Int. J. Disaster Risk Sci. 2010, 1 (1): 17–23
doi:10.3974/j.issn.2095-0055.2010.01.004

ARTICLE

Research on Integrated Disaster Risk Governance in the Context of Global Environmental Change

Peijun Shi[1,2,3,*], Ning Li[2,3], Qian Ye[1,3], Wenjie Dong[4], Guoyi Han[1,3], and Weihua Fang[1,3]

[1]State Key Laboratory of Earth Surface Processes and Resource Ecology, Beijing Normal University, Beijing 100875, China
[2]Key Laboratory of Environmental Change and Natural Disaster, Ministry of Education of China, Beijing Normal University, Beijing 100875, China
[3]Academy of Disaster Reduction and Emergency Management, Ministry of Civil Affairs and Ministry of Education, People's Republic of China, Beijing 100875, China
[4]College of Global Change and Earth System Science, Beijing Normal University, Beijing 100875, China

Abstract To achieve sustainable development, understanding of the impact of global environmental change on natural resources and the frequency, intensity, and spatial-temporal patterns of all kinds of hazards should be advanced. In recent years, severe losses of human lives and property have been caused by very large-scale natural hazards all over the world, such as the freezing rain and snowstorm disaster in China in 2008, Typhoon Sidr in Bangladesh in 2007, and Hurricane Katrina in the United States in 2005. Strengthening the study on integrated disaster risk governance has become a pressing issue of sustainable development. Supported by the Chinese National Committee for the International Human Dimensions Program on Global Environmental Change (CNC-IHDP), its Working Group for Risk Governance proposed to the IHDP in 2006 to launch a new international research project on integrated risk governance (IRG) in the context of global environmental change. The IRG-Project was accepted by the IHDP Scientific Committee as a pilot science project in 2008 and was approved in 2010 as a full IHDP core science project under the Strategic Plan 2007–2015. The research foci of this international science project will be on the issues of science, technology, and management of integrated disaster risk governance based on case comparisons around the world, in order to advance the theories and methodologies of integrated disaster risk governance and to improve the practices of integrated disaster reduction in the real world.

Keywords catastrophic disaster coping, disaster risk, global environmental change, sustainable development

1 The Scientific Significance of Integrated Disaster Risk Governance Research in the Context of Global Environmental Change

In recent years, different types of catastrophes have frequently emerged worldwide, including the freezing rain and snowstorm disaster in southern China in early 2008, Hurricane Katrina in 2005 with its destructive impact on New Orleans in the United States, and the heat wave over Europe in 2003. According to the statistics of the World Bank (2006), from 1984 to 2003, more than four billion people in developing countries were afflicted by different kinds of natural disasters, while economic losses between 1990 and1999 exceeded those between 1950 and 1959 fifteenfold. As shown by both the Emergency Events Data (EM-DAT) of the Center for Research on the Epidemiology of Disasters (CRED), Belgium, and the historical data of disasters from the reinsurance companies, Swiss Re and Munich Re, frequency of disasters has shown a rising trend over the last two decades (Scheuren et al. 2008). Worldwide, the total number of flood and windstorm events increased approximately 7 percent annually between 1988 and 2006, and 8 percent between 2000 and 2007. Casualties and economic losses caused by these natural disasters also grew. According to the United States National Research Council (NRC 2006), from the 1960s to the 1990s, there was a rapid upwards trend of these losses. In developing countries, in many cases disaster losses have been greater than 3 percent of GDP and triggered serious economic crises. Mortality has also been concentrated in developing countries. For instance, in the 1990s, 90 percent of the 880,000 people who lost their lives during natural disasters worldwide were in developing countries (Perrow 2007). These catastrophes share a common feature, that is, through a chain of disasters, their impacts far exceeded the coping capacity of the social ecological systems of the directly affected areas, as well as of the world as a whole. In the face of this new phenomenon, the international science community generally felt the inadequacy in the current development of research on risk analysis, especially on the governance of catastrophic disaster risks. For the safe and stable social and economic development in disaster areas and even in the whole world, it is expected that research on risk governance will make new breakthroughs, including the creation of new concepts, new technologies, and new management models. As a discipline directly serving the social and economic safety of human society, it is of

* Corresponding author. E-mail: spj@bnu.edu.cn

paramount importance that new research results, models, and theories of disaster risk science are applied in actual risk governance in a timely and effective fashion.

