seems that decision makers in developed countries are more concerned about stakeholder involvement than their colleagues in developing countries.

When grouping the answers of case study users according to the recognition of the assessment report, it becomes evident that highly recognized papers have not only a higher scientific impact (as measured by the SSCI) but are also more influential. 22.2 % of the potential users of well-recognized documents were not aware of the report and assessment, as compared to 60.9 % of users of little-known papers. One-third of the former knew both the report and assessment before they had been contacted, but only 8.7 % of the potential users of lowly recognized papers knew about it. Moreover, all of the users of highly recognized case studies affirmed that they will talk about the assessment’s findings within their organization, compared to “only” 60.9 % of the decision makers that evaluated less recognized reports. Likewise, users of highly integrated assessments stated to a higher degree that they will talk about it within their organization. However, these assessments did or will not influence the actions for almost half of the potential users (42.9 %). Only 13 % and 26.7 % of the users of middle and lowly integrated assessments testified that the assessments will have no influence on their behavior. Interestingly, when asked about saliency, also 42.9 % of the users confirmed that the findings of the well-integrated assessments are relevant (compared to only one-fourth for hardly integrated assessments) and no user stated that the assessment does not address needs (compared to 20 %).

Of particular interest is the saliency of an assessment. When asked “Does the assessment report address your needs?,” middle recognized assessments received the highest amount of “No, not all” answers, followed by low integrated and single-hazard assessments. The highest amount of “Yes and the findings are relevant” answers given by decision makers were received by highly recognized and highly integrated papers. More surprising, however, is the fact that the findings of single-authored papers are considered as more relevant than multiple-authored ones. Similarly, the findings of single-hazard assessments are considered as slightly more relevant than the ones of multiple-hazard assessments. A possible explanation is that most of the single-authored papers refer to a single-hazard assessment carried out for a specific local area, resulting in clearer recommendations for the potential decision makers and thus in a higher saliency (taking into account that Mileti’s book is edited by a single author but the assessment involved many authors). Less significant is the publication date, although users were slightly less aware of more recently published assessments (60 % not aware at all) than they were concerning older reports (46.9 %). This is another indicator that knowledge is transferred via the pipeline model.

Interesting findings also appear when we cross-covariance the answers of producers and users with regard to the same assessment. For instance, assessments that—according to the answers of potential users given in the questionnaire—did not or will not influence the actions of the decision makers were in many cases not very well integrated assessments. Moreover, the authors of such assessments estimated the influence of their report quite properly. Most knowledge-producers affirmed that their assessment does not address the need of users and did or will have—at maximum—impact on science but not on practice. On the other hand, authors of well-recognized and highly integrated assessments were correctly pessimistic about the influence of their assessments on practice. Knowing that their report is scientifically highly recognized, they mostly estimated properly the limited influence on practical decision making. This leads to the assumption that the case study producers are fairly acquainted with the needs of decision makers in policy

and practice. Hence, knowledge-producers can estimate more or less accurately the influence of their scientific work and are well aware of the limiting factors that prevent a higher impact on policy and practice. Moreover, there is a significant relationship between the user's view on credibility and legitimacy. If a potential decision maker considered an assessment not credible, in most cases the same user also regarded it as not legitimate. A negative credibility and legitimacy, however, does not necessarily lead to a low saliency and vice versa.

6 Conclusion

6.1 Barriers and Bridges

What are factors that hinder the co-production and transfer of knowledge across the boundaries of science, policy, and practice? Generally speaking, many factors that aggravate greater coherence among and between these arenas are attributed to the “socially-absent” character of most natural hazards, the “structural” character of both academic and public organizations, and the “public good” character of natural disaster management (Weichselgartner and Obersteiner 2002). Considered more precisely, a huge variety of influential factors exist, comprising such diverse aspects as different needs and objectives, institutional reward systems and incentives for collaboration, language and cultural differences, and divergent standards of credibility and legitimacy. Such barriers contribute to and result in failures that typically occur when knowledge is transferred through the traditional pipeline mode in which scientists set the research agenda, do the research, and then transfer the results to potential users, assuming that they diffuse automatically through the practice community (Fig. 3).

A first group of factors is of functional nature, such as divergent objectives, needs, scope, and priorities. Responders of the questionnaire survey pointed out that many practical problems are not relevant for or not known to scientists. As one producer pointed out, researchers “often work on some sort of obscure, trivial issue that doesn't impact practical decision making.” In other words, researchers do not necessarily pick research questions that make a difference in the lives of those studied and then take action to implement those research findings. On the contrary, scientific research grants increasingly encourage huge research teams working on extensive, multi-faceted questions that don't translate well to practitioners. Moreover, practical disaster risk assessment is often limited by the available data or the budget for data collection. In contrast, scientific research frequently focuses on methodologies that may not be accurate in the absence of detailed and accurate input data. While science is based on facts, decision making—especially in traditional risk management—is more cost-benefit-oriented, determined by risk-benefit analyses, and often ends up in the domain of finance departments. However, the benefits of mitigation—in the best case the absence of disasters—are hardly measurable in monetary terms. A well-known but still apparent drawback is the fact that both scientists and practitioners often ignore the interrelations between the physical environment, society, and man-made environment when considering natural hazards. As a result, hazard protection is a socially isolated activity and disaster response an event-focused reaction—both highly professionalized but seldom viewed as an integral part of a larger development context (Weichselgartner 2003).

