Journal of Natural Disaster Science, Volume 26, Number 2, 2004, pp55-61

Management of Change, Disaster Risk, and Uncertainty: an Overview

Aniello AMENDOLA
IIASA, International Institute for Applied Systems Analysis
Risk Modeling and Society
A-2361 Laxenburg, Austria

(Received for 10 Jun., 2004 and in revised from 7 Jan., 2005)

ABSTRACT

This overview, based on the keywords change, disaster risk, and uncertainties, focuses on issues emerging from the 2001-2004 IIASA-DPRI Forum on Integrated Disaster Risk Management; the uncertain effects of global climate change, implications for disasters due to differential vulnerabilities and rate of change. Other subjects addressed are the characterizing the uncertainties inherent in early warning systems, development of more adequate indicators for describing disasters, the need to investigate changes after disasters in order to develop stronger resilience, and movement towards institutional changes in order to address the global dimensions of disasters in a more and more deeply interconnected world.

1. INTRODUCTION

"Change, risk, and uncertainty are the three basic, linked components that need to be managed" (Green 2003). Risk management is a process in time that implies choices under uncertainties made for matching often-conflicting objectives, most parameters of the process changing with time. Management choices also affect change, the main consequences of disasters are changes. Changes, risks, and uncertainties also derive from choices and actions made by multiple actors. Their implications range from local to global scales. The differential rate of changes in environmental and sociotechnical systems and consequent mismatches are factors that contribute to risk. Without pretending to be exhaustive, this overview primarily develops issues emerging from the annual multidisciplinary forum on Integrated Disaster Risk Management (IDRM) by the IIASA and DPRI (Disaster Prevention Research Institute), Kyoto University.

2. CLIMATE CHANGE AND EXTREME EVENTS

Extreme atmospheric events resulting in hurricanes, windstorms, tornadoes, droughts, fires, floods and other weather-related disasters account for a large proportion of the increased losses from natural disasters over the last decades. More alarming even than the size of past losses is the trend for losses to increase. More than 1.5 million people died in the past two decades because of climatic events, and more than ninety percent of those deaths have occurred in developing countries (Red Cross, 2002; Munich Re, 2003). How do these events correlate with global warming? Can increased weather variability, in the form of droughts, windstorms, floods, hurricanes, and other weather-related extremes be more disruptive than the consequences of higher average surface temperatures and related average weather conditions?

Scientists more frequently are asking such questions, and the media propagating them, sometimes as established truths. For a long time, the research agenda on global climate change has been concerned essentially with the foreseeable effects of average temperature-increase and precipitation regime. Much less emphasis has been placed on weather variability (MacDonald 1998, 1999). At the same time, research on natural hazards seems to have proceeded independent of the climate change community. At the last IIASA-DPRI Forum in 2004, it was apparent that "there is not enough exchange and sharing between climate change researchers and policy makers and their counterparts working on natural hazards, especially flood and drought" (Wisner, 2004).

Bridging the gap between research on global climate change and natural hazard has been among the objectives of IIASA activities, since Mac Donald (1998, 1999) focused attention on the fact that a small increase in water surface temperatures would lead to increased atmospheric water contents and thereby to possible higher precipitation and, in some regions, more frequent flooding. The spatial scales of the most extreme events, however, are much too small to be captured by current climate models. He also warned that the clustering of frequencies of extreme climatic events, in relation to fluctuation in sea surface temperature (such as ENSO), might have very important economic and financial consequences. He questioned whether these fluctuations are affected by global warming.

The roles of global warming and human interventions in hydrological and economic systems were approached in 1999 at a conference on Global Change and Flood Risks in Europe held at IIASA (see collection of papers in Linnerooth-Bayer and Amendola, 2003). Bronstert's (2003) review of research on climate change and European flood risks showed conflicting evidence of a correlation between climate warming and more intensive, frequent flooding in some European regions and no correla-

KEY WORDS: management of change, disaster risk , uncertainty, integrated disaster risk management

tion in others. The difficulties and uncertainties involved in separating the effects of global warming from the many other human-induced factors that influence the frequency and intensity of flood events and resulting losses appeared to be overwhelming owing to model limitations and the unknowns inherent in scientific investigations. Similar results on the relationship between global warming and riverine flooding were published by Milly et al.; Palmer and Rälsänen; and Schnur, in the journal *Nature* in 2002. They indicate that global warming may have increased the risk of flooding in selected, very large river basins, but they also point out the limitations of available climate models which do not have a resolution fine enough for accurate application at the river-basin level and to the large and inherent uncertainties.

Based on the UN's International Panel on Climate Change conclusions that, though there are uncertainties, some extreme events are projected to increase in frequency and/or severity due to changes in the mean and/or variability of climate (IPGC, 2001), increased research efforts and better interaction with the natural hazards research community were to be expected.