In view of the theoretical and practical significance of undertaking such research, the Chinese National Committee for the International Human Dimensions Program on Global Environmental Change (CNC-IHDP) has taken prompt action. A proposal of developing a core IHDP science project to specifically tackle the issues of integrated risk governance was officially submitted by Dr. Yanhua Liu, Chairman of CNC-IHDP, and Dr. Quansheng Ge, General Secretary of CNC-IHDP, to Professor Oran Young, Chairman of the IHDP Science Committee (SC), during the IHDP Science Committee Regional Workshop held in Beijing in early November 2006. In the proposal, the basic framework of the integrated risk governance project was drafted, based on the research work conducted by the CNC-IHDP Risk Governance (RG) group. The IHDP SC showed great interest in the proposal and responded promptly by coordinating and organizing a special working group formed by thirty international experts and cochaired by Professor Peijun Shi of Beijing Normal University and Professor Carlo Jaeger of the Potsdam Institute for Climate Impact Research. After several workshops held in the United States, China, and Germany and numerous meetings with different interest groups, the working group completed the first draft of the IRG-Project Science Plan in September 2008. This draft was formally accepted for review by the IHDP Science Committee during its meeting in New Delhi, India in October 2008. After the review process involving more than a hundred experts from around the world, the IRG-Project Science Plan was formally accepted and the IRG-Project was officially launched in late 2010.

It is hoped that by strengthening international cooperative research projects on integrated disaster risk governance, the IRG-Project can provide an excellent opportunity of joining efforts to explore large-scale disaster coping strategies and the formation mechanisms of different disaster risks on the background of global environmental change and the need to discover risk countermeasures for governance and adaptation. The research outcomes of the IRG-Project can both advance the scientific understanding of very large-scale disasters for high-risk industries and regions, and support regional sustainable development and the harmonious development of humans, nature, and society.

2 Progress of International Research on Integrated Disaster Risk Governance

Integrated disaster risk research in the context of global environmental change has important practical value for large-scale disaster risk governance, and is also of theoretical and practical importance for developing earth systems science and promoting regional and global sustainable development. On 11 December 1987, the 42nd General Assembly of the United Nations declared the last decade of the twentieth century as the International Decade for Natural Disaster Reduction (IDNDR). Since then, scientists in various natural and social science disciplines, decision-makers in the business sectors and policy-makers in governmental and non-governmental organizations in different countries all over the world have undertaken research on integrated disaster risk management from different angles and implemented a series of engineering projects for disaster reduction and disaster risk governance. Although great progress has been made in the international strategy for disaster reduction, scientific theories on how to deal with new challenges remain elusive, including how to move from single disaster risk governance to integrated disaster risk governance, from disaster risk reduction to disaster risk transfer (for example, how the financial burden can be widely shared), and from regional disaster risk governance to global disaster risk governance.