A second group is social factors, such as cultural values, communication, understanding, and mistrust. Scientists are often unable to tolerate the impreciseness of the “big picture” whereas “broad-brush” but with specific recommendations is often more useful to practitioners. As a result, scientists propose solutions that are often unworkable in practice, often due to a poor understanding of the institutional and other constraints to implementing changes in practice. It seems to be important to determine how decision makers can or will use the provided information to develop mitigation programs and measures. This requires an understanding of the socioeconomic and political-administrative context of the hazard planning process, as past studies have shown that scientific information can play no role in such planning processes. On the other hand, community boundaries are based on political-administrative areas for politi-

cally decision-making processes and administrative convenience. Traditionally, emergency managers consider a community to comprise a group of people that share the same geographically defined area, with the underlying assumption being that the group is relatively homogenous and socially cohesive. In reality, the occupants of a spatially defined area are rarely homogeneous but likely belong to a mosaic of communities that are inter-related and overlapping. Consequently, effective emergency management requires that decision makers understand and respond to the diversity of communities.

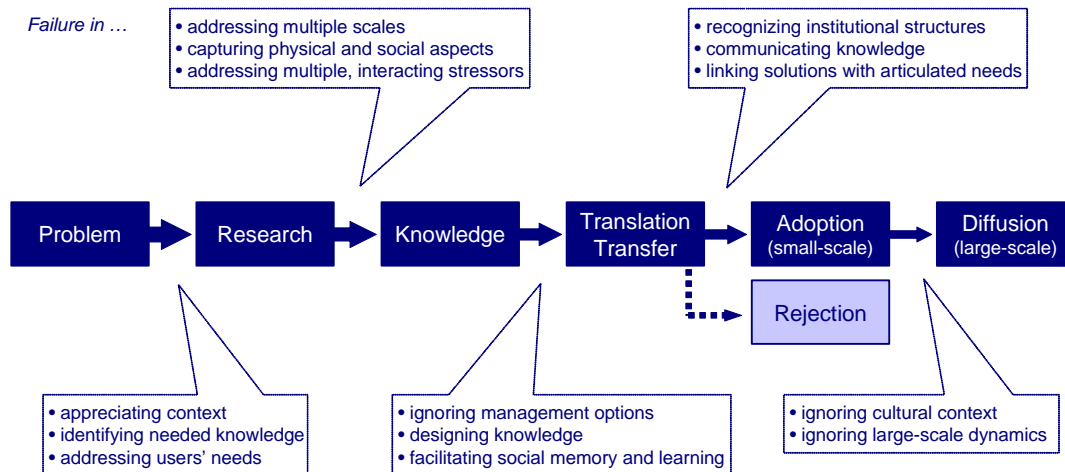


Fig. 3: Pipeline knowledge transfer and common failures (own graphic)

Moreover, theoretical and conceptual research-based findings are rarely directly usable by policy makers and practitioners, and the language of science is often too complex and intimidating for many practitioners and policy makers. As a result, authorities and scientists mostly interact at the level of data transfer but seldom at the level of equal partners that develop things together. Perhaps the scientific community will need to define the current and increasing risks more clearly, convey them in unison and hence, more forcefully, without shying away from pointing out the inherent uncertainties. In particular, risk-related communication between science and its varied audiences is all too often structured on a “deficit model” that assumes that the public simply does not know enough and that information flow should therefore be unidirectional, from knowledgeable experts to the ill-informed public. Mistrust plays an important role in disaster response, and the military-style command-and-control response is especially problematic.

Third, structural factors, such as different institutional settings and standards, clearly restrict the co-production and transfer of knowledge across boundaries. Scientists and researchers have other timeframes and deadlines than decision makers in policy and practice. Scientists involved in policymaking are constrained by political structure and agendas. Likewise, practitioners involved in scientific activities need to follow scientific standards. In contrast, scientists often do not take the time to fully explain how certain methods were conducted. Articles are written for those who already have a strong background on and expertise in the topic and not for practitioners who have the desire to implement scientific ideas and findings. An important barrier is the reward system for scientists, which is based largely on products for the academic arena. Researchers are rewarded for scientific publications, with little acknowledgement for their work on brochures, reports, and wider dissemination. Or to plagiarize one assessment producer: “we are rewarded for writing to our peers and not to the communities that need us.” However, numerous development planners, disaster managers, and emergency responders do not read the majority of academic journals. Decision makers need specific conclusions and clear recommendations that they can

act upon, rather than conceptual and theoretical arguments about frameworks and the terminology of disaster management.

6.2 *Discussion*

By analyzing solely the knowledge products (i.e. scientific publications), the coverage of the knowledge systems in the domains of vulnerability and resilience is necessarily incomplete. According to findings from the Knowledge Systems for Sustainable Development Project (2005), knowledge systems are more usefully conceptualized from an actor- and institution-focus than from the conventional information-focus. In addition to the shortcomings of the acquired dataset, availability of time and work force limited the sample size of case studies and the amount of knowledge-users included in the questionnaire survey. Hence, the study should be considered as non-exhaustive and explanatory.