The 3rd IIASA-DPRI Forum again attempted to analyze the relationships between global warming and weather-related disasters. No significant change in assessment capability based on the available predictive models emerged in the comprehensive presentation of Ikebuchi (2003). Nor could the 2002 catastrophic Elbe floods in Europe be related with global warming in Nachtnebel's report (2003). He concluded that research on possible links of flood risk to climate change should be pursued, but that it is more urgent to improve flood forecasting tools (indeed only one of the two severe rainfall events provoking the Elbe disaster could be predicted by forecasting systems) and non structural measures such as land use control and insurance.

Whereas a causal link between global warming and flooding remains speculative, Kaczmarek (2003) gave evidence of important links in Europe between the temperature cycles of the European weather and North Atlantic Ocean Oscillation (NAO). NAO as ENSO is a recurrent oceanic phenomenon associated with variations in "normal" climatic variability, providing new climatic resource opportunities and hazards. "Questions exist today as to whether the recurrence and intensity of these phenomena are being affected by the forces pushing Global Climate Change. This is as yet a mute point" (Lavell, 2004)

We are again at a point of departure in our short review. There appear to be good reasons to worry about future intensification of climatic extremes, but "we simply do not know" (Green, 2003). Stronger interaction between the two types of research communities is crucial. From this interaction the need for stronger mitigation efforts by reducing greenhouse emissions might be determined as well as inputs for more effective adaptation to climate changes. In any case, the projected sea level rise would aggravate the consequence of storms, hurricanes, floods, and tsunami even if their frequencies and intensities do not change.

Under this uncertainty about the future, what choices should we make, and what decisional criteria should apply? In the presence of high uncertainties and ignorance, as Green states, cost benefit analyses based on probability distributions (recurrence times) are useless. Moreover, Green states that "the critical form of uncertainty is doubt which is removed to the extent that we can become confident that one option should be preferred to all others" and that "confidence is conceptually quite different to probability". He introduces a fuzzy distribution for the concept "confidence"; but, if probability is not useful, then even fuzzy measures of uncertainties/certainties are useless. The latter introduce a number of new problems (even mathematical ones as there is no universally accepted set of operations that can be used with them) which add further subjectivity with respect to the already subjective meaning of probability. Neither the Bayesan probability scale used by the IPCC nor its translation into qualitative statements (Weiss, 2004) is useful for framing decisions; rather, they are possibly useful for risk communication. We are confronted with risks characterized by very severe consequences, irreversibility (at least in medium time), and very uncertain occurrences. In order to develop robust defense strategies, attempts to characterize uncertainty such as the *Assess-Risk-of-Policy* Framework (Lempert et al. 2004) that do not depend on expert consensus on probabilities might be helpful. Characterizing uncertainties is not contrary to what should be the guiding principle in such a case, i.e. a precautionary approach[1]; and, equity and efficiency should characterize any strategy taken for the adaptive measures (Linnerooth-Bayer and Amendola, 2000).

Precaution and equity therefore seem to have inspired the IPCC report on changing the politics and discourse of catastrophic weather by the tacit recognition that northern hemisphere countries are, or will be, contributing to weather-extreme losses in the developing world[2]. In response, climate-change negotiators have called upon parties to "consider" actions to meet the specific needs and concerns of developing countries with respect to the adverse impacts of climate change; e.g. the UNFCCC Climate Impact Relief Fund for weather-related disasters. As Linnerooth-Bayer (2003) discusses, the northern hemisphere countries could absorb a portion of the losses from weather-related disasters in the developing world by offering support for national insurance schemes in the form of backup systems for national public-private insurance, micro-insurance schemes, and government insurance for public infrastructure losses. Ex-ante financial instruments such as "Charity Catastrophe Bonds" also would offer complementary opportunities (Woo, 2001).

If climate change may affect future patterns of weather extremes, "normal climatic variability in the form of the ENSO cycle and inter-annual variability is already a great challenge" (Wisner 2004). Resilience to disasters should be established by medium and long-term risk management schemes (Lavell, 2004). The unavailability of ex-ante financial measures can set back economic development, depending on the size of a single catastrophic

---

[1] "Rather than seeing 'precaution' as being in tension with 'science based regulation', research… …suggests that key elements of a precautionary approach are entirely consistent with sound scientific practice in responding to intractable problems in risk assessment such as ignorance" (Stirling, 1999).

[2] Catastrophes and poverty were an early concern of IIASA activities (see the special issue of IIASA Options http://www.iiasa.ac.at/Admin/INF/OPT/Spring98/index.htm) which concern was reinforced after the devastating effects of the Hurricane Mitch (see http://www.iiasa.ac.at/Admin/INF/OPT/Winter99/options-fw99.pdf) when NGOs openly raised the question of holding the "North" accountable for their weather-related disaster losses as a result of the North's historical emissions of greenhouse gases.

event (as Mechler and Pflug (2002), and Mechler (2004) have demonstrated in the case of Honduras). Cycling variability however means that extreme weather events cannot be treated as statistically independent ones governed by an exponential distribution. Indeed, extreme events may be clustered in time, and clustering implies that losses over a shorter interval can lead to ruin even though individual losses are relatively small (MacDonald, 1999). Therefore, development of strategies to cope with this variability responds to efficiency criteria, and, at the same time, is beneficial against possible enhancement of such phenomena caused by Global Climate Change.

