View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by International Institute for Applied Systems Analysis (IIASA)

Mountain Research and Development Vol 24 No 1 Feb 2004: 4–9

Juergen Weichselgartner
Jan Sendzimir

Resolving the Paradox

Food for Thought on the Wider Dimensions of Natural Disasters

Recent disaster statistics reflect an alarming trend of increasing losses from natural disasters. Typically, the insurance industry, scientific experts, and thus the media, refer to such "external" factors as population increase, the potential for damage in hazard-prone areas, and land use and climate change as the primary causes of this trend. Although these factors increase vulnerability to natural disasters, we argue that "internal" factors such as disaster-related science and policy are also responsible for the inability to stem or reverse the upward trend in disaster damage. The paradox of concurrent increases in economic loss and disaster-related research raises questions about the approaches and tools used in hazard assessment and disaster management. 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. We conclude with some thought-provoking suggestions for addressing problems in disaster management.

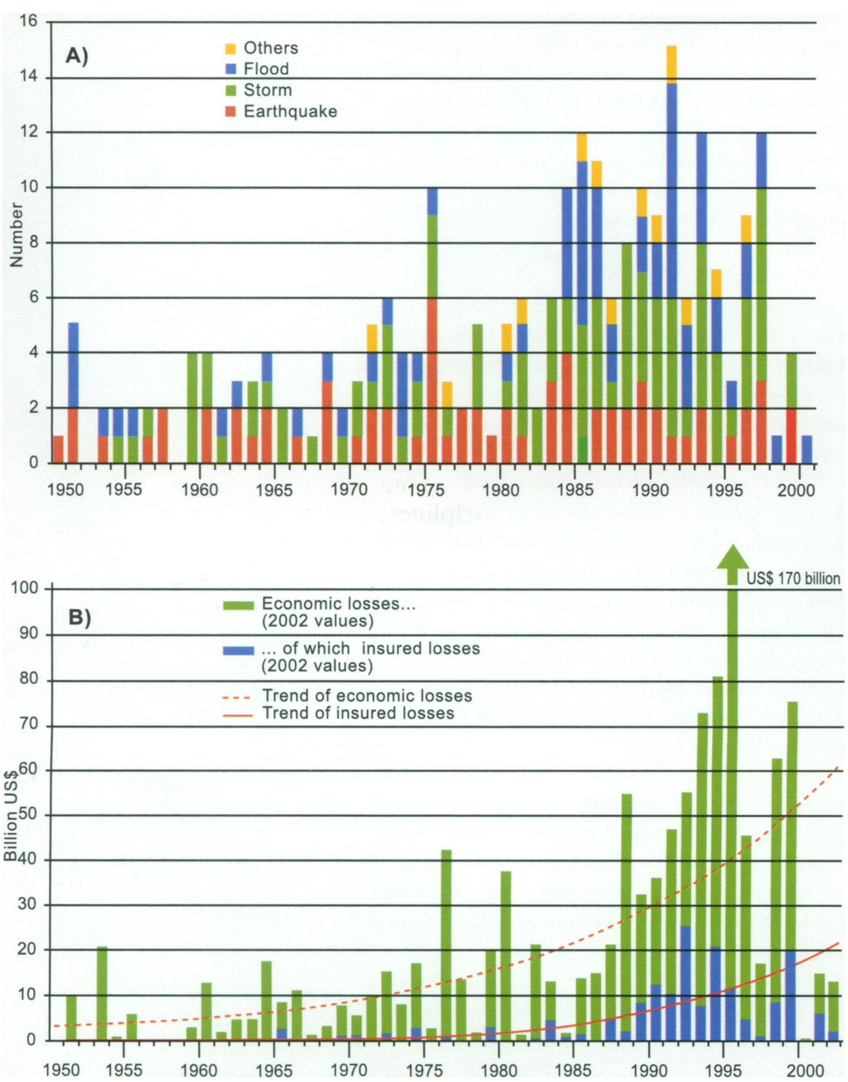

FIGURE 1, A AND B Increase in major natural disasters (A) and economic losses (B) since 1950. The trend curves verify the alarming increase in losses from disasters in the past 5 decades. (Source: Munich Re Group 2003)

Dramatic increase in disasters and economic loss

Statistics on the frequency of major natural disasters and losses resulting from disasters reveal two clear trends: major disasters and economic damage are both increasing (Figure 1). The common explanations for these trends focus on the inevitable consequences of development: climate change, population increase, assets in risk-prone areas (growth in Gross World Product), and poorly adapted land use changes that reduce the buffering capacity of landscapes. Few ponder the paradox that while losses from disasters and investment for research on disaster theory and methods are rising, our tools and techniques for hazard assessment and disaster management are increasingly being questioned. Since traditional knowledge and techniques have not reversed the upward trend in losses, it seems obvious that fundamental conceptual barriers and profound changes in ecological, economic and social processes must be considered as additional factors, especially in sensitive ecosystems such as mountain areas.