2.1 Emphasizing Capacity Building for Integrated Disaster Risk Governance

Over the last decade, developed countries have achieved remarkable progress in risk research and risk management. Many scholars (Alexander 2000; Blaikie et al. 1994; Bouchaud and Potters 2000; Bunting et al. 2007; Burton, Kates, and White 1995; Haimes 2004; Jasanoff 1986; Jorion 1997; Linnerooth-Bayer, Mechler, and Pflug 2005; Morgan et al. 2002; Renn 2008; Sen and Drèze 1995), research institutions, and international organizations (ICSU 2008; UNISDR 2004; NRC 2006; OECD 2003; World Bank 2006; UNDP 2004) have synthesized the progress of various research undertaken over the years on disaster risks and laid a solid foundation for further research on integrated disaster risk governance. Today with rapid globalization, new risks are emerging, which are challenging the human coping capacity constantly. The potential risks and consequences of social, economic, and technological developments, such as nuclear deterrence during the cold war, computer network hacking, nanotechnology, the subprime mortgage crisis, and global climate change, exceed the current governance capacity of society. Environmental hazards such as earthquakes, tsunamis, and hurricanes also severely affect human society. To cope with risks from catastrophes, the United Nations organized two World Conferences on Disaster Reduction in Yokohama (1994) and Hyogo (2005), Japan, and issued the Yokohama and Hyogo Declarations. The Yokohama Declaration aimed to build a safer world in the twenty-first century and stressed the mobilization of all possible forces for achieving the goals set out for the UN-IDNDR. Based on an assessment of the implementation of the strategy and actions stemming from the Yokohama Declaration, the Hyogo Declaration elaborated on the relationship between global sustainable development and disaster risk reduction. It called on the member countries of the United Nations to pay close attention to the increasing frequency and severity of various disaster risks that may be triggered by global environmental change and the huge barriers this may create for realizing the global sustainable

development objective, and to attach great importance to strengthening the capacity of nations and communities to resist disasters.

The United Nations International Strategy for Disaster Reduction (UNISDR) explicitly proposed the establishment of a social system of living with risk and stressed the promotion of regional sustainable development by starting with building the capacity of communities to resist risks (UNISDR 2004). For developing countries, it is extremely important to stress the development and enhancement of integrated risk governance. Due to the impact of global environmental change and especially global warming, some small island countries and coastal developing countries are highly vulnerable and have low resilience and poor adaptation to disasters. They are bearing greater risks in the face of global environmental change. In the United Nations Millennium Development Goals (UN-MDG), developing the science and technology of integrated risk governance, reducing the impact of various disasters, and improving the capacity of coping with different disasters are part of an important policy for the sustainable development of human society.

In response to UN-MDG, the 6th IHDP Open Meeting held in Bonn, Germany in 2005 included global security as its main theme for discussion, to probe into policy, economic, social, and technological approaches for realizing sustainable development and disaster risk reduction. World Conferences on Disaster Reduction held in Davos, Switzerland in 2006 and 2008 have also underlined the core topic of promoting regional sustainable development and disaster risk reduction, and especially stressed the recovery and reconstruction of ecological systems as important infrastructure developments of countries and regions, so as to slow the aggravation of various disaster risks, and reduce the frequency of disasters.

2.2 Focusing on Catastrophic Disaster Risk Caused by Global Warming

Increasing evidence from observations has shown that global warming has led to an increase in frequency of abnormal weather and climatic conditions, aggravated disaster impacts, and has caused catastrophic disasters in some regions (Emanuel 2005). In its *Fourth Assessment Report*, the Intergovernmental Panel on Climate Change (IPCC) indicated that the impacts of global warming on human society are not only widespread, but also profound. Impacts such as frequent abnormal climatic conditions and disastrous weather, expansion of drought affected areas and increased drought and storm frequency, and more frequent tropical cyclones in some regions, for example, will cause huge risk to the sustainable development of human society and economy, even the very existence of life on earth (WMO 2007). In formulating measures to cope with catastrophic disasters, policy-makers of governments at all levels, producers, and scientists must pay close attention to global warming, regardless of the share of contribution of its natural and human causes and its future direction. Especially the possible contribution of global warming to the increase in large-scale disasters will be of central concern. For instance, frequent abnormal weather and climate caused by global climate warming may impact the normal operation of some infrastructures worldwide and increase the risk of production accidents. In regions experiencing power shortages due to high temperatures in summer, air-conditioning significantly increases total energy consumption. Consequently, the electric grid is overloaded, causing interruptions of grid operation and production accidents. In recent years, this phenomenon has occurred frequently in the eastern part of China, including the Pearl River Delta, the Yangtze River Delta, and the Beijing-Tianjin-Tangshan area. Recent increases of heavy snowfall in Europe has caused higher traffic hazard risk as well as damaged power grids in some areas, impacting the normal power supply and making the disaster situation worse. Freezing rains and snowstorms in southern China in early 2008 damaged the power grids and triggered a catastrophe that had rarely occurred in history.