3. RISK AND THE RATE OF CHANGE

Another factor of risk, which probably had too low attention in disaster research, is the rate of change. As early as 1994, Bella et al. warned of the limitations in current global change research when restricted to steady state effects, in which some regions may gain and others loose. The most serious risks may arise from climatic transitions and possible consequent disorders. The authors recognized that with rapid changes "society would have to cope with physical, social and ecological systems that no longer fit the environments in which they evolved". This might result in three types of risk:

- *Technological Risks*. Structures such as dams adequately designed for present conditions might prove insufficient for future ones;
- *Social Risks*. Unprecedented global population shifts beyond national and regional boundaries;
- *Ecological Risks*. Changes in the frequency and severity of diseases, pest outbreaks, etc.

Social and technological responses were classified as "Mild" to "Catastrophic". The former might not be distinguished from dynamics without climate changes; whereas the latter could escalate up to desperate population migrations, revolutionary political changes, crisis and wars.

Consideration of the differential rate of change as a cause of disasters may not be restricted to climate. An interesting pictorial model used to study the "changes" is the Five- Store Pagoda Model (Okada and Tatano, 2000; Okada, 2001), which identifies a number of different layers which make up the complex socio-technical systems that may breakdown in a disaster. The lower the layer, the slower the speed of change of this component. Mismatches between layers can provoke/ aggravate a disaster. At the top layer, everyday activities have a much greater rate of change than that of the building environment which normally adapts itself, after a certain delay, to new needs. Infrastructures follow these changes. If destructive events occur when infrastructures have not yet completely adapted to economic activities and, therefore, are not sufficiently reliable and "redundant", damage done to infrastructure networks may have long lasting effects on the recovery process, or even nullify development efforts. Even longer periods are needed to change the "culture" layer. A mismatch can have serious consequences if a society is not yet prepared to cope with threats linked to changes induced by new technologies (side effects surprise); as well as "resistance" to the too rapid introduction of imported socio-cultural behavior (demonization of 'globalization', whichever form it may assume, hence terrorism). As an example, consequences of human activities on the natural environment (bottom layer) may be very slow (e.g., global warming) but also very slow (if not impossible) to reverse. Perturbations of the natural and socio-cultural environments are reasons for major disasters.

4. EARLY WARNING SYSTEMS AND UNCERTAINTIES

Whereas the resilience and capacity of a society must be established from the perspective of climatic variability and possible future changes, a large uncertainty in coping with actual events "is the contradiction between the increasing ability to prognosticate the occurrence of these phenomena at a global scale and the difficulty of predicting particular impacts at the local scale" (Lavell, 2004). The development and implementation of early warning systems with improvement of data acquisition and forecasting capability and, what is most important, their integration in policy and 'people-centered' design and implementation (Basher, 2004), therefore, should be given high priority.

Early warning systems and the anticipation of proximate hazards are not limited to climatic events. The lack of such systems dramatically increased the number of victims of the 2005 tsunami in Southeast Asia. Unlike other timely warning areas, seismic warning is not yet a mature science. Improvements in hazard assessment however have already resulted in time-dependent seismic hazard mapping (Sokolov et al. 2003), and anticipation of proximate earthquakes is producing integrated efforts for mitigation and preparedness, such as the Tonankai initiative in Japan (Kameda 2004, Okada, 2004). In addition, the 4th IIASA-DPRI Forum panel on advances in seismic hazards assessment showed that the accuracy of timely earthquake warnings is improving, even if predictions to date are not reliable or accurate enough to be used routinely for public warning. On the one hand, prediction methods [Kossobokov (2004): Peresan et al. (2204); and Panza et al. (2004)] have passed scientific testing in real-time prediction experiments and their improvements deserve more general attention; on the other, they could be used for improving seismic risk preparedness and prioritizing mitigation.