The need for new paradigms in research and practice

It is increasingly recognized that inadequate perspectives and poorly adapted management practices are compounding problems and contributing to uncertainty. This forces us to move beyond external causes to examine "internal" causes—our perspectives and methods, as well as the social patterns that contribute to the risk of disaster.

"Internal" rather than "external" focus

We must first overcome denial: difficulties in quantifying uncertainty often lead to a failure to address uncertainty at all, especially with regard to social processes. As a result, we use reductionist approaches to study natural disaster-related aspects whose driving forces can be tightly controlled and manipulated, ie, *external* factors such as geophysical processes that we can engineer.

At the same time, we often avoid the study of complex human–nature interactions, for which we often lack social and environmental data at the appropriate spatial and temporal scales. Traditional hazard mitigation policy considers natural hazards as isolated, linear processes. With flooding, for example, most risk analyses consider a line of causality that proceeds from meteorological conditions through temporal and spatial variability to the (economic) impact of floods on society. This emphasis on nature as a set of determinants, without adequate integration of social, political, legislative and biophysical contexts, has led to a narrow focus on geophysical processes and risk exposure, and a preference for technical fixes and structural measures in risk management. On the other hand, many social scientists model disasters as primarily negative events with solely economic impacts on society and, consequently, most models reflect only utilitarian functions both abstracted from the biophysical world and from socio-ecological consequences.

Complex rather than linear approaches

Hence natural risk management options reflect a biased analysis of causality, and present linear cause-and-effect approaches that blind us to the reality of how complex adaptive systems operate at multiple levels. Since most people see life as a series of events and ignore system structure (feedback loops) and behavior (delays, emerging properties with unexpected impacts), disasters are rarely viewed as an integral part of a much larger development context.

As a result, policy options are constrained to reactionary, end-of-the-pipeline responses such as emergency management or humanitarian assistance. Unsurprisingly, disaster management is an event-focused reaction, based on schemes and programs that treat those affected as "clients," with a culture of experts and technology that do things *to* and *for* them, rather than *together with* them. Communicating and transporting different ideas and concepts between social systems is still problematic, given the different operating principles and vocabularies in disaster-related science and policy. Traditional flood engineering, for instance, provides concrete results that relieve anxiety about uncertainty but often reduce options for adding natural capacity to absorb runoff and flexibly integrate different disciplines that could also contribute to flood prevention.

Increasing resilience

How can we broaden the focus of risk management to simultaneously decrease the impacts of disasters and increase the capacity to respond, while working between crises to increase the resilience and adaptiveness of society to natural hazards? Above all, we must improve our understanding of functional uncertainties in complex dynamic systems and broaden cooperation throughout society, across different sectors, disciplines, political borders, and spatial and temporal scales. This requires integration of management and development policy over the short, medium and long terms, as well as generation and adoption of paradigms that reflect our emerging understanding of processes operating at a variety of temporal and spatial scales (see Box 1 and Figure 2). We therefore recommend the establishment of a disaster-related science policy forum that elaborates holistic programs—temporally and financially adapted to the long-term horizon of disaster-related problems—and thereby addresses and communicates problems of uncertainty.

A narrow, event-oriented, reductionist view cannot portray holistically complex dynamic systems. Scientific education should be restructured to include courses and training in system dynamics, helping students to perceive themselves as a part of a larger ecosystem, one in which their

"People now live in more risky areas and the vulnerability of the insured objects has increased—for example if a PC or television gets wet, you have to throw it away." (Jens Mehlhorn, head of the flood group at Swiss Re in Zurich)

Can we learn from an integrated early warning system designed over 200 years ago?