Despite these limitations, focusing on generic assessment-related matters identified a number of linkages between specific vulnerability and assessment determinants as well as failures and barriers—functional, structural, and social—that inhibit the co-production of used and applied knowledge. It is the quality of these relations that determines the grade of influence of research-based knowledge on action. Hence, the internal relationships of a knowledge-action system can be better understood as arenas of shared responsibility, embedded within larger systems of power and knowledge that evolve and change over time. Arguing in a similar way, Kerkhoff and Lebel (2006) recently provided valuable suggestions on reconfiguring those relationships by adopting a notion of research-action arenas.

The findings of both the case study review and questionnaire survey indicate that divergent institutional settings and standards clearly restrict a cross-border co-production of knowledge. Unsurprisingly, decision makers do not always use the most appropriate available scientific information to influence policy decisions and, likewise, scientists do not primarily consider the needs of decision makers when conducting research. Differences in approach and method in vulnerability and resilience research can be attributed to the central questions of interest, the disciplinary composition and history of the knowledge production team, and the intended users. Difficulties exist in integrating disciplinary perspectives within the research team as well as between the scientists and the various types of local decision makers. According to this study, scientific assessments which have been designed in “academic isolation” have significantly lower impact than assessments designed with input from internal and external people.

Influential scientific assessments cause changes in issue domains, defined as arenas in which interested actors seek to address an issue of common concern about which they have different beliefs and policy preferences (Clark et al. 2006: 11). It is assumed that adjusting academic standards and settings to more resolution-exploring and problem-solving structures would facilitate behavioral changes, and not just rational ones. Furthermore, faster and more effective transmission of existing and new knowledge to policy and decision makers, as well as better communication of this knowledge to the public can accelerate processes of change. Assuming that both formal and informal institutional settings constrain social learning and change, existing rules, laws, customs, norms, and particularly reward systems for career advancement become focal points of triggering potential change. On individual level, academic researchers need to strike a balance between pushing theoretical boundaries and generating information for practical use.

As a consequence of social barriers of understanding, language, and trust, differences arise from ambiguities in framing problems and in the diverse ways in which the nature of problems are perceived. Divergent views exist regarding the perceptions of the problem character, the need for action, and the type and priority of actions that should be taken. Moreover, differences result from uncertainties in the factual knowledge base of vulnerability and resilience. Since individual and collective cognitive processes have a strong tendency to maintain internal coherence and resist change, boundary work is a feasible way to

encourage successful dialogue and resolve conflicts between scientists and practitioners. Based on communication, translation, and mediation, intermediary bodies can play an important role in the co-production of disaster-relevant knowledge, especially in developing countries in which formal networks that provide bi-directional links across scales tend to be less dense and stable.

Assessments vary in the type of influence they have, ranging from no impact to attitudinal changes (“it will influence my beliefs”) and behavioral changes (“I will consider the findings in the future”). Moreover, the influence of the same assessment varies across potential users. However, there seems to be a relationship between credibility and legitimacy. Users who considered assessments as untrue also, for the most part, considered them as unfair. While publication date and gender are not influential factors with regard to knowledge production, both factors are more influential concerning the potential use of knowledge. Differences exist between male and female decision makers regarding the use of information sources, the information considered to be most important, and the credibility of assessments. Traditional knowledge transfer through the pipeline model requires time, resulting in delayed—and maybe not the most appropriate—use of research-based knowledge. Furthermore, it seems that knowledge produced in the domains of vulnerability and resilience addresses more the needs of decision makers working in the disaster management arena than it does for users dealing with other policy fields. Clearly, the former consider the assessment’s findings as more relevant. In short: research-based knowledge in the domains of vulnerability and resilience is considered as highly credible and legitimate by multiple users. It is, moreover, considered as relevant by decision makers—particularly by those working with disaster mitigation and response—but it addresses only to a low degree the needs of these users.

There is evidence that assessments of vulnerability and resilience increase their influence—or at least saliency—when they are co-produced for defined socio-ecological systems in specific areas to meet local decision-making needs. A clear identification of the assessment’s purpose, its unit and scale, and the intended audience followed by specific recommendations is obviously more important for decision makers than addressing theoretical aspects of state-of-the-art methodology. In particular, scale should be a concern of both the unit of scientific analysis and of the administrative decision-making to avoid scientific assessments being implemented at geographic scales that are incompatible with the local management units (Cash and Moser 2000). The goal is to systematically understand the complex process of interactions within and between societal arenas, spatial and temporal scales, and coupled human-environmental systems and to integrate them into a more comprehensive analysis.

The fact that twelve case studies refer to a single-hazard and eight to multiple-hazards supports the tendency of increasing acceptance that “single-stressor-single-outcome” approaches fail to capture the reality of vulnerability and resilience for most socio-ecological systems. However, only 20 % of the case studies analyzed attempt to integrate practical elements and consider socioeconomic and geophysical aspects across spatial scales. A shift toward more co-productions of knowledge might improve data constraints and modeling capabilities, which still limit the tools for addressing the problem of up- and downscaling, and thus increase the low number of assessments addressing particular systems in multi-stressor contexts.