Once again, a fundamental attention must be paid to the management of uncertainties in early warning systems and in the communication of major hazards, as well as to conflicts in decisions with respect to financial costs and social disruption. To be effective, the warning process should utilize the integrated effort of scientists, administrators, and the public (Alexander, 2004). Only by such integration, and in presence of high social cohesion, can systems efficient in the case of real hazard occurrences and robust enough to resist disruption from false alarms be implemented. Despite the time that has elapsed since its proposal, the in-field work of De Marchi et al. (1993), after interviews with leading responsible persons in emergency planning and management, resulted in a classification that still now provides a very useful framework for understanding the nature of the uncertainties to be managed. In addition to *scientific uncertainties* (difficulties in risk assessment or forecasting), the other dominating uncertainties are

- *situational*: inadequate available information in relation to the necessary decisions
- *legal/moral*: possibility of future liability or guilt for actions or inaction

- *societal*: high when there is little integration between the public and concerned institutions
- *institutional*: the withholding of information by agencies for bureaucratic reasons
- *proprietary*: contested rights to know, warn or conceal (especially these concerning technological risks).

In the Tonankai project, Tsuchiya (2004) showed how daily losses caused by traffic interruption after a seismic warning are much higher than the actual daily losses after an earthquake. This certainly concretely affects only a subset of the communication network, and he doubted the practicability of such a warning. A very dramatic case is that of the emergency plan to evacuate 800,000 people from the very congested area around Mt. Vesuvius in Italy. In that case evacuation is foreseen to be for a long time being impossible to return once the anticipated explosive eruption takes place. Therefore, people will be dislocated to different Italian prefectures for shelter and assistance. The costs and risks of false alarms would be enormous. The associated legal/moral uncertainties are therefore overwhelming[3].

5. DISASTER RISK AND DIFFERENTIAL VULNERABILITY

Whereas a casual relation between global warming and the increased severity and frequency of climatic disasters is still not clear, there is no doubt that anthropogenic factors enhance vulnerability and exacerbate disaster severity. The burden is unequally distributed. Whereas economic losses are greater in industrialized countries, poor countries bear the greater burdens of natural disasters. Up to 95 percent of the deaths in recent disasters have occurred in poor countries. The global pattern of economic losses also is uneven, and, relative to GNP, the poor suffer disproportionately more financial costs. As Shah et al. (2001) noted; it is only in poor countries that drought turns to famine often resulting in population displacement, suffering, and loss of life. The social and economic costs of such occurrences may undo, in just a day or month, the achievements of years of development efforts. In this, the role of infrastructure losses is very important (Freeman and Pflug, 2003).

More and more, researchers are focusing the attention on “differential vulnerabilities” (Comfort et al. 1999, Tobin 1999), population aging resulting in larger vulnerabilities (Mitchell, 2003), violence as generator of vulnerability to natural hazards (Wisner 2003) and ‘hidden victims of disaster’ (Hoffman 2003). The pattern of differential vulnerability suggests a fractal structure; spatially differentiated exposure to hazards and an uneven capability in coping with them from the global to local level, thereby constituting a serious problem from the environmental justice perspective. This has been made clear by flood risk case studies done in Boston and Buenos Aries, the emphasis having been on improving the circumstances of the most disadvantaged sectors of the public in both cities (Suarez 2002).

If poverty is the major cause of vulnerability to disasters, fighting poverty means fighting disasters; but disasters may impede any chance of development; a vicious circle that must be broken. To do this, a better understanding of the natures of disasters is needed. A disaster should be characterized as a vector of multiple indicators for hazards and consequences, a significant but often neglected dimension being the disaster capability of exacerbating (and/or creating new) inequities. Neither severity scales nor disaster records indicate how losses are distributed or which parties are excluded from the recovery process. These few thoughts were expressed when discussing the rational for the Kyoto IDRM Forum (Amendola, 2003). A recent study of disaster indicators and their application to Latin American countries (Cardona ed. 2004) shows significant improvement in the characterization of disasters for the design of integrated risk management. It is worthwhile to summarize the rational for the proposed system of indicators.

The authors recognize the difficulty in achieving effective disaster risk management given the lack of a comprehensive conceptual framework that facilitates assessment and evaluation from an integrated, multidisciplinary perspective. “Disaster risk management needs risk *dimensioning*, and risk sizing signifies to take into account not only the expected physical damage, victims and economic equivalent loss, but also social, organizational and institutional factors”. Current indices and evaluations are not based on a holistic approach that is adequate for the diverse nature of decisions to be taken (of the different planning and control agencies responsible for the economy, housing, environment, public works, etc.) and diverse decision-makers (a mayor or a community at the local level vs. central government) involved. There is the need to understand how vulnerability is generated and how it accumulates. Different degrees of detail are needed on a micro-social or micro-territorial scale than aggregation and decisions on macro scales.