"It is a tragic irony that 1998, the penultimate year of the Disaster Reduction Decade, was also a year in which natural disasters increased so dramatically[...]. It is becoming increasingly clear that the term 'natural' for such events is a misnomer." (UN Secretary-General Kofi Annan at the closing ceremonies for the UN International Decade for Natural Disaster Reduction in 1999)

Natural hazards are embedded in a spatial and temporal context; improvement of approaches to deal with them requires interdisciplinary research teams and advanced research methods. Historical and autobiographical research bears significant potential for hazard research because it enables those exposed to disaster to ensure that their risk perceptions are recorded and integrated into culturally sensitive bottom-up mitigation strategies and disaster reduction programs. Moreover, participatory research methodologies make it possible for communities and researchers to gain a better understanding of issues affecting communities. Thus, research becomes a reciprocal process in which traditional top-down hierarchies are dismantled and all participants become equal collaborators, for the benefit of cost-efficient risk management.

Natural disasters such as floods do not occur in a social or historical vacuum. This is why flood hazard research needs to combine knowledge of social and natural factors, as well as historical and contemporary approaches and tools. Societies exposed to natural disasters should not be assessed ahistorically—as is often done after great flood disasters, where post-disaster research and reports focus mainly on meteorological conditions, geo-hydrological aspects, and technical fixes and measures. Based on a comparative assessment of a contemporary prediction system and a 200-year-old early flood warning system on the Elbe river in Saxony, Germany (Figure 2), recent hazard research suggests that there is a need to support the (re-)development of a collective memory regarding large-scale natural disasters, in order to increase contemporary awareness and adapt response mechanisms. Indeed, today the different components of flood early warning systems are frequently considered in isolation, and expensive flood forecasting is promoted without adequately addressing the distribution and implementation of flood warnings—as was demonstrated by the Elbe river flood in 2002.

Historical research has revealed that along the same problematic stretch of river, more than 200 years ago the authorities already successfully stemmed major flood risks for many decades, after massive damage resulting from an extreme event in February 1784. In the winter of 1798/99, realizing that the weather pattern might recreate the dangerous conditions of 1784, with a frozen river and enormous amounts of snow accumulated upstream, which could suddenly thaw, leading to huge ice blocks and water masses invading the area, the Saxon authorities designed an elaborate early warning system based on collective close observation of the environment and involvement of the population and the army. A legal act was passed to regulate flood prevention measures, including the implementation of 16 signal cannons along the Saxon Elbe river. The army was instructed to make the ice masses explode with bombs and cannon balls if necessary. Officers were asked to reconnoiter the hazardous areas along the riverbanks where ice was known to have accumulated before, and to determine the best routes for intervention. If bombing the ice masses was found not to suffice and sudden flooding was to be expected, the army was instructed to use signal cannons to warn the population downstream. An existing procedure was refined to operate this acoustic warning system. Starting with the warning post furthest upstream within Saxony, each post was to shoot three warning signals for the guard further down the valley as soon as the ice jamming broke up or the water rose beyond a certain level. The population was thus warned early enough to be able to protect itself and its

actions help to shape the Earth in ways large or small, positive and negative. On the practical side, we must enhance flexibility by emphasizing science as a process that fosters reassessment and is integrated with management practices.

One collaborative framework that has proven useful in disaster management is Adaptive Management, which allows people involved in science, policy-making, economic affairs and education to collaborate in developing and communicating new ideas and practices to address uncertainty. Such citizen–science dialogues broaden stakeholder participation in formulating and criticizing goals, constraints,