While scientific literature and data (i.e., statistics, census, and maps) are considered to be most critical for scientific assessments, there is a trend among knowledge-producers to not only use scientific information sources but also a broad variety of sources, including information provided by governments and NGOs. The fact that particularly authors of recently published documents disseminate their research findings to a higher degree through reports demonstrates that knowledge arenas are not stable but dynamic. This might be related to a relative increase of non-academic funding of scientific research. External sources of research funding increasingly seek evidence of applicability as an important indicator of performance. They expect the delivery of intermediate and final reports, and not of scientific papers. In contrast, the

number of producers who particularly produce knowledge for and disseminate it to the general public, non-governmental organizations, and the private sector is still very low.

By virtue of their multi-faceted and dynamic character, the knowledge domains of vulnerability and resilience inevitably pose difficulties for discipline-based non-collective knowledge production. In both knowledge domains, many facts are uncertain, values often in dispute, and decisions two-edged. Such problems cannot be addressed by incompletely designed tools and programs, which inevitably generalize, decontextualize, and reduce much of what is important about the character of vulnerability and resilience. Forms of knowledge production are necessary that entail making connections not only across discipline boundaries but also between scholarly inquiry and policy and practice. Hence, knowledge systems are needed that overcome technocratic reductionisms, integrate an extended range of sources and types of information, and engage in the co-production of knowledge through the interaction of producers and users, thus enhancing the quality of associated decision making.

On the basis of the empirical findings emerging from case studies analysis and questionnaire survey, the following propositions can be made with regard to the core questions of the VARIP project:

1. *How adequate is the knowledge base to support efforts for vulnerability reduction and building resilience? How is that knowledge distributed among actors?*

While the production and quality of knowledge differ considerably, sufficient knowledge exists to reduce present vulnerabilities to natural disasters. Unsatisfying is the transformation of existing knowledge into practical applications. On the one hand, many scientists set the research agenda and do the research without input from other disciplines and practitioners and then transfer the findings to potential users. On the other hand, many users make insufficient use of the existing possibilities to obtain research-based information. Both parties, however, are increasingly aware of the problem resulting from the use of limited information sources and distribution channels. The availability of consistent hazard and exposure data and technology to achieve integrated vulnerability assessments is often limited or beyond the resources of local governments.

2. *To what extent do the actors make use of the knowledge available to them? How relevant and pertinent is the knowledge to the needs of decision makers?*

Actors in policy and practice use insufficiently the research-based knowledge available; actors in science and research produce insufficiently knowledge that is useable. The latter still consider scientific literature and data (i.e., statistics, census, and maps) as the most critical information source for scientific assessments; decision makers use primary governmental and internal institutional information sources. It seems that the trickle down approach, i.e., by and by research will be taken up by users without additional effort by the producers, is still the default relationship between disaster-related scientists and practitioners. The practice of bringing research findings into the policy and practice arenas by publishing in peer reviewed journals is deeply embedded in the science system, manifested not only in attitudes, but also in incentive structures that reward publications in media with scientific impact and participation in forums with academic relevance. As a result, knowledge production is mostly “career driven” and “academic driven” (“publish or perish”). Though often relevant for practitioners, findings are rarely presented in a way that they can be used and applied by decision makers.

3. *What barriers and failures limit the transfer of knowledge and feedbacks in the science-practice interface? Do the barriers and failures occur in the transfer of knowledge principally from science to practice or from practice to science? How important are the intermediaries between science and practice and who are they?*

Main barriers that limit the knowledge transfer are divergent objectives, needs, scopes, priorities, institutional settings, and standards. Hence, failures occur in both domains. Maybe more important, however, are differences in the “language” used, a lack of understanding of the counterpart’s “modes of operation,” and mistrust, all hindering the co-production of knowledge. As a result, intermediary bodies and boundary organizations play an important role in “translating” and “coordinating” knowledge, particularly in developing countries with sparse networks and existing mistrust among actors. The case study analysis could not shed much light on the question of who the intermediaries are. Generally it can be said that boundary organizations, such as the International Red Cross and Red Crescent Movement to mention just the prominent one among many others, are more noticeable regarding disaster response activities than in mitigation-related boundary work.

4. *How does the nature of institutions shape the science-practice interface? To what extent is institutional fragmentation a problem? How permeable are the boundaries of institutions to new information?*

Researchers in the knowledge domains of vulnerability and resilience are constantly confronted with barriers, whether they rise up between the sciences and the humanities, between scientific disciplines, between the functional silos in a faculty, or between the scientist’s world of ideas and the practitioner’s world of action. Moreover, research grants increasingly encourage huge research teams, often located in institutions that are higher recognized and better equipped. In contrast, institutions with lower recognition and fewer resources are limited with the scope of their research. In addition, most funding schemes and research programs do not allow comprehensive long-term research and are not equipped to deal with disaster studies that will take a generation to take effect. Fragmentation of responsibilities is also a problem for decision makers in policy and practice. Issues related to vulnerability reduction are handled in different arenas within the political-administrative system: separate ministries, departments, programs, budgets, and time horizons, often with minimal relation to each other. Authorities and responsibilities are highly specialized by function and territory and fragmentation of jurisdictions among federal, state, and local governments hinder inter-agency communication and thus development of comprehensive disaster mitigation plans. Although there is an increasing number of cross citations and papers classified in multiple knowledge domains indicating an increasing integration of the different knowledge domains (Janssen et al. 2006), the case study review suggests that particularly research on ecological and social vulnerability and resilience needs to be more integrated.