To achieve cross-national comparisons from 1980 to 2000, a proposed system of indicators has been benchmarked for different periods and countries. It is comprised of four groups of independent indicators:

1. The Disaster Deficit Index, DDI, deals with economic loss that a country might suffer when faced with a catastrophic event and the implications in terms of the resources required to confront the situation.
2. The Local Disaster Index, LDI, attempts to represent spatial variability and risk dispersion in a country resulting from small and recurrent events. This index represents the proneness of a country to low level or small-scale disasters and their cumulative impact.
3. The Prevalent Vulnerability Index, PVI, characterizes prevailing vulnerability conditions reflected in exposure in disaster-prone areas, socioeconomic fragility, and the lack of social resilience; aspects that favor the direct impact as well as the indirect, intangible impact in the case of the occurrence of a hazard event.
4. The Risk Management Index, RMI, measures a country’s performance level of risk management, taking into account the organization, development, and institutional action taken to reduce vulnerability, the reduction of the loss in case of haz-

[3] As discussed elsewhere (Amendola, 1998), this emergency plan was the first mitigation action after many years during which risk was ‘removed’ by the public and administrations, and uncontrolled development was allowed. Incentives now are being offered (up to 30,000 Euros per family) to move away from the most seriously menaced areas. To be effective, such measures should be accompanied by the creation of new attraction poles for economic activities far from the hazardous zones.

ard events, response preparedness in case of crisis, and efficiency of recovery (P. 4 – Cardona ed. 2004).

The reader is referred to the published report, which includes quantification exercises made for different countries in Central and South America. This system of indicators should provide a significant step forwards in representing risk, given its strength in the ability to disaggregate results and identify factors that should guide decision making of different scales. Also included in PVI are such "Indicators of Socio-economic Fragility (SF)", as poverty, human insecurity, dependency, illiteracy, social disparities, unemployment, inflation, debt, and environmental deterioration (P. 40, Cardona ed. 2004):

- Human Poverty Index,
- Dependents as a proportion of the working age population
- Social disparity, concentration of income.
- Unemployment as % of the total labor force.
- Inflation, food prices in annual %
- Dependency of GDP growth on agriculture in annual %
- Debt servicing as % of the GDP.
- Human-induced Soil Degradation.

As simple aggregate loss indicators can no longer be considered sufficient to characterize disaster impacts, long-term consequences of disasters should include the investigation of differential effects; losses in a particular sector or activity need to be studied keeping in mind possible beneficial impacts on competitors. A disaster results in changes, and, in any change there may be losers and winners. Permanent losses in one zone of a country might be accompanied by economic improvements in other zones; e.g. in addition to studying the long term effects of the earthquake on *Kobe Port activities* (Kajitani et al. 2001), it would be of great interest to accompany the study with insights into what was happening in other Japanese ports (or elsewhere).

Changes should be studied in depth, in all their multiple dimensions; organizational learning (Comfort and Sungu, 2002), social response attitudes (Sugiman 2002), land use (Kakumoto et al. 2002), etc.; but, a disaster also may mobilize 'latent' human resources. As an example, Friuli, one of the poorest Italian regions, was impacted by a severe earthquake in 1976, but is now part of the Northeast '*economic wonder*' in Italy. This is not explained simply by the resources allocated for its reconstruction, but more deeply by the new spirit of the communities severely affected by the earthquakes. This of course is possible when the effects are localized and absorbed by resources existing somewhere else in a country or community of countries. This kind of investigation adds knowledge which will help make communities more resilient to disasters.

In addition, changes due to the effects of globalization and increasing interdependence should be the subject of greater in-depth analyses, because of the implications for disaster risk management. Allmann (2000) warned that the Chi-Chi earthquake showed the vulnerability and interdependence of a modern, networked, high-tech society, and that effects of earthquakes can no longer be considered local; damage to production facilities in other locations would have an impact of very different dimensions, and in a worst case scenario of global dimensions the insurance sector could be much more severely affected.

As a different example, the human suffering pattern in the recent Southeast Asia tsunami was of unprecedented global dimension. Human losses were not only in the affected countries but throughout the globe. In northern Europe, the number of victims, mostly tourists, was probably greater than those in all natural disasters suffered at home for decades. Also in Europe, immigrants from that region suffered severe loss of life in their families living in the directly involved countries. Such global dimension accounts for the general mobilization of immediate aid, and the long-term engagements in early warning systems (hopefully to be fulfilled).

6. INSTITUTIONAL CHANGES

Uncertainties about future changes, the social disruption that inequalities can create, and increasing interdependencies of losses and suffering show that disaster risk cannot be viewed simply as a national issue. Unfortunately, increasing awareness is not yet reflected in strong institutional arrangements, not even within the European Union which places a very strong emphasis on environmental protection and related technological accidents but which did not enter the fight against natural disasters in its legal framework for common actions of member countries.

Moreover, even at the national level, disaster risk management requires integrated efforts not only with respect to the multiplicity of physical hazards, but in establishing measures to manage risks so that they are integrated within the planning and management of cities and regions, and to mitigate losses to achieve a better resilience to disasters. However, we are still far from these objectives. Every country lacks a coherent framework for coping with natural and man-made disaster risks by means of a consistent all-hazards approach. There also is an urgent need for consensus building within the research community towards a desirable general framework[4].