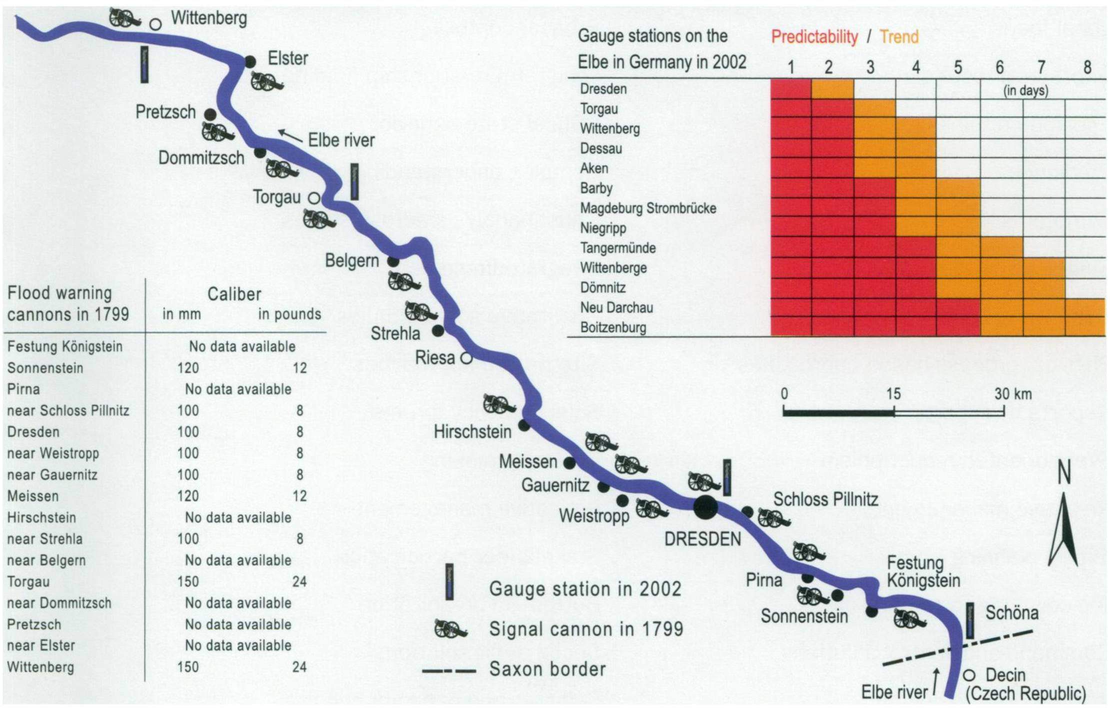

FIGURE 2 Comparative view of early flood warning systems along the Saxon stretch of the Elbe in Germany: the closely linked 1799 signal cannon system and the electronic prediction system refurbished after the 2002 flood. (Sketch by Juergen Weichselgartner)

possessions against impending flooding. Implementation of this system reduced massive damage and casualties. The local authorities also had to ensure that sufficient personnel and infrastructure were available to protect the dikes, defrost bridges, and provide the population with food and clothing whenever necessary.

By re-activating such historical data, hazard and disaster researchers could help broaden contemporary hazard research perspectives, develop a collective disaster memory, and design adequate self-help measures adapted to local environments.

FURTHER READING

Deutsch M. 2000. About the flooding of the Elbe and Saale rivers in February/March 1799 [in German]. *Erfurter Geographische Studien* 9:7-44.

Weichselgartner J, Deutsch M. 2002. Vulnerability assessment as a flood protection concept: Recent and historical observations [in German]. *Hydrologie und Wasserbewirtschaftung* 46(3):102-110.

Pfister C, Brázdil R, Glaser R. 1999. *Climatic Variability in Sixteenth-Century Europe and its Social Dimension.* London: Kluwer.

"Mitigation has to be done at the local level. The people living in hazard-prone areas and having practical knowledge and experience have to be involved in the planning processes. We should not dictate mitigation from the top down; but financing it is another question." (Interview with Markus Priesterath, instructor at the Kuratorium Fluthilfe, Department of the Interior, Germany, after the 2002 Elbe flood)

different scenarios and policy options, so that political "buy-in" increases.

Whatever approach we use must contribute to an ongoing process that does not focus on isolated physical processes or single events but on human development as a whole. In this regard, scientists and practitioners have to increase their awareness of the linkages between disasters and development, and the implications of these linkages for their work. In practice, disaster and development are treated in different arenas within the educational and political system: separate ministries, disciplines, departments, programs, budgets, literature, and space and

TABLE 1 Proposals for disaster-related research and practice to adopt diverse views and techniques. (Modified after Weichselgartner and Obersteiner 2002)

From... ⇨	...to
Hazard/risk concept	Vulnerability/resilience concept
Local focus	Broader context
Short-term results	Long-term relationship funding
Equilibrium thinking	Critical state behavior
Prediction	Complex understanding
Symptoms	Causal analysis across scales
Single parameter	Integrated research
Quantitative physical studies	Qualitative social studies
Physical process-based approaches	Site hazard approaches
Reports by experts	Science policy forums
Event-oriented reductionism	Systems thinking
Re-active management	Pro-active management
Expert planning	Stakeholder participation
Top-down organization	Bottom-up organization
Command-and-control solutions	Social audit solutions
Intervention	Self-help and capacity building
Response	Mitigation
Probabilities	Possibilities

time frames, often with minimal relation to each other.