5. *What major conflicts exist among actors and institutions in the interactions between science and practice? To what extent are the conflicts primarily about values or facts? Does social justice enter into the decision-making process?*

Major conflicts result from functional, structural, and social barriers that divide knowledge systems. Depending on the quantity and quality of interactions between actors, conflicts range from a “knowing-better mentality” to mistrust and problems in understanding each others language, needs, and standards. Typically, vulnerability reduction and disaster mitigation has to compete with other societal needs, resulting in exclusion in governments’ priority lists. The multidimensional and often invisible and infrequent nature of vulnerabilities is in contrast to the clear responsibilities and time and financial budgets of authorities. The conflicts are not primarily about values and facts, but they are certainly hidden in the contextual surroundings, such as how much attention is paid to vulnerability, how politically contested it is, and how it is linked to other issues (e.g., security and terrorism). Given the analysis of environmental risks regarding issue attention, framing, and actors (Schreurs et al. 2001), it can be assumed that a variety of cognitive and contextual factors influence the progress in the area of vulnerability and resilience. Unsurprisingly, different actors compete on responsibility and funds, seeking to realize their needs and interests, and less about meeting the

values and needs of the people at risk. In most case studies, no knowledge governance procedures are adopted to integrate the less powerful and often more vulnerable actors in determining research objectives and disseminating research findings.

6. *What is the role of consensus in the science-practice interface? How is consensus built? How are conflicts resolved? Who are the consensus builders and mediators and what are the major processes they use?*

On the basis of this study, no propositions are possible. Achieving consensus might not be feasible, or even required, if differences in opinion are recognized in order to deal with them constructively (i.e., social learning takes place).

7. *What factors contribute most to adaptive capacity? How large is the gap between the capacity to adapt and the adaptation that actually occurs? What causes this gap and how can it be reduced? What new elements of enlarged capacity would contribute most to greater resilience in the face of environmental change over the short run, the longer term?*

On the basis of this study, no propositions are possible.

8. *To what extent has social learning evolved among the principal actors? To what extent has social learning ameliorated or exacerbated vulnerability? What most limits or facilitates the ability to learn from one's own experience and the experience of others?*

Little can be said about social learning. Processes of social learning are usually codified in shared practices, tools, and concepts. The fact that boundary organizations are both important and successful in knowledge transfer underlines the existing deficit in interacting and collaborating across the different barriers. One could even say: boundary organizations are the result or outcome of the lack of co-producing knowledge. Learning can be supported if scientists would more actively engage in activities that enhance self-reflection, e.g., assessing the assessment processes and products. The approach of adaptive management, which allows collaboration in developing and communicating new ideas and practices to address uncertainty, may be a possible pathway for making policy and institutions more flexible in the face of global change (Weichselgartner and Sendzimir 2004).

9. *Where is the science-practice interface vulnerable to failure? Where is the science-practice interface most vulnerable to failure to future risks?*

Without a co-production of knowledge involving different actors there is the danger of generalization and decontextualization, resulting in undifferentiated “communities at risk” or “vulnerable countries.” Scientific approaches based on static thinking and linear causalities are contradictory to the multidimensional and dynamic structure of vulnerability and resilience. Likewise, single-discipline concepts are not capable of offering valuable solutions to the multi-layered problems. On the practitioners' side, cooperation and collaboration across society is hindered when disaster schemes and programs treat people as “clients” in disaster management processes, ignoring the experience of those most at risk, and where “paternalistic” science and technology do things *to* them and *for* them, rather than *together with* them. Most hazard protection strategies lose effectiveness when top-down approaches ignore local social dynamics and are, in turn, ignored as socially isolated and irrelevant. This becomes even more important in times of rapid global change processes. Related is the fact that too little attention is devoted to the loss of local knowledge and traditional adaptation strategies.

10. *How can the science-practice interface be best improved?*

Generally speaking, reducing the functional, structural, and social barriers would certainly lead to improvements in the SPPI (specific recommendations are given in the next section). Consequently, there are many feasible ways making improvements: broader joint programs, flatter hierarchical networks, more cooperative actions, or a global vulnerability platform providing a library and database and thus facilitates information exchange between knowledge-producers and -users. Less frequent but promising could be the collaborative work on a common goal, such as decision support systems to be integrated in disaster planning tying together spatial-temporal information with multiple perturbation scenarios that depict spatial-temporal reactions. Also example communities in terms of vulnerability reduction could be selected, observed, and evaluated.