Global warming has also affected the global ecosystem. According to primary observations, large-scale infectious diseases in recent years such as Severe Acute Respiratory Syndrome (SARS) and bird flu have all been closely associated with the poor condition of the global ecological system and especially the damage to biological diversity. New understanding of hazard-formative environments for large-scale disasters is of important value for revealing the mechanisms and processes of global environmental changes causing elevated global risk levels, and for formulating new strategies for integrated disaster risk governance.

2.3 Paying Close Attention to Potential Spatial-Temporal Transfer of Globalization-Induced Catastrophic Disaster Risks

As an important part of global change, globalization has accelerated in recent years due to the promotion by the World Trade Organization (WTO) and other economic and trade organizations. China and India, with the highest proportion of the world's population, have both become an important factor in accelerating the process of globalization. Through trade, finance, science and technology, and other approaches, rapid development of globalization has clearly increased the spatial diffusion of various risks (World Bank 2006).

Facilitated by the WTO framework, the circulation of important strategic materials such as petroleum and other energy and mineral resources has been accelerated among countries and regions in the world, and the exchange of financial products has also shown a trend of exponential rise. Due to the rapid growth of such exchanges, the spatial diffusion of different risks has been accelerated and their scope of influence has been expanded. According to some studies (Dilley et al. 2005), the existence of some high-risk regions in the world is not only associated with natural hazards in these places, but also with their level of internationalization in the process of economic and social development. Since China joined the WTO, for example, urbanization and the development of industrial zones with high dependence on international markets have accelerated in the economically

developed eastern coastal regions, including the Pearl River Delta, the Yangtze River Delta, and the Beijing-Tianjin-Tangshan area. Affected by the 2008 global financial crisis, the manufacturing and export economy was exposed to greatly aggravated risks, and the impact is far-reaching in those coastal regions with a high dependence on international trade.

Worldwide promotion of disaster insurance and reinsurance in diversified forms by developed countries has also expanded the affected area spatially. For instance, in recent years international insurance companies such as Swiss Re and Munich Re have been permitted to provide reinsurance services in China, so have some international direct insurance companies and brokers for insurance services. Various risks in China have been transferred, through international insurance and reinsurance, to other countries in the world. During the rapid development of the Chinese market economy, international insurance and reinsurance companies have gained their shares in the Chinese insurance and reinsurance market as well as shared the cost from various risks in China. This phenomenon indicates that management of disaster risk has been not only a question of natural science and technology, but also closely linked with economics, social science, and international trade.

2.4 Recognizing the Great Scientific Importance of Integrated Research on Disaster Risk by the International Scientific Community

In 2008, the International Council for Science (ICSU) officially proposed a science program of Integrated Research on Disaster Risk (IRDR) concerning natural and human-induced environmental disaster risk, with the objectives of (1) comprehending hazard, vulnerability and risk, that is, identification of the sources of risks, hazards forecasting, risk assessment and dynamic modeling; (2) understanding decisions in the context of complex and changing risks, that is, identifying the linked decision-making systems and their interaction, understanding decisions on the background of environmental hazard and improving the quality of decision-making behavior; and (3) reducing risk and control losses through knowledge-based actions, that is, assessing vulnerability and seeking effective approaches for risk reduction. This project stresses focusing on capacity building to realize these targets, including the capacity of disaster mapping, the coping capacity at different disaster reduction levels for various disasters, and the capacity for improving disaster prevention. Emphases are also placed on case studies and demonstrations, risk assessment, data management and monitoring, and on how to inform global actions with regional practices and vice versa. In launching this project, ICSU emphasized the globalized nature of disaster impacts, and the role of social and human factors and the effects of global environmental change in disaster risk formation. It also elaborated on the starting point of the research program, that is, focusing on risk and disaster risk reduction requires integrated multidisciplinary and multidimensional exploration of various disasters and disaster chains, and emphases on capacity building of data and information services and data and information sharing in the program.