Regulations, financial provisions (think of the flood insurance program in the USA, where there is no parallel approach in that country for such other risks as wild fires and earthquakes), physical planning and control agencies separately act on specific kinds of risks, mostly without uniform requirements and criteria. Generally, only emergency planning and rescue agencies attempt an all-hazards approach, but response represents only one step in the risk management process which should start from hazard identification, prevention, mitigation, preparedness, early warning and response to end up with provision for loss compensation and recovery. In each of these other steps, competencies generally are distributed among different organizations, each dealing with selected issues relevant to specific hazards, often without cooperation, and disaster risks are not adequately integrated in planning activities. Furthermore, very seldom in the planning and risk management process is community awareness and participation enhanced in such a way as to become an essential component of risk prevention and mitigation policy (Shaw 2004). Gopalakrishnan and Okada (2003) maintain that current institutions are largely technocratic and bureaucratic, they neglect social and cultural symbiosis, and for this reason there has been far too little implementation of disaster mitigation measures. They draw attention to the importance of coordinated legislation, cultural values, and the recognition that disasters are social constructions.

[4] See report on Discussion Group 5 in the Proceedings of the 2nd IIASA- DPRI Forum.

They identify eight key elements for new institutions; awareness/access, autonomy, affordability, accountability, adaptability, efficiency, equity and sustainability.

The limits of the market call against deregulation[4]; however, to be effective regulations need to be implementable, but difficulties in implementation are evident, even in developed countries (Alesch and Petak 2001). This cannot be the result only of conflicting long-term versus short-term objectives; the weighting of immediate needs or wishes vs. devoting resources (when available,) to mitigation of future risks. Analysis of the complete pattern of causes and remedial measures deserve further research. In this spirit, the IIASA-DPRI Forum instituted reflection on 'Implementation Science' (Wisner 2004) aimed "at the systematic study of the relationship between the production of the knowledge necessary for prevention or mitigation of loss due to hazards and the successful implementation or use of that knowledge".

7. SOME CONCLUSIONS

This short review derives from a very subjective perspective on lessons learnt and highlights of the IIASA- DPRI discussion forum. A different perspective would focus on other aspects worth discussion and provide the reader some different starting points for new research.

It raises - without responding - a number of questions, and proposes a few suggestions:

- Not only would North-South solidarity compensate for effects of possible human induced climate changes but would be beneficial because of its contribution to reducing international social disruptions. As Wisner (2003) proposes, links should be established between disaster risk research community and research for peace (Friedenforschung);
- Resilience to cyclic climate fluctuations already is a major challenge, calling for long term measures, which also would guard against possible increases in rate and intensity of weather- related extreme events caused by global climate change;
- Attention must be paid to the rate of change, and the marked interdependencies of losses;
- Early warning systems are effective when people centered and in a clear institutional frame that is based on trust and social cohesion, keeping in mind the nature of the uncertainties involved;
- Better characterization of disaster risks is possible via indicators that present in a sufficient degree of detail the risk situation tailored to diverse decisions and decision makers. Such indicators are being developed to include differential vulnerabilities;
- Studies of changes occurring after disasters should aim at understanding how to improve resilience and reduce exacerbation of inequalities;
- Wide-scoping reflection is needed to obtain institutions that are able to approach disaster risk management holistically for the successful implementation of regulations and knowledge.

REFERENCES

Because this review principally concerns outcomes of the IIASA-DPRI conferences on Integrated Disaster Risk Management, to avoid needless repetition only the number of these events is given in hereafter. Proceedings have been published on the web. The complete references are:

- The 1st Forum: IDRM Reducing Socio-Economic Vulnerability, IIASA, Laxenburg, Austria, 1-4 August 2001, http://www.iiasa.ac.at/Research/RMS/dpri2001/.
- The 2nd Forum: IDRM Vulnerability and Resilience of Large Urban Systems (Megacities), IIASA, Laxenburg, A, 29-31 July 2002, http://www.iiasa.ac.at/Research/RMS/dpri2002/.
- The 3rd Forum: IDRM Coping with Regional Vulnerability, Kyoto International Conference Hall, in Kyoto, Japan, 3-5 July 2003, http://idrm03.dpri.kyoto-u.ac.jp/proceedings.htm.
- The 4th Forum: IDRM Challenges of Implementation, CUEBC, Ravello (Salerno), Italy, 3-7 July 2004, http://www.iiasa.ac.at/Research/RMS/ dpri2004/.

Alesch D. J. and W. Petak, 2001. Overcoming obstacles to implementing earthquake hazard mitigation policies. The 1st IIASA-DPRI Forum.

Alexander, D., 2004. From seismic prediction to earthquake warning (or not). The 4th IIASA-DPRI Forum.

Allmann, A. and G. Smolka, 2000. Increasing loss potential in earthquake risk: a reinsurance perspective. Euro-Conference on Global Change and Catastrophe Risk Management: Earthquake Risks in Europe, IIASA, A, July 6-9, 2000, http://www.iiasa.ac.at/Research/RMP/july2000.