Disaster management is more than the science of adept reaction to crisis or a policy of professionalized, event-focused response. Rather, it must become a continuous effort to assess all processes that influence risk at all scales. Such flexible learning processes increase our resilience to shock, as we diminish the impact of disturbance and increase our adaptability to uncertainty. To move beyond entrenched concepts that can block new ideas and methods, we need to use techniques such as modeling and employ all the information available to improve our knowledge about system behavior in crisis. We also need to enhance "Double Loop Learning" by making our paradigms explicit and subject to revision. Table 1 lists suggestions that might help integrate diverse views and techniques into disaster-related research and practice.

Future courses of action

The "precautionary principle" was recently proposed at the European level as a paradigm to further promote risk-related dialogue. As we have seen, the farther we look into the future, the more uncertain we are about functional relationships, interdependencies and outcomes. And since we can never predict with certainty what action—or lack of action—will trigger a disaster, we cannot define with certainty what it is that requires precaution. We appear trapped in cycles of recurring disasters when, in the face of such continuing uncertainty, technical solutions remain the dominant scientific approach and the default bureaucratic reflex.

Science and policy require more than technology or structural defense measures to address uncertainty. They involve human action—a social process in which knowledge and convictions are created

FIGURE 3 The result of a "Space for Rivers" initiative in Switzerland: the resilience of the Emme valley to flooding has been increased by allowing part of the Emme to return to its natural riverbed. This structural measure is cost-efficient, protects the river against undesired influx (thus improving water quality), helps conserve a natural ecosystem, and improves the quality of recreation areas. View of the Emme near Utzenstorf. (Photo courtesy of the Federal Office for Water and Geology, FOWG)

rather than certainties. Both the Netherlands and Switzerland offer good examples ("Space for Rivers" initiatives) of stakeholder-driven collaboration between society and scientists that is developing innovative approaches to flood hazards (Figure 3). Recognizing that engineered solutions cannot deliver full flood security, these programs allow experimentation with new policies and practices that increase society's resilience to floods and reestablish natural processes as the structuring agents for the river basin. Similar programs could help confront threats to mountain ecosystems—including invasive species, land degradation, natural hazards, pollution, fragmentation, and mass tourism—by experimenting with innovative views, theories, policies and practices to address conflicts emerging from the twin goals of preserving nature and promoting development.

AUTHORS

Juergen Weichselgartner and Jan Sendzimir
International Institute for Applied Systems Analysis (IIASA), Schlossplatz 1, A-2361 Laxenburg, Austria.
jw@iiasa.ac.at (J.W.); sendzim@iiasa.ac.at (J.S.)

Juergen Weichselgartner is a geographer specializing in hazard and disaster-related research. He holds a PhD in Geography from the University of Bonn, Germany, and has a long-standing interest in human–environment interactions and second-order cybernetics. He is currently a research scholar at IIASA and secretary of the International Geographical Union's Commission on Hazards and Risks.

Jan Sendzimir works as a research scholar at IIASA, and as a visiting professor at the Technical University of Wroclaw. He holds a PhD in Systems Ecology from the Department of Environmental Engineering, University of Florida. His current projects apply the Adaptive Management process in guiding scientific research policy development for sustainable development in river basins.

FURTHER READING

Kasperson JX, Kasperson RE. 2001. *Global Environmental Risk.* Tokyo: United Nations University Press.
Munich Re Group. 2001. *Topics 2000: Natural Catastrophes—The Current Position.* Special Millennium Issue. Munich: Munich Reinsurance Group.
Scheffer M, Carpenter S, Foley JA, Folke C, Walker B. 2001. Catastrophic shifts in ecosystems. *Nature* 413: 591–596.
Sendzimir J, Light S, Szymanowska K. 1999. Adaptively understanding and managing for floods. *Environments* 27(1):115–136.
Sterman JD. 2002. All models are wrong: Reflections on becoming a systems scientist. *System Dynamics Review* 18(4):501–531.
Weichselgartner J, Obersteiner M. 2002. Knowing sufficient and applying more: Challenges in hazards management. *Environmental Hazards* 4(2–3): 73–77.

ACKNOWLEDGMENTS

Our research was made possible in part by Grant No. EVG1-CT-2001-50001 (Marie Curie Individual Fellowship of the European Commission), provided to Juergen Weichselgartner. The authors are indebted to the Munich Reinsurance Group for providing updated data for Figure 1, to Mathias Deutsch, University of Erfurt, for supplying historical data used in Figure 2, and to the Swiss Federal Office for Water and Geology (FOWG) for providing Figure 3.