3 Objectives, Scientific Issues, Research Foci, and Technical Methods of the IHDP IRG-Project

Given the role the IRG-Project aims to play in global integrated risk governance, in the following sections we briefly introduce important aspects of this project, especially its research foci and methods.

3.1 The Research Goal of the IRG-Project

As addressed in the IRG-Project Science Plan (Integrated Risk Governance Project 2010), the goal of the IRG-Project is to (1) reveal the dynamic process of formation mechanisms for catastrophes; (2) explore the governance mode of "transition in and transition out"[i] for mitigating catastrophic disasters that exceed the current coping capacity; (3) improve various models and modeling tools; and (4) establish integrated disaster risk science that meets the requirements of sustainable development. These should be based on adequate comprehension of dynamic changes in local or regional social ecological systems in the broad context of global environmental change, and achieved by comparing and analyzing typical cases worldwide.

3.2 Scientific Questions Addressed by the IRG-Project

Scientific questions addressed by the IRG-Project are primarily on the relationship between climate change and various natural disasters at different scales; how to define the critical point where certain occurrence is at its entry- and exit-transitions (see endnote); the dynamics of disaster risk "transition in" and "transition out"; what can be done in "transition in" and "transition out" stages; and how to evaluate institutional capacities in coping with risks.

Technically, the IRG-Project mainly focuses on accurately measuring various risks; improving models for assessing disaster chain risk; improving tools for modeling disaster risk scenarios; securing information for emergency response; and improving financial measures for risk transfer of catastrophic disasters.

Managerially, the IRG-Project focuses on exploring the political and economic institutions that are beneficial for risk governance; the cooperation mechanisms that are beneficial for risk governance and emergency response; the way government, business, and the public share the burden of risks; improving the national and international standards for risk governance; and enhancing the managerial levels of institutions to cope with catastrophic disaster risk.

3.3 Research Foci of the IRG-Project

In connection with the research objectives and scientific issues of the IRG-Project, the following research foci have been proposed:

3.3.1 Formation Mechanisms, Processes and Dynamics of Catastrophic Disaster Risk

Based on an adequately clear understanding of the impact of global environmental change on various catastrophic disaster risks, the IRG-Project research teams will explore the mechanisms of interaction between global or regional social ecological systems and major hazards, elaborate on the evolution and change of catastrophic disaster risks, and create dynamic models for scenario modeling of catastrophic disaster risks. This research will help us deepen understanding of risk chains that have profound impact on the world, especially those potential and extremely complex disaster risks that have exceeded human coping capacity, such as global financial crises and infectious diseases, including pandemic influenza and SARS, and various serious natural disasters in close connection with global climate change.

3.3.2 Transformation Mechanisms of "Transition in" and "Transition out" of Catastrophic Disaster Risk

With a focus on better understanding the dynamics of coping with catastrophic disaster risk in global or regional social ecological systems, research in this area will focus on capturing signals of risk inoculation, determining the critical points where "transition in" and "transition out" take place in social ecological systems of different scales, integrating and optimizing measures of preparation, emergency response, recovery, and reconstruction, and establishing a modeling system for assessing emergency plans for catastrophic disaster risk governance. Special attention will be paid to understanding what causes the sensitivity and vulnerability of social ecological systems of different scales and how to develop adequate measures to improve their resilience and adaptation to catastrophes.

3.3.3 Models and Simulations for Assessing Catastrophic Disaster Risk

To study catastrophic disaster risks with extremely low probability, historical comparisons and scenario analyses will be applied. Research will focus on improving the models for assessing losses, developing models for assessing indirect economic losses, and establishing the modeling system for assessing global or regional impacts of catastrophes. More emphases will be on developing the indicator systems and models and modeling methods for disaster chains of catastrophic events, establishing a web-based global and regional catastrophic disaster risk information system, improving and increasing the capacity of mapping global and regional catastrophic disaster risks, and the capacity to provide information services and diffusion of catastrophic disaster risk information, and developing a web-based, graphic-oriented, searchable risk network based on the Google Earth concept.