Amendola, A., 1998. Earthquakes and volcanoes: managing multi-factor natural risk in Italy. In Études et Dossiers No 219: Selected papers from the M.O.R.E. 13 Seminar on Multi-Factor Risks, Hannover, Germany, June 11-12, 1998, The Geneva Association, 1998.

Amendola, A., 2003. The conference road map: a few comments on climate change, man-made disasters and the IDRM research agenda. The 3rd IIASA-DPRI Forum.

Basher, R., 2004. Drought resistance and resilience: the roles of early warning, networking and the UN International Strategy for Disaster Reduction. The 4th IIASA-DPRI Forum.

Bella, D. A., R. Jacobs, and H. Li, 1994. Ecological indicators of global climate change: a research framework, Environmental Management, 18, 4, 489-500.

Bronstert, A., 2003. Floods and climate change: interactions and impacts. In Linnerooth-Bayer, J. and A. Amendola, eds., 2003. Flood risk in Europe. Risk Analysis, 23, 3, June 2003.

Cardona, O. D., ed. 2004. Information and indicators program for disaster risk management, IADB - ECLAC – IDEA, Execution of Component II: Indicators For Disaster Risk Management, Operation Atn/Jf-7907-Rg, Results of the System of Indicators' Application on Twelve Countries of the Americas, Universidad Nacional de Colombia, Manizales, October.

Green, C., 2003. Change, risk and uncertainty: managing vulnerability to flooding. The 3rd IIASA-DPRI Forum.

Comfort L., B Wisner., S. Cutter, R. Pulwarty, K. Hewitt, A. Oliver-Smith, J. Wiener, M. Fordham, W. Peacock and F. Krimgold,1999. Reframing disaster policy: the global evolution of vulnerable communities. Environmental Hazards, 1, 39-44.

Comfort, L. and Y. Sungu, 2002. Organizational Learning From Seismic Risk: The 1999 Marmara And Duzce, Turkey Earthquakes. The 2nd IIASA-DPRI Forum.

De Marchi, B., S. Funtowicz and J. Ravetz, 1993. The management of Uncertainty in the Communication of Major Hazards, EUR 15268

EN, Commission of European Communities.

Freeman, P. K. and G. Ch. Pflug, 2003. Infrastructure in developing and transition countries: risk and protection. In Linnerooth-Bayer, J. and A. Amendola, eds., 2003. Flood risk in Europe. Risk Analysis, 23, 3, June 2003.

Gopalakrishnan, C and N. Okada, 2003. Enhancing the Effectiveness of Integrated Management for Disaster Risk: The Case for Institutional Innovations. The 3rd IIASA-DPRI Forum.

IPCC, Intergovernmental Panel on Climate Change, 2001. Impacts, adaptation, and vulnerability. Contribution of Working Group II to the Third Assessment Report (pp. 1032-1090). Cambridge, Cambridge University Press. Working Group II Summary for Policymakers, Report approved at the Sixth Session of the IPCC WGII, Geneva, Switzerland, 13-16 Feb.

Hoffman, S., 2003. The hidden victims of disaster. Environmental Hazards, 5, 67-70.

Ikebuchi, S., 2003. Global warming and weather-related disasters. The 3rd IIASA-DPRI Forum.

Kaczmarek, Z., 2003. The impact of climate variability on flood risk. In Linnerooth-Bayer, J. and A. Amendola, eds., 2003. Flood risk in Europe. Risk Analysis, 23, 3, June 2003.

Kajitani, Y., H. Tatano and N. Okada, 2001. Long-term Effects of the Hyogo Nanbu Earthquake on Economic Activities at the Port of Kobe. The 1st IIASA-DPRI Forum.

Kakumoto, S. et al., 2002. Analysis of earthquake damage using spatial temporal GIS (DiMSIS): a case study for Duzce Municipality in Turkey. The 2nd IIASA-DPRI Forum.

Kameda, H., 2004. National advanced seismic hazard program (government of Japan). Science-policy-implementation. The 4th IIASA-DPRI Forum.

Kossobokov, V., 2004. Earthquake prediction basics. The 4th IIASA-DPRI Forum.

Lavell, A., 2004. The Niño and Niña in Latin America: challenges for policy and practice. The 4th Annual IIASA-DPRI Forum.

Lempert, R., N. Nakicenovic, D. Sarewitz, and M. Schlesinger, 2004. Characterizing climate: change uncertainties for decision – makers: an editorial essay, Climatic Change, 65, (1-2), 1-9. Linnerooth-Bayer J., 2003. Climate Change, Adaptation and Insurance. The 3rd IIASA-DPRI Forum.