6.3 *Recommendations*

Despite growing synergy among conceptual frameworks and increasing consensus on the issues of importance, research on vulnerability and resilience is still facing theoretical and practical challenges, namely to address and capture concurrently socioeconomic and geophysical factors, multiple and interacting stressors, cross-scalar influences and outcomes, as well as to confront aspects of governance, gender, and social justice. Likewise, concepts to link research-based knowledge with action vary regarding their underlying assumptions, scope, and influence, forming a fragmented and often contradictory set of approaches.

Given the rapid changes in coupled human-environment systems and the need to mitigate and adapt to changing conditions, the knowledge domains of socio-ecological systems and knowledge systems are of crucial importance. It is time to interrelate and tie the two domains closer together—in both theoretical and practical terms. Not only disaster management but also knowledge management plays an important role in reducing disaster vulnerability and enhancing resilience. Single-disciplinary concepts based on single-stressor focus, static thinking, and linear causalities are contradictory to the socially divergent, multidimensional, dynamic, interactive, and scale dependent character of vulnerability and resilience. Single-discipline approaches and single-technical fixes are not capable to solve the multi-layered natural disaster problem. Ultimately, reduction of natural disaster impacts is only successful if the structures and practices in disaster *and* knowledge management are properly adjusted, taking into account societal and natural conditions.

Needless to say that there is no magic bullet. One feasible way for knowledge-producers and -users to generate a deeper mutual understanding of each other's needs and constraints is to increase the amount and intensity of face-to-face interaction by creating institutional contexts where both are encouraged to interact. Obviously, designing such contexts necessitates precious resources—temporal, spatial, and financial. Different research activities of the Science, Environment and Development Group at Harvard University's Center for International Development resulted in findings that indicate how effective systems have to be designed to harness research-based knowledge and know-how with action. The empirical evidence presented in this case study supports some of these findings. Hence, knowledge systems in the domains of vulnerability and resilience can increase the effectiveness by

- creating dense social networks that provide bi-directional links across scales;
- strengthening integration of ecological and social research approaches and tools;
- creating mechanisms for early problem identification and framing in concert with practitioners in order to better match the needs of various users;

- recognizing mutual dependencies and interactions and building trust for self-reflection to recognize individual mental frames and images;
- providing space for safe-to-fail experimentation to accumulate experiences from such trials in order to improve the capacity to cope with surprises, uncertainty, and change;
- combining understanding from multiple sources in order to obtain discoveries which can be adapted to diverse local contexts and capacities without ignoring impacts across dimensions or people;
- engaging not in pipeline “transfers” but in the “co-production” of knowledge through the close interaction of producers and users, hence building a “knowledge-action system”;
- undertaking efforts to be perceived as salient, credible, and legitimate by multiple users in order that their decisions and findings are more likely to be accepted and treated as just even in the presence of differences of interest and conflict;
- including mechanisms to facilitate social memory and learning by providing a reservoir of experience from which solutions to new problems can be drawn, as well as an open window for new practices which may be needed under changed contexts;
- providing mechanisms for linking solutions proposed by research with articulated needs and problems of practitioners in order to reduce the discrepancies in activities of different actors resulting in more timely and context-appropriate solutions.

Likewise, programs aiming at reducing vulnerability and enhancing resilience should

- involve a variety of actors in setting up the research agenda;
- establish a shared problem perception within this group of actors;
- be designed to be equally “producer driven” and “user driven”;
- avoid the use of generalizing, decontextualizing, and reductionist approaches;
- include processes of participation, integration, learning, and negotiation;
- engage both ends of the producer-user spectrum in a dialogue out of which emerges a negotiated view of what is both feasible and desirable;
- take into account aspects of governance, equity, gender, and social justice;
- engage with boundary organizations with dual accountability to users and producers;
- develop possible scenarios with regard to future states of a vulnerability and resilience and new management approaches.

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Appendix A: List of Selected Case Studies

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Appendix B: List of Survey Participants