3.3.4 Case Comparisons and Paradigms of Catastrophic Disaster Governance

The IRG-Project will carefully select representative catastrophe cases worldwide, such as the 2008 freezing rain and snowstorm disaster in southern China, the 2008 Wenchuan Earthquake in China, the 2005 Hurricane Katrina in the United Stated, the 2004 Indian Ocean Tsunami, the 2003 heat wave in Europe, the 1995 Hanshin-Awaji Earthquake in Japan, the 2008 global financial crisis triggered by the subprime mortgage crisis in the United States, African drought and grain crises, global food security crises, bird flu, and so on, for comparative case studies on catastrophe governance. After analyzing the structure and function of the social ecological systems of countries or regions suffering from these catastrophes, a database of case comparisons will be developed for global catastrophic disaster risk governance which then can be used to compare how different countries or regions, through coping with catastrophic disaster risks, have "entered into" and "transited out of" catastrophes, to evaluate their experiences and lessons learned, to make policy recommendations, and to provide an overview of catastrophic disaster risk governance models.

The above research foci may be summarized as: (1) understanding catastrophic disaster risk; (2) revealing the "transition in and out" mechanisms of catastrophic disaster risks; (3) establishing models and modeling methods for catastrophic disaster risks; and (4) comparing cases of coping with catastrophic disaster risks.

3.4 Research Strategies of the IRG-Project

The research strategies of the IRG-Project departs from a clear focus on understanding coupled social ecological systems and dynamics of "transition in" and "transition out" for mitigating catastrophic disasters, taking on a modeling approach that is informed by robust empirical case studies through effective international cooperation networks.

3.4.1 Focusing on Social Ecological Systems

To undertake the IRG-Project research under the framework of the IHDP development strategy, it is necessary to always represent the broad intersection between disciplines and to deepen our understanding of the interaction between humans and nature in global environmental change. We must also strive for understanding the structure, function, and dynamic change of the past, present, and future global and regional social ecological systems, that is, the human and natural systems.

3.4.2 Comprehending "Transition In and Out"

By acknowledging the spatial-temporal randomness of catastrophic disaster risks and the critical thresholds of coping with these risks, the IRG-Project is encouraging more research on understanding how catastrophic disaster risks enter and exit affected social ecological systems of different scales, that is, the "switching" mechanisms in the governance process of catastrophic disaster risk systems.

3.4.3 Taking Advantage of Models and Modeling

To tackle the complexity of catastrophic disaster risk systems, the IRG-Project will take full advantage of using modern nonlinear science in improving models of complex systems, developing, on the basis of empirical analyses of adequate cases and optimizing conceptual models, different quantitative models for catastrophic disaster risk governance, and making use of scenario simulation to improve tools for the assessment of catastrophic disaster risks and the evaluation of capacities for coping with catastrophes.

3.4.4 Reviewing Experiences and Lessons in Coping with Catastrophic Disaster Risks

In order to gain experiences and learn the lessons from the process of coping with extremely rare risks, identify successful actions that can improve human coping capacities, and gradually improve the sustainable development strategies and actions that enable us to live with risks, using case studies is extremely important in the IRG-Project research work. The IRG-Project will pay close attention to the cases of coping with catastrophic disaster risks around the world.

3.4.5 Establishing Effective International Cooperation Networks

The IRG-Project will not only fully use the existing research and exchange network of IHDP but also work closely with other integrated risk research bodies and organizations, such as the International Institute for Applied Systems Analysis and the Disaster Prevention Research Institute of the Kyoto University (IIASA-DPRI) expert team, the International Risk Governance Council (IRGC) expert team, the OECD catastrophic disaster risk financial management expert team, and the ICSU-IRDR expert team. We shall take advantage of the modern internet system and establish the information and knowledge exchange platform for multidimensional and multilevel academic exchange and cooperation.