Linnerooth-Bayer J. and A. Amendola, 2000. Global Change, natural disasters and loss sharing: issues of efficiency and equity. The Geneva Papers on Risk and Insurance 25, 203-219.

Linnerooth-Bayer, J. and A. Amendola, eds., 2003. Flood risk in Europe. Risk Analysis, 23, 3, June.

MacDonald, G.,1998. Climate and catastrophic weather events. Paper presented at the Engineering Academy of Japan, 17 Apr. 1998. IIASA, Laxenburg, Austria.

MacDonald, G.J., 1999. Climate and Catastrophic Weather Events, Report IR-99-034, IIASA.

Mechler, R., 2004. Estimating financial vulnerability to natural disasters. The 4th Annual IIASA-DPRI Forum.

Mechler, R. and G. Pflug, 2002. The IIASA model for evaluating ex-ante risk management: case study Honduras. Report to the IDB. Washington DC, IDB.

Milly, P.C. D., R.T. Wetherald, K.A. Dunne, and T.L. Delworth, 2002. Increasing risk of great floods in a changing climate. Nature 415, 514-516.

Mitchell, J. K., 2003. European River floods in a changing world, In Linnerooth-Bayer, J. and A. Amendola, eds., 2003. Flood risk in Europe. Risk Analysis, 23, 3, June 2003.

Munich Re, 2003. Topics, Vol. 10, Natural Catastrophes in 2002, Munich Re Group.

Nachtnebel, H.P., 2003. The 2002 Elbe flood in central Europe. The 3rd IIASA-DPRI Forum.

Palmer, T.N. and J. Rälsänen, 2002. Quantifying the risk of extreme seasonal precipitation events in a changing climate. Nature 415, 512-513.

Okada, N. and H. Tatano, 2000. Evaluation of seismic disaster risk taking into account human behavior, in confronting urban earthquakes, Report on fundamental research granted by the Ministry of Education and Research, JP.

Okada, N. 2001. Integrated disaster risk management: a new perspective and illustrations from Japanese challenges. The 1st IIASA-DPRI Forum.

Okada, N. et al., 2004. Special session on the Tonankai Earthquake Initiative Project. The 4th IIASA-DPRI Forum.

Panza, G.F., A. Peresan, F. Vaccari and A. Gorshkov, 2004. Earthquake preparedness: the contribution of earthquake prediction and deterministic hazard research. The 4th IIASA-DPRI Forum.

Peresan, A., L. Romashkova, G.F. Panza, V. Kossobokov, and I. Kuznetsov, 2004. Earthquake predictions: present day reproducible recipes and future possibilities. The 4th IIASA-DPRI Forum.

Red Cross, 2002. World Disaster Report, Geneva, Switzerland.

Schnur, R., 2002. The investment forecast. Nature 415, 483-484.

Shah. M, G. Fischer and H. van Velthuizen, 2001. The challenge of integrated mitigation: food vulnerability and climate change. The 1st IIASA-DPRI Forum.

Shaw, R. (2004) Sustainability of Community-Based Flood Risk Management in Bangladesh. The 4th IIASA-DPRI Forum.

Sokolov, V., A., C.H., Ovcharenko and K.L. Wen. (2003): Time-dependent seismic hazard assessment for the Taiwan region: new conception and ideas for seismic risk management. The 3rd IIASA-DPRI Forum.

Stirling, A., 1999. On science and precaution in the management of technological risk. European Commission, Joint Research Centre, IPTS Seville, EUR 19056 EN.

Suarez, P. 2002. Urbanization, climate change and flood risk: addressing the fractal nature of differential vulnerability, The 2nd IIASA-DPRI Forum.

Sugiman, T., 2002. A sociological lesson from the 1995 Hanshin Earthquake in Japan: acceleration of two trends toward modernized and post-modern societies. The 2nd IIASA-DPRI Forum.

Tobin A., 1999. Sustainability and community resilience: the holy grail of hazards planning? Environmental Hazards ,1, 13-25.

Tsuchiya, S., 2004. Collaborative modeling of metropolitan earthquake disaster vulnerability assessment. The 4th IIASA-DPRI Forum, and, DPRI-IIASA Workshop on the Dai-dai-toku (Tonankai Initiative): November 17 and 18, Kyoto University, Japan.

Weiss, C., 2004. Expressing Uncertainty. IFIP/IIASA/GAMM Workshop on Coping with Uncertainties, 13-16 December, Laxenburg, Austria.

Wisner, B., 2003. Violent conflict and disaster: the scientific, moral, and policy challenges to integrated disaster risk management. The 3rd Annual IIASA-DPRI Forum.

Wisner, B., 2004. Highlights and central messages from the 4th Annual IIASA-DPRI Forum.

Wisner, B., 2004. the challenge of "implementation science". The 4th IIASA-DPRI Forum.

Woo, G, 2001. Risk acceptance as a charitable donation. The 1st Annual IIASA-DPRI Forum.