No.	Producer	Organization
1	Neil Adger	Tyndall Centre, University of East Anglia
2	Linda Anderson-Berry David King	Disaster Mitigation Policy Planning Services, Australian Bureau of Meteorology Centre for Disaster Studies, James Cook University
3	Jerry Buckland Matiur Rahman	Menno Simons College, University of Winnipeg Department of Environment and Geography, University of Manitoba
4	Stephanie Chang	Centre for Human Settlements, University of British Columbia
5	George Clark Susanne Moser Kirsten Dow Samuel Ratick	Harvard College Library, Harvard University Institute for the Study of Society and Environment, National Center for Atmospheric Research Department of Geography, University of South Carolina Department of Geography, Clark University
6	Timothy Collins	Department of Geography, Arizona State University
7	Susan Cutter Michael Scott	Department of Geography, University of South Carolina Department of Geography, Salisbury University
8	Mohamed El-Raey Omran Frihy	Institute of Graduate Studies and Research, University of Alexandria Institute of Coastal Research, Alexandria
9	Mike Gillen	School of Geography Planning and Architecture, University of Queensland
10	Julio Kuroiwa	National University of Engineering, Lima
11	Clement Lewsey	National Oceanic and Atmospheric Administration, National Ocean Service
12	Amy Luers David Lobell	Department of Geological and Environmental Sciences, Stanford University Department of Geological and Environmental Sciences, Stanford University
13	Daanish Mustafa	College of Arts and Sciences, University of South Florida
14	Karen O'Brien Jennifer West Lynn Nygaard Robin Leichenko Suruchi Bhadwal Henry Venema Guro Aandahl	Center for International Climate and Environmental Research, Oslo Center for International Climate and Environmental Research, Oslo Center for International Climate and Environmental Research, Oslo Department of Geography, Rutgers University The Energy and Resources Institute, New Delhi International Institute for Sustainable Development, Winnipeg Centre for Development and the Environment, University of Oslo
15	David Odeh	Odeh Engineers, Inc., North Providence RI
16	Nathan Wood	U.S. Geological Survey, Vancouver
17	Doracie Zoleta-Nantes	Department of Geography, University of the Philippines
18	Uwe Grünewald Wolf Dombrowsky Willi Streit Annegret Thieken Theresia Petrow Bruno Merz	University of Technology Cottbus, Hydrology and Water Resources Management University of Kiel, Disaster Research Center University of Kiel, Disaster Research Center GeoForschungsZentrum Potsdam, Section Engineering Hydrology GeoForschungsZentrum Potsdam, Section Engineering Hydrology GeoForschungsZentrum Potsdam, Section Engineering Hydrology
19	Dennis Mileti	Institute of Behavioral Science, University of Colorado
20	Klaus Jacob Vivien Gornitz	Lamont-Doherty Earth Observatory, Columbia University National Aeronautics and Space Administration, Goddard Institute for Space Studies
No.	User	Organization
1	Gaby Breton	Canadian Center for Intern. Studies & Cooperation Vietnam, Natural Disaster Mitigation Program (Leader)
2	David Farmer Ross McKim Cheryl-Lee Norris	Cairns City Council (Chief Executive Office) Cairns City Council, Cairns Local Disaster Management Group (Executive Officer) Cairns City Council, Disaster Management Unit (Coordinator)
3	Gerry Delorme Doug Peterson Marc Bruyère Shelley Napier	Manitoba Health, Office of Disaster Management (Director) Manitoba Floodway Authority (Manager Environmental Services) Manitoba Emergency Measures Organization, Eastern Region (Regional Emergency Officer) Manitoba Emergency Measures Organization, Interlake Region (Regional Emergency Officer)

4	Ines Pearce Don Ballantyne Phyllis Shulman Jacqueline Meszaros	City of Seattle Office of Emergency Management (Seattle Project Impact Director) ABS Consulting, Operational Risk Consulting Division (Director) City of Seattle, Legislative Department (Legislative Assistant) National Science Foundation (Program Officer)
5	Thomas Ambrosino Frank Stringi	City of Revere (Mayor) City of Revere, Department of Planning & Community (City Planner)
6	Scott Vail Kim Seidler	State of California, Office of Emergency Services, Fire and Rescue Branch (Deputy Chief-Admin) City of Chico, Planning Division (Director)
7	Lewis Dugan Tony Hucks Amenda Rutherford	Georgetown County, Emergency Management (Manager) Georgetown County, Fire Department (Assistant Fire/EMS Chief) Waccamaw Regional Council of Governments (Land Use and Transportation Planner)
8	Essam Hassan El-Shinnawy	Egyptian Environmental Affairs Agency (Technical Officer) Coastal Research Institute (Director)
9	Russell Taylor Darryl Leggett	NSW Rural Fire Service (Manager Community Education) Fire Protection Association Australia (NSW State Secretary)
10	Luis Rene Vallenias Alfredo Siu Delgado	National Institute for Civil Defense (INDECI), National Education and Training Management Unit (Director) National Institute for Civil Defense (INDECI), Regional Office Arequipa (Regional Director)
11	Claudine Roberts John Fontaine David Persaud	Ministry of Community Development, Dominica (Assistant Local Government Commissioner) Ministry of Community Development, Dominica (Local Government Commissioner) Ministry of Public Utilities and the Environment, Trinidad and Tobago (Environmental Manager)
12	Ricardo Hurtado	Commission for Ecology and Sustainable Development of Sonora (CEDES), Conservation Unit (Director)
13	Abdul Qayum Sarah Zaidi Muhammad Sabir	Government of Pakistan, Planning and Development Division (Deputy Chief) Research and Information System for Earthquakes Pakistan (RISEPAK) (Coordinator) Ministry of Finance and Economic Affairs (Senior Economist)
14	Vimal Khawas Mruthyunjaya Damodar Tripathy	Council for Social Development India (Associate Fellow) Indian Council of Agricultural Research, National Agriculture Innovation Project (National Director) Research and Consultancy Pvt. Ltd, Orissa (Managing Director)
15	Michael Mulhare Blanche Higgins Bruce Vild	Rhode Island, Department of Environmental Management, Office of Emergency Response (Chief) Rhode Island Statewide Planning Program, Land Use Section (Supervising Planner) Rhode Island Statewide Planning Program, Economic Development Section (Supervising Planner)
16	Jonathan Allan Will Ewing William Bain Jay Wilson	Oregon State Department of Geology, Coastal Section (Team Leader) City of Toledo, Fire Department (Fire Chief) City of Newport (Mayor) Oregon Emergency Management (Coordinator Earthquake, Tsunami, and Volcano Program)
17	No responders	
18	Jürgen Plaggenborg Peter Kammel Jens Seifert	State of Saxony, Ministry of Interior (Officer Disaster Protection) City of Pirna, Fire Department (Chief) City of Dresden, Environmental Department (Officer)
19	Kathleen Tierney James Kendra Robert Stallings David McEntire	Natural Hazards Research and Applications Information Center, University of Colorado (Director) Emergency Administration and Planning Program, University of North Texas (Program Coordinator) School of Policy, Planning, and Development, University of Southern California (Professor em.) Emergency Administration and Planning Program, University of North Texas (Associate Professor)
20	Joe Picciano MaryAnn Marrocolo Sean Waters	Federal Emergency Management Agency, Region II (Acting Director) NYC Office of Emergency Management (Assistant Commissioner for Planning and Preparedness) Federal Emergency Management Agency, Region II (Officer)