4 Summary

Exploring strategies for catastrophic disaster risk governance in the context of global environmental change has become imperative. The initiation of the IHDP-IRG Core Science Project and the implementation of the ICSU-IRDR program will improve understanding of catastrophic disaster risks and the formulation of measures for catastrophic disaster risk governance. Taking into account the current status of and requirement for such research, the following aspects need to be strengthened in research on catastrophic disaster risk governance:

4.1 Better Understanding of the Formation and Change of Catastrophic Disaster Risk in the Context of Global Environmental Change

It is clear that our current understanding is still very limited on many fundamental issues associated with catastrophic disaster risks. The IRG-Project will provide a platform for the international risk community to tackle the issues including the interaction of humans and nature and the formation mechanisms of disaster risk in the global system, the global trend of disaster risks and their spatial-temporal patterns in the face of global warming, the predictability of global environmental change and the changing patterns of natural disasters and ecological disaster risks, globalization and global dissemination and diffusion mechanisms of catastrophic disaster risks, catastrophe impacts on the affected regions and the world as a whole, and feedback mechanisms.

4.2 Developing a New Generation of Integrated Risk Assessment Models and Simulation Models

By collecting data and developing a comprehensive database, the IRG-Project will coordinate and work with other international organizations to carry out in-depth research on: (1) model systems of risk assessment with consideration of different spatial-temporal dimensions and formation mechanisms of various catastrophic disasters; (2) scaling-up and scaling-down of models considering different risk formation mechanisms; (3) vulnerability and resilience assessment models with small or incomplete samples; (4) improvement of regional integrated catastrophic disaster risk models; and (5) the development of regional social vulnerability assessment models.

4.3 Improving Research and Practice for Integrated Catastrophic Disaster Risk Governance

As an application oriented research program, the IRG-Project will pay attention to carrying out in-depth research on: (1) institutional design for adapting to different catastrophic disaster risks in the face of global environmental change; and (2) regional standards for catastrophic disaster risk governance, regional and global catastrophic disaster risk governance models, review and application of regional experiences in catastrophic disaster risk governance, and regional catastrophic disaster risk modeling and classification of high-risk areas under different scenarios, including different

spatial-temporal dimensions, formation mechanisms, and vulnerability and resilience of the exposed units.

4.4 Exploring Better Mechanisms of Catastrophic Disaster Risk Transfer from an Interdisciplinary Perspective

By developing a community information service platform for governing catastrophic disaster risks, the IRG-Project will organize and coordinate both natural and social scientists, engineers, business decision-makers, and government policy-makers to conduct research on (1) technology innovation for reducing catastrophic disaster risks with different spatial-temporal dimensions and formation mechanisms; (2) construction of business and community safety and catastrophic disaster risk management systems; (3) mechanisms for promoting insurance and reinsurance for catastrophic disaster risks; (4) institutional design and technological development for improving the catastrophe emergency response and relief systems; (5) organizational structures for promoting and improving the emergency response volunteer systems; and (6) the mechanism for promoting and improving the public financial support systems for catastrophic disaster risk education.

Acknowledgments

This article was completed with the support and guidance from Research Fellow Yanhua Liu, Chairman of CNC-IHDP, and Research Fellow Quansheng Ge, General Secretary of CNC-IHDP, as well as with guidance and help from the members of the IHDP-IRG Science Program Expert Team, especially Professor Carlo Jaeger, cochair of the IRG-Project planning team.

The research project this article is based on is sponsored by the International Cooperation Project of the Ministry of Science and Technology, "Global Climate Change and Catastrophe Governance" (2008DFA20640) and the International (Regional) Exchange Project of the National Natural Science Foundation, "Case Study on Core Science Projects of IHDP-IRG" (40821140354).

Note

i "Transition in" or "entry-transition" refers to transitions by which a given social ecological system switches into emergency or crisis mode, in dealing with a hurricane or a financial collapse, for example. "Transition out" or "exit-transition" refers to transitions by which a given social ecological system switches back from emergency or crisis mode to a normal mode, which may or may not be the same it was in before the crisis (Integrated Risk Governance Project 2010, 75). See *Integrated Risk Governance Science Plan* (Integrated Risk Governance Project 2010) for details.

References

Alexander, D. 2000. *Confronting Catastrophe—New Perspectives on Natural Disasters*. Oxford: Oxford University Press.

Blaikie, P., T. Cannon, I. Davis, and B. Wisner. 1994. *At Risk: Natural Hazards, People's Vulnerability, and Disasters*. London: Routledge.

Bouchaud, J. P., and M. Potters. 2000. *Theory of Financial Risks: From Statistical Physics to Risk Management*. Cambridge: Cambridge University Press.

Bunting, C., O. Renn, M. V. Florin, and R. Cantor. 2007. The IRGC Risk Governance Framework. *John Liner Review* 21 (2): 7–26.

Burton, I., R. W. Kates, and G. F. White. 1995. *The Environment as Hazard*. New York: Guilford Press.

Dilley, M., R. S. Chen, U. Deichmann, A. L. Lerner-Lam, and M. Arnold. 2005. *Natural Disaster Hotspots: A Global Risk Analysis*. Washington, DC: World Bank.

Emanuel, K. 2005. Increasing Destructiveness of Tropical Cyclones over the Past 30 Years. *Nature* 436: 686–88.

Haimes, Y. Y. 2004. *Risk Modeling, Assessment, and Management*. New York: John Wiley.

ICSU (International Council for Science). 2008. *A Science Plan for Integrated Research on Disaster Risk: Addressing the Challenge of Natural and Human-Induced Environmental Hazards*. Paris: ICSU.

Integrated Risk Governance Project, International Human Dimension Program for Global Environmental Changes (IHDP). 2010. *Integrated Risk Governance Project Science Plan*. Bonn, Germany. http://www.irg-project.org.

Jasanoff, S. 1986. *Risk Management and Political Culture*. New York: Russell Sage.

Jorion, P. 1997. *Value at Risk: The New Benchmark for Controlling Market Risk*. New York: McGraw-Hill.

Linnerooth-Bayer, J., R. Mechler, and G. Pflug. 2005. Refocusing Disaster Aid. *Science* 309 (5737): 1044–46.

Morgan, M. G., B. Fischhoff, A. Bostrom, and C. J. Atman. 2002. *Risk Communication: A Mental Models Approach*. Cambridge, MA: Cambridge University Press.

NRC (National Research Council) of the National Academies. 2006. *Facing Hazards and Disasters: Understanding Human Dimensions*. Washington, DC: The National Academies Press.

OECD (Organization for Economic Co-operation and Development). 2003. *Report on Emerging (Systemic) Risks in the 21st Century*. Paris: OECD.

Perrow, C. 2007. *The Next Catastrophe: Reducing our Vulnerabilities to Natural, Industrial and Terrorist Disasters*. Princeton: Princeton University Press.

Renn, O. 2008. *Risk Governance: Coping with Uncertainty in a Complex World*. London: Earthscan.

Scheuren, J.-M., O. le Polain de Waroux, R. Below, D. Guha-Sapir, and S. Ponserre. 2008. *Annual Disaster Statistical Review: The Numbers and Trends 2007*. Melin, Belgium: Center for Research on the Epidemiology of Disasters (CRED).

Sen, A., and J. H. Drèze. 1995. *The Political Economy of Hunger*. Oxford: Clarendon Press.

UNDP (United Nations Development Program). 2004. *Reducing Disaster Risk: A Challenge for Development*. New York: United Nations.

UNISDR (United Nations International Strategy for Disaster Reduction). 2004. *Living with Risk: A Global Review of Disaster Reduction Initiatives* (2 vols). New York and Geneva: ISDR, United Nations.

WMO (World Meteorological Organization). 2007. *Climate Change 2007: The Physical Science Basis, Summary for Policymakers*. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Paris, February, 2007.

World Bank. 2006. *Hazards of Nature, Risk to Development: An IEG Evaluation of World Bank Assistance for Natural Disaster*. Washington DC: World Bank.