Appendix C: Questionnaire for Assessment-Producers

Name:

Institution:

Assessment Reference:

1. Who was involved in formulating the research questions?

Only the authors Colleagues of our institution External colleagues

Others Please specify:

2. How regularly do you use the following information sources for your work and how important do you consider them? Please check all and rank them by importance.

	regularly	occasionally	rarely	not at all	Rank
Internal institutional sources	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	1
Governmental sources	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	1
Non-governmental sources	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	1
Scientific sources	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	1
Media sources	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	1
Personal communication	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	1
Others, please specify:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	1

3. What sources and information were most influential and critical to the assessment?

1. Please name and specify why:
2. Please name and specify why:

4. Who was the intended audience for this assessment and what was its intended use?

Please specify:

5. What changes/additional information would you make/add to this assessment if its purpose was to be an immediately actionable plan for practitioner use?

Please specify:

6. Beside the above mentioned publication, were there any other ways of disseminating the findings of the assessment? Please check all that apply.

- No
- Yes, scientific papers
- Yes, reports Please specify for whom:
- Others Please specify:

7. Do you think that the assessment addresses the need of users?

No

Please specify why:

Yes

Please specify why and which:

For whom might it be relevant? Please specify (if possible, include contact details):

8. Are you aware of any impacts of your assessment, especially on policy and practice?

No

Yes Please specify:

9. How do you evaluate the influence of the assessment? Please check all that apply.

It had only limited impact on science and practice

It had scientific impact, but not on practice

It influenced the beliefs of readers and thus will have impacts in the future

Others Please specify:

10. Where do you see existing conflicts among actors and institutions in the interactions between science and practice?

Please specify:

11. How can knowledge transfer at the science-practice interface be improved?

Please specify:

Appendix D: Questionnaire for Assessment-Users

Name:
 Institution:
 Responsibility:
 Assessment Reference:

1. What information sources do you consult to obtain new information relevant to your work? How regularly do you use them and how important do you consider them? Please check all and rank them by importance.

	regularly	occasionally	rarely	not at all	Rank
Internal institutional sources	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	1
Governmental sources	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	1
Non-governmental sources	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	1
Scientific sources	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	1
Media sources	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	1
Personal communication	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	1
Others, please specify:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	1

2. Were you aware of the assessment before we contacted you? Please check all that apply.

- No, not at all
- No, but I heard that something was done
- Please specify:
- Yes, I knew about the assessment, but not this report
- Please specify:
- Yes, I knew about the report, but I did not read it
- Please specify:
- Yes, I knew the assessment and the report
- Please specify:
- Yes, I was involved
- Please specify:

3. What sources and information have been most influential and critical to your work?

- 1. Please name and specify why:
- 2. Please name and specify why:

4. What kind of influence did/will the assessment have? Please check all that apply.

- I did/will talk about it within my organization
- It did/will influence my beliefs
- I did/will use the work or refer to it to convince other people
- It did/will not influence my actions related to my work

I did/will consider the findings in the future

Please, specify reasons why this assessment did/will influence your work or not:

5. Does the assessment report address your needs? Please check all that apply.

No, not at all

Please specify why:

No, but I see the strengths of the assessment

Please specify:

For whom might it be relevant? Please specify (if possible, include contact details):

Yes, it addresses some of my needs

Please specify which:

Yes, but the results and findings are not relevant

Please specify why:

Yes, and the results and findings are relevant

Please specify why:

What should the assessment have addressed to be more relevant and useful?

Please specify:

6. Do you believe that the assessment is accurate and technically sound?

No Please specify:

Yes Please specify:

What would have improved the accuracy and technical soundness of the assessment?

Please specify:

7. Do you find the assessment respectful of stakeholders and unbiased?

No Please specify:

Yes Please specify:

What could have improved the fairness of the assessment process?

Please specify:

8. What else what you like to tell us or might be of interest for us?

Please specify: