IHDP-Integrated Risk Governance Project Series

Peijun Shi · Carlo Jaeger
Qian Ye *Editors*

Integrated Risk Governance

Science Plan and Case Studies of Large-scale Disasters

BEIJING NORMAL UNIVERSITY PUBLISHING GROUP
BEIJING NORMAL UNIVERSITY PRESS

Springer

IHDP-Integrated Risk Governance Project Series

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About this Series

This book series, entitled "IHDP-Integrated Risk Governance Project Series" for the International Human Dimensions Programme on Global Environmental Change—Integrated Risk Governance Project (IHDP-IRG Project), is intended to present in monograph form the most recent scientific achievements in the identification, evaluation and management of emerging global large-scale risks. Books published in this series are mainly collected research works on theories, methods, models and modeling, and case analyses conducted by scientists from various disciplines and practitioners from various sectors under the IHDP-IRG Project. It includes the IRG Project Science Plan, research on social-ecological system responses, "Entry and Exit Transition" mechanisms, models and modeling, early warning systems, understanding regional dynamics of vulnerability, as well as case comparison studies of large-scale disasters and paradigms for integrated risk governance around the world. This book series, therefore, will be of interest not only to researchers, educators and students working in this field but also to policy-makers and decision-makers in government, industry and civil society around the world.

The series will be contributed by the international research teams working on the six scientific themes identified by the IRG Project science plan, i.e., Social-Ecological Systems, Entry and Exit Transitions, Early Warning Systems, Models and Modeling, Comparative Case Studies, and Governance and Paradigms, and by six regional offices of the IRG Project around the world.

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ISSN 2194-6728 ISSN 2194-6736 (electronic)
IHDP-Integrated Risk Governance Project Series

ISBN 978-3-642-31640-1 ISBN 978-3-642-31641-8 (eBook)
DOI 10.1007/978-3-642-31641-8
Springer Heidelberg New York Dordrecht London

Library of Congress Control Number: 2012942018

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

Foreword I

The Millennium Development Goals, which range from halving extreme poverty to halting the spread of HIV/AIDS by the 2015 target date, were established by countries around the world when Heads of State met at the United Nations in New York in 2000 to adopt the UN Millennium Declaration. Any observer, looking back on the first eight years of the new century, can see that many challenges remain if the world truly wants to see these goals met. Beyond the numerous evident obstacles, rapid changes and uncertainties in both ecosystems and societies, as well as in the interactions between the two, present nebulous challenges.

From the "9–11" terrorist attack in the US in 2001 to China's Wenchuan Great Earthquake in 2008, from the Tsunami in the Indian Ocean to the global sub-prime financial crisis, losses in human lives and properties caused by natural hazards and nefarious human actions have increased dramatically. Although many of these disasters differ in the ways societies have responded and in the specific contexts in which they occurred, they share important commonalities: Their impacts were not confined to political boundaries, and they required multi-scale, multi-actor, cross-sectoral responses to reduce human, economic and environmental losses, which, despite wide-ranging mobilizations, were immense anyway. The scale and intensity of these events took governments by surprise and challenged longstanding institutionalized solutions to disaster planning, response, management and recovery. These losses, which show an upward trend corresponding to the frequency and intensity of large-scale disasters, provide the reasons for urgent action to improve the effectiveness of response systems.

Both experience and lessons learned from IHDP's first decade efforts strongly demonstrate that to better understand and then effectively respond to these mounting challenges on very large-scales requires not only innovations and technologies from the sciences, including the social sciences, but also new developments in institutions, policies and management mechanism at all levels of government. As identified in the IHDP's strategic plan for the next decade, we are now facing a challenge of developing a better understanding of the dynamics of coupled socio-ecological systems, which fully integrate the impacts of human actions into analyses of global environmental changes.

First initiated by the Chinese National Committee for the IHDP (CNC-IHDP) in 2006 during the Earth System Science Partnership (ESSP) Open Science Conference in Beijing, a global study of very large-scale risks was formally launched at an international workshop held in Beijing in September, 2007. Under the leaderships of Prof. Peijun Shi, Beijing Normal University (BNU), and Prof. Carlo Jaeger, Potsdam Institute for Climate Impact Research (PIK), a group of scientists and supporting staff from both BNU and PIK worked extensively for the past two years. After the first workshop, the Planning Group met at Beijing Normal University (February 2008), where the initial outline for this project was drafted. Two writing workshops held in Santa Barbara, USA and Potsdam, Germany, were produced a Pilot research plan for the project. The Pilot research plan was then submitted to the IHDP Scientific Steering Committee in New Delhi, India (October 2008) for further comment. Community input was discussed by the Planning Group at a meeting in Beijing (January 2009) and used to guide further revision of the Science Plan. Several anonymous reviewers provided substantive comments, and their input led to the final revision of the final document.

The Plan describes the rationale for an enhanced global scientific research effort on very large-scale disasters over the next decade and poses five key science questions—about socio-ecological systems, about transition-in and transition-out, about models and modeling, about comparative case studies, about governance and paradigms.

The Science Plan was advocated by the Scientific Committee of IHDP in Bonne, Germany on October 2010 and launched formally in Beijing, China on May 10, 2011. I firmly believe that this plan will provide an excellent cooperated platform for integrated large-scale disasters (LSD) risk governance under the global climate change and make up a net of global LSD risk researches quickly. I also expect that this plan can provide scientific evidence and strategic advices to policy makers of LSD risk governance. Based on IHDP-IRG Project, the fruits of research presented in this book illuminate the practical value and research meaning of IHDP-IRG Project and promote the substantial development of areas and global.

May 11, 2011

Former Chairman of IHDP Scientific Committee
Chairman of IHDP-IDGE Core Science Project
Professor of College of Environmental Science and Management
The University of California, Santa Barbara

Foreword II

Rapid economic development in the world, especially in countries with emerging markets and large populations; the exponential increase of computer and Internet users; innovations in multi-media and telecommunication technologies; findings in genetic and nano-technologies—these among numerous other examples illustrate the emergence of human societies into a new age. Along with the benefits of this emergence, however, come certain costs, such as how the impacts of man-made and natural disasters, which in previous ages were confined to one country or region, are now, through the globalization of economic processes and the reach of mass media outlets, amplified, influencing every corner of the world.

At least on some spatial and temporal scales, the development of human societies on a global scale has clearly begun to have an inordinate influence on complex planetary environmental systems, which themselves have considerable variability. In fact, some international organizations and research institutions, such as the IPCC, have indicated that human activities are now the major driving factor behind global environmental change. But human influence is not limited to the abstract, statistical trends of climatic processes of interest only to atmospheric and environmental scientists. On the contrary, recent research indicates that the frequency, intensity and impacts of natural weather hazards are strengthening, a portentous change that should worry individuals in all societies.

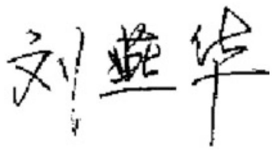
Research on catastrophes in the past has shown that, although such events impacted all countries, the attributes of natural and social catastrophic risk in different countries strongly depended on differences in social and political systems during different periods of the catastrophe. Mechanisms, policies, and laws for hazard prevention, response and reconstruction, on the one hand, differ for different cultures. On the other hand, however, human societies, for their own evolutionary needs, must all develop secure social and natural environments, which should be a primary and universally recognized responsibility of all governments. In the context of economic globalization, a contribution and dispersal mechanism to mitigate impacts of large-scale disasters (LSD) is also necessary.

Motivated by these understandings, the Chinese National Committee for the IHDP proposed an International Research Cooperative on Risk Governance to the

IHDP in 2006. We were so glad that IHDP Scientific Steering Committee accepted the proposal and took the lead to organize and form a task group which is consisted of a group of internationally distinguished scientists. In the past two years, this group, supported by both Beijing Normal University and Potsdam Institute for Climate Impact Research, conducted a thorough, cooperative survey of catastrophes in the context of global environmental changes. Altogether, more than 100 individuals have participated in planning workshops/meetings and/or have contributed written material to the planning process. Although it is not possible to thank each individually, their collective contributions are gratefully acknowledged.

It is my hope that this Science Plan can be used to stimulate not only more scientific research in the field of risk governance to work cooperatively for the purpose of better understand great challenges from the changing Earth environment but that it can also assist government at all levels to better understand and respond more efficiently and effectively to threats, so the real people who compose the abstract society can benefit most from this project.

The fruits of research presented in this book, based on IHDP-IRG Project, illuminate that the response strategy of integrated LSD risk governance has a very wide application and important innovative academic value. The comparative case studies on LSD risk governance represent the different experiences and lessons which can be learned by us in varied countries and areas during the risk governance process. Under this scientific plan, I expected that scientific workers can create more LSD risk governance strategies for human society, and also the Chinese companions who involves in this subject can summarize the response's experiences and lessons of China and absorb the advanced experiences of risk governance in order to develop the enterprise of LSD and make more contributions to LSD risk governance discipline.



May 11, 2011

State Council Adviser of the People's Republic of China
Former Vice Minister of Ministry of Science and Technology of China
Chairman of Chinese National Committee for IHDP
Researcher of Geographical Science and Resources Institute
The Chinese Academy of Sciences

Preface

About IHDP-IRG Project

Integrated Risk Governance Project (IRG Project) is an international science project sponsored by International Human Dimensions Programme for Global Environmental. Change (IHDP). IRG Project was proposed in 2006 by Risk Governance Group (RG) of Chinese National Committee for International Dimensions Programme on Global Environmental Change (CNC-IHDP). Designated by IHDP Scientific Committee, IRG Project Scientific Planning Committee was formed to prepare the IRG Project science plan. IHDP Scientific Committee finally approved the IRG Project as the pilot project in 2009. Later on, upon further revision by IRG Project Scientific Planning Committee in view of the reviews and comments of various anonymous commentators, IRG Project was officially approved as one of the 8 core science projects of IHDP at Bonn Meeting of IHDP Scientific Committee in October 2010. On May 10, 2011, the IHDP-IRG Project was formally launched in Beijing, China. As a ten-year international cooperative research project, the IRG Project's mission is to improve the governance of new risks that exceed current human coping capacities by focusing on the transitions in and out of the occurrence of relevant risks in the context of global climate changes.

About the Book Series for IHDP-IRG Project

In order to timely represent and report the progress of IHDP-IRG Core Science Project, the Project Office decided to irregularly edit and publish the achievements of this international research project. In addition to disseminate regularly the relevant information of IRG Project via the project official website and the newsletter of IHDP-IRG Project, as well as its official peer-reviewed journal, International Journal of Disaster Risk Science (IJDRS), an agreement of publishing a book series both in Chinese and English, which covers the systematic research achievements of IHDP-IRG Core Science Project, was made between the IRG Project and Springer, through Beijing Normal University Press, China.

The Book Series for International Human Dimensions Programme on Global Environmental Change—Integrated Risk Governance Project (IHDP-IRG Project) is to present in monograph form the most recent scientific achievements in the identification, evaluation and management of emerging global large-scale risks. The books published in this series are mainly collected research works in theories, methods, models and modeling, and case analyses conducted by scientists from various disciplines and practitioners from various sectors under the IHDP-IRG Project. The Book series include IRG Project Science Plan, research on social-ecological system response, “Entry and Exit Transition” mechanism, models and modeling early warning systems in the integrated risk governance as well as case comparison studies of large-scale disasters and integrated risk governance paradigm. This book series, therefore, will be not only of interest to researchers and students working in this field but also to policy and decision makers in the government, industry and civil society around the world.

Integrated Risk Governance IHDP-IRG Project Science Plan and the case studies of large-scale disasters is the first book of the book series for IHDP-IRG Project. This book consists of two parts: Part I: Integrated Risk Governance Project Science Plan which outlines the challenge, research programme, outcomes, and implementation strategy of IRG Project; Part II: Case Studies of Large-scale Disasters, including case analyses of experience, lessons learned and recommendations on various large-scale disasters around the world, such as Tangshan and Wenchuan Earthquake and Great Ice-storm in China, European Heat Waves, and Hurricane Katrina in USA. The Community Model of Integrated Natural Disaster Risk Governance and Paradigm of Catastrophe Risk Governance in China are also presented.

The editorial office of the book series is hosted by International Project Office (IPO) (Beijing) of IHDP-IRG Project, with Peijun Shi (the co-chair of the project and professor of Beijing Normal University) and Carlo Jaeger (the co-chair of the project and professor of Potsdam Institute for Climate Impact Research) as its chief editors and Professor Qian Ye (the executive director of IPO and professor of Beijing Normal University) as its technical editor.

Professor Shi Peijun is the executive vice-president of Beijing Normal University. He got his Ph.D. degree of paleogeography at Beijing Normal University. He is the vice chairman of the Expert Committee of the National Disaster Reduction Commission of China. He is also a member of OECD’s High Level Advisory Board on Financial Management of Large-scale Catastrophes. Prof. Shi’s research focuses on natural disaster theories and risk governance. He has been the principal investigator of many national and ministerial research programs and has published numerous journal papers and books.

Carlo Jaeger is Professor for modeling social systems at Potsdam University in Germany, chair of the research domain “Transdisciplinary Concepts and Methods” at the Potsdam Institute for Climate Impact Research, and chair of the Global Climate Forum. He holds degrees in economics (Ph.D., Frankfurt University), sociology (diploma, University of Bern), and human ecology (habilitation ETH Zurich) and has worked extensively on interactions between technological progress and environmental problems, in particular the role of information technologies for urban development. He is member of the Scientific and Technical Council of IRGC (International Risk Governance Council), and has served on the boards of various scientific organizations. He has considerable research experience in the field of stakeholder dialogues. His current research interest is focused on the role of financial markets in managing climate change.

It is expected that the book series will be contributed by the international research teams working on the six scientific themes identified by the IRG Project science plan, i.e., Social-Ecological Systems, Entry and Exit Transitions, Early Warning Systems, Models and Modeling, Comparative Case Studies, Governance and Paradigms, as well as six regional offices of IRG Project around the world.

May 20, 2012 IHDP-IRG Project IPO

Acknowledgments

We are profoundly grateful to a series of institutions and people whose initiatives and support made IRG Project possible in the first place. They include:

- The Ministry of Science and Technology (MOST) of the People's Republic of China; former Vice-Minister Yanhua Liu of MOST;
- International Human Dimensions Programme on Global Environmental Change (IHDP);
- Oran Young (former chair), Andreas Rechkemmer (former executive director), Falk Schmidt (former officer) of IHDP;
- The Integrated Risk Government Council (IRGC);
- The International Disaster and Risk Conference (IDRC);
- Beijing Normal University (BNU);
- The Potsdam Institute for Climate Impact Research (PIK);
- The Global Climate Forum (GCF).

Special thanks for inspiring conversations go to Nicole Dewaendre, Hans Föllmer, Mickey Glantz, Jill Jäger, Jay Kadane, Rupert Klein, Wolfgang Kröger, Ragnar Löfstedt, Granger Morgan, Christian Mumenthaler, Joachim Oechslin, Elinor Ostrom, Ortwin Renn, Gene Rosa, Alois Rust, Teddy Seidenfeld, Sander van der Leeuw and many more. Finally, we thank the reviewers appointed by IHDP for their stimulating comments.

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Part I
Integrated Risk Governance Project Science Plan

Chapter 1
Executive Summary

The Scientific Planning Committee of IHDP-IRG Project

We propose a 10 year international effort in risk research to learn how to deal with risks that exceed current coping capacities.

This effort shall use key insights developed by researchers operating in the framework of IHDP, as well as in other settings. We will study risk occurrences as events in the dynamics of socio-ecological systems (see the glossary for brief comments on key words like "risk", "risk occurrence", etc.). We will focus on the entry transitions by which a given socio-ecological system switches into emergency or crisis mode, e.g. in dealing with a hurricane or a financial collapse, and the exit transitions by which the system switches back from emergency or crisis mode to a normal mode. We are especially interested in cases where the system switches back into a different normality than the one it had before the crisis. We are particularly interested in systems in which the system's resilience increased after a switch back and future risks are reduced as a result of social learning.

To study these transitions, IRG Project shall develop a creative network of senior and junior researchers and practitioners in developed and developing countries. In the spirit of grounded theory, IRG Project will proceed through a sequence of comparative case studies complemented by other methods. In particular, we will use multi-agent modelling to study the interaction between the economy and other parts of socio-ecological systems. We will start by investigating a small number of contrasting cases and stepwise add other cases as the investigation proceeds. IRG Project is conceived as a process of discoveries, and therefore will consciously create the space for surprises. The discoveries to be made shall contribute to an effective framework of integrated risk governance in view of the considerable risks humankind is facing in the 21st century.

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P. Shi et al. (eds.), *Integrated Risk Governance*, IHDP-Integrated Risk Governance Project Series, DOI: 10.1007/978-3-642-31641-8_1,

Fig. 1.1 Residents stand next to where the landslide took place in the village of Mabono in Bulambuli district, about 270 kms (170 miles) northeast of Kampala on August 30, 2011. Landslides triggered by heavy rains in eastern Uganda killed at least 29 people on August 29 as mud submerged homes and entire families. At least 15 people died in Mabono. (Michele Sibiloni/ Imaginechina)

Fig. 1.2 Nov. 21, 2011—San Pedro, California, U.S.—A view of the scene after heavy weekend rains caused a portion of the cliffside and roadway on Paseo del Mar into collapse into the ocean in San Pedro, California. No one was hurt and no structures were damaged as a result of the slide. (Imaginechina)

Fig. 1.3 An aerial view of a house in flooded area of Sanghar on November 27, 2011. Aid groups warned on November 9 that vital relief efforts for five million people affected by floods in Pakistan's fertile southern belt could be cut back because of a shortfall in foreign donations. (Rizwan Tabassum/Imaginechina)

Fig. 1.4 March 15, 2011—Miyako, Iwate, Japan—People stand on the roofs of collapsed houses after the tsunami devastated Miyako city (Imaginechina)

The present science plan starts by setting out the challenge faced by risk research in view of sustainable development—a challenge that has both practical and theoretical dimensions. We then describe the research strategy with which we will tackle this challenge. The strategy combines different methods by focussing on a sequence of comparative case studies. Next, we indicate the outcomes to be produced, ranging from input into professional training and education to synergies with practical efforts at improving integrated risk governance. Finally, we delineate the implementation plan, with special emphasis on a cooperative scheme linking researchers in developing and in developed countries (Figs. 1.1, 1.2, 1.3, 1.4).

Chapter 2
The Challenge

The Scientific Planning Committee of IHDP-IRG Project

Large-scale disasters, which exceed the current coping capacity of socio-ecological systems, are on the increase. Recent examples include the 2008 drought in Ethiopia and other African countries, China's great ice storm of 2008, hurricane Katrina of 2005 in the U.S., the European heatwave of 2003, as well as the global financial crisis of 2008. An important feature of these disasters is the striking inequality between the vulnerability of people most exposed to the different disasters and the privileged position of others. This is part of the moral mazes (Jackall 2009) in which risk professionals nowadays operate. And in the years to come, the challenge will rise much further (Fig. 2.1).

During the period from 1984 through 2003, the population influenced by natural disasters exceeded 4 billion people, mostly in developing countries. The economic losses due to disasters in 1990–1999 surpassed those during the period 1950–1959 about 15 times (World Bank 2006). Current work by the Center for Research on the Epidemiology of Disasters reveals an upward trend in the frequency of disasters over the past two decades (Scheuren et al. 2008). Damaging floods and storms in particular have increased by about 7 % per year between 1988 and 2006—they exhibit an average annual growth rate of about 8 % between 2000 and 2007. Likewise, human and economic losses are on the increase. Economic losses have increased substantially from the 1960s through the 1990s (NRC 2006). In developing countries, these losses are likely to trigger serious economic damage to developing countries, in some years exceeding 3 % of a country's GDP. Deaths from natural disasters are similarly concentrated in developing countries. 90 % of the 880,000 estimated deaths in the 1990s, for example, occurred in developing countries (Perrow 2007) (Fig. 2.2).

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P. Shi et al. (eds.), *Integrated Risk Governance*, IHDP-Integrated Risk Governance Project Series, DOI: 10.1007/978-3-642-31641-8_2,

Fig. 2.1 A car buried by 3 m of snow for three days were dug up in Huanan county, Jiamusi, China on December 27, 2010. (Shaofeng Liu/Imaginechina)

Although these disasters differ in the ways societies responded to them or in the specific contexts in which they occurred, many of them share important commonalities. Their impacts were not confined to political boundaries, they required multi-scale, multi-actor, cross-sectoral responses, and the human, economic and environmental losses were often immense. The scale and intensity took many governance systems by surprise and challenged longstanding institutionalized solutions to disaster planning, response, management, and recovery. These losses, which show an upward trend corresponding to the frequency and intensity of large-scale disasters, provide an urgent case for improving the effectiveness of our response systems. In a recent overview of the role of research in disaster management, the US National Research Council (NRC 2006) emphasized the need for systematic comparative research that examines the nature of catastrophic disasters and which sheds light on how societies improvise and innovate in their responses. While many factors contribute to any specific disaster, there is little doubt that global environmental change triggered by human activities plays a major role. In the case of climate change this has begun to raise serious concern in the insurance industry (Dlugolecki 2000).

Increasing risks are one of the most significant aspects of the human dimensions of global environmental change. Sustainable development has been defined as a pattern of development ensuring that humankind meets the needs of the present without compromising the ability of future generations to meet their own needs. It is precisely this ability that is compromised by a growth pattern that does increase

Fig. 2.2 Bath tub in front of dilapidated house, Kolmanskop, Namibia, Africa (Imaginechina)

the expected value of income per capita but at the same time amplifies many risks that threaten future generations. The willingness to accept increasing risks as long as they do not materialize in the immediate present is one of the most important features of unsustainable development. Slowing down and ultimately reversing this tendency towards increasing risks is one of the most important challenges of our times. The ability—and perhaps even the willingness—to do so is quite limited, however. One reason for this is the difficulty to understand the risk dynamics. Different circumstances cannot and should not be ignored (Ostrom 2005), but they often are. Plausible explanations may deflect attention from the need for more subtle analysis, as when a focus on forces of nature puts the different possibilities to cope with them into the background (Mileti 1999). Growth of population, of income per capita, of energy use, of production of pollutants all matter, but how can the relevance of each one of these factors be assessed? And how do they relate to the economic mechanisms that enable entrepreneurs to take risks at a global scale (Shiller 2004)?

The ability to take huge risks is a precondition of the technostructure that enables humankind to communicate, travel, and trade all around the globe, and to produce unprecedented welfare by doing so. But clearly this ability has somehow gotten out of hand. As a result, a major question of fairness arises both with regard to the relation between highly industrialized and less developed countries, and to the relation between present and future generations. It is a complex issue, because future generations are quite likely to be richer in monetary terms and better off in many other respects than present ones. But at the same time they are quite likely to face even larger risks than we do presently. The lack of fairness in dealing with risk between generations is compounded by the lack of fairness within present generations. Risks to health, welfare, and safety are distributed very unevenly across humankind, and it is hard to justify this distribution by any widely recognized standards. And those parts of humankind that currently face the greatest risks also have less rosy prospects for their offspring. Under these circumstances, there is a long way to go in order to achieve something that deserves the name of sustainable development. The know-how on risk governance that is currently available is certainly helpful to address this situation, but it is hardly sufficient. IRG Project shall contribute to further enhance that know-how as an integral component of the transition towards sustainable development.

2.1 Rationale

Shakespeare's Merchant of Venice—with his combination of risk and uncertainty, the rule of law and legal loopholes, credit and interest on credit, bankruptcy and sudden fortune, greed, cruelty, and solidarity—marks the birth of modern risk governance.

Modern society could not have emerged without a new fabric of financial institutions (Bernstein 1996). This fabric enables entrepreneurs to risk large losses by sharing with other agents the—positive or negative—consequences of taking these risks. This new approach to risk has evolved hand in hand with scientific knowledge about risk, provided by a wide range of disciplines, including economics, engineering, geography, mathematics, and more. From a practical point of view, clearly insurance firms are key to the modern approach to risk. But modern insurance is impossible without credit, and banks providing credit are continuously engaged in their own process of risk assessment. Insurance firms in turn have expanded their business to an extent that they needed an insurance of their own operations, and so re- insurance has become another pillar of modern risk governance.

To be able to function, today's insurance industry needs possibilities to invest huge amounts of money in ways that are profitable by themselves—because otherwise nobody would be willing to put the necessary amounts of money aside—while allowing insurers to turn their assets back into money very quickly if the need arises. These possibilities are provided by stock markets, which have become another essential component of the contemporary fabric for handling risk. At the same time, stock markets generate risks of their own, and to handle these a wide variety of hedging operations has been developed. While hedge funds concentrate on this kind of operations, hedging is a standard procedure in many companies, be they in insurance, banking, other services, or manufacturing. Finally, the whole system of market-based risk businesses relies on government as a further stabilising factor in the face of risk. This holds for central banks, but also for various systems of social security. From a theoretical point of view, key insights are due to the work of mathematicians. In the 17th century, two French mathematicians (Pascal and Fermat) developed a mathematical concept of probability in order to analyse various gambles. Their concept was rooted in the distinction of two finite sets: a set of equally likely possible events and a subset of favorable ones. The simplest case is a coin with the possibilities of heads and tails together with a bet that heads will obtain. Because of its link with the notion of possibility, their concept had non-trivial philosophical ramifications (Hacking 2006). Already Aristotle had noticed that even in a finite world there is infinity of possibilities. But if there is infinity of equally probable possibilities, each one of them must have a probability of zero, and so what actually happens will always have zero probability. It took several generations of mathematicians to develop a concept of probability that would work well with infinite sets.

The results are the axioms of Kolmogorov, which today are the canonical way to frame mathematical probability theory. But now out of an infinite set of possible events-represented, e.g., by the real numbers between 0 and 1—one can define a set of favorable events that is "unmeasurable", i.e. such that no probability can be obtained for a favorable event to occur. While these may seem technicalities of no interest for the practitioner, they are linked to all sorts of philosophical puzzles (Hendricks 2001). The use of mathematical probability theory has given to the practical machinery for risk governance an aura of reliability, objectivity, and precision. How far this aura can be sustained in the face of both subtle theoretical problems and drastically increasing global risks remains to be seen.

In the past decades, massive advances have been made in risk analysis, management, and governance. They have been synthesized by a range of scholars (Alexander 2000; Blaikie et al. 1994; Bouchaud and Potters 2000; Bunting et al. 2007; Burton et al. 1995; Haimes 2004; Jasanoff 1986; Jorion 1997; Linnerooth-Bayer et al. 2005; Morgan et al. 2002; Renn 2008; Rodriguez et al. 2006; Drèze et al. 1995) and of organizations (ICSU 2008; ISDR 2004; NRC 2006; OECD 2003; The World Bank 2006; UNDP 2004). The resulting literature provides a rich toolbox to address a large variety of risk problems. Again and again, however, the history of risk governance has been marked by the emergence of risks that exceeded the coping capacity of their times. This led to the formation first of the insurance industry, later of re-insurance. At the beginning of the 21st century, humankind as a whole again faces risks that exceed our current coping capacity. Paramount are the risks that come with nuclear weapons (Sagan 1993; Shultz et al. 2008). At the time of writing, the most urgent ones are those implied by today's global financial system (Shiller 2004). Global environmental risks, especially those of climate change, seem to exceed current coping capacity as well (WBGU 1998). The risks of pandemics, of asteroid impacts, of technologies like nanotechnology may well be in the same category. These risks cannot be dealt with in isolation: an ill-conceived climate policy may trigger a financial crisis that destabilizes critical regions to the point of nuclear conflict. More generally, risk governance often requires the capacity to navigate a landscape shaped by a combination of major risks—a landscape known as risk society (Beck 1992; Lahsen 2007).

Risk society poses the challenge of how to establish integrated risk governance at a global scale. The challenge is most dramatic in the case of very large risks like those of nuclear weapons, global financial markets, or climate change. But it arises in the face of more regional risks as well. When in early 2008 unusual harsh weather conditions hit parts of China, they met an infrastructure that was highly vulnerable, and they did so in the very days in which millions of Chinese were travelling thousands of miles in the course of holiday visits to their relatives. Such regional risks raise major challenges in their own right. But they also convey important experiences in view of the unprecedented global risks humankind faces in the 21st century.

The practical task of integrated risk governance arises at a time when the theoretical tools of risk analysis require a serious overhaul. We have already mentioned that the use of mathematical probability theory is greatly contributing to the legitimacy of the modern fabric of risk governance. And we have indicated that mathematical notions of probability arose out of the distinction between favorable and unfavorable events. For practical risk governance, however, this is not sufficient. One often needs the ability to rank possibilities as being more or less favorable—as when comparing the risks of a thunderstorm with those of a hurricane. The standard mathematical tool that has been developed for this purpose is the concept of a utility function, associating a real number to each possible event. This concept has become a key element not only of risk analysis, but actually of economic theory at large.

However, a series of experimental results and theoretical findings have highlighted serious limitations in any approach to risk, based on the combination of mathematical concepts of probability and utility (Machina 1987; Jaeger et al. 2001; Kahneman 2003). First, it has been shown beyond doubt that when people take decisions in real life, they do not follow that mathematical model—and this holds even for professional economists trained precisely on that model. And second, if people would try really hard to follow the model, they would waste their lives making the necessary computations without reaching any practical decision—just as chess players could not make a single move if they tried to analyse all its possible consequences. As scholars, then, we find ourselves in a situation where institutions that have been extremely successful at dealing with risks in the past are confronted with a new dimension of risks that exceeds their coping capacity. And a key reason—although certainly not the only one—for the limitations of this coping capacity lies in the theoretical toolbox these institutions are relying on. What will be needed in order to realize a perspective of sustainable development, then, will be a combination of practical advances in integrated risk governance with theoretical advances in our understanding of risk and uncertainty. This implies a research agenda of unusual breath that will require trans-disciplinary cooperation by highly specialized researchers from very different fields. And the cooperation will need to involve a patient dialogue with practitioners faced with risks and disasters, often under a time pressure that is at odds with the rhythms of creative research.

Tackling such a research agenda requires a series of steps, starting with a very limited task that can be addressed with the intellectual and institutional resources available at the beginning of the effort. For reasons that will be discussed in Sect. 2.3, "Research Program", we start with a few comparative case studies on the onset of specific disasters—what we will call the entry transition in the unfolding of crises in socio-ecological systems.

2.2 Purpose

Our vision is to achieve advances in risk research by focusing on a specific phenomenon through a series of comparative case studies. The phenomenons we have chosen are the transitions in and out of the occurrence of particular risks. These transitions are of considerable relevance for practical risk governance. Moreover, risk professionals are particularly apt to study the complex character of the socio-ecological systems in which the risks to be investigated occur. We will develop a research network with substantial creative potential by emphasizing work in small groups based on guided self-organization, and by consciously mixing people with very different backgrounds: senior and young researchers in both developing and developed countries, as well as selected policy makers and practitioners with an interest in innovative research.

2.3 Objectives

The mission of IRG Project is to improve the governance of new risks that exceed current human coping capacities. We do so by focusing on the transitions in and out of the occurrence of relevant risks. We are convinced that there is a need for new insights in the field of risk analysis, and that these insights will include conceptual and theoretical advances. However, we have the firm intention to orient our research on the practical needs of risk governance.

From a practitioner's point of view, the following four points require special attention:

(1) The need to strengthen institutional capacities in the context of diagnosing the impacts of catastrophic disasters.

One example is China's ice storm in February 2008: Governmental institutions had a difficult time to understand the extent (impacts on life-lines and energy in particular), as well as the human dimension of the event (e.g. the problem of public transportation: millions of citizens wishing to use public transport to reach their homes to celebrate the commencement of the new year). The challenge in this case is to develop tools which may help government officers in charge of dealing with such disasters to dimension the potential impacts of an event in the context of various sectors, so that a more efficient and timely response is provided in such cases.

(2) The need to strengthen institutional capacities to deal with collateral events which may be triggered by a main or initial event.

As an example, the earthquake that occurred in February 2010 in Chile triggered a tsunami which devastated several coastal towns. It also generated a blackout that affected 90 % of the country's population, in some locations for several days. Moreover, looting, riots and prison escapes were among the side effects of the earthquake. The situation was further exacerbated by the government's initial assessment that no international help was required. Such an example, which manifested itself in other regions of the world in similar cases, introduces the challenge of developing models which can also forecast potential collateral events.

(3) The need to assess as quickly as possible whether there are enough resources or not to cope with an event.

During hurricane Katrina, many people were faced with the impossibility of evacuation prior to the hurricane due to the lack of public transportation during the incident. The weakness in assessing the impacts of the event in terms of needs to evacuate people forced the government to use more costly means (evacuation by helicopters or boats) to carry out the evacuation. In this context, it is important for government agencies at all levels to assess as quickly as possible the impact of an event, and from such an impact the foreseen needs in terms of resources to respond to the event efficiently and timely. Therefore, there is a challenge to develop tools which may help government agencies in charge of responding to such disasters to assess whether there are enough resources to cope with an event as quickly as possible.

(4) The need to assess the roles of agents in improving the entry and exit strategies:

In the context of the recovery processes after a disaster, it has been stated by the World Bank (2006) that in some cases, governments have requested resources to reconstruct facilities, but to the same standards which existed before the disaster to the point that vulnerabilities and risk were being recreated as before. In other disasters, one can witness that affected populations rebuild their houses again to the same degree of risk which existed before the event. Such examples exemplify the challenge of researching the key dynamic patterns of exit transitions, in order to find mechanisms which should be introduced during the recovery processes to avoid the reconstruction of risks in the public and private sectors. To this end, it is important to assess the role of agents in improving both entry and exit strategies.

2.4 Discoveries

These practical needs point to four main research questions that will be addressed within IRG Project:

(1) In what respect does a given risk exceed the capacity of given coping institutions or mechanisms?
(2) What aspects of entry and exit transitions foster/hinder robustness and learning with regard to the relevant risks?
(3) What are the key dynamic patterns of the entry and exit transitions?
(4) Who—i.e. which agents—can do what in order to improve entry and exit switches and thus risk governance?

Along these four tracks, IRG Project will develop answers to the increasingly urgent overarching question: How can risk governance be improved and synergies be created at multiple governance levels, up to the point where risks that currently leave most people profoundly helpless become challenges that can be tackled in a responsible way? There is simply no guarantee that a satisfactory answer can be found to this overarching question. Therefore, a sensible research strategy must involve inquiries that can be expected to contribute to it, but that promise interesting results even if the overarching question should turn out to be elusive. For research to address a really hard question, one needs to prepare for many kinds of failures. As the saying goes, the best possible strategy is the one of Christophorus Columbus, who searched for a new way to the Indies, discovered America instead, and did not realize it.

But clearly, this cannot be an excuse for throwing research resources after ill-conceived activities and pursuing them stubbornly regardless of whatever failures one may experience. There are simple principles that can guide this kind of investigation:

- define limited tasks that will lead to useful outcomes regardless of their contribution to the overarching question;
- operate in direct, personal contact with practitioners and use the practical issues they are faced with as signpost that help you not to get lost in the infinity of unresolved questions;
- form small teams, because large teams are good at improving existing knowledge, at applying it to new problems, but not at discovering truly novel knowledge;
- form teams combining senior with junior researchers, because discoveries are usually made by not yet established researchers, but such researchers need encouragement, training, guidance, and challenges provided by senior scholars;

- evaluate researchers more than research projects, because good researchers may be able to make significant discoveries precisely by following hints and intuitions that arise in the course of the research process;
- iterate a sequence of different methodological steps, using case studies to improve models, models to inform surveys, surveys to enrich conceptual analyses, new concepts to design better case studies;
- be patient, accepting that it may take many years until a long series of attempts yielding limited, but real successes lead to significant breakthroughs;
- combine very different skills among researchers whose personalities resonate with each other.

The last point is especially important in an endeavour like IRG Project. Only if a culture of mutual respect and curiosity can be established amongst researchers from fields as different as civil engineering, anthropology, mathematics, political science, and more, can the insights we are looking for emerge. It may well be that a major resource of IRG Project will be the fact that this is a truly intercultural activity, bringing together scholars from all continents in a mode of true dialogue. The history of IRG Project as a Chinese initiative, picked up first by Europeans, and then by scholars from all continents and a large variety of countries, may help the researchers involved to explore new data, methods, and concepts so as to discover truly novel insights.

When aiming at discoveries in a field as rich as the one of risk analysis and risk governance, one needs to find a terrain where empirical work and practical experience can focus the creativity of the researchers so as to achieve interesting results in a reasonable time. The focus on entry- and exit- transitions—to be discussed in more detail in the following section—seems to offer an excellent opportunity to engage in such a process of inquiry.

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Chapter 3
Research Programme

The Scientific Planning Committee of IHDP-IRG Project

Modern risk governance is relying to a large extent on quantitative methods. These come in two major kinds, one close to the world of engineers, the other to the world of economists. Both rely on mathematical concepts and methods, and both are embedded in discourses of a less formalized kind, drawing on notions form the world of the humanities. One of the most important notions of this kind when dealing with risk and uncertainty is the idea of individual rationality.

According to this idea, an individual can be rational all by itself. It may or may not be faced with other individuals, and if so these other individuals may or may not be rational—it is always possible for the single individual to be rational in its decisions and actions. And being rational here means being consistent. In this view, it is irrational for somebody to smoke if one cares about one's health and knows that smoking causes cancer. But it is not irrational for somebody to risk one's life by climbing in the mountains if one enjoys the adrenaline flow triggered by that risk. The basic unit of analysis then is an individual agent with given preferences and a given situation one finds oneself in. That agent may be a physical person, a household, a business, a political institution, etc. If the agent is faced with some risk, one can always asks what a rational choice is in the face of that risk. And in fact risk governance over the past centuries has evolved mainly as an effort to find and implement choices that are rational in this sense.

Markets, institutions, societies are then looked at as aggregates of rational agents. And in this tradition of inquiry one has tried time and again to identify situations where aggregates of rational agents behave as rational agents, too.

Such situations are then said to lead to congruence between individual and collective rationality. This turns out to be possible when the differences between

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P. Shi et al. (eds.), *Integrated Risk Governance*, IHDP-Integrated Risk Governance Project Series, DOI: 10.1007/978-3-642-31641-8_3,

the agents to be aggregated can be neglected—leading to the device of a representative agent—and when moreover there are no external effects. Clearly, the former condition rules out differences in values, tastes, etc., while the second condition rules out free, but scarce public goods like education, clean water, etc.

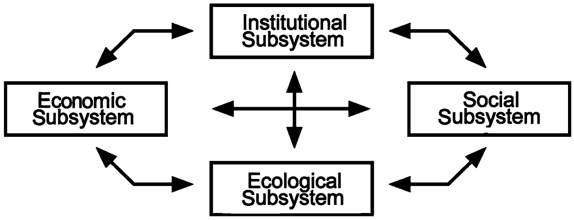
Global environmental risks are then analysed as “tragedies of the commons” (Hardin 1968), i.e. as situations where the second condition is not met. Various devices can be introduced to achieve the desired congruence between individual and collective rationality. In one way or another relevant devices establish exclusive property rights for resources that without these rights could not be allocated unambiguously to single agents.

Establishing and maintaining the property rights that lead to congruence between individual and collective rationality is the focus of the economic approach to risk. A new kind of insurance contract, say for flood damages, then introduces a new property right and at least in theory this might suffice to achieve an optimal compromise between avoiding such floods by suitable measures and accepting them to a certain degree, compensating the resulting damages with the payments following from the insurance contract. Under suitable assumptions, the cost of purchasing such insurance does indeed provide the incentive for actions that are both individually and collectively rational.

The engineering view of risks enters the picture by assessing the probabilities of various possible consequences and the measures available to reduce the probability of adverse consequences. The dramatic differences in the death toll of earthquakes in developing countries and earthquakes of similar strength in highly industrialised countries are testimony to the paramount importance of engineering in dealing with risk. While the economic view of risk sets the stage for individual and collective rationality to coincide, the engineering view enables agents—individual and collective—to act on that stage.

In recent years, a broader view of human action has emerged out of studies of coupled man-environment systems. Example, since several decades the study of socio-technical systems has produced important insights on organizations engaged in activities as diverse as mining, manufacturing, computing, communicating, etc. (Emery and Trist 1965; Zha et al. 2006). More recently, the study of environmental problems has led to a view of human action as embedded in socio-ecological systems. These are systems of human beings operating in a shared environment and drawing on the resources of a shared language (Crawford and Ostrom 1995). Young et al. (2006) explicitly frame an agenda of scientific research in terms of socio-ecological systems (SES). They do so by stressing the profound changes that SES at all scales—from mountain villages to multi-national companies—are experiencing because of the increasing global connectedness that is affecting them. The research program of IRG Project is designed as an integral component of this agenda.

Fig. 3.1 Socio-ecological system (Scientific Planning Committee of IRG Project Science Plan 2010)



3.1 Socio-Ecological Systems

Humans are not alone; they are part of complex socio-ecological systems (SES) (Gallopín 1991), also labelled as social-ecological systems (Berkes and Folke 1998; Tabara and Pahl-Wostl 2007), as coupled human-environment systems (Turner et al. 2003), human ecological systems (Jaeger 1994) and in similar ways. SESs can be found at all scales, from the local household with its surroundings to the society of nations inhabiting planet Earth. In any SES, human and ecological (or environmental, or natural, or biophysical) subsystems interact. This is important for IRG Project, because risk, and particularly the impact of an event or perturbation when it materializes, often affects not only humans but also the environmental subsystems with which they are connected, thereby impinging on human coping capacity (e.g. when a flood erodes the soil, it affects the productivity of the land and the economic condition of the farmers, leading to a reduced capacity to cope with further floods).

For the purposes of this discussion, the SES can be conceptualized as composed by the following subsystems in interaction: social, economic, ecological, and institutional (Fig. 3.1). The coping capacity of the SES as a whole is linked to the four subsystems, but human coping capacity obviously resides in the institutional, social and economic subsystems.

A key aspect of the current wave of globalization is the fast increasing connectedness (Young et al. 2006) of the global socio-ecological system (SES), both within the human sphere (e.g., economic interdependency, flows of trade, information, and people; networks of telecommunications, etc.) and the natural sphere (where there is an augmentation and intensification of the global linkages among the biotic and abiotic processes in land, oceans, and atmosphere). Furthermore, as human activities intensify, interconnect and extend to the global scale—in such polymorphic ways as international trade, communication networks, cultural convergence, global crime (Held et al. 1999)—they also start to link with ecological processes operating at the same (or smaller) scales.

Changing connectedness has many different implications for the resilience of a system. Increasing connectedness leads to faster spread of information, populations, and decisions, but also of viruses, and diseases. While in some senses an increased global connectedness is essential for improving the governance of global, systemic risks, high connectedness also has other consequences for governance. In a "wired world" disturbances rapidly transfer across markets and

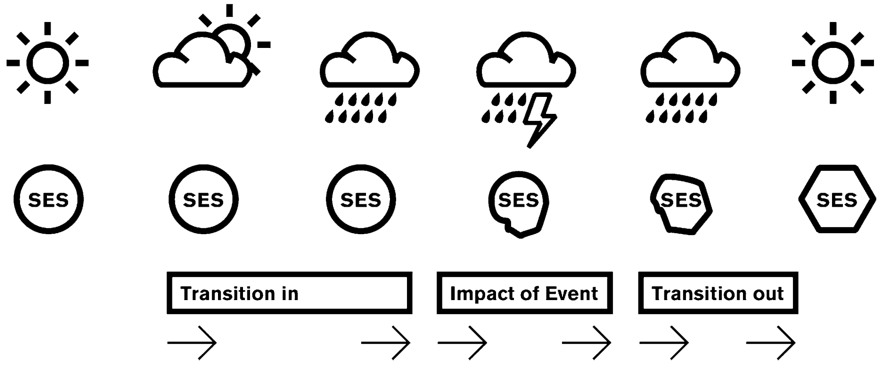


Fig. 3.2 Entry and exit transitions (Scientific Planning Committee of IRG Project Science Plan 2010)

societies, ramifying the effects of change. In such a situation, the sources of change in the global SES may arise far away from the impacts. Accordingly, the costs and benefits of policies become fuzzier, and the world becomes more uncertain. From the institutional side, important adjustments and even the creation of new kinds of institutions may be needed to deal with this situation of 'distributed causality'.

But there is a more worrisome side to increasing connectedness. It has long been established (Gardner and Ashby 1970; May 1973) that in networks whose components are connected at random, an increase in complexity leads almost inevitably to the destabilization of the system. This means that increasing (at random) the number of connected elements, increasing the density of links or connectedness, and/or the strength of the interactions between linked elements, increases the probability of the system becoming instable. These studies suggest that the increase in complexity and connectedness (especially non-evolved and non-planned connectedness) may lead to decreased stability and increased vulnerability, and to a sharp increase in the costs or error. Globalization is increasing the connectedness of the global SES, and also the strength of many of the linkages and, while the newly evolving global SES is certainly not a random network, the new linkages are certainly not the last ones added.

3.2 Entry and Exit Transitions

Risk is a concept that denotes a potential negative impact that may arise from a future event, and is different from the actual occurrence of the event. Perturbation, stress, hazard, or shock are terms denoting threats to a system, either sudden or gradual. The relation between risk, occurrence of the hazard, and entry and exit transitions can be illustrated in a very simplified way as in Fig. 3.2.

Risk is caricaturized here by increasingly threatening signals: cloudiness and heavy rain. There is no transformation of the considered SES until the perturbation materializes (i.e. the full manifestation of the thunderstorm). In this illustration, the impact of the perturbation upon the system leads to a transformation of the SES, including the human coping capacity (because, by definition, in the cases considered in IRG Project the risk exceeds this capacity).

The transitions “in” (entry) and “out” (exit) are processes that occur before and after the hazard materializes, although in some cases they may extend in time absorbing the interval in which the perturbation manifest itself (e.g., in the cases of continuous or for cumulative perturbations). Our focus on entry and exit transitions builds on previous work on the social amplification of risk (Kasperson et al. 1988; Kasperson and Kasperson 1996; Lofstedt and Renn 1997; Pidgeon 2003). Risk experiences are rarely intelligible without considering the communication processes that shape not only the salience, but even the very definition of what is happening. In the risk community, an awareness of this situation has led to far-reaching reflections on the relations between science and society (Wilsdon et al. 2005).

In this perspective, the concept of transition will be explored in detail as part of the research activities of IRG Project. This includes its relation to concepts of phase transition and related concepts in other fields of inquiry. We expect that this will also contribute to further clarify the broad and important notion of a sustainability transition (NRC 1999; Raskin et al. 2002; Elzen et al. 2004; Adams and Jeanrenaud 2008).

For the time being, an entry transition will be defined as the sequence of changes in the decision-making processes, including the deployment and reorganization of actions, actors and resources, that is associated to the preparedness of the human components of the SES to cope with the risk.

An exit transition is the sequence of changes in the decision-making processes that takes place after the event has materialized, indicating the return of the coping mechanisms and actors and the underlying structures and processes back to the “normal” situation (if the disturbance did not overwhelm human coping capacity) or to a new condition or transformed system (indicating that human coping capacity has been exceeded by the perturbation).

It should be noted that the transformations of the coping capacity may be different from the transformations suffered by the SES as a whole (losses of lives, economic losses, etc.) as a consequence of the impacts of the events. They may be:

Positive: when the new system or condition has incorporated learning, showing increased robustness, improved effectiveness, etc. leading to an improved human coping capacity in comparison with the pre-perturbation situation.

Negative: when the net result of the occurrence of the hazard leads to a weakened human coping capacity, forgetting of the lessons learned, etc. making the system more vulnerable to future risks.

The study of entry and exit transitions which mark the beginning and end of emergencies is of course particularly relevant when after the emergency the system settles in a different pattern of normality than the one it was in before. In this sense, the emergency as a whole can mark a transition between two longer-term states of the system. Such transitions, in turn, are especially interesting when they are not just analogs of the phase transitions in physical systems, but when they represent true historical branching points.

What we can learn by studying such branching points "is to give more priority to our assumptions regarding temporality, choice, and agency" (Wilkinson 2009). Abstract as this may sound, it will be essential if we are to overcome the limits of the pattern of rationality activated by current practices of risk management. This task is part of the unfinished business of integrating the mechanistic worldview of Newtonian and Hobbesian descent into a richer framework that can accommodate the creative reality of human freedom (Whitehead 1929). Many steps in this direction have already been undertaken, and risk research may have a pivotal role to play in further advances (Jaeger et al. 2001).

A remarkable toolbox for this purpose is a piece of mathematical logic known as branching space–time theory (Belnap 2005, 2007). It holds promise to transform the amalgam of probability and utility that provides the basis of contemporary risk management into a frame better suited for tackling the global risks of our times. The framework of branching space–time can be vital to overcome the obsession with single optimal trajectories that in the world of management and economics corresponds to the deterministic outlook of physics from Newton to Einstein. The tension between formal modelling and storytelling that characterizes the risk literature (as many other fields) can become a source of precious insights if and only if we get rid of that obsession.

However, it is unlikely that much progress in this direction could be made by research unrelated to practical challenges and experiences. The theoretical questions to be addressed have so many ramifications that the link to actual practice in dealing with concrete risks is helpful—perhaps even indispensable—to organize cumulative research in this field. Therefore, the focus on entry and exit transitions is not meant to blind IRG project to the broad theoretical and conceptual questions with which contemporary risk research is confronted. Quite the opposite, we have chosen this focus in order to develop a research program that can tackle those questions in a meaningful and practically useful way.

A number of questions need to be answered in the course of IRG Project in order to develop practical criteria that could be used to improve governance in concrete risk situations. For instance, when does the entry transition begin? With the initial perception of the risk, with the first operational changes in the decision-making mechanisms, or when a full alert system is in place? When does it end? When the hazard materializes, when the exit transition begins? Similar questions need to be answered for the exit transitions.

3.3 Illustration: Early Warning Systems

In the particular case of entry strategies, early warning is playing a great role in minimizing both loss of live or injuries, as well as material and economic losses (BMBF 2004; Bussiere and Fratzscher 2006; Herman et al. 1997; Dakos et al. 2008;

Wagner et al. 2001). For example, the 26 December 2004 tsunami provoked over 250,000 fatalities. As stated by the International Strategy for Disaster Reduction of the United Nations, UN-ISDR, and by the Director General of the Office for the Coordination of Humanitarian Assistance, UN-OCHA, should there have been a tsunami early warning system in place in the Indian Ocean, the number of people killed and injured would have been reduced dramatically. But it is not enough to have some early warning system in place, it is also essential to design it so as to facilitate the learning processes required to deal with the relevant phenomena (Chabay 2004).

In a similar case, the European heat wave in the summer of 2003 provoked at least 70,000 fatalities (Jaeger et al. 2008). Should there have been an efficient early warning system in place, nearly all of these fatalities could have been avoided.

These two examples point to the effectiveness of early warning systems in reducing the impact of natural events. Early warning systems are one of several examples of "entry" type transitions which allow institutions to cope with disasters in a more efficient way. It is important to recognize the need to promote "people-centred" or "end-to-end" early warning efforts, which ensure that the population at risk is targeted with such warnings, and that such people understand the warnings and know how to react to them. On the occasion of the Third International Early Warning Conference in March 2006, the Platform for the Promotion of Early Warning introduced four elements that are vital for efficient early warning (Fig. 3.3). As can be seen, in addition to the typical elements related to monitoring hazards and disseminating the warnings, critical elements to consider in the context of efficient early warning are:

- The identification of vulnerable groups of the population, and in particular their location, so that warnings can reach such groups as quickly as possible.
- Ensuring that warnings are understood and reacted upon by vulnerable groups, and that such groups are aware of how to react if such warnings are issued.

3.4 Models and Modeling

Broadly speaking, the community of risk analysts consists of three quite separate groups. First, there are the people trained in economics who take it for granted that some version of expected utility is the ultimate yardstick in risk governance. Second, there are the engineers and natural scientists who feel comfortable with quantitative assessments as long as they relate to physical quantities and standard statistical techniques. And third, there are social scientists who emphasize issues of meaning and interpretation.

In general, there is little dialogue and even less cooperation between representatives of the three groups. IRG Project will consciously bring together researchers with these different kinds of background, and it will combine concepts and methods of a more qualitative character—in particular comparative case

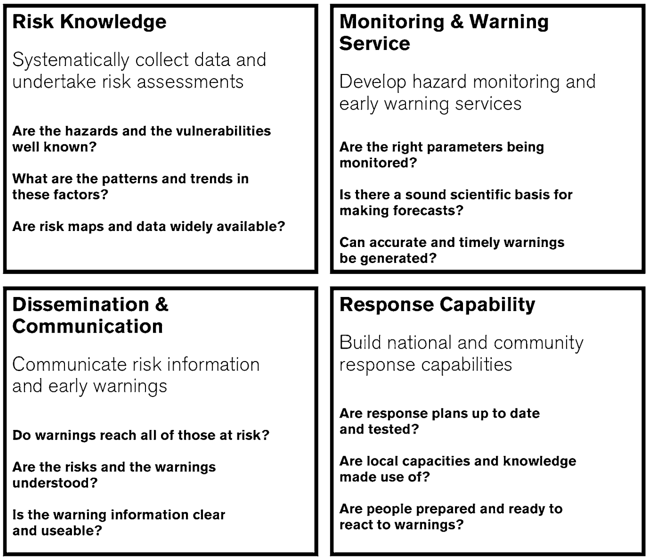
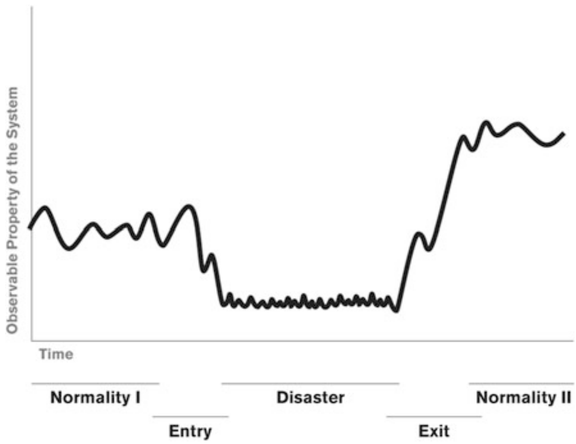


Fig. 3.3 Aspects of early warning systems (Scientific Planning Committee of IRG Project Science Plan 2010)

Fig. 3.4 A minimal model of entry and exit transitions (Scientific Planning Committee of IRG Project Science Plan 2010)



studies in the style of grounded theory—with quantitative approaches—in particular simulation models based on quantitative data (Shi et al. 2000). Figure 3.4 offers a first sketch of what it can mean to model entry and exit transitions of risk occurrence.

The relevance of this kind of dynamic modeling is perhaps best explained in relation to the view of economic systems as governed by an equilibrium of supply and demand (Fig. 3.5). In this view, there is a single equilibrium from which the economy may be nudged away by exogenous shocks, but to which it will return

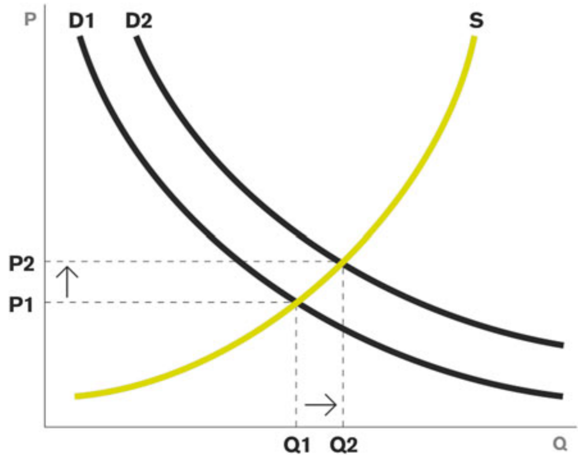


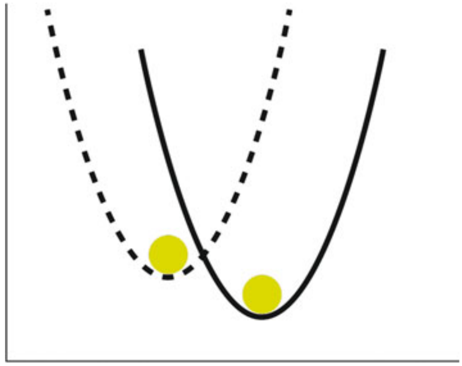
Fig. 3.5 The metaphor of supply and demand (Scientific Planning Committee of IRG Project Science Plan 2010)

sooner or later. The position of the equilibrium may shift due to external circumstances—e.g. discoveries of new technologies or shifts in tastes—but this does not change the fundamental process. Policy-makers may wish to induce such a shift of the economic equilibrium in order to internalize some external effect. An example is the wish to reduce the risks of climate change resulting from the fact that today's agents can burn fossil fuels without having to pay for the damages this may cause later on. In this case, policy will have to shift the demand schedule (e.g. by increasing demand for renewable energy) or the supply schedule or both. This can be done by modifying prices through taxes, subsidies, tradeable permits, and similar instruments.

The metaphor of the invisible hand, as framed by the standard idea of an equilibrium of supply and demand, then leads to a view of the economy as one-equilibrium system (Fig. 3.6). A suitable measure related to the difference between supply and demand defines a trough in which the system moves around as if it was subject to a force of gravity combined with friction: exogenous shocks lead to random oscillations that are damped in the course of time. This is the basic structure of the so-called dynamic stochastic general equilibrium (DSGE) models used by central banks and many research institutions. None of these models, however, was able to foresee even the possibility, let alone the timing, of the financial crisis that set in in 2008. In the one-equilibrium picture, a transition to sustainability requires changing some parameters of the system as a whole so as to move its equilibrium around while maintaining the dynamics that let the system converges to its unique equilibrium.

However, it is well-known in the theoretical literature—although unfortunately ignored in most practical policy measures—that in a system of inter dependent markets more than one equilibrium results. This is the content of one of the most important findings of mathematical economists in the last decades, the so-called Sonnenschein-Mantel-Debreu theorem (Kirman 1992). This result would hold even in a world where the future prices of all goods and services could be known

Fig. 3.6 A one-equilibrium system (Scientific Planning Committee of IRG Project Science Plan 2010)



in advance. It is even more relevant in a reality where the future is largely a matter of guesswork, so that different guesses lead to different equilibria. As a result, the economy we live in behaves like a multi-equilibrium system (Fig. 3.7), where random shocks can lead to a shift from one equilibrium to another one. And it is this shift, with its entry and exit transitions, that is represented by models like the one sketched in Fig. 3.4.

In the case of risk occurrences, the absence of learning may lead to a return to the previous equilibrium, while processes of social learning may enable it to achieve an equilibrium better suited to deal with similar risks in the future. But of course a risk occurrence may also disrupt a system in such a way that it will actually move into a state of greatly increased vulnerability.

Models of entry and exit transitions need to distinguish between these possibilities, and that would be impossible with single-equilibrium models. Moreover, usually non-monetary factors like institutional arrangements need to be considered together with monetary processes. In particular, the interaction between various risks in a socio-ecological system is structured by a variety of conventions that evolve in the course of time (Young 1993; Yoon 2006). This process is particularly important in view of market dynamics (Gintis 2007) and should lead to a new generation of models of socio-ecological systems, models that involve heterogeneous agents, combine monetary and non-monetary processes, and display multiple equilibria as well as shifts between them with their entry and exit transitions.

To develop this kind of models, databases about risk occurrences are essential (Shi et al. 2000). However, for many important aspects of such models quantitative data are hard to find. Example, it is quite difficult to produce reliable estimates of damages from large environmental disasters. IRG Project will use advanced methodologies suited for this purpose and develop them further. An interesting example is given by disaster chains. They structure disasters into a hierarchic causality graph. For assessing the risks imposed by specific disasters, one decomposes the risks of each node of a disaster chain into probabilities and losses and applies specific modeling approaches to estimate them.

We will use this technique in the perspective of Bayesian Risk Governance. This has implications for the treatment of both probabilities and losses.

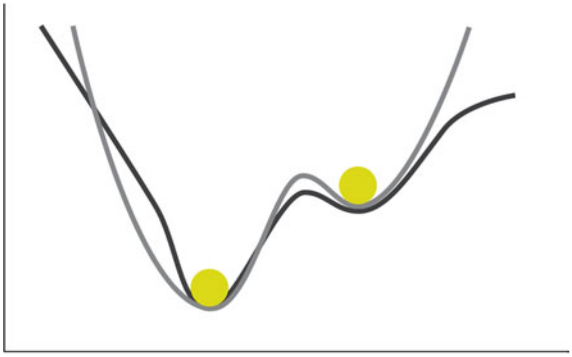


Fig. 3.7 A multi-equilibrium system (Scientific Planning Committee of IRG Project Science Plan 2010)

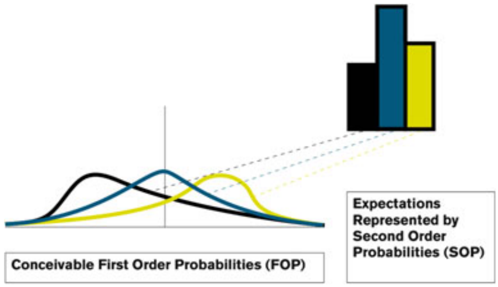


Fig. 3.8 Bayesian risk assessment I (Jaeger et al. 2008)

Probabilities: A disaster chain can be modeled as a Bayesian Belief Network (BBN). In such a network, the probabilities and conditional probabilities of specific nodes may first be derived by applying methods of "hardcore" or "softcore" Bayesianism. When time series are available, hardcore Bayesianism uses mathematical algorithms for statistical inference. When they are not, softcore Bayesianism uses expert elicitation for identifying the probabilities.

Sometimes, it will be useful to represent beliefs about possible futures by using second order probabilities (Jaeger et al. 2008, see Fig. 3.8). A range of possible futures is then represented as a set of stochastic scenarios, and the relevant beliefs are represented as weights attached to those scenarios. Once the BBN is set up, it can use any incoming information for updating its probabilities (Fig. 3.9). Again, these could be done using measurement and data that add to existing time series, or new rounds of expert elicitation.

Losses: Regarding losses of specific disaster nodes, we will distinguish between direct and indirect losses. For disaster nodes where historic experience is available, we can base our analysis on historic figures. An important distinction must be made between direct and indirect losses. Accounting for direct losses is a cumbersome but well-established procedure. The complication here is to judge whether historic figures can easily be extrapolated. For assessing this, we will apply methods of hardcore Bayesianism. The same methods may also help us identify structural breaks in historic figures that we must account for. Assessing indirect

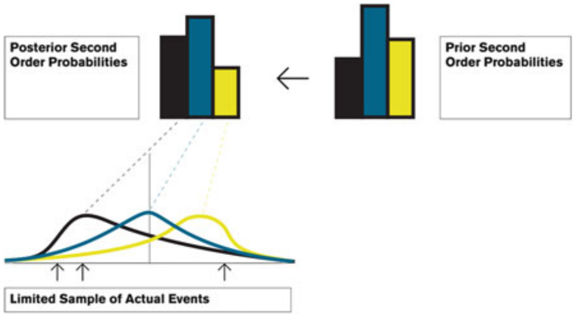


Fig. 3.9 Bayesian risk assessment II (Scientific Planning Committee of IRG Project Science Plan 2010)

losses of a disaster event, however, poses a challenge. Here, we want to apply innovative methods like the one pioneered by Hallegatte (2008). He used an adaptive regional input–output model for assessing the economic losses of hurricane Katrina in the Louisiana region.

These techniques are essential for assessing the future growth of damages from various kinds of disaster (Fig. 3.10). Since several decades, e.g., the growth rates of—insured and uninsured—losses from weather related disasters exceed those of GDP by several percentage points. As a result, in a few more decades all of GDP would go into compensation for such disasters. Clearly, this will not happen; but how will the present trend come to an end? Most likely by processes of social learning that enable people all around the world to better cope with weather extremes. These processes will probably be triggered by entry transitions of extreme events, and they will need to consolidate in the exit transitions.

Both when dealing with direct and indirect losses, we may encounter situations where social and climate change invalidate past data. In such cases we will apply tools from softcore Bayesianism for eliciting loss distributions to expect from experts. Once we will have identified both probabilities and losses to be expected, we will recombine them in order to come up with quantified risks. For studying the dynamics of large-scale risks, we will model the social interaction of societal actors. The actors themselves we will model as Bayesian belief agents. A Bayesian belief agent has expectations in the form of knowledge-based probabilities for events or processes that are relevant for him. He updates these knowledge-based probabilities when new information becomes available for him. New information may be generated by natural dynamics, or by the dynamics of the social system.

With this background, we will model basic patterns of endogenously generated mutually induced updating processes of personal beliefs. In our opinion, a basic understanding of such endogenously driven updating processes is indispensable for comprehending the social dimension of managing large-scale risks. Remarkably, this applies to managing large-scale natural risks like earthquakes or extreme whether events (both sudden or slow onset) as well as to managing socially generated risks like financial or political crises.

Rapid loss estimation (RLE) is the near real time estimation of casualties, injuries and economic damage based on loss modeling, pre-event databases and

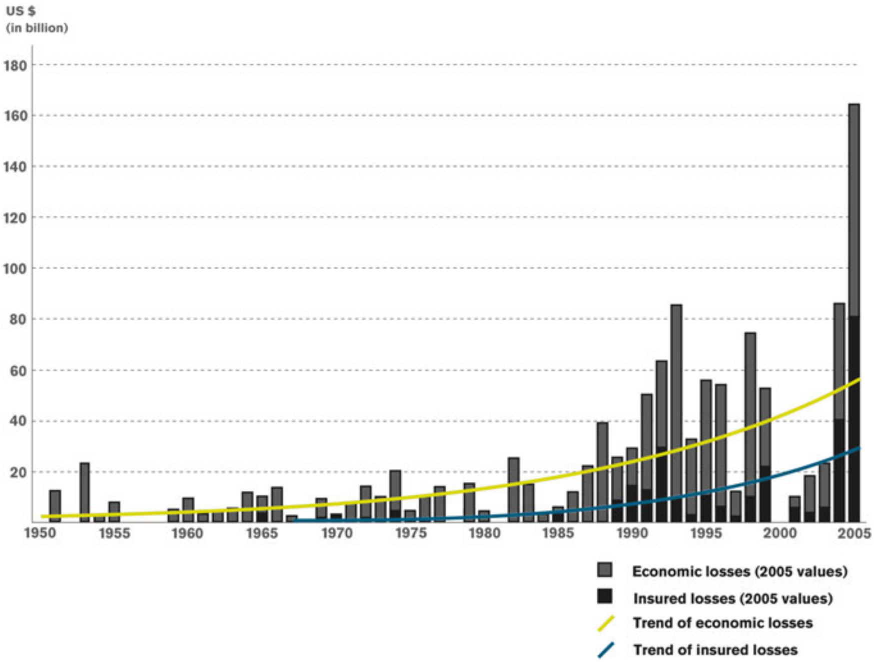


Fig. 3.10 Growth of damages from weather related disasters (Scientific Planning Committee of IRG Project Science Plan 2010)

other information, and near real time estimation of the hazard parameters. RLE is critical to understand how far a social system is from its ordinary state and to what extent extrinsic intervention is needed to return to its original state or transform to a new equilibrium state. Giving that the occurrence probability of large-scale disasters is relatively small, models of loss assessment and risk quantification based on historical events may be misleading for the purpose of rapid disaster evaluation and short-run emergency management, but also for the longer-term concerns of risk governance. Models of rapid disaster evaluation based on the real-time disaster information and data obtained from various means such as remote sensing images, local media, verbal information and messages from impacted regions etc. become effective and efficient tools that can be easily adopted and implemented by government and emergency agencies. These models can also be used to estimate the impacted areas and populations of present and the near future.

Before this background, a conceptual model for early warning (entry), risk assessment and loss estimation, emergency response, recovery, reconstruction, risk transfer and integrated risk governance of multi-hazard disasters will be developed. Natural catastrophe models are now widely used in insurance industries for "Nat CAT" risk pricing and portfolio management. These models focus on the quantification of probable maximum loss (PML) and exceedance probability (EP) of individual peril, and the direct losses of buildings, contents, business interruption etc. are estimated. However, the indirect losses and losses due to secondary disasters such as mountain flood followed by large earthquake are usually not estimated. In this science plan, we propose to shift the focus of development of individual peril models to multi-peril platforms in which the risk of multiple hazards generated from a large-scale disaster can be quantified systematically and the risk at different stages of disaster relief, emergency response and recovery can be monitored.

Very large-scale disasters (VLSD) usually develop as disaster chains—rather than as individual disasters—as a result of interaction of geosphere, biosphere, hydrosphere, atmosphere and the social system. Therefore, individual hazard or multi-hazard methods may underestimate the intensity or complexity of VLSD. The disaster chain methods for assessing VLSD have been developed to provide a comprehensive understanding of logic relationships and correlations between various hazards driven by a single large-scale disaster. The development of models of disaster chains aims to quantify both individual and integrated losses and risks so as to first identify and then manage unexpected circumstance that might otherwise be unduly neglected.

3.5 Comparative Case Studies

Methodologically, IRG Project will follow a grounded theory approach (Glaser and Strauss 1967). We follow this route in a pragmatic mode, in order to create the intellectual space for discoveries about what it means to "manage the unexpected" (Weick and Sutcliffe 2001). In this perspective, the key point about grounded theory is the willingness to expose ourselves, the researchers, to the unexpected as well, but to do so in a methodologically controlled way. We start with the concepts of socio-ecological systems and of entry and exit transitions introduced in the previous sections, and with the broad conjecture that:

- entry transitions determine to a considerable extent how well the socio-ecological system in question will be able to deal with a risk that exceeds its current coping capacity;
- exit transitions determine to a considerable extent how well the system in question will be able to learn from past risk occurrences in view of future risks;
- resilience and vulnerability of socio-ecological systems are particularly visible during entry and exit transitions.

This threefold conjecture will then be stepwise refined and modified on the basis of data and theoretical reasoning. The notion of "theoretical sampling" plays a central role in grounded theory (and has interesting similarities with sequential experiment design in laboratory experiments with physical systems characterized by large numbers of degrees of freedom). We will use this idea by first defining two case studies that prima facie offer major contrasts in view of our initial conjecture—interesting candidates are the Chinese winter storms of 2008 and the

European heat wave of 2003, the floods of 2008 in Iowa, U.S., and in Southern China, and the financial crisis in Greece 2010. The initial cases will then be carefully investigated, and on the basis of this investigation a next group of cases will be selected in such a way as to introduce additional contrasts to the ones found in the first round.

In this spirit, a suite of case studies will be used to develop a conceptually dense theory on the basis of new observations, combined with the use of modelling and other tools. This process holds promise for innovative descriptions and explanations of key features and mechanisms—and for formulating concrete applied improvements of existing risk governance settings. Therefore, a set of carefully selected case studies will provide a central source of information and analysis for IRG Project. It is appreciated, however, that to be effective such case studies must be tightly grouped to reflect research questions and objectives (Amendola et al. 2008). Each one should be designed to be a case study of some central issue or hypothesis tightly linked to conceptual or methodological issues whose analysis will further the understanding of entry and exit transitions and how they may be improved. Designing an effective set of case studies involves a series of methodological issues (Yin 1984). To ensure that each case is soundly designed and structured, the project will identify a limited set of conceptual issues that each case will be expected to answer. Each case is envisioned to require 3 years of research and preparation and will be reviewed by the project steering committee and other case study authors annually. These reviews will not only provide continuing peer review but will also serve to draw the studies together into a common format and approach.

To date, a number of potential cases have been identified and are being explored. Besides the floods mentioned above, they include:

- the 2008 ice storm in China
- the 2003 European heat wave
- the Katrina hurricane in the U.S.
- the 1995 Kobe earthquake in Japan
- the 2004 Indian Ocean tsunami
- the 2008 Wenchaun earthquake in China
- the African drought and food crisis
- the 2008 global financial crisis
- the 2010 Greek financial crisis
- the pressure on food prices from biofuels
- the swine-flu epidemic

Attention will also be given to the complex array of risks associated with rapid urbanization in China and other parts of the world. In addition, consideration will be given to novel or new risks, such as cybernetic failures or terrorism, or the potential for future disease epidemics. To ensure comparability between case studies—a major need—a common case format and protocol will be formulated. Case studies tend to be complex because they involve multiple data sources and produce large amounts of data for analysis. Also, not all independent parameters can be expected to be identical between case studies—in contrast to laboratory experiments. Yet, this aspect provides the case study approach with the advantage of applicability to real-life, contemporary human situations, such as the role of entry and exit strategies in future risk governance situations. The case study comparisons contribute to developing a robust platform upon which to develop a typology of risks and of possible strategies to deal with them.

The case studies are focused on four forms of risk:

- environmental risks
- health-related risks
- financial system risks
- technology related risks

The focus will be on the first category, but never in isolation. Each case study will be oriented towards possible insights and lessons that are useful in view of global risks. A clear case study comparison analysis provides the scope to disentangle cultural differences and state-type differences (developing, emerging, or developed; strong and weak) from other elements contributing to the entry and exit transitions adopted by various actor-types in each integrated risk case study. Namely, such comparison begins to address the IRG Project research question of: "Who (or which regions) can do what in order to improve entry and exit switches and thus risk governance?" Thus, through case study comparison IRG Project highlights approaches to dealing with risk that can be appropriately expanded and implemented in a realistic world system.

Two case study comparison types are of great interest as learning tools:

- studies comparing similar risk outcome types in different countries (i.e. China's Wenchuan Earthquake vs. Japan's Kobe Earthquake) and
- studies which compare responses by different nations in the global context when the same risk outcome affects multiple nation states (the 2003 European heat wave in various European nations).

Both types of comparisons will be systematically pursued in the course of IRG Project. Still, it is important to emphasise the following points from the outset:

- case studies will be selected and performed sequentially, gradually increasing the number of studies to be performed in parallel;
- the research will proceed through an interplay of empirical and theoretical reasoning that will yield useful output already in the first years of research;
- major insights to be gained are likely to crystallize around specific discoveries that may emerge after several years of careful research;

starting from single discoveries, systematic understanding will be sought, until a more fundamental logic of the relevant processes can be made explicit.

3.6 Governance and Paradigms

Generally, a disaster event consists of hazard, hazard-affected bodies and hazard-formative environment. As a complex system, a disaster system has the common characteristics of such systems, namely multilayer system architecture, intertwined system functioning and nonlinear system process (Shi 1991). In particular, one may distinguish between mechanical and emergent processes—the former obeying some well-defined law without much novelty arising in the course of time, and the latter unfolding in highly surprising ways time and again. The integrated disaster process is an integrated system of mechanical and emergent disaster dynamics, where the two are linked by mutual feedbacks and interactions. A general action mode of the process is discussed by Shi et al. (2005a, b), namely "disaster area/ disaster victim/disaster effect" amplifying and reducing both the mechanical and the emergent processes.

Due to the complexity of the integrated disaster process, it is necessary to adopt an integrated mode when implementing risk governance measures (Fig. 3.11). In fact, the cognition of integrated disaster processes in the academy is of core status in the disaster research all the while, and becomes an essential theoretical problem of disaster science research. Wisner et al. (2003) put forward the "pressure-release" model (PAR) of the disaster forming process, which is used to explain the evolution of vulnerability (Villagrán de León 2006); Burton et al. (1995) initiated the "adaptation and adjustment" model (DAA) of the disaster forming process, in order to explain the evolution of adaptability; Mileti et al. (1999) defined the "integrated effect model among geophysical system, human system and frame system" (ESC), aiming at introducing the evolution of resilience; by recognizing the structure and functioning of urban nutrition system at five different levels, Okada (2004) established the "pagoda model" (PM) to describe the disaster forming process.

Based on the characteristics of the integrated disaster process and the aforementioned models, Shi et al. have proposed an integrated risk governance mode (Figs. 3.11, 3.12; Shi 1991, 2003, 2005; Shi et al. 2005a, b, 2006a, b). This mode clarifies the responsibility among the central, departmental and local governments and promotes an integrated governance system to deal with disasters. In this system, governments of all levels cooperate to realize the "vertical to the end and horizontal to the margin" integration.

From the perspective of the disaster process, the integrated mode elaborates the overall planning before, during and after a disaster to realize the integration of disaster preparedness, emergency, recovery and reconstruction. From the perspective of the relevant disaster departments, it emphasizes the harmonization of governments, enterprises and communities to realize the integration of disaster capacity construction, insurance and relief. The three types of integration mentioned above are the core content of the integrated disaster risk governance mode.

Although the general properties of the integrated risk governance models were well demonstrated, or at least to some extent, in the community of risk research,

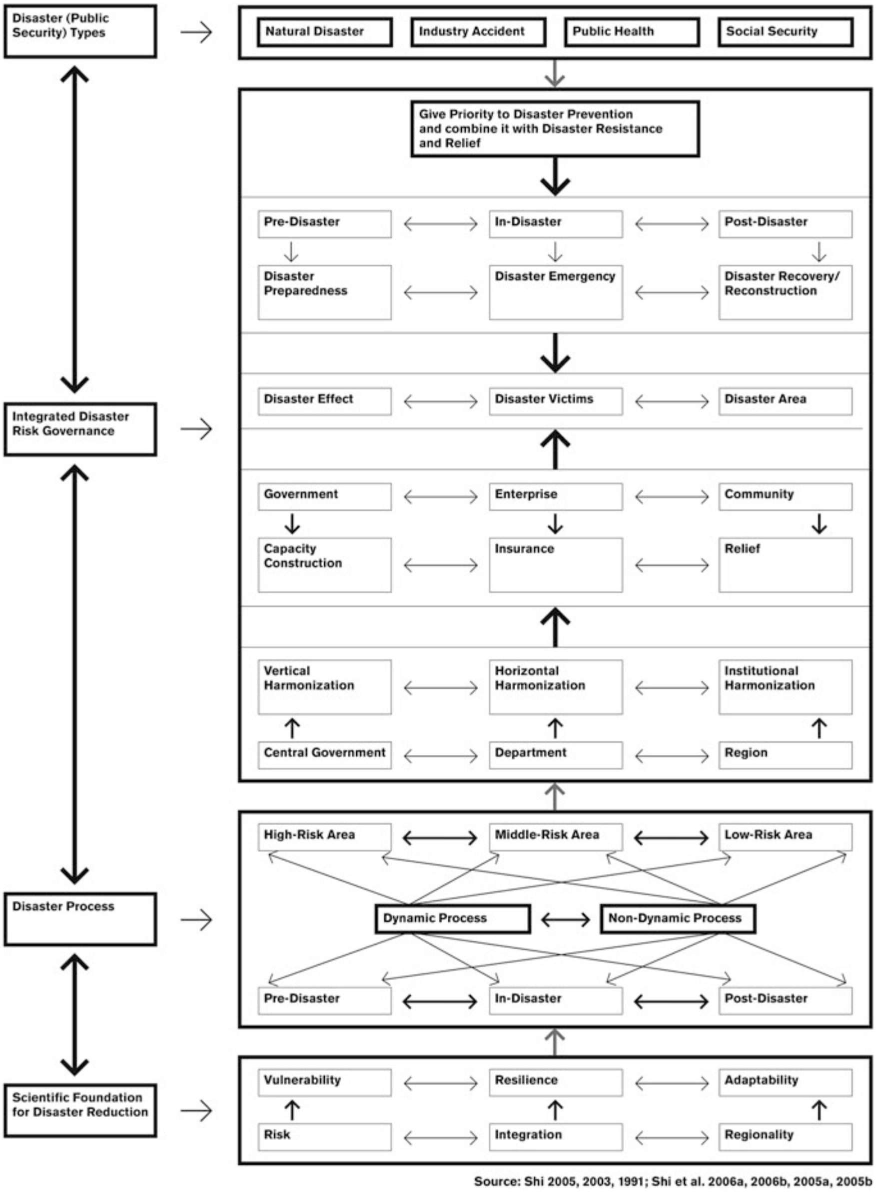


Fig. 3.11 Integrated risk governance model I (Scientific Planning Committee of IRG Project Science Plan 2010)

there remains a huge gap between the common theory and methodology of integrated risk governance and their application for an individual large-scale disaster occurring in a given region.

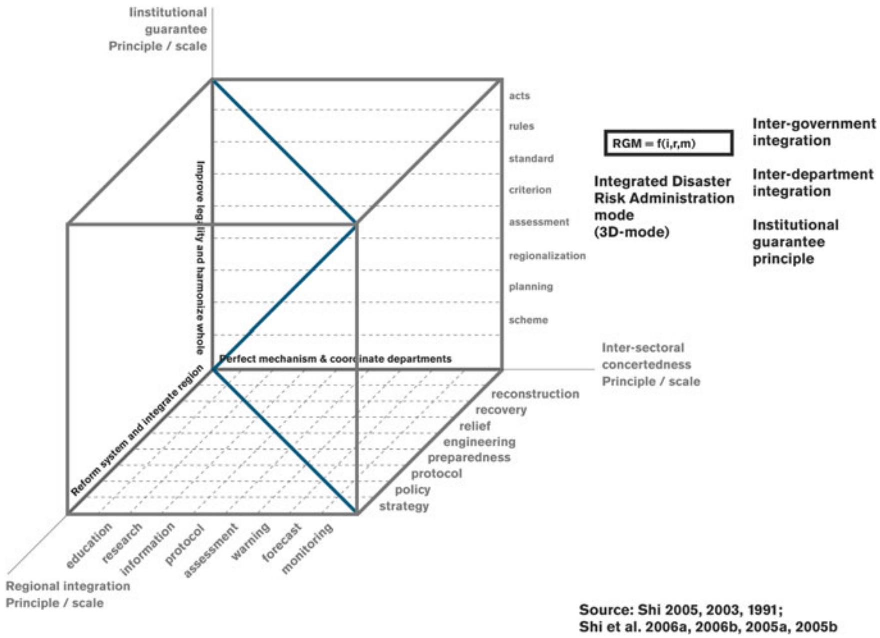


Fig. 3.12 Integrated risk governance model II (Scientific Planning Committee of IRG Project Science Plan 2010)

Fig. 3.13 Drought in Australia's main food growing region—the Condamine river in town of Parkes, part of the Murray-Darling basin, located over 400 km west of Sydney March 7, 2007. (Imaginechina)

There are two principal elements contributing to this gap. One is the fact that a large-scale disaster for a certain region usually is an event of very low possibility of appearance at a larger scale. It is very hard to make a useful prediction and to take tailor-made governance all the way to a specific large-scale disaster in a given

Fig. 3.14 A Thai motor taxi driver walks through floodwaters on a boat in Bangkok on November 2, 2011. The death toll from Thailand's worst floods in decades surged above 400 on Wednesday as public anger simmered over the authorities' handling of the crisis (Tang Chhin Sothy/ Imaginechina)

region, or even to investigate its probability and to roughly project its damages. So far, most of the large-scale disasters have been recognized as unpredictable random events. Another reason is that even if one knows a similar disaster will happen, it is still difficult to make an appropriate response or action plan since no perfectly proper example can be found.

There always are important differences between socio-ecological systems—differences of the social administrative system, the stage of development, capacity building, levels of science and education, culture, etc. Therefore, it is very urgent to develop some quasi-operational paradigms to follow for regions of some similarity in at least some of the above mentioned features. With the help of such paradigms, once a large-scale disaster appears, society can take suitable measures based on previous experience. And these paradigms can only emerge through studies of socio-ecological systems with their entry and exit transitions. For example, some developing countries faced by an earthquake may take advantage from the paradigm used in the Chinese government's response to the Wenchuan Earthquake in Sichuan on May 12, 2008. This paradigm in turn was informed by the Chinese winter storm at the beginning of 2008 and by many other cases. Or some developed countries faced with hurricanes and storm surges may learn from the paradigm the US government enacted after hurricane Katrina in 2005. And of course learning at the level of such paradigms is not a matter of simple imitation, but of analysing previous cases in view of the interplay between disasters, institutions, physical processes, and human actions.

The more paradigms can be investigated and summarized for different large-scale disasters related to socio-ecological systems in different regions, the better. There is no panacea for dealing with disasters, but there is an opportunity to learn to improve current practices at all scales, from the local community to the whole globe (Figs. 3.13, 3.14).

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Chapter 4
Outcomes

The Scientific Planning Committee of IHDP-IRG Project

Complexity is a key feature of socio-ecological systems, and surprises lie at the heart of risk governance. Integrated risk governance cannot evolve as the mechanical application of a few general principles.

It requires familiarity with a wide variety of specific situations along with the ability to creatively use rich concepts—like the ones of entry and exit transitions—in order to see analogies and differences between those situations when addressing a newly arising problem. IRG Project will produce this kind of insights. It will do so with a focus on the entry and exit transitions of risk occurrences that exceed current coping capacities. In particular, IRG Project will produce insights on what kinds of transitions can be expected to be helpful, and which ones should rather be avoided when facing specific risk challenges. We will embed these insights in the broader knowledge basis currently available in risk studies and convey them to different groups of practitioners.

Of course the primary way to communicate scientific findings is via papers presented at scientific conferences and texts published in journal articles and scholarly books. Such will be the routine of IRG Project, too. We will pay special attention on joint papers produced by researchers from very different background—in terms of scholarly specialization, geographical origin, gender and age. And we will foster a culture where each researcher involved in IRG Project produces a continuous stream of publications, rather than operating in the too frequent mode of publications arising only in selected periods of time by selected individuals.

Finally, we will pay attention to the balance between insights focussing on understanding the dynamics of various risks and insights focussing on improving

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the practical efforts at dealing with those risks. We see the relation of understanding and action not as an asymmetric hierarchy in either way, but as one of mutual support between two basic modes of the human condition. Besides scholarly publications, there will be an on-going interaction with mass media, including recent media like the internet. We see this as a natural process that will become part of the routine of IRG Project, but we do not see the media as a primary focus of our outreach effort. The reason for this is that IRG Project intends to produce insights that can and should be taken up by professionals dealing with risks in various functions, and for that purpose more specialized channels are appropriate, starting with professional education.

4.1 Professional Education

In the coming decades, students of public administration, engineering, medicine, law, etc. will need to become "risk literate" all over the world. IRG Project will produce teaching material for this purpose, with special attention to the needs arising not only in developed, but also in developing countries. The material will be built around the cases studied in IRG Project as well as further cases that are well documented in the literature. It will use the conceptual framework of socio-ecological systems, resilience, vulnerability, and global environmental change that is emerging out of the research unfolding in the IHDP framework and beyond. It will integrate this conceptual framework with quantitative tools like Bayesian risk analysis and complex system modeling.

The material will include a textbook complemented with web-based lectures, exercises, and supporting material that will be regularly updated. It will be elaborated in cooperation with leading universities in developed countries, but also with major universities from developing countries. Researchers engaged in IRG Project will actively participate in teaching both in developed and developing countries. One important aspect which will be taken into consideration is the need to elaborate all training and teaching materials in various languages, particularly due to the need of such products in all corners of the world. While initially all training material will be prepared in English language, efforts will be made to translate such material to languages such as Chinese, Spanish, and French in order to target audiences in all continents of the world. In addition and taking into consideration the need to elaborate documents in a variety of formats, IRG Project will launch an effort to increase the reusability of technical documentation through a novel approach to structure and format its content in a modular fashion that addresses both the information and learning needs of the target audiences. The novel approach aims at avoiding redundancy, improving consistency and strengthening collaboration in the elaboration of content.

4.2 Advanced Training

A related, but different task is to enable professionals dealing with risk governance to maintain and improve their knowledge and skills in the course of their working life. This is especially important with regard to issues of integrated risk governance, as this is bound to be an area of massive change—sometimes to the better, but sometimes also for worse—in the 21th century. IRG Project will provide two kinds of products for advanced training in view of integrated risk governance. First, course material—both written and web-based—documents recent advances in research. This shall be used by educational institutions, but also by government agencies, companies, and professional associations. Again, researchers engaged in IRG Project will actively participate in this kind of teaching, and they will do so both in developed and developing countries.

The second kind of material will be a case based database (CasDAT), suitable both for purposes of research and of advanced training. CasDAT will refer to various existing databases, like the disaster/risk databases of Munich Re and Swiss Re. It will differ from other databases by providing richer qualitative information, particularly on entry and exit transitions. It will also document debates about specific risk occurrences as well as about specific instruments of risk governance. CasDAT will be key platform for the work performed in IRG Project, and it will be made accessible to users worldwide in an open source mode. The database will be structured in such a way that it allows for analysis, particularly to find similarities and contrasts among countries and agencies in the way in which such agencies manage the Entry/Exit strategies in case of disasters; as well as changes over time and in the spatial extension related to the various levels at which risks and disasters are managed (local, municipal, provincial, national). CasDAT shall be built with full exploitation of the advances of internet technology, taking advantage of growing capabilities of information gathering, sorting, and updating. Moreover, close collaboration with the on-going Disaster Reduction Hyperbase (DRH) work at Beijing Normal University is one of the defining features of IRG Projects since its very beginnings. It will be natural to use these materials in workshops and summer schools organized within IRG Project. As several institutions currently involved in IRG Project have a well-established practice of advanced training, this will also provide an excellent opportunity to test the course material in the classroom before publishing it for use by others.

4.3 Managing Risk Occurrences

As stated in the Mission Statement of IRG Project, the main goal of the project is to improve governance in the face of risks that exceed current human coping capacity. In line with the scope of governance, such a goal is not only relevant for government agencies, but also for agencies from the private sector, including

Non-Government Organizations, and even the mass media which also deal with both the entry and exit strategies in case of disasters.

In order to bridge the gap between science and practice, IRG Project will involve the targeted users of its research throughout the process. The more practical outcomes of research will be presented in terms of tools which will allow staff in government and non-government agencies to manage events more efficiently. These tools shall allow staff members to manage the information concerning relevant risks on a more coherent basis. This will involve external modules related to information management structures such as geographic information systems, commercial database software, and spatial imaging software (Google Earth for example).

However, the real success of IRG Project will be assessed in the context of those individuals and agencies that make use of its results and outputs when dealing with specific risk occurrences. IRG Project shall enable practitioners to recognize more easily and efficiently when a given risk exceeds given coping capacity, and it shall offer them examples and methods for how to deal with situations where this is the case. In particular, it shall help them to act fast enough in those critical moments where an entry transition can and must be shaped. Besides supporting practitioners faced with single risk occurrence, IRG Project shall also provide know-how for the design and maintenance of early warning systems that are established in view of future occurrences. To this end, the concepts and methods developed by IRG Project should provide means to improve existing early warning systems (and the related entry strategies), as well as to design new early warning systems taking into account new findings.

In addition, IRG Project shall provide information to agencies in charge of response and recovery in case of disasters (exit strategies) which can be used to improve Standard Operating Procedures in order to ensure an efficient and timely response in case of a risk occurrence.

The Bayesian techniques that IRG Project will use in its modeling work are a key ingredient for further improving existing early warning technologies in many fields, ranging from environmental disasters to financial crises. Moreover, the understanding of entry-transitions that will be provided by our research shall help to address a key difficulty of many early warning systems: how to structure the communication process in such a way that a warning reaches its intended audience in a fast and effective way, avoiding panic while triggering decisive action.

4.4 Managing Unacceptable Risks

Integrated risk governance must deal with two very different kinds of risks: those that we have to accept as part of the human condition and those that we have to eliminate in order to achieve a sustainable development of humankind. All sorts of accidents, diseases, and crises are part of human life and must be accepted as such. The task in the face of such risks is to develop the capacity to cope with them in a responsible way, to enable people to avoid suffering as far as possible and to find meaning in coping with unavoidable suffering.

But in the past decades, more and more people have become aware or risks whose occurrence is unacceptable by any reasonable standard. They include nuclear war as well as the disasters caused by mass poverty, the dangers of massive sea-level rise as well as the possibility of future genocides. In the 21st century, integrated risk governance will be characterized not only by sound ways to handle the occurrences of those risks that we have to accept, but also by significant progress in avoiding those risks that we have to refuse, even if it will take a very long time to get rid of them.

The concept of persistent problems becomes essential here. Persistent problems are those whose ultimate causes have to be found in the previous development and implementation of an inadequate set of solutions to deal with them. The accumulation of side effects and structurally unresolved matters derived from multiple wrong decisions in different domains of action is the source or persistent problems.

The choice of one-dimensional solutions to problems that are inextricably interlinked together and that demand a more integrated approach can often result in the worsening of the initial conditions in which such problems originally emerged. When the set of issues at stake and their interactions are poorly defined, both on their social and ecological grounds, apparently 'exact' measures for action, as those often provided by technical fixes, may appeal to policy makers. However, new rebound effects may emerge and lead to even harder conditions to tackle in the next cycle of development. By studying entry and exit transitions in dealing—poorly—with persistent problems, IRG Project can make a significant contribution to the governance of unacceptable risks.

4.5 Learning to Learn

IRG Project will produce a broad range of publications including journal articles, research and policy briefs, as well as a website targeted at national and international communities of researchers and practitioners. It will do so to communicate specific findings, but also with a more subtle purpose in mind: enhancing the capability for further learning about integrated risk governance. A key contribution towards this goal will be the training and mentoring of a new generation of highly motivated researchers uniquely positioned to conduct multi-disciplinary research on the entry/exit transitions of various risks, and who appreciate the value of practical problem solving in the face of daunting risks.

These researchers need to be aware of the fact that risks are always embedded in particular structures of power and privilege. From the field of Integrated Sustainability Assessment (Rotmans et al. 2008; Tàbara and Ilhan 2008) it has become clear that unless new tools and methods are developed which are specifically addressed to tackle changing status structures and related ways of agent transformation, there is little chance of progress toward a transition to sustainability.

Fig. 4.1 An aerial view taken on November 7, 2011 shows a boat turned over in a flood-affected area of the French southeastern town of Roquebrune-sur-Argens. Heavy rain and flooding hit southern France at the weekend, seeing hundreds of people evacuated, three killed in flood-related accidents. In Var, one of the worst-hit regions, more than 1,600 people were evacuated or assisted by authorities and about 3,900 homes were without electricity (Boris Horvat/ Imaginechina)

Effective transitions in risk governance often require changes in the distribution of critical resources in the relevant socio-ecological system. Advantages and disadvantages of socio-ecological risks are distributed unevenly across agents and such inequality may often be the main reason that impedes the transformation of agents which can make a difference in taking adequate long-term structural risk remedial actions. Dealing with large-scale complex risks often is a matter of empowering specific agents in particular contexts of action so as to enable them to

Fig. 4.2 Deadly tornado hit north Minneapolis, MN, U.S. on May 22, 2011 (Imaginechina)

participate in the changing of existing risky conditions in which they have to operate.

Learning how to bring about such empowering is an on-going process that requires considerable modesty: only by acknowledging the limitations of our knowledge, understanding, and capabilities will there be a chance of overcoming these limitations where needed. Not the least merit of discussions about the precautionary principle in risk governance is to raise awareness of the ignorance we are often trapped in (Stirling 2003). If in the coming years IRG Project will enable researchers and practitioners in the arena of integrated risk governance to learn how to overcome again and again the barriers against further learning, it will have fulfilled its mission (Figs. 4.1, 4.2).

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Chapter 5
Implementation Strategy

The Scientific Planning Committee of IHDP-IRG Project

In scientific research as elsewhere, truly creative work is based on small groups of people connected by rather loose organizational ties and a strong shared culture. In this spirit, we will implement our research strategy by fostering and gradually expanding such networks. The implementation strategy, therefore, has to be simple, and the organizational structure of IRG Project shall be lean.

In terms of current management concepts, IRG Project shall function as a process organization, with specific comparative case studies as well as modeling and other efforts being processes interacting with specific segments of the outside world, and central management operating as a support process at the service of research. We will start with a first process comparing two contrasting cases and supported by a minimal administrative structure, add further research processes step by step and strengthening the administrative structure as the need arises. The interface with practicioners shall be established at the level of the different research processes, not as an add-on run separately. This places the burden of developing a shared language among researchers and practicioners on the researchers themselves—not an easy task, but a powerhouse of creativity in a field like integrated risk governance.

In the same spirit, the interface with other international (and national) research programs shall be firmly rooted in the relevant research processes. Joint publications as well as long-lasting involvement in practical operations are yardsticks by which the effectiveness of these interfaces can be assessed. We see the people involved in coordinating IRG Project as supporting the research done by themselves and by others, not as managing it in a highly directive manner. IRG Project shall form a space for research inspired by the ideas outlined in this science plan,

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P. Shi et al. (eds.), *Integrated Risk Governance*, IHDP-Integrated Risk Governance Project Series, DOI: 10.1007/978-3-642-31641-8_5,

create and maintain a culture of high-quality research, and patiently work towards the surprising insights that will provide first elements for answering our overarching question—and we reiterate it: How can risk governance be improved and synergies be created at multiple governance levels, up to the point where risks that currently leave most people profoundly helpless become challenges that can be tackled in a responsible way?

5.1 Twin Program Offices

The daily management of IRG Project will be conducted in parallel by the twin program offices located in Beijing, China and Potsdam, Germany. Beijing Normal University and the Potsdam Institute of Climate Impact research will host the twin International Program Offices (IPOs). Both offices will receive input from the IRG Project Science Advisory Committee and oversee the overall management and operations of IRG Project.

The roles of the twin IPOs are:

1. to assist the IRG Project Scientific Advisory Group to implement IRG Project efficiently with considerable effort made to assure good communications at the operational level among the different research groups,
2. to maintain uniformity and standardization of database, models, tools, and procedures used on all platforms and in all research groups,
3. to foster close cooperation with other international research programs.

There are a large number of international programs with scientific goals that are complementary to those of IRG Project and where collaboration would be advantageous. They include ICSU, ISDR, and IRGC. IRG Project IPOs will work with those potential collaborators to explore the possibility of cosponsoring workshops, sharing of technical expertise, technologies and equipment, or developing specific research experiments. IPOs will also explore the opportunity to make significant contributions to other international programs in policy application and training decision makers. Other programs might enhance IRG Project's research capabilities by contributing specialized tools such as models for natural hazards, or providing critical data.

5.2 Budget

IRG Project provides a platform for researchers, policy makers and business decision makers to exchange ideas, data, knowledge, experience. IRG Project will play a role for coordinating, organizing and moderating research efforts to deal with issues related with very large-scale disasters. We expect the overall activities of IRG Project to start with a total budget of about $5,00,000 in the first year, gradually expanding to the scale of about 2 million$ in the tenth year.

IRG Project will apply for funds on a project basis with national and international foundations, with government institutions, private businesses, and donors. When cooperating with businesses, IRG Project will explicitly include NGOs in the relevant activities, so as to have a system of checks and balances in place in order to guarantee both its impartiality and its credibility.

The members of IRG Project will provide their own resources, helping to finance the twin IPOs if they are in a position to do so. The twin International Program Offices will submit their annual budgets for daily operations to the management of the institutions hosting them. The funds of the IPO in Beijing for the next 5 years have been secured and provided by the Ministry of Sciences and Technology, the Ministry of Education and the National Natural Science Foundation of China. The IPO in Potsdam is operational and shall be further funded on a project basis.

5.3 Communication

The main activities of IRG Project will consist in doing research, and doing it well. Communication within single research groups will be based on intensive face-to-face contacts, advanced computer technology (e.g. archiving systems with versions and sub-versions), and the standard scientific materials.

Between research groups, communication will be mainly internet based. IRG Project will encourage its members to hold local, regional, and international workshops so that researchers can have face-to-face discussions on emergent issues. And it will also encourage its members to continuously improve internal memos and documents so that they become important elements of the writing of working papers and eventually publications in the open literature. Besides the outreach activities that are an integral part of the single research processes, IRG Project will conduct additional outreach activities based on its website (update monthly), newsletters (initially semi- annual), books, research papers, policy recommendations, etc. IRG Project will hold its Scientific Advisory Committee meeting annually and its science conference every 2 years.

5.4 Timeline

How can one look for an insight without knowing it? The paradox of inquiry led Socrates to consider gaining an insight as a kind of remembering. It leads us to imagine the development of IRG Project as a journey of discovery: the starting point is well defined, the initial equipment is given, the first steps can be indicated, and they are consciously planned so as to lead us into a surprising terrain that will enable and force us to change our plans. What we will not change is the focus on discoveries that will help us addressing our overarching question and its different elements.

This requires the willingness to invest several years exploring the terrain, being satisfied with small, if robust findings. In these first years we will perform no more than 5 case studies, with a strong emphasis on the comparison between different cases. In parallel, we will explore conceptual issues related to entry- and exit-transitions. After 3–5 years, we expect to be able to make a first major discovery, perhaps of one key entry mechanism. From there, again over a period of several years, we expect to proceed towards a more systematic understanding of those transitions, including their relevance for practicioners. And then, as far as we can see from today, we may even become able to spell out the fundamental logic of the transitions, and thereby deliver a key for developing integrative risk governance of the kind required for truly sustainable development.

Appendix 1
The Scientific Planning Committee

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Appendix 2
Milestones of the Science Plan Preparation

October, 2006: IRG Project was initiated by CNC-IHDP during the ESSP Beijing Conference.

March, 2007: At the IHDP SSC meeting in Brazil, CNC-IHDP made a formal proposal that IRG Project be considered as a potential IHDP core project.

September, 2007: IHDP formed a Scientific Planning Committee (SPC) for a core project on Integrated Risk Governance, and the Committee held its first meeting in Beijing, China.

February, 2008: The IRG Project Pilot Research Plan was drafted in Beijing, China.

June, 2008: An IRG Project special workshop was held by the SPC in Santa Barbara, USA.

August, 2008: The IRG Project Pilot Research Plan was finalized in Potsdam, Germany.

October, 2008: The IRG Project Pilot Research Plan was presented at and approved by the IHDP SSC in New Delhi, India; the Pilot Research Plan was published on the IRG Project website.

November/December, 2008: Comments on the Pilot Research Plan were collected from SPC members and further interested scholars.

January, 2009: The IRG Project Science Plan was drafted in Beijing, China.

March, 2009: The IRG Project Science Plan, edited in Potsdam was submitted for review.

March, 2010: The IRG Project Science Plan, finalized on the basis of the reviews, was submitted to IHDP.

Appendix 3
Glossary

This glossary has entries for four kinds of risk-related words:

– words for which a canonical use has been developed by some group of specialists; e.g. "cost-benefit-analysis";

– words for which different canonical uses have been developed by different groups of specialists; e.g. "probability";

– words for which a particular usage is proposed in the science plan of IRG Project; e.g. "entry transition".

Terms in *italic* refer to other entries in this glossary.

Adaptive Capacity

Researchers and practicioners dealing with risk sometimes use this expression to talk about a capability to deal with new challenges; "over the past century, farmers have shown a great capacity to adapt to technological change"; increasing adaptive capacity is seen as necessary condition for reducing *vulnerability*.

Bayesian Risk Governance:

In the present science plan, we use this phrase to talk about an approach to *risk governance* where one takes initial decisions on the basis of whatever information, intuition and arbitrary starting points are available and then strives to improve one's decisions again and again by learning from the consequences of ones actions.

When sufficient data are available, the learning process can take advantage of the methods developed in Bayesian statistics, if not, learning will have to happen on a case-to-case basis.

Catastrophe:

a) In ordinary conversations a catastrophe usually is a sudden event where something really bad happens.

b) Some risk researchers use the word "catastrophe" to talk about crises like hurricane Katrina, where the built environment is affected, community life is disrupted, and the mass media and high-level political authorities are heavily involved.

c) In mathematics a catastrophe is a pattern that can arise in stable dynamical systems (roughly speaking functions that can be used to represent things that tend towards some equilibrium). Some such systems depend on real-numbers as parameters; if these parameters are varied continuously within a certain boundary, the system changes somewhat but stays stable; if the paramters cross the boundary, stability is lost.

Contingent Valuation

Economists have developed the method of contingent valuation to deal with situations where they want to transform some non-monetary preference in a monetary one. To find out how much somebody values the existence of a particular forest, one can ask him how much he would be willing to pay to preserve that forest. (As an alternative, one may try to observe how much somebody actually pays for a visit to a similar forest.) A sample of such interviews can then be used to produce monetary values to be used in cost-benefit-analysis.

Coping Capacity

Researchers and practicioners dealing with risk sometimes use this expression to talk about a capability to deal with crises; "St. Petersburg has shown an amazing capacity to cope with the siege by German troops"; coping capacity is sometimes seen as a component of *adaptive capacity*.

Cost-Benefit-Analysis (CBA)

Economists have developed the method of CBA to deal with situations where some agent—typically a government agency—must choose between different actions. A CBA associates to each action a monetary cost and a monetary benefit. The action that maximizes this difference is then considered the one to be chosen. *Risk* and *uncertainty* are dealt with by using *probability* measures to form expected utilities. Differences in the timing of costs and benefits are dealt with by *discounting*. Non-monetary effects are translated into monetary values by methods like *contingent valuation*.

CBA becomes misleading when it is used as a substitute for a debate needed to reach agreement on critical issues like:

– the range of possible actions

– selecting among actions with indistinguishable cost-benefit differences

– how to aggregate the preferences and *probability* judgements of different people

– how to deal with preferences that rule out certain trade offs, like a trade-off between genocide and economic growth

– how to form preferences and *probability* judgements where they are not given.

Cost-Effectiveness-Analysis

A term from economics for a *Cost-Benefit-Analysis* where only actions with the same benefit or the same costs are compared. This restriction can lead to considerable reductions in the data requirements of a CBA.

Crisis:

In ordinary language, a situation where the future of some entity is at stake; "the patient had a serious crisis last night"; "the team was invigorated by the crisis".

Some researchers and practicioners dealing with risks see emergencies, *disasters* and *catastrophes* as specific kinds of crises.

Danger

In everyday conversations, a situation involving the possibility of harm; "international tensions lead to a danger of war"; "the dangers of car traffic".

Definition

In natural language, the word "definition" is used in many ways. One can define a boundary, an object, a symbol, a word, etc., and one can do so in many ways.

In many fields, some words are defined by other words with phrases like "A hazard is a source of harm". Defining words by words can only work among people who already share a whole language.

An important kind of *definition* works with paradigmatic examples and some intuition of similarity: "An illness is something like a cold, a stomach flu, etc."

Definitions usually leave many ambiguities unsettled (even in formal languages like mathematics), but they can enable people to greatly expand their use of words.

Disaster

a) In natural language, a word used in similar ways to "*catastrophe*".

b) Some risk researchers use the word to talk about crises that involve greater management challenges as emergencies but still not as massive ones as *catastrophes*.

Discounting

If a child prefers one ice-cream now to one ice-cream tomorrow, but is indifferent between one ice-cream now and two ice-creams tomorrow, economists say that the child discounts ice-cream at a rate of 100% per day. In order to compare monetary values with different dates —e.g. in *cost-benefit-analysis*— one often assumes that a person has the same discount rate for different time horizons (the child would then be indifferent with regard to four ice-creams the day after tomorrow, etc.) and for different goods, and that all people have the same discount rate.

There are major controversies about whether actual discount rates are morally defensible, because even rates of 2% and less tend to make huge risks in the distant future irrelevant for present decisions.

Emergency

a) In ordinary conversations, the word "emergency" is often used to talk about situations that require some exception from normal rules of proceeding in order to avoid great harm.

b) Researchers and practicioners dealing with *risk* often use the word "emergency" to talk about situations that present an imminent *danger* of, or damage to, life, health, property, or the environment.

c) Some researchers use the word "emergency" for situations that involve less far-reaching challenges than "*disasters*".

Essentially Contested Concepts

Some philosophers, especially philosophers of law, use this phrase to talk about situations where different people insist on using some word while disagreeing about how to use it. Examples are words like fairness, justice, freedom, peace (perhaps also sustainability). The point is that such words may be useful and necessary as they enable people with conflicting views and interest to engage in potentially fruitful conversations - even if the fruits of the conversation will not include an agreement on how to use these words in the future.

Entry-Transition

In the present science plan, we focus on transitions by which a given *socio-ecological system* switches into *emergency* or *crisis* mode, e.g. in dealing with a hurricane or a financial collapse.

Exit-Transition

In the present science plan, we also focus on transitions by which a given *socio-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*.

Exposure

Researchers and practicioners dealing with risk use the word "exposure" to characterise situations where a *danger* arises; "the *dangers* posed by exposure to asbestos".

Governance

Political scientists use the word "governance" to highlight structures and processes of collective decision-making where public authorities interact with private businesses and a variety of other groups and organizations.

Hazard

A word from ordinary language used in risk debates mainly in two ways: to talk about the potential of something to do harm; „the hazards presented by the ill-considered use of mathematical models", "the hazards of terrorist nuclear explosives" or to talk about a thing or event that may do harm: "the asbestos hazard", "a run-away chemical reaction can be a serious hazard".

Integrated Risk Governance

In the present science plan we use the phrase "integrated risk governance" to characterize patterns of risk governance where the different risks are not treated in isolation; e.g. climate risks are not treated separately from risks to national security, economic development, and public health.

Management

In the present science plan we use this word to talk about the professional activity of getting things done in some organisation with the help of other people and various resources (like available time, machinery, money and knowledge).

Management

In the present science plan we use this word to talk about the professional activity of getting things done in some organisation with the help of other people and various resources (like available time, machinery, money and knowledge).

Probability

(a) In everyday conversations about different possibilities, these are often compared as being equally, or more, or less likely —or probable —than others.

(b) Risk researchers and practitioners often treat the probability of some event as a number between 0 and 1. They then apply the rules for mathematical probabilities to these numbers. If a possibility appears again and again, the probability that it will be realized is often seen as the limiting value that one would get by counting the cases where it has been realized and dividing it by the number of occasions where the possibility did arise.

(c) Economists and decision analysts often use the word "probability" to characterize the willingness of an agent to engage in a bet with well defined stakes. Leaving one's home without an umbrella is then seen as equivalent to betting that it will not rain, where the stakes depend on one's clothes and further circumstances.

(d) Mathematicians use the word "probability" for functions that associate real numbers to certain subsets of a set while satisfying the rules known as the Kolmogorov axioms. An example is a function that associates to any number of fields on a chessboard that number divided by 64: the whole chessboard has a probability of 1, a single row or column a probability of 1/8, a single field has probability 1/64, etc.

Rational

(a) In everyday conversations this word often expresses a property of people or actions by which the choice of a specific course of action is not determined by emotions, but can be explained by words giving a plausible chain of proximate and indirect reasons.

(b) In economics a property of people or organisations whose choices of actions can be seen as consistently following from a set of preferences that obeys a number of axioms (e.g. if I prefer A to B and B to C then I prefer A to C).

(c) In philosophy a word whose use is the object of major disputes —perhaps an essentially disputed concept.

Resilience

Researchers and practicioners dealing with risk use the word "resilience" to talk about the ability of *socio-ecological systems* to recover quickly and easily.

Risk

(a) In everyday conversations, the word "risk" is used to talk about *dangers*, their probabilities, and various related things; "some people like the excitement that comes with risk"; "we should avoid the risk of war".

(b) In economics, the word "risk" is usually used to talk about the *subjective expected utility* of an action.

(c) In some applications, the risk of some damage resulting from some event is defined as the product of the quantity of damage and the *probability* of it occurring.

(d) Many researchers and practioners dealing with risk use that word to talk about situations where some harm can be caused by some event, where the harm can be more or less likely and more or less large, but without trying to compute a *subjective expected utility*.

Risk Governance

Researchers and practicioners dealing with risk use the phrase "risk governance" to talk about *governance* with regard to one or several risks —e.g. the risk of war, of poor economic performance, of social conflict, climate change, famine, industrial accidents, etc.

Risk Occurrence

In the present science plan, we use the phrase "risk occurrence" to characterize situations where some *danger* becomes a reality.

Socio-Ecological System (SES)

A key term used in the present science plan. Households, farms, villages, nations, industries, the internet, a school, a queue at a bus stop all are socio-ecological systems. Each one of them involves one or more physical persons interacting with a range of things in a setting structured by some human language.

In many contemporary socio-ecological systems, e.g. cities, it is possible to distinguish an environmental subsystem from three other subsystems: the economic reality of business firms and professional activities, the institutional reality of governments and political activities, and the social reality of kinship and private activities.

In the perspective of *integrated risk governance*, an important feature of SESs is the fact that their specific grammar, i.e. the human language structuring them, distinguishes between normal and exceptional modes of operation: an SES involves complex patterns of rules, and these patterns allow for ways of handling exceptions.

Subjective Expected Utility (SEU)

Economists use this phrase to talk about an elaborated scheme of risk analysis. The scheme starts with an action that may have one or several consequences and an agent whose preferences amongst these consequences can be represented by a *utility* function. Moreover, the agent is willing to bet on various possibilities in the sense of *subjective probability*. If an action has a countable number of consequences, its SEU is given by the sum of the products of utility of a consequence times the *probability* of that consequence given the action. (If the consequences are not countable, the sum is replaced by an integral, whose existence is guaranteed by suitable assumptions.)

Subjective Probability

The use of the word "*probability*" sketched under point c) in the entry *probability*.

Sustainable Development (SD)

Politicians and other participants in international public debate use the phrase "sustainable development" to characterize development that meets the needs of the present without compromising the ability of future generations to meet their own needs. SD is often characterized by a balance of environmental, economic, and social dimensions.

Uncertainty

In natural language, a word used to talk about situations where a doubt arises or persists, where something that might be known is in fact not known.

Economists sometimes use the word *uncertainty* to talk about situations where doubts cannot be expressed by means of *probability*, e.g. because the range of possible alternatives is not known.

Utility

Economists use this word to describe preferences by means of real numbers. If somebody prefers A to B, A is given a higher utility index than B. A utility index does not characterize a thing or situation as such, but the relation between some agent and a thing or situation.

Utility indices are also applied to uncertain situations when somebody prefers one such situation to another situation.

Vulnerability

Researchers and practicioners dealing with risks use the word "vulnerability" to characterize the predisposition of humans and their livelihoods to be damaged.

Appendix 4
The Project Organization

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Part II
Case Studies of Large-scale Disasters

Chapter 6
Experience, Lessons and Recommendation of China's Response to the Wenchuan Earthquake Disaster

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The Wenchuan Earthquake occurred at 14:28 on May 12, 2008 in Sichuan Province of China. It shocked the world, caused huge losses of lives and properties of people, and had immense effects on the development of economy and society in Sichuan, Gansu, Shaanxi, Chongqing and Yunnan. In the aftermath of the earthquake, the Chinese people were remarkably united as one, and conducted powerful, orderly and effective disaster relief with great efforts in the face of daunting difficulties. They achieved a considerable success in earthquake rescue and relief, under the firm leadership of the Chinese Government via the direct command of the State Council's Earthquake Rescue and Relief Headquarters.

6.1 Seismic Regime and Disaster Effects of the Wenchuan Earthquake

The Wenchuan Earthquake has been the earthquake with the highest reported destruction, widest coverage and most difficult disaster relief since the foundation of new China.

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Fig. 6.1 Disaster scene of wenchuan earthquake. **a** Chinese firefighters search for quake survivors and victims in the rubble of collapsed houses after the May 12 earthquake in Yingxiu town, Wenchuan county, Aba Tibetan and Qiang Autonomous prefecture, southwest Chinas Sichuan province, 16 May 2008. (Chuanming Wu/Imaginechina) **b** Mess around Beichuan Earthquake area in the Wenchuan Earthquake. (Imaginechina)

6.1.1 Seismic Regime

6.1.1.1 High Seismic Intensity and Frequent Aftershocks

The Wenchuan Earthquake reached magnitude 8.0 on the Richter scale, thereby far exceeding the well-known Tangshan Earthquake in 1976, with the maximum intensity of 11 (Fig. 6.1). By 12:00, October 10, 2008, the main seismic area had recorded a total of 33,125 aftershocks, including 32 aftershocks measuring 5.0–5.9 and 8 aftershocks measuring over 6.0. The earthquake impacted a wide range of regions, with large areas heavily affected. 417 counties, cities and districts, 4,667 towns and 48,810 villages in 10 provinces, autonomous regions and municipalities directly under the central government, including Sichuan, Gansu, Shaanxi, Chongqing and Yunnan were affected, with a total affected area of approximately 5,00,000 km^2, including 51 extraordinarily affected areas and heavily affected counties, cities and districts with a total area of 1,32,000 km^2 (Beijing Normal University 2008).

6.1.1.2 Serious Secondary Disasters and Difficult Disaster Relief

The areas hit most heavily by the disaster were found in mountain and valley areas with underdeveloped transportation systems. After the earthquake, about 13,000 places were identified having high risks of geological disasters such as rock collapses, landslides, and debris flow. Additionally, 35 quake lakes with relatively

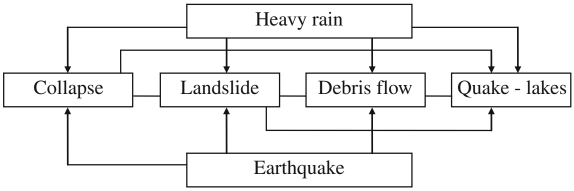

Fig. 6.2 Wenchuan earthquake disaster chain (Chen et al. 2008; Shi et al. 2008, 2011)

large size were formed. Other potential risks such as fire disasters, explosions and toxic substance leakages were also found in the affected provinces of Sichuan, Gansu and Shaanxi. With transportation, power and communication disrupted on an enormous scale, it was difficult not only to receive immediate information on disaster effects but also to send rescue personnel, materials, vehicles and large-scale equipment to the quake-hit areas (Fig. 6.2) (Chen et al. 2008; Shi et al. 2008).

This historically rare earthquake disaster, which caused huge losses of lives and properties of people, and had immense effects on the development of economy and society, shocked the whole nation and drew global concern.

6.1.2 Disaster Effects

6.1.2.1 Heavy Casualties

As of October 10, 2008, the earthquake claimed a total number of 80,000 victims including 69,227 confirmed victims and 17,923 missing. More than 3,74,600 people were injured.

6.1.2.2 Collapse and Damage of a Large Number of Buildings

7,967,000 rooms in buildings were assessed as collapsed and 24,543,000 as damaged. Some towns and numerous villages in urban areas of Beichuan County, and Yingxiu Town of Wenchuan County were almost destroyed entirely.

6.1.2.3 Widespread Infrastructure Damage

24 expressways, 163 national and provincial highways, 7 major railway lines and 3 railway branch lines were damaged and disrupted. 22 airports in many regions including Chengdu were damaged. Power, communication, radio and television as well as water conservancy infrastructure were damaged. 6 counties (districts) and 125 towns experienced a power cut, and over 30,000 communication base stations, 1,096 radio and television stations, 2,473 reservoirs, 822 hydropower stations, 1,105 dykes and 20,769 pipelines were damaged.

6.1.2.4 Serious Damage to Industrial Development

17,826 industrial enterprises were affected and 5,645 industrial enterprises above designated size stopped production. In Sichuan, Gansu and Shaanxi, 1,37,000 hectares of farmland and 4,86,000 hectares of forest land were destroyed; agricultural and forest infrastructures such as greenhouses and warehouses for fire prevention materials were damaged; a huge number of livestock, poultry and aquatic animals were killed. More than 1,38,000 shopping networks were damaged and the tourism market was interrupted completely.

6.1.2.5 Severe Impact on People's Livelihood

The affected population accrued to 46,257,000 and over 15,106,000 people had to be relocated emergently due to the disaster. A large number of people became homeless and lost their sources of production materials and income. Public service facilities such as institutions, schools and hospitals were largely destroyed and failed to operate normally.

6.1.2.6 Damage to the Ecological Environment

Natural environment such as vegetation covers, bodies of water and land were largely damaged and large areas of wildlife habitats were seriously destroyed. In Sichuan, Gansu and Shaanxi heavily hit by the disaster, the area of soil erosion increased by 20,000 hectares compared to the pre-earthquake statistics. The self-regulation capacity as well as resources and environment bearing capacity of the ecological system declined seriously.

6.1.2.7 Huge Economic Losses

According to survey made by the Ministry of Civil Affairs (undertaken jointly with relevant regions and sectors), the total direct economic losses in Sichuan, Gansu and Shaanxi was 845.136 billion Yuan, of which 771.717 billion Yuan occurred in Sichuan (Shi et al. 2008 and 2009). In terms of the losses in the three provinces, 29.9 % was from damaged houses of urban and rural residents, 20.95 % from damaged infrastructures, 13.34 % from damaged urban and rural non-residential houses, 9.67 % from industry loss (including the national fortification industry), 8.09 % from the service industry loss, 6.17 % from loss of social utilities, 3.97 % from agriculture loss, 3.47 % from loss of residents' properties, 2.59 % from land resources loss, 0.83 % from loss of cultural relics, 0.52 % from mine resources loss, 0.49 % from loss of natural reserves, and 0.01 % from loss of other resources (The Compilation Commission of the Wenchuan Earthquake Disaster Atlas 2009; China National Disaster Reduction Commission and Expert

Group for Earthquake Rescue and Relief of Ministry of Science and Technology, 2008).

6.2 Response to the 2008 Wenchuan Earthquake Disaster

6.2.1 The Role of CPC: Launching the Highest Level of the State Emergency Response Plan

After the disaster, the CPC Central Committee quickly responded by calling the earthquake rescue and relief as the most important and urgent task for the whole party and the whole nation in the aftermath of the earthquake. In the evening of May 12, 2008, the General Headquarters of Earthquake Rescue and Relief (hereinafter referred to as the General Headquarters) was established (Hu 2008), with Premier Jiabao Wen as General Director and Vice Premiers Keqiang Li and Liangyu Hui as Deputy General Directors. The General Headquarters set up 10 work teams and 1 expert committee, i.e. the rescue and relief team, the people's livelihood team, the seismic monitoring team, the health and epidemic prevention team, the media team, the production restoration team, the infrastructure assurance team, the post-disaster reconstruction team, the water conservancy team and the public security team as well as the State Expert Committee for Wenchuan Earthquake. With carefully organizing and planning, the General Headquarters established a working mechanism with a top-to-bottom thoroughly communication, coordinating between military and civil society, national mobilization and regional coordination, promptly organized different rescue forces to disaster areas, urgently allocated a huge number of relief resources and materials to disaster areas, carefully relocated the affected masses; advanced the post-disaster restoration and reconstruction timely, and initiated national effort for the earthquake rescue and relief. The General Headquarters also set up their frontline headquarters in Chengdu, the capital of Sichuan, which suffered most from the earthquake. The General Headquarters promptly made the overall arrangement and frontline command the nationwide earthquake rescue and relief. From May 12 to October 14, 2008, the General Headquarters held 26 meetings in total to discuss and decide on a series of major issues regarding the earthquake rescue and relief mission. Under the firm leadership of the General Headquarters, the Chinese people wrote an impressive new chapter in the history of the Chinese nation, with the heroic spirit, powerful united force and great feat.

6.2.2 The Role of Central Government: Initiating the Nationwide Response to the Catastrophe

To effectively and timely reduce disaster losses, the CPC Central Committee and the State Council conducted a nationwide earthquake rescue and relief combat, with the fastest rescue response rate, the widest mobilization scope and the largest resources in the history of China, in order to rescue lives of people affected and reduce the losses caused by the disaster to the utmost degree. Saving people's lives was listed as its No. 1 priority by the General Headquarters and made all efforts to reach this goal. It is reported that 84,017 people were rescued from the ruins; 1,490,000 trapped people were rescued and over 4,300,000 sick and injured people received timely treatment, including over 10,000 seriously injured patients sent to 375 hospitals in 20 provinces, autonomous regions and municipalities. The General Headquarters strived to relocate all affected people. 15,100,000 affected people were properly relocated and settled down and 8,810,000 affected people were rescued. Primary and middle schools were reopened before the new semester. Effective measures were taken to ensure that there would be no major disease epidemic after the disaster and the affected people could have access to food, clothing, clean drinking water, lodging and medical treatment. The General Headquarters organized central and local forces to carry out the urgent repairs of infrastructures such as transportation, power, communication, radio and television, water conservancy, water supply and gas supply, to timely treat and resolve secondary disasters such as quake lakes, to carry out aftershock monitoring, meteorological service, technical support, coal, power and oil transport assurance, and to timely and accurately publish the updated disaster effects, creating favorable conditions for earthquake rescue and relief as well as post-disaster restoration and reconstruction. The General Headquarters actively organized the funds appropriation and materials supply while taking measures to strengthen the supervision and inspection of the use of funds and materials, to ensure that the materials would timely and effectively be used for the disaster areas and the affected people.

The General Headquarters strengthened the policy support, and did the best to conduct the production restoration in disaster areas. Thus, a great progress was achieved in restoring industry, agriculture and tourism in disaster areas. The General Headquarters organized the national force for scientific assessment and planning, and effectively formulated relevant rules, guidelines and plans. The Central Finance established special funds, organized the implementation of counterpart assistance and legally and orderly executed post-disaster restoration and reconstruction. The restoration and reconstruction work was promoted in an all-around manner, Three years after the disaster, the restoration and reconstruction task was almost completed. The people in disaster areas are starting their new life.

6.2.3 The Role of Local Governments: Mobilizing and Coordinating Actions to Defeat the Catastrophe

Faced with the extremely serious earthquake disaster, party committees and governments at various levels as well as their officers and masses of people within the disaster areas were promptly mobilized to take rapid actions as the mainstay. 146,000 officers and soldiers of the PLA and armed police as well as 75,000 reserve forces and policemen performed frontline services, playing the role of major forces and storm troops. The whole nation cared for the disaster areas and united to fight against the disaster. The social sectors donated funds and goods valuing 75.197 billion Yuan RMB, a record in the disaster relief donation history of China. While combating with the extremely serious earthquake disaster, the party, government, military and civilians united as one, displaying the Chinese nation's uniting and striving characters; and they were fearless of dangers and difficulties as well as undaunted by repeated setbacks, displaying the Chinese nation's characters of caring for life and advocating rationalism. Under the overall and systematic leadership and guidance of the General Headquarters, the entire nation withstood many trials and difficulties, yet still managed with an unprecedented effort to rescue lives and provide assistance to urban areas and rural areas, to military forces, factories and mines, to institutions and grassroots, to communities and schools. The national earthquake rescue and relief was very successful, showing the great forces of the party and the state, the people's army, the Chinese people, the reforming and opening-up and the socialist system with Chinese characteristics. The catastrophe tested the Chinese government and Chinese people as well as the overall national strength of China.

6.2.4 The Role of Sciences and Technology: Assessing Disaster Impacts and Developing Reconstruction Plans

Facing a huge number of collapsed and damaged houses, large-scale damaged infrastructures, huge losses of industrial and agricultural production and serious destruction of the ecological environment caused by the great earthquake, the General Headquarters led to make a complete and rapid disaster effects assessment, and to formulate the restoration and reconstruction program in accordance with the law, and to establish a nationwide counterpart assistance mechanism for quick restoration and reconstruction. On June 4, 2008, at its 11th executive meeting, the State Council passed the *Regulations on Post-Wenchuan Earthquake Restoration and Reconstruction* (hereinafter referred to as the *Regulations*), which was promulgated for implementation on June 8, 2008. China did it for the first time in the history of responding to catastrophes. The *Regulations* consisted of 9 chapters and 80 articles, including General Provisions, Transition Settlement, Survey and Assessment, Restoration and Reconstruction Planning, Implementation of Restoration and Construction, Funding and Policy Support, Supervision and Management, as well as Legal Responsibilities and Supplementary Provisions, all of which have laid a solid legal foundation for restoration and reconstruction. According to the *Regulations*, the relevant ministries, commissions and the State Wenchuan Earthquake Expert Committee carried out a quick scientific assessment on the scope, extent as well as restoration and reconstruction bearing capacities of Wenchuan Earthquake. Based on it, the central government made the *Guidance on Post-Wenchuan Earthquake Restoration and Reconstruction* (hereinafter referred to as the *Guidance*), and each disaster area made the *Plan on Post-Wenchuan Earthquake Restoration and Reconstruction* according to the *Guidance*. It was required to complete the major restoration and reconstruction tasks within approximate 3 years, with the basic living conditions and economic and social development levels reaching or exceeding the levels before the earthquake, It is also required to strive to build new livable and workable environment which is ecological sustainable, safe and harmony in order to provide a solid foundation for sustainable economic and social development in the area. To achieve the overall target of the plan, based on the counterpart assistance mechanism from non-affected provinces (municipality directly under the central governments and autonomous regions) to seriously affected disaster areas established during the emergency rescue period, the General Headquarters, in accordance with the damage assessment results of disaster areas and the *Plan on Post-Wenchuan Earthquake Restoration and Reconstruction*, utilized national strength to accelerate the restoration and reconstruction in earthquake disaster areas, and reasonably made allocations to establish the counterpart assistance mechanism, under the principle of “one province assisting one heavily-hit county” and in accordance with the assistance party’s economic capacities and the disaster effects of the affected party. The major disaster areas in the 24 counties (municipality directly under the central governments and autonomous regions) were granted support from 20 corresponding provinces (municipality directly under the central governments and autonomous regions) and Shenzhen Special Economic Zone. Tianjin supported 2 major disaster counties in Shaanxi and Shenzhen supported 4 major disaster counties in Gansu.

6.2.5 The Role of Media: Raising National Spirit and Forming Cohesion

In the response of the catastrophe, the party, governments, military and civilians in China made cohesive forces with ideals, form firmness with belief, gathered concerns and love with true affection, and largely cultivated and popularized the great earthquake rescue and relief spirit of “all people of one mind, uniting as one, fearlessness of dangers and difficulties, unyieldingness with repeated setbacks, putting people first and respecting science” (Hu 2008). Under the uniform deployment of the General Headquarters, all local governments and sectors fully supported disaster areas. Great efforts were made towards the mobilization of personnel, support of materials, medical treatment for the injured, relocation of the affected people, building of temporary and transitional lodgings. Facing the serious earthquake disaster, the whole nation shared sorrow and difficulties, and united as one; Chinese people at home and abroad made a concerted effort and mutual cooperation to form a solid life community. In the extremely somber disaster, neither the army nor the civilians gave in under the great pressures and huge difficulties. They pertinacious challenged their physical and mental limit, and rushed to the disaster areas, going to the extremely dangerous areas and helped the affected people.

Throughout the process of earthquake rescue and relief, the rescue efforts raced against time and fought against death, fully representing the essence of Chinese socialist system to care for life and protect people. On the National Mourning Day, 1.3 billion Chinese people jointly mourned over the victims in the disaster, which represented the nation's respect to human life. In response of the catastrophe, we insisted on combining the strength of science and technology with pertinacious struggle, to give play to proactive spirit of people as well as science and technology. The spirit of earthquake rescue and relief was the concentrated reflection of the national spirit and thereby an important part of the overall national strength, and its implication was enriched and enhanced in repose of catastrophes one after another. This spirit played an inestimable role in encouraging people in the disaster areas and even nationwide to battle against the hardships and reconstruct their homes.

In general, Fig. 6.3 shows the working framework for coping with the Wenchuan Great Earthquake on May 12, 2008, containing both successful practices regarding the Chinese government's "national catastrophe response" and some experience and lessons to be rethought and learned from.

6.3 Experience, Lessons and Recommendations

6.3.1 Experience

Through arduous efforts, the basic living conditions and the safety of people in disaster areas were effectively secured. Public orders were promptly restored and post-disaster reconstruction has been undertaken in an orderly manner. The response of the Chinese People and its government to the Wenchuan Great Earthquake achieved success, showing the superiority of the socialist system, the competence of the Party and the government for exercising power, battle effectiveness of the people's army and the cohesive force of Chinese nation. Reviewing the rescue and relief since the earthquake, the following experience can be summarized:

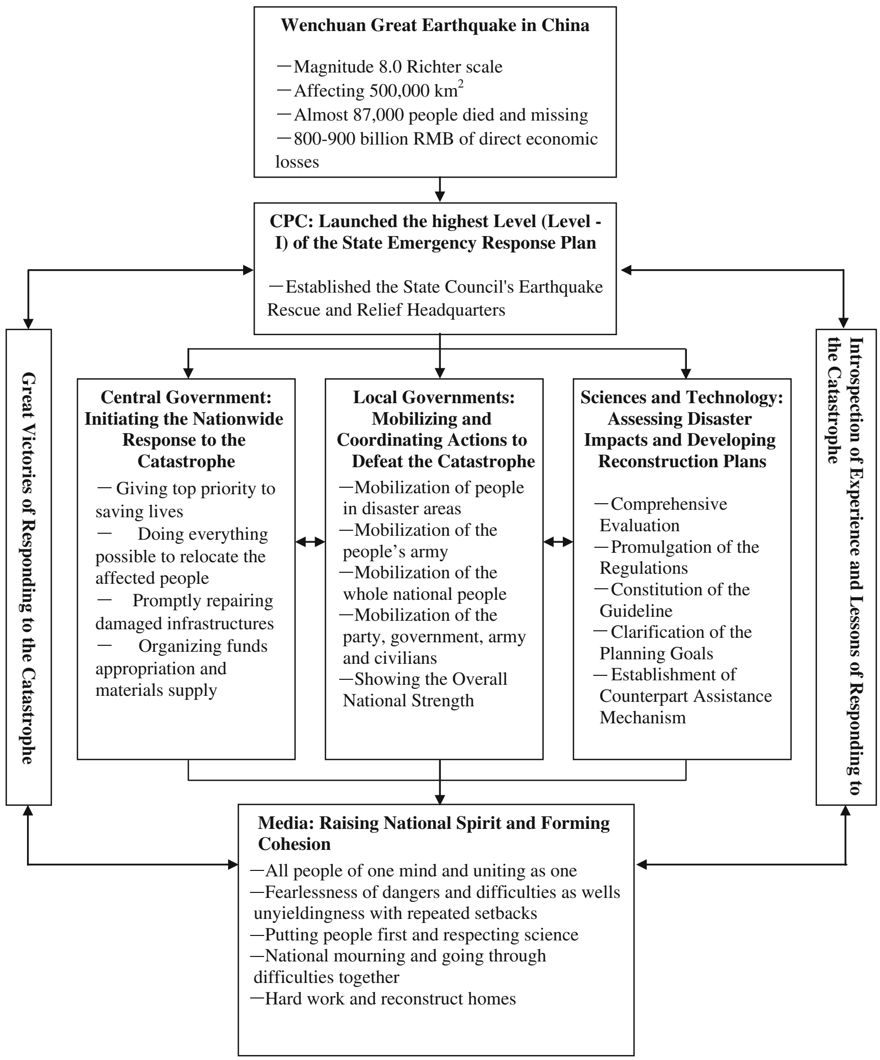

Fig. 6.3 Framework of the Chinese government's "national response to the wenchuan earthquake catastrophe of May 12, 2008"

The firm leadership and scientific decisions of the CPC Central Committee and the State Council were the fundamental political guarantees for the victory.
The persistence in putting people first and the scientific outlook on development were the solid ideology base for the victory.
The persistence in unified coordination and command as well as close operation were the important organizational grantees for the victory.
The people's army advancing bravely to overcome difficulties was the solid mainstay for the victory.

The people from all walks of life united as one, which was the strong cohesive force for the victory.
The timely, accurate, open and transparent information dissemination and media coverage created good public opinion environment for the victory (The State Council's Earthquake Rescue and Relief Headquarters, 2008).

The 6 aspects, as shown in Fig. 6.3, showed that the Chinese government's "mode of national response to the catastrophe" achieved great success again.

6.3.2 Lessons

In the process of responding to the catastrophe, while comprehensively summarized the major achievement and experience, the major problems and weakness of the disaster prevention and reduction abilities and emergency system establishment in China are identified as follows:

6.3.2.1 Low Levels of Disaster Resistance in Urban and Rural Constructions

Distributions of power grids, highways and other major infrastructures in the region were not fully reasonably designed. The density of the railway network was relatively low with only one major line which was constructed without adequate considerations for such factors as topographical conditions, geological structures and disaster risks. The earthquake resistance and fortification requirements were not fully implemented. The supervision of the disaster resistance and fortification of the general construction works was weak. There was no management of the rural residence construction, with the non-fortification status.

6.3.2.2 Weak Capacities of Emergency Rescue and Relief in Disaster Areas

The emergency rescue system was inadequate. Various professional forces such as personnel search and rescue, urgent repair of infrastructures and medical aid were too weak. The emergency equipment for search and rescue, communication and medical treatment and epidemic prevention was inadequate. The remote maneuvering capacity was weak. The number and variety of materials reserves could barely meet the demand for catastrophe response. The emergency production reverse system was not established.

6.3.2.3 Imperfect Management System for Catastrophe Response

The central and local governments did not have sound emergency response systems for major natural disasters and emergencies. The trans-regional and trans-departmental joint command and integrated coordination mechanisms still needed improvement. Some emergency plans had problems such as indefinite objectiveness, weak applicability and inadequate connection. Some enterprises' emergency plans were not sound and other enterprises had no emergency plans at all.

6.3.2.4 Low Level of Monitoring, Warning and Forecasting for Disastrous Earthquakes

Worldwide seismic forecasting and warning systems are still at a stage of exploration and short-term seismic forecasting is an extremely difficult process. China's instant reporting network for seismic intensities is not sound and the warning systems have not been established, with grate gaps from developed countries in terms of disaster information acquisition and processing, disaster reduction by remote sensing.

6.3.2.5 Weak of Disaster Risk Prevention Consciousness

The public lacked the commonsense of earthquake prevention and disaster resistance as well as the self-rescue and mutual rescue skills. There was no earthquake disaster insurance, and the disaster insurance coverage was low. It is limited to use insurance to spread risks of catastrophes.

6.3.3 Recommendations

6.3.3.1 Further Improvement of the Policies and Measures for Catastrophe Response

Aiming at the above-mentioned problems and weaknesses, equal attention must be paid to benefit promotion and disaster elimination, the combination of disaster prevention with disaster mitigation, consideration of both temporary and long-term solutions, as well as cooperation between governments and different social sectors. It is also necessary to improve risk monitoring, emergency treatment, rescue and relief, as well as restoration and reconstruction for diverse types of emergencies. By promotion of the emergency management mechanism and system establishment in an all-around manner, the damages caused by emergent pubic events can be reduced to the greatest extent, and the people's life and property securities can be guaranteed to the greatest limit.

6.3.3.2 Enhancing Urban and Rural Constructions as well as Disaster Prevention Capacities

Strengthen the disaster risk assessment of major infrastructures. Strictly implement the standards for disaster resistance and prevention during the processes of planning, design, construction and operation, and appropriately increase the standards for high-risk areas as the development of economy. Enhance the disaster resistance capacity establishment of railways, highways and civil aviation, and improve the overall capacities of regional transport coordination for catastrophe response. Raise the disaster resistance and fortification standards of the power system and enhance the disaster tolerance and backup of the communication networks. Enhance the earthquake resistance and fortification of urban and rural construction works supervision, and revise the seismic design specifications and classification fortification standards while perfecting the seismic safety management system and mechanism for rural residence. Strengthen the construction of disaster prevention and reduction infrastructures, and include emergency shelters and other facilities into urban and rural planning. Appropriately increase the earthquake resistance and fortification standards for such public facilities as schools and hospitals. In combination with the implementation of post-disaster reconstruction, relocate or carry out safety transformations for enterprises and facilities with unreasonable arrangements or hidden safety problems.

6.3.3.3 Improving the Emergency Management System and Mechanisms

In order to meet the requirements of catastrophe prevention and maintenance of stability of economic and social development, we should enhance the disaster prevention and reduction duties of governments at different levels, establish and improve the emergency management and command mechanism by establishing a unified responsibility and power in normal and exceptional circumstances, form the working mechanism of centralized leadership, generalized command, sensitive response and efficient operations to increase the capacity of the party committees and governments at varying levels to effectively respond to disasters, further improve the coordination and interlink mechanisms among sectors, local governments, military forces and armed police and ensure close intra-liaison between them, to encourage action and joint operation between the superior and the subordinate, between bars and blocks and between the military and the local government upon occurrence of any emergency event.

6.3.3.4 Enhancing the Buildup of a Policy and Regulation System

Establish and improve the laws, regulations, policies and measures for emergency management. Study and formulate the implementation rules for the Emergency Response Law. Improve the standardizations of organization and command, monitoring and warning, information release and processing procedures, as well as logistics guarantees, and especially emphasize on to define the law enforcement agency for "Emergency Response Law". Draft and revise some laws and regulations such as the *Emergency Response Law of the People's Republic of China* and during the draft, make natural disaster assistance regulations and establish catastrophe insurance and reinsurance systems in compliance with national conditions, to further enhance the national capacity for integrated disaster relief, restoration and reconstruction. Formulate policies and measures for supporting R & D, promotion and application of relevant science and technologies in connection with disaster prevention and mitigation, risk control and emergency technologies, and speed up the development of the policies and measures for disaster risk science.

6.3.3.5 Revising and Improving Different Emergency Plans

Speed up the development of emergency planning systems in different regions, industries and institutions, make and improve emergency plan measures, and enhance the force of constraint for emergency plans. Organize the assessment of the existing emergency planning systems for timely revision and improvement, further increase the scientific background, completeness and operability of the emergency plans, and strengthen the connection between emergency plans. Regularly carry out the drills for emergency plans, enhance tans-departmental, trans-industrial and trans-regional comprehensive drills, to constantly increase the capacity of coordination in disaster response.

6.3.3.6 Improving the Emergency Management Assurance System

Enhance the equipment system construction for emergency materials, optimize the storage layout and approaches, and reasonably, determine the storage types and scale, and establish an efficient allocation and transportation mechanism. Improve the long-term and standardized system of emergency assurance funds input and appropriation, improve fast and orderly measures for epidemic prevention, protection and medical treatment, establish emergency commanding platforms for governments at different levels, improve information sharing mechanism, and enhance the capacities of disaster monitoring, studying and judging, early warning decision-making and handling. Make efforts to build the professional and social emergency rescue forces, improve equipment, enhance remote maneuvering capacities, establish regional rescue bases, and improve rescue efficiencies. Establish a social mobilization mechanism of counterpart assistance, social donation and volunteer services with sound management, increase the consciousness and initiative of enterprises, social groups and citizens to participate in risk prevention.

6.3.3.7 Enhancing the Capacity of Disaster Monitoring and Pre-Warning

Strengthen the study of occurrence patterns of emergency events such as natural disasters, improve the monitoring system and warning release system, and further expand the coverage of warning information. Improve the seismic monitoring and rapid reporting network for intensities, carry out the earthquake early warning prevention works, appropriately release forecasting opinions on earthquake mid and long-term seismic trends including earthquake key monitoring fortification areas. Formulate and implement the *National Disaster Prevention and Reduction Science Program*, to further enhance the technical development of natural disaster monitoring and warning systems and raise the capacities and levels of forecasting disastrous earthquakes. Further strengthen the development of seismic integrated assessment technology, and develop seismic disaster risk maps for regions within the country.

6.3.3.8 Improving the Social Risk Prevention Consciousness

Enhance education and popular science communication of disaster prevention and mitigation, and integrate emergency knowledge of disaster prevention and risk avoidance, self-rescue and mutual rescue, into educational propaganda of schools and communities. Strengthen the emergency management and risk prevention knowledge training of leaders at different levels, and increase their coordination and command capacities for dealing with disastrous events. Increase national risk prevention consciousness through the "National Disaster Prevention and Reduction Day" activity (May 12 of each year). Improve the system for timely and accurate information release, public opinion guidance and public opinion analysis. Enhance discipline construction and scientific platform construction in disaster prevention and mitigation, as well as the international exchange and cooperation in the area, establish and improve the disaster prevention and reduction cooperation mechanism with relevant international institutions and governments of different countries, and make efforts to support and encourage the implementation of IHDP-IRG Project.

6.4 Conclusions and Discussions

1. The Sichuan Wenchuan Earthquake which shocked China at 14:28, May 12, 2008 has been the earthquake with the strongest destruction, widest coverage and highest difficulty for rescue and relief since the foundation of the new China. The Wenchuan Earthquake had Magnitude 8.0 on the Richter scale, with the highest intensity of XI. As of 12:00, October 10, 2008, there were a total of 8 aftershocks of Magnitude over 6. The earthquake affected 417 counties,

autonomous regions and municipalities in 10 provinces and municipalities. The affected area is approximately 5,00,000 km^2. The most affected areas include 51 counties autonomous regions and municipalities with an area of 1,32,000 km^2. The earthquake and the post-earthquake induced disasters caused the result of 69,227 victims, 17,923 missing people and 3,74,600 injured people. The disaster caused direct economic losses of 845.136 billion Yuan to Sichuan, Gansu and Shaanxi, including 771.717 billion Yuan to Sichuan.

2. The Chinese Government accomplished a great victory by engaging the whole nation to respond to this catastrophe, with major achievements as follows: Over 1,486,000 trapped people were relocated and over 84,000 people were rescued from the ruins. There were 4,380,000 medical treatments for the injured and no major disease epidemic occurred after the earthquake. The affected people were properly resettled and their basic livelihood was secured. Emergency repair and maintenance were promptly organized, with great efforts to repair infrastructures. Secondary disasters were strictly prevented and efforts were made to avoid any further casualties. Policy supporting and guidance were enhanced and production restoration was achieved in disaster areas. Scientific assessment and planning were executed and the restoration and reconstruction were carried out in an orderly manner according to the laws. The *Regulations on Post-Wenchuan Earthquake Restoration and Reconstruction* and the *Overall Plan for Post-Wenchuan Earthquake Restoration and Reconstruction* were promulgated for implementation. The information was timely and accurately released and the guidance for public opinions was enhanced. The major experiences include: firm leadership and scientific decision of the CPC Central Committee and the State Council, persistence in putting people first and close cooperation and coordination, the people's army advancing bravely to overcome difficulties, the people from all walks of life united as one, as well as the timely, accurate, open and transparent propaganda and coverage, forming the great earthquake rescue and relief spirit of "all people of one mind, uniting as one, fearlessness of dangers and difficulties, unyieldingness with repeated setbacks, putting people first and respecting science".
3. The historically destructive earthquake has thoroughly exposed the problems of low levels of disaster resistance and fortification of the urban and rural construction in the disaster areas, weak assurance capacities for emergency rescue and disaster relief, imperfect systems and mechanisms for catastrophe response, low levels of monitoring, early warning and forecasting disastrous earthquakes and weak of disaster risk prevention consciousness. Therefore, it is imperative to enhance the disaster prevention capacities of urban and rural construction, to improve the emergency management system and mechanism for disasters, to enhance the construction of policy and regulation systems, to revise and improve various emergency plans, to improve the emergency management assurance system, to enhance the capacity of disaster monitoring and early warning systems, and to improve the social risk prevention consciousness.

From the perspective of the response capacities of social-ecological systems in disaster area to the grate earthquake disaster, since the disaster area is located along the eastern boundary of the Yun-Gui Plateau and the Tibetan Plateau, one of the three regions in China with a high frequency and intensity of earthquakes, along with adverse natural conditions and precipitous mountains, the ecological system has an extremely low capacity for adapting to the immense earthquake disaster. Given that the disaster area is the relatively centralized residing area for minorities, where the economy and society are undeveloped and the disaster resistance and fortification level of urban and rural construction is also relatively low, a catastrophe would ensue once an intensive destructive earthquake would be encountered. Facing such a rare catastrophe, the decisive action of the Chinese Government to "mobilize the whole nation to respond to the catastrophe" promptly coped with this disaster in the century and minimized the duration of post-earthquake effects. According to the overall planning, the disaster area restoration and reconstruction will be expected to be complete within about 3 years after the earthquake. Similar to Chinese government's response to the sleet and snow disaster in South of early 2008, the characteristics of "easy entry transition and quick transition-out" is in an obvious contrast with the one of "hard entry transition and slow exit transition" demonstrated by the western developed countries to respond to catastrophes. As compared with the Japanese government's response to the 1995 Kobe Earthquake, the action of China to mobilize the whole nation in response to the Wenchuan Earthquake has also shown relatively high efficiency. However, as compared to western developed countries, the mode of "national response to catastrophe" taken by the Chinese government has shown a considerable disadvantage in resource utilization due to the lower disaster fortification level in the vast disaster area and minimal awareness of citizens towards risk prevention. With reference to the successful experience of western developed countries in catastrophe risk transfer, we can increase the disaster fortification level in high-risk areas, and combine the catastrophe insurance with the improvement of the "national catastrophe response mode", which will definitely increase the efficiency and benefit of resource utilization for China's catastrophe response, and improve China's capacity to respond to catastrophes as a whole.

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Chapter 7
Experience, Lessons and Recommendations of China's Response to Sleet & Snow Disaster in South

Peijun Shi, Weihua Fang, Wenjie Dong, Ning Li, Wei Xu and Shi Chen

From January 10 to February 6 of 2008, the large-scale sleet & snow weather occurred in southern China for five times successively. The disastrous weather happened to coincide with the Spring Festival travel rush during the traditional Spring Festival in China, with most of the regions happened once in 50 years and some of the regions happened once in 100 years (Academy of Disaster Reduction and Emergency Management at Peking Normal University, co-funded by the Ministry of Civil Affairs and the Ministry of Education 2008). In some hilly and mountainous areas in the south, the accumulation of the four previous disasters resulted in a catastrophe rarely seen in the history of China. 20 provinces (municipality directly under the central governments and autonomous regions) of the country were effected to different extents, among which Hunan, Guizhou, Jiangxi, Guangxi, Hubei, Anhui, Zhejiang and Sichuan were the worst (Fig. 7.1). The continuous sleet & snow weather led to the simultaneous occurrence of different disasters, brought great damage to power and transportation facilities, resulted in heavy damage to people's lives and properties as well as industrial and agricultural productions, made the normal routine of production and living disturbed. After the disaster happened, the CPC Central Committee and the State Council attached great emphasis on it. The leaders of the central government went to the frontline to command, and rapidly deploy the large-scale national disaster rescue and relief.

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P. Shi et al. (eds.), *Integrated Risk Governance*, IHDP-Integrated Risk Governance Project Series, DOI: 10.1007/978-3-642-31641-8_7,

Fig. 7.1 In Liaojialin Village, Xiaoxita Town, Yiling District, Yichang, Hubei, farmer Zhengfu Huang's house collapsed due to the snow disaster. (Junfeng Liu/Imaginechina)

7.1 Sleet & Snow Disaster in South and the Causes

7.1.1 Disastrous Weather Process and Features

7.1.1.1 Disastrous Weather Process

From January 10 to February 6 of 2008, the large-scale sleet & snow weather occurred for five times successively in most part of China, especially southern China (Table 7.1) (Expert Committee of National Disaster Reduction Commission 2008). In general, this lasting extreme sleet & snow weather happened once in 50 years and happened once in 100 years for few regions. The sleet and snowfall was primarily concentrated in the middle and downstream areas of the Yangtze River, most areas of southern China and the northwestern part of Yunnan. The total precipitation in these areas reached 50–100 mm. In the south of Anhui and Anhui, a large part of regions south of the Yangtze River, and some areas of southern China, the precipitation even exceeded 100 mm. Compared with the same period in ordinary years, in most regions north of the Yangtze River, most part of regions south of the Yangtze River, most part of southern China, the western part of Yunnan and the southeastern and western part of Tibet, the

Table 7.1 Five sleet & snow weather processes occurring since January 10, 2008

Process	Snow & heavy snow areas	Sleet areas
The first process (January 10–16)	Central part of Shaanxi, southern part of Shanxi, Henan, central and northern part of Anhui, northern part of Jiangsu, Hubei, Hunan, and northwestern part of Jiangxi	Central and southern part of Hunan, and western and southern parts of Guizhou
The second process (January 18–22)	Eastern part of Hubei, southern part of Henan, middle and northern parts of Anhui, northern part of Jiangsu, and northern part of Hunan	Southern part of Anhui, majority areas in Hunan, Guizhou, and northeastern part of Guangxi
The third process (January 25–29)	Heavy snow occurred in southern part of Henan, eastern part of Hubei, and northern parts of Anhui, Jiangsu and Zhejiang. The depth of snow on January 28 reached 20–45 cm	Most areas in Jiangxi, most areas in Guizhou, and some areas in Hunan
The fourth process (January 31–February 2)	Middle part of Hunan, northern part of Jiangxi, southern part of Anhui, southern part of Jiangsu, and northern part of Zhejiang. The depth of snow in local areas on February 2 reached 20–35 cm	Guizhou, Hunan, Jiangxi, Zhejiang and Yunnan
The fifth process (February 4–6)	Hunan, northern part of Jiangxi, western part of Guizhou and eastern part of Yunnan	Eastern part of Yunnan and western part of Guizhou

precipitation was 1–2 times higher than average, with that some of the regions exceeding 2 times. The temperatures in the northwestern, central and eastern parts of China were 1–4 °C lower than average compared with the ordinary years, with the temperature in central and eastern parts of Hubei, most part of Hunan, central and eastern parts of Guizhou, central and northern parts of Guangxi, most part of Gansu, western parts of Ningxia and Inner Mongolia and southern part of South Xinjiang lower than over 4 °C.

7.1.1.2 The Weather Features

In general, the sleet & snow weather has been rare since the foundation of new China, with wide effected areas, long duration, low average temperatures, abundant average precipitation and thick ice accretion and snow cover.

Wide Effected Areas

The continuous sleet & snow weather influenced 20 provinces (municipality directly under the central governments and autonomous regions) including Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Henan, Hubei, Hunan, Guangdong, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang and the Xinjiang Production and Construction Corps. From the sleet & snow day distribution between January 10 and February 3 in China, we can see that the sleet & snow weather occurred in most part of China except southern China, the northeastern part of China and Yunnan., and there were 10–20 sleet & snow days in Hunan, most areas of Hubei, the northwestern part of Jiangxi, the middle and southern parts of Anhui and the middle part of Guizhou.

Long Duration

From December 1, 2007 to February 2, 2008, the longest days of continuously harsh conditions with the average daily temperatures below 1 °C in the middle and downstream areas of the Yangtze River and Guizhou, as the second-largest in the same period in history, were only less than of that in winters of 1954/1955. The number of days with sleet & snow weather in middle and downstream areas of the Yangtze River and Guizhou, as the maximum in the same period in history, exceeded that of 1954/1955. In Hunan province with the largest scope and longest duration, the duration also exceeded that of 1954/1955. In Hunan, the number of sleet & snow weathers were the largest in the recorded history, with the duration less than that of 1982/1983 and 1954/1955. In most parts of Hubei, the number of days of continuous low-temperature was 16–18, the longest since 1954/1955, and the number of days of continuous sleet & snow was 15–18, also the longest compared to recorded average. In Anhui the number of days of continuous snow were 24, the longest since the foundation of China and also the longest in the record, with exceeding of the recorded high during 1954/1955 and 1968/1969 (16 days in both periods).

Low Average Temperature

The continuous sleet & snow weather was accompanied by lower lowest average temperatures (2–4 °C lower than that of normal years), and lower highest temperatures (5–10 °C lower than that of normal years). The temperature in Guizhou, Hunan, Hubei and Jiangxi were the lowest compared with the temperature in the same period in history, with the precipitation and snowfall the third largest in history. The highest temperature in middle and downstream Yangtze River and Guizhou, as the lowest value in history, was lower, which was less than the lowest value during 1976/1977. The average temperature in Hubei and Hunan reached a record low compared with the same period in history and the average value of the highest temperature in many areas was the lowest once in 100 years.

Heavy Average Precipitation

The amount of precipitation in six provinces (autonomous regions), i.e. Henan, Sichuan, Shaanxi, Gansu, Qinghai and Ningxia exceeded the historical maximum precipitation since 1951. The snow in Zhejiang was the heaviest since 1984. The precipitation in part of Jiangsu, Anhui, Jiangxi, Guangdong, Guangxi and Yunnan exceeded 100 mm. The precipitation in Tongling of Anhui and Jiujiang of Jiangxi exceeded 150 mm. In some areas of Anhui and Jiangsu, the depth of snow over reached 30–50 cm, the highest depth in the past 50 years. Over 90 % areas of Shanghai, Jiangsu, Anhui, Henan, Hubei and Shaanxi were covered by snow and 40–75 % areas in Guizhou, Hunan and Chongqing were covered by snow.

Thick Ice Accretion and Snow Cover

In Wuhan city of Hubei province, a maximum snow cover depth was 27 mm, the second highest depth compared with that of 1954/1955 (32 mm). The thickness of ice accretion on electric wires in Guizhou broke the meteorological record. The duration of sleet & snow weather in 49 counties (municipality directly under the central governments) exceeded the historical record. The duration, snow cover depth and degrees of influence of regional heavy snow in Jiangsu set a new record. The depths of snow cover in 23 cities and counties (autonomous regions) exceeded the highest record of 1961, with a maximum depth of 37 cm snow in Nanjing City, the maximum since 1961. In addition, Low ground wind speed and high atmospheric humidity inhibited the removal of snow cover and ice accretion through wind or evaporation. The average daily wind speed and highest wind speed recorded by Yizhang Meteorological Station in Chenzhou City of Hunan Province (adjacent to Nanling along the Beijing-Zhuhai Expressway) were lower than 1.8 and 3.5 m/s, respectively, which were lower than 5 m/s, the threshold speed to remove covered snow. The average relative humidity in Yizhang Station was as high as over 75 %. During the third and fourth processes, the relative humidity was as high as over 80 %.

7.1.2 Losses from the Disasters

The sleet & snow disaster resulted in serious losses, which were far exceeded the similar disasters in the past ordinary years. The disasters affected 21 provinces (autonomous regions, municipality directly under the central governments and Corps) (Table 7.2). 129 people died and 4 people went missing due to the disasters. Around 1,660,000 people were relocated emergently. 11,874,200 ha of crops were damaged. 1,690,600 ha of crops produced no harvest. 485,000 compartments of houses went collapsed. 1,686,000 compartments of houses were damaged.

Table 7.2 Sleet & snow disaster effects, by Provinces (as of February 30, 2008)

Provincial-level administrative area	Number of affected people (ten thousand people)	Death toll due to the disasters	Number of missing people due to the disasters	Number of people emergently relocated (ten thousand people)	Affected crop area (ten thousand hectares)	No-harvest crop area (ten thousand hectares)	Number of collapsed rooms (ten thousand rooms)	Number of damaged rooms (ten thousand rooms)	Direct economic losses (hundred million Yuan)
Shanghai		2		0.2	1.07	0	0	0.1	1.6
Jiangsu	245.3	7		2.1	23.24	12.0	0.9	1.7	27.8
Zhejiang	2381.9	9		13.6	83.29	4.08	0.4	0	174.3
Anhui	1342.3	12		13.1	69.53	6.36	9.1	17.3	132.3
Fujian	167.6			0.5	3.28	0.12	0.1	21.3	30.9
Jiangxi	2210.0	7		22.6	146.80	35.30	4.2	23.1	272.0
Henan	94.1			0.8	13.94	0.27	0.3	0.6	6.8
Hubei	2279.8	13		21.7	141.77	11.20	9.8	17.0	114.2
Hunan	3927.7	20		27.7	250.01	45.87	6.7	30.0	172.0
Guangdong	419.0			29.0	41.47	2.12	0.2	0.1	33.6
Guangxi	1399.0	2		5.8	86.11	4.91	5.9	7.2	200.0
Chongqing	548.6	2		0.6	24.63	2.77	0.3	1.4	9.6
Sichuan	1059.9	5		4.5	53.56	5.40	2.1	8.8	58.3
Guizhou	2654.8	27		11.2	148.97	31.75	3.1	12.8	198.3
Yunnan	1139.6	22	4	11.0	59.09	11.07	3.9	19.7	50.8
Shaanxi	185.0			1.0	25.33	2.0	0.4	0.9	4.6
Gansu	448.0				13.58	4.53	0.4	3.3	17.8
Qinghai	70.5				0	0	0.5	1.4	4.2
Ningxia	116.6			0.5	1.08	0.11	0.3	0.9	4.7
Xinjiang	35.1	1					0.1	1.0	1.8
Xinjiang Production & Construction corps	2.7				0.67		0	0	1.2

Table 7.3 Losses due to great disastrous events since 1998

Great disastrous events	Number of affected provinces	Death toll and number of missing people	Number of People emergently relocated (ten thousand people)	Number of collapsed rooms (ten thousand rooms)	Direct economic losses (100 million RMB Yuan)
The great sleet & snow disaster in 2008	21	132	166.0	48.5	1516.5
The great flood of Huaihe river Basin in 2007	3	39	144.1	13.3	195.9
No. 4 Tropical storm *Billes* in 2006	6	843	336.9	39.1	348.2
No. 8 Extremely strong Typhoon *Sangmei* in 2006	3	483	180.1	13.7	196.5
The great drought in Sichuan and Chongqing in 2006	2				222.7
No. 14 Typhoon *Yunna* in 2004	6	183	66.0	7.22	198.9
The great flood of Huaihe river basin in 2003	3	31	217.8	38.9	364.3
The great flood in 1998	29	2291	1664.0	583.3	2104.4

The direct economic loss due to the disasters was 151.65 billion Yuan. Provinces (autonomous regions) such as Hunan, Guizhou, Jiangxi, Anhui, Hubei, Guangxi, Sichuan and Yunnan were hit relatively severely by the disaster (Expert Committee of National Disaster Reduction Commission 2008).

7.1.3 Analysis of Historical Comparison

From the perspective of historical comparison of disaster losses (Table 7.3), the disaster this time was the great disaster.

Table 7.4 Comparison of the sleet & snow disaster in 2008 with the freezing weather and snow disasters from 2002 to 2007

Years	Death toll	Number of emergently relocated people (ten thousand people)	Number of collapsed rooms (ten thousand rooms)	Direct economic losses (ten million Yuan)
The great sleet & snow disaster in 2008	133	166.0	48.5	1516.5
Freezing weather and snow disasters in 2002	102	0.1	0.16	108.91
Freezing weather and snow disasters in 2003	9		3.38	47.8
Freezing weather and snow disasters in 2004	24	2.7	5.9	96.6
Freezing weather and snow disasters in 2005	79	7.6	10.7	72.9
Freezing weather and snow disasters in 2006	10	1.6	7.7	169.0
Freezing weather and snow disasters in 2007	31	5.4	1.4	186.5
Annual average losses from 2002 to 2007	42.5	2.9	4.9	113.6

Compared with the great disasters since 1998 and judging from the affected area, the death toll, the number of missing and relocated people, the number of collapsed buildings and direct economic losses as a result of the sleet & snow disaster, we can define the sleet & snow disaster as a large-scale disaster. The affected areas and direct economic losses are of same scale as those of the 1998 Great Flood and the 1999–2001 Great Drought. The death toll, the number of missing and relocated people and the number of collapsed buildings was far more than the average of the sleet & snow disaster in recent years. It is rare in history that the losses were so huge in a disaster (Shi et al. 2008).

Compared to the losses of freezing weather and snow disasters from 2002 to 2007 (Table 7.4), the number of effected people and relocated people, the number of collapsed buildings and the direct economic losses exceeded the annual average level from 2002 to 2007, with the number of relocated people, the number of collapsed buildings and the direct economic losses over 10 times larger than the average of 2002–2007.

7.1.4 Economic and Social Impact

7.1.4.1 Livelihood of the General Public

A large number of houses were collapsed and damaged in the disaster, and a more serious impact was the damage to the livelihood of people already living in poverty (Shi et al. 2009). Due to the sleet & snow weather, roads and airlines failed to operate in many areas. As a result, the transportation of subsidiary agricultural products was difficult. With the supply shortage, the prices of subsidiary agricultural products in some regions soared. People in remote mountainous or areas suffered severely from the disaster and experienced limited access to necessities such as food, clothing, quilts, drinking water and candles as well as means of production such as seeds and other goods necessary for farming. The agriculture and animal husbandry production and people's life were severely impacted. Moreover, the disaster happened to coincide with the Spring Festival travel rush, with busy traffic and transportation. Some of the railways, roads, and airlines were blocked or even forced to close. 870,000 passengers were stranded, among whom, 80,000 passengers in Hunan province needed to be assisted, and 107,000 passengers were along the roads of Guizhou Province in rush hours. Some of the passengers were stranded for more than 40 h, and suffered both physically and psychologically. Few passages had emotional instabilities. The total number of stranded passengers in railways and roads who needed assistance reached 6555,000.

7.1.4.2 Severe Damages of Power Facilities

Due to the disaster, 35,710 power lines in the national grids (including the system of State Grid Corporation of China, the system of China Southern Power Grid Co., Ltd., and the power lines from local grid companies and power suppliers) and 2007 Transformer Substations were shut down. 8,501 towers along 110–500 kV power lines collapsed. The power systems of 13 provinces (autonomous regions and municipalities directly under the central government) were affected. Power failure occurred in 170 cities and counties. Power plants were 42,000,000 kW below capacity (the maximum) due to coal shortages. 19 provinces (autonomous regions and municipalities directly under the central government) conducted power rationing (Expert Committee of National Disaster Reduction Commission 2008).

7.1.4.3 Severe Block for Transportation

Due to power system collapse and power failure in areas such as Hunan, Jiangxi and Guizhou, Beijing-Guangzhou, Beijing-Jiujiang and Beijing-Shanghai Railways were disputed, the power supply network for trunk lines of the Beijing-Guangzhou Railway and Shanghai-Kunming Railway was damaged, the power failure occurred in the railway communication signal systems, and the transportation in some of the sections was postponed. At the most severe moment, 387 passenger trains were stranded at Beijing-Guangzhou and Shanghai-Kunming Railways, and 1800,000 passengers were stranded at main passenger railway stations. The railway contact network power supply, connecting bridges, tunnels and culverts, communication signals, rolling stocks, way stations as well as houses in working areas along the line and other facilities were damaged. 82,000 km of roads across the country were damaged by the disaster, including 6,869 km of highway with the damages mainly in road surfaces, guard rails, marked lines and greening trees, and few roadbeds and side slopes collapsed. The main highways in the disaster areas were closed due to freezing temperatures. Many national and provincial roads were jammed. The north-Guangdong section and Hunan section of Beijing-Zhuhai Highway were closed bi-directional at a time. A maximum of more than 20,000 vehicles and more than 100,000 passengers were stranded. 230,000 km of roads across China were closed several times due to freezing weather, with severe traffic jams, 700,000 stranded vehicles, 2,160,000 person-times of stranding, 1,100,000 passenger vehicle lines stopping operations, and the influence on the routine travel of more than 34,000,000 people. The rain and snowfall lead to the cancellation of 3,840 flights across China, the delay of 9,550 flights, and masses of stranded passengers in the airports. 14 airports in mid- and downstream of Yangtze River were closed at a time. The runways, vehicles and equipment, water supply, heating and electricity facilities and buildings of airports in 4 provinces including Guizhou, Jiangxi, Hunan and Hubei were damaged.

7.1.4.4 Supply Shortage in Power Coal and Refined Oil

Due to power interruption and traffic retardation, and other factors such as early holidays in some coalmines and overhauls, the coal supply was greatly impacted. Power coal inventory of some power plants declined sharply. The number of days serviceable by stored coal decreased from approximately 15 days during normal use to approximately 7 days, less than half of the level in normal days. During the hardest period, 86 power plants had stored coal but could not afford 3 days of operation. Shutdown of up to 42,000,000 kW resulted from the coal shortage. 19 provinces (autonomous regions and municipalities directly under the central government) conducted power rationing. Distribution of refined oil and liquefied gas in disaster areas, especially distribution by vehicles in roads, were seriously influenced. Accidents and hidden dangers in oil equipment and pipelines increased and the supply of refined oil faced huge pressure. Power failure in large areas of

Guizhou affected the pipeline transportation of refined oil in the southeastern area and threatened the market supply in Guizhou and Yunnan, with some areas limited or stopped gas used in production.

7.1.4.5 Severe Damages of Crop Production

11,874,200 ha of agricultural crops were affected by the disaster, with 5,842,600 ha damaged and 1,690,600 ha deprived of harvest. 66 % of the total area hit by the disaster across the country was found in the six provinces such as Henan, Hubei, Jiangxi, Guangxi, Guizhou and Yunnan. The economic crops and garden crops such as rape, vegetables and mandarin orange suffered the most. 50 % of the rape area grown in autumn and winter across the country was affected, with the output of rapeseeds reduced by 1,700,000 t. 35 % of vegetable area grown in autumn and winter across the country was affected. 6,060,000 livestock and 62,750,000 poultries died. The improved breeding systems were greatly damaged. The facilities such as plastic covered greenhouses and sheds for domestic livestock and poultries were seriously damaged or completely ruined. Water resource facilities, irrigation and waterlog discharging canal system facilities, dikes, water reservoirs and culverts and brakes in the countryside were also severely damaged.

7.1.4.6 Severe Damages of Forestry

22,666,700 ha of forest land were affected, accounting for 7.4 % of total forest area in China. 2,140 state-owned forest centers, 1,158 state-owned nurseries of young plants, 663 nature reserves and 29,127 other state-owned units suffered damages. The forestry infrastructures were severely damaged. The disaster resulted in huge losses for farming and forestry revenues. Since forest revenue accounts for more than 50 % of the combined revenues from farming and forestry, the farming and forestry revenue of the present year and of the coming 3–5 years and the would be seriously impacted. The institutional reform of the collectively owned forest rights would be affected as well. The impact on ecological construction was great. The disaster-hit forest zones were the areas with most rapid development, the highest vitality and the greatest forest resources. The affected forest area accounted for 1/10 of the total forest area in China, equivalent to the increased forest area in a Five-year Plan. The disaster in forestry affected the target of national forest coverage rate of 20 % in 2010. Shutdown of forestry enterprises affected the employment of nearly 1000,000 people, as well as the supply of forestry products in several years. As it was difficult to plan trees for the damaged forest and the forestry infrastructures were severely damaged, the pressure for restoration of forestry production was huge.

7.1.4.7 Industrial Enterprises Stopping Operations in Large Areas and Severe Damages of Infrastructures

Due to power outrage and transportation blockage, 1794 coal mines in Jiangxi, Hunan, Guizhou and Yunnan were shut down; More than 83 % industrial enterprises in Hunan Province and 90 % industrial enterprises in Jiangxi Province were shut down; The chemical fertilizer production in Guizhou Province was reduced by 300,000 t; All enterprises of Aluminum Corporation of China in Guizhou were shut down, with the monthly industrial output values dropped by 1 billion Yuan. Water supply plants in some cities were shut down; 42,000 km of water supply pipe network were cracked because of the freezing weather; More than 1,800 km of the sewage pipe network was damaged; The garbage and sewage could not be timely treated and the environmental pollution was severe; 333,000 fixed communication posts, 53,000 km of power lines and 19,000 mobile base stations were damaged or destroyed; The damage of 705 television transmitting stations and 89,000 km of closed-circuit TV transmission network resulted in the interruption of communication, information and television network transmission in both rural and urban areas; Normal operations of 174 security exchange offices were influenced; Many cities restricted or stopped the supply of natural gas for production and living. Moreover, 133 gas stations of CNPC and Sinopec collapsed; The refine oil transportation line in the Southwest was stopped intermittently; 36,000 middle schools and elementary schools suffered from the disaster, with 23,000 school rooms collapsed (a building area of about 1,420,000 m^2) and about 4,080,000 m^2 of dilapidated houses formed.

7.1.4.8 Wide Impact on Ecological Systems

Ecological systems in vast areas of the south suffered from great damages due to the sleet & snow disaster. The ecological systems in natural forest, secondary forest and planted forest was damaged, mostly damaged and completely damaged, respectively. The ecological systems for wild animals were wildly impacted. In some natural forest, the rare and endangered animals were affected to difficult degrees, with some of them died. In addition, some aquatic ecosystems suffered from deteriorated water quality due to the polluted snowmelt. As a result, the water areas were polluted, and the normal development of aquatic was impacted. The risks caused may continue for a long period of time.

7.1.5 Causes of Disaster Formation

The sleet & snow disaster mainly occurred in southern China with dense population, and happened to coincide with the Spring Festival travel rush. The powerful disaster formative factors and special mountainous and hilly terrain led to power grid failure, transportation interruption and serious damage of agricultural and forestry sectors, and finally the rare catastrophe. The formation of this catastrophe could not be assigned to an individual factor, but was the result of a disaster system (consisting of hazard formative factors, hazard formative environment and hazard affected bodies) (Academy of Disaster Reduction and Emergency Management at Beijing Normal University, co-funded by the Ministry of Civil Affairs and the Ministry of Education 2008). The specific disaster formation causes are the following three aspects (Shi 2008):

7.1.5.1 The Special Mountainous and Hilly Terrain Making the Disasters Worse

The sleet & snow weather has made the record since the foundation of new China compared with similar disasters, with wide effected areas, long duration, low average temperatures, abundant average precipitation and thick ice accretion and snow cover. The serious disasters were closely related to the special landforms and terrains as well as meteorological features in disaster areas. The disasters mainly happened in hilly and lower mountain areas as well as plateau areas in China, especially in Yungui Plateau and Nanling area, with the elevations in most areas above 300–500 m, in some areas higher than 1,000 m and in few areas more than 2,000 m. There is a law that the temperature drops approximately 0.6 °C if the elevation increases by 100 m. The temperate in mountainous areas are generally lower than that in plains. Large power supply and communication facilities are usually built on high mountains. In the disaster areas, the humidity was very high and in almost saturation statues, and the ice and snow could not evaporate. The wind in disaster areas was almost static wind, with low speed. Sleet accumulated on buildings for several days and formed ice quickly in buildings. The pressure of the ice accretion and snow cover exceeded 10 times of the design pressure. Finally, damages of power supply and communication facilities occurred. The combined effects of landscape and meteorology resulted in a long period of ice accretion in large areas, which was the main cause for the sleet & snow disaster. The most seriously affected area was Chenzhou City of Hunan Province. The average elevation of the majority of counties, cities (districts) was above 300 m. The elevation of about 30 % of Chenzhou City was higher than 500 m, with that of the particular areas exceeding 1,000 m. 50 % of the section from Chenzhou to Shaoguan in Guangdong of Beijing-Zhuhai Highway exceeded an elevation of 300 m, with particular sections from Liangtian to Yizhang reaching more than 500 m and the land on both sides even exceeding 1,000 m. Throughout the entire extreme sleet & snow weather period, the average temperatures of large areas in Chenzhou was between −2.0 and −8.0 °C, which greatly intensified the disaster formation effect of the extreme weather.

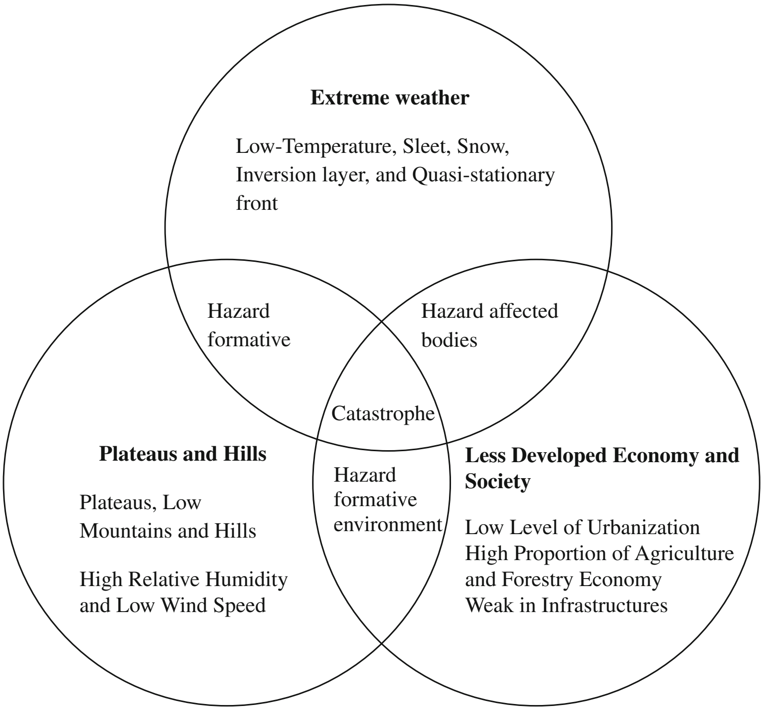

Fig. 7.2 Schematic figure for interaction of main factors in the disaster system

7.1.5.2 With the Disasters Occurred in Population-Dense Areas and Happening to Coincide with the Spring Festival Travel Rush, the Economic and Social Impact was Further Aggravated

The sleet & snow disaster happened to coincide with the Spring Festival travel rush. During the Spring Festival travel rush, the large passenger flow and goods circulations made the infrastructures, power and water supply, commodity safeguard and social management in the extreme status. In addition, the disasters mainly occurred in most areas of southern South, with high population densities (The population density in the severely affected areas such as Anhui, Jiangxi, Hubei, Hunan, Guangxi and Guizhou was higher than 200 people/km^2, much higher than the average population density of China, i.e. 133 people/km^2.), dense traffic lines, infrastructures with weak abilities to resist freezing, large proportion of agricultural and forestry production as well as few anti-freezing methods known by people. The interplay of these various factors resulted in a series of problems, which greatly increased the social impact and the rescue difficulties of the disasters (Fig. 7.2).

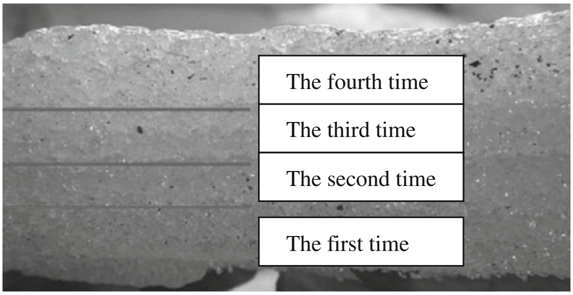

Fig. 7.3 Accumulated Ice layers for four times in Yuxiang noodle plant in Chenzhou City, Hunan Province (from January 10 to February 6, 2008)

7.1.5.3 Chain Features of the Disasters Amplifying the Disaster Effects

During the rare sleet & snow weather processes, the interaction of extreme meteorological factors and terrain factors made the snow cover and ice accretion on buildings grow thick. In addition, the temperature increased slightly at noon every day or after each weather process, to make the snow cover and ice accretion melt temporarily. As a result, the ice layers formed during the first four weather process were over 40 cm high (Fig. 7.3), which greatly increased the load of buildings, and caused damages to power grid facilities in wide range of disaster areas and led to unprecedented large-scale power blackout. Through detailed analysis, it was found that this secondary disaster—power blackout—was the fundamental cause for the failure of lifeline and production line systems such as railways, roads, power, communication and water and gas supply. Flows of people, information and materials were impeded and the normal order of production and life was hindered. The historically rare "power blackout and water shortage" and "road blockage" were formed, with the normal production and life of people severely impacted and lots of vehicles and personnel stranded. The disaster chain can be simply summarized as follows: low temperature—sleet & snow—freezing weather—creation of pressure by snow and ice (natural disaster) → power blackout—water shortage—road jamming—airport closure (production accidents) → station congestion—passenger accumulation (social security) → living environment damage—drinking water source pollution—food quality affection (public health event).

Photo by Peijun Shi

The areas hit by the great sleet & snow disaster were densely populated areas and important channels for traffic flow, electric power transmission and transportation of coal and other materials in the country, with accumulated and amplified effects of secondary and derivative disasters and an overall impact on people's production and life as well as the economy and the society. According to the comprehensive judgment, the sleet & snow disaster were catastrophes in China. The central government, local governments and all sectors of the society gave full support to disaster relief. The ability of the government and society to handle catastrophes was tested, and experience and inspirations were gained for prevention and emergency treatment of future catastrophes (Shi 2008).

7.2 Response to the Sleet & Snow Disaster in the South

7.2.1 Launch of the State Level-II Emergency Response Plan

In order to organize and coordinate the efforts throughout the whole country to cope with the sleet & snow disaster, the State Council established the Emergency Command Center for Coal, Power and Oil Transportation and Disaster Rescue and Relief (hereafter referred to as the Emergency Command Center) on January 28, 2008, to arrange and coordinate the catastrophe. A total of 29 party, government and army organizations participated in this temporary organization successively. Its office was set in the National Development and Reform Commission. The establishment and work of the Emergency Command Center were conducted simultaneously. The first plenary session was held on the evening of January 29. In the meeting, task priorities of “road access, power supply guarantee and relocating people” were identified quickly based on a comprehensive analysis and judgment of the disaster effects. 6 command offices were established to strengthen the command and coordination in key fields such as “coal, power, oil and transport assurance”, “emergent repair of roads”, “emergent repair of power grids”, “disaster relief and market guarantee”, “post-disaster reconstruction” and “publicity through the press”. In response to the disaster, the Emergency Command Center was on duty round the clock, met every night to plan, arrange, command and manage the disaster relief, and reported timely to the CPC Central Committee and State Council. All command offices timely coordinated and communicated with each other to solve major issues. In the 208th routine meeting of the State Council held on February 13, 2008, the progress of disaster relief was analyzed and the decision to Shift the work priority from disaster relief to post-disaster reconstruction was made. On February 15, 2008, the State Council approved and forwarded the *Report on Arrangement for Disaster Relief and Post-disaster Reconstruction* issued by the Emergency Command Center, marking a significant success in dealing with the catastrophe with national-wide efforts. As a temporary organization, the Emergency Command Center completed its three-week missions and its cessation was announced (National Development and Reform Commission 2008).

7.2.2 Overall Arrangement for Nation-Wide Catastrophe Response

According to the disastrous weather forecast issued by the China Meteorological Administration, the leaders of the State Council immediately delivered important instructions. The Emergency Office of the State Council issued disaster early warning notices on January 10, 15, 19 and 21, 2008 successively, requiring the areas and sectors concerned to implement various measures to deal with the snowstorm (Emergency Management Expert Group of China Emergency Management Office 2008). On January 14, the National Development and Reform Commission initiated the trans-departmental economical operation and coordination mechanism and arranged to the production increase and emergent transportation of power coal. On January 18, the Ministry of Public Security initiated the transportation emergency management mechanism, and the Spring Festival travel rush in railways started five days in advance. On January 25, Premier Wen Jiabao visited Hebei and Beijing to inspect the Spring Festival travel rush and held a work meeting at Beijing West Railway Station to emergently arrange the work related to Spring Festival travel rush, transportation of power coal as well as logistics and transportation on holidays. In the meeting, the policies on organizing passenger transportation, strengthening rapid power coal transport and implementing the "green passage" for fresh and living agricultural product transportation were developed. From January 25 to January 27, some structures of Guizhou and Hunan power grids collapsed, leading to a large-scale power blackout. Some sections in trunk railway lines in Beijing, Guangzhou, Shanghai and Kunming were impeded, and Beijing-Zhuhai Expressway was severely congested. On January 26, the General Office under the State Council held an emergency meeting to discuss coal, power, oil, transportation and emergency disaster rescue. On January 27, the State Council held a video and tele-conference to conduct the detailed arrangements. The Political Bureau of the Central Committee of the CPC and the State Council held routine meetings on January 28 and February 1, respectively, to discuss emergency disaster rescue. During this period, top leaders from central authorities of the CPC, including the General Secretary Hu Jintao visited key coal production provinces and worst-hit areas to direct coal production, emergent transportation and emergency disaster rescue. On January 30, the State Council held the work meeting of the National Disaster Reduction Committee to fully analyze the disaster effects and arrange production and life assurance work for people in disaster areas. On the same day, the China Meteorological Administration initiated the second-level emergency response plan. The Ministry of Civil Affairs and the State Electricity Regulatory Commission timely initiated the second-level disaster rescue plan and second-level emergency response plan for the large-scale power blackout. The Ministry of Railways, the Ministry of Communications and the Ministry of Public Security launched their emergency plans. Government at all levels in disaster areas conducted emergent mobilization. Power grids and state-owned telecommunication enterprises implemented their social responsibilities. The PLAs and armed police fought against the disaster in the frontline. By February 12, 2008, 319,000 person-times of PLAs, 348,000 person-times of armed police and 1,882,000 person-times of police reservists were engaged in the disaster rescue. In addition, 5,930,000 person-times of police officers were at the frontline, to maintain orders, direct traffic, remove ice and snow and rescue people. Hence, the campaign to fight against the disaster involving the central government and local authorities was fully organized and a positive outcome was achieved.

7.2.3 *Nation-Wide Actions*

According to the overall requirements of catastrophe response of “to ensure transportation, power supply and people’s wellbeing” by the CPC Central Committee and State Council, the whole nation responded to the catastrophe, overcame difficulties and made obvious achievements. The Emergency Command Center under the State Council and relevant sectors, with their great sense of political responsibilities, made immediate responses in the following five aspects: emergent repair for road access, emergent transportation of power coal, emergent repair of power grids, people’s livelihood’s assurance in disaster areas and market supply guarantee in disaster areas. The national-wide efforts were successful for responding the catastrophe.

7.2.3.1 Mobilization of the Strength from the Society to Conduct Emergent Repair for Road Access

Smooth transportation is fundamental and essential for power supply and people’s wellbeing. The Emergency Command Center held a number of dedicated meetings for road access. The authorities for traffic, railways and public securities strengthened the united command. These authorities mobilized the strengths from all walks of life for removing snow and ice, timely guiding the stranded vehicles, dispatching diesel locomotives and generator equipment as well as making access to Beijing-Guangzhou Railway and Shanghai-Kunming Railway, with the joint efforts of the people’s governments at all levels and relevant sectors in disaster areas as well as the great support from the PLAs, the armed police force and police officers. These authorities mobilized the migrant workers to spend the Spring Festival locally instead of returning to their homes in order to reduce the transportation flow. These authorities strengthened the untied command and information release to avoid any further traffic congestions, and strengthened the scientific support to judge the disaster effects scientifically. With the combined efforts of all related parties and various measures, the emergent repair for road access achieved a remarkable accomplishment. By February 3, all airports affected by the disaster were reopened. On February 4, the Beijing-Zhuhai Express Way reopened, and on February 5, the 3,500,000 passengers stranded in Guangzhou were transported successfully.

7.2.3.2 Reasonable Arrangement of Production and Transportation to Conduct Emergent Transportation for Power Coal

The major coal producing provinces (autonomous regions) and leading coal mining enterprises made a great effort to increase coal production. Railway and traffic sectors organized to conduct emergent transportation of power coal. As a result, the daily transportation capability of power coal reached up to 43,000 freight cars, with the year-on-year growth rate of 53.9 %. Daqin Railway conducted the daily transportation of 1000,000 t, with the year-on-year growth rate of 22 %. At four ports in the north including Qinhuangdao Port, the daily Ship-loading amount reached 1,300,000 t, with the year-on-year growth rate of 24 %. The Emergency Command Center strengthened the coordination of power coal production, transportation and demand, and set up a “point to point” of coal, railway and power plant supply joint for some important power plants in urgent need of power coal. With the collective efforts of all related parties, on February 24, the amount of coal storage in direct power supply stations reached 27,700,000 t, which was enough to maintain a power supply for 14 days.

7.2.3.3 Concentration of Advantages for Power Grid Repair

The State Grid Corporation of China and China Southern Power Grid gathered a lot of technical forces all over the country to repair the power supply facilities for railways and daily use to ensure the needs of peoples’ wellbeing. The maximum number of technical staff at the forefront for emergent grid repair amounted to 420,000. The railway and road sectors made the prior arrangement for the transportation of materials that emergent repair of power facilities needed. The local governments, People’s Liberation Army, Armed Police Forces, Public Security and the militia reserve forces provided full support. Sinopec and CNPC timely supplied the oil for power generation. By February 6 (the New Year’s Eve), 95 % of the power supply lines which had been affected by the disaster were recovered, and 99 % of the transformer substations which were shut down due to the disaster were recovered. The emergent repair of power grids achieved the decisive victory.

7.2.3.4 Implementation of Policies and Measures to Ensure the People’s Livelihoods in Disaster Areas

The Emergency Command Center and relevant regions and sectors followed the requirements of “ensuring food, clothing, housing and medical treatment” and timely organize to dispatch the disaster areas necessary grain, edible oil, fast food, tents, cotton-padded clothes, quilts with cotton wadding, electric torches, radios, electricity generators, refined oil, liquefied petroleum gas and other materials for disaster rescue. Homeless people were properly settled; the passengers stranded were rescued and assisted. The ministries of finance and civil affairs appropriated

1.824 billion Yuan as the emergency fund from the Central Government for life subsidies of natural disasters, and later 0.71 billion Yuan was appropriated as the temporary subsidies for urban and rural residents entitled to basic living allowances in severely-affected areas. The health authorities at all levels sent altogether 25,000 medical teams to disaster areas for the ill and injured, and organized to implement the prevention and control measures for secondary, derivative and concurrent public health events, to ensure no epidemic diseases from happening after the great disaster.

7.2.3.5 Strengthening Organization, Coordination and Market Regulation to Ensure the Market Supply in Disaster Areas

The Emergency Command Center paid close attention to both disaster relief and market supply in disaster areas. The food supply sectors timely organized raw grain processing, eatable oil dispatching and delivering local reserves. The sectors of finance and commerce conducted the proper delivery of storage meat and other necessities into markets, organized “Southern vegetables transported to north”, “Northern vegetables transported to south”, and “Western vegetables dispatched to east”, and timely imported materials such as pork and bean oil. The agricultural sectors timely helped farmers in disaster areas for the emergent reconstruction of basic facilities and the planting of fast-growing vegetables, commanded the primary anti-season vegetable production bases in the north and the winter vegetable production regions in the north and winter vegetable production bases in the south to increase their production, and strengthened the information guidance, organized the production and sales connections of fresh agricultural products for farmers in disaster areas and non-disaster areas, to guide the agricultural product wholesale markets in disaster areas as well as provinces to jointly guarantee the post-disaster fresh agricultural product supply. CNPC and Sinopec gave priorities to guarantee the supply of oil for vehicles transporting edible oils, vegetables and other fresh agricultural products. Transportation sectors did not charge vehicles for transporting materials such as agricultural products and necessities to disaster areas with bridge tolls and road tolls. The price and finance sectors reduced half of the administrative fees on sales in markets and administrative fees on owners private business for the above-mentioned fresh agricultural products. Relevant development, reform and price authorities at all levels adopted a temporary intervention policy on the price of necessities and materials for disaster relief, which strengthened the market and price supervision in the disaster areas and maintained the price stabilities of major commodities and normal market order in disaster areas.

The actions of the whole country in the above mentioned five aspects integrated the emergency resources between the central and local authorities, improved the emergency actions of all related sectors in the society, made the government, enterprises and communities play their active roles, resolved general and key problems of responding to the catastrophe, and achieved great effects.

7.2.4 *Strengthening Government's Guidance on Information*

In order to strengthen the authority, timeliness, accuracy and comprehensiveness of the catastrophe information release, the Emergency Command Center, the Publicity Department of the CPC Central Committee and the Information Office of the State Council strengthened the information guidance, kept the direction of public opinions, and created good public opinion environment for disaster relief.

7.2.4.1 Strengthen the Information Guidance of Disaster Relief

The Emergency Command Center successively published 21 issues of announcements to guide all regions and sectors concerned to guide blocked traffic lines, emergently repair gird, emergently transport power coal, guide the stranded passengers, properly arrange the migrant works to spend their Spring Festival in the locations where they worked, and stabilize the commodity prices in affected areas, as well as to guide the disaster areas to strengthen the prevention of secondary disasters concerning geology, infrastructures, forestry, public health and animal and plant diseases.

7.2.4.2 Establishment of Press Release System to Crate Good Atmosphere for Public Opinions

The Emergency Command Center organized press conferences on a number occasions and opened a column of "Authoritative Release" in major media such as *People's Daily* and CCTV as well as and key websites with daily news released on the progress in disaster relief. The Publicity Department of the CPC Central Committee organized central and local news media as well as major news websites to timely publicize the major measures promulgated by the central government and other relevant authorities as well as advanced role models and affecting stories in disaster relief to boost the spirits and inspire the will to fight, with the guiding principles of disaster relief, persistence on unity and stability and encouragement of positive propaganda.

7.2.4.3 Winning over the Understanding and Support from International Communities

The International Communication Office of the CPC Central Committee strengthened the disaster relief propaganda, actively guided the public opinions on Internet, and organized foreign media for interviews in affected areas. The Ministry of Foreign Affairs notified foreign embassies and missions as well international organizations in China timely about the disaster effects and disaster relief.

International communities highly evaluated the Chinese government and the people in the fighting against the sleet & snow disaster in southern China.

7.2.5 Rapid Formulation of the Post-Disaster Restoration and Reconstruction Plan

Acting upon the requirements of the CPC Central Committee, the Emergency Command Center rapidly formulated the “Guiding Plan for the Post-Sleet & Snow Disaster Restoration and Reconstruction” (hereinafter referred to as the *Guiding Plan*), and was distributed to lower authorities after being approved by the State Council. The *Guiding Plan* specified the emergent repair of damaged infrastructures with a special focus on power grids, rapid restoration of agricultural production with a special focus on restoring agricultural and water conservancy facilities as well as a quick restoration of people’s livelihoods in disaster areas. Aims, tasks, responsibilities, work priorities, deadlines and policy measures were clearly identified, and principles such as “planning first, overall arrangement, distinguishing degrees of emergency, highlighting priorities, giving priority to self-rescue, government support, and funding mainly from local sectors with the central government fund as the supplement” were stated. It is required to raise fund from various channel, make overall arrangement of the central finance funds, investment within the central finance budget and civil relief funds, and to well conduct the post-disaster restoration and reconstruction. Under the framework of the *Guiding Plan*, all disaster-stricken provinces formulated their own respective post-disaster reconstruction plans.

To put the post-disaster reconstruction policy as formulated by the central government into practice, the central government allocated 28.543 billion Yuan, of which RMB 25.543 billion Yuan came from the Ministry of Finance and RMB 3 billion Yuan from the National Development and Reform Commission. In addition, in accordance with the decision made by the Standing Committee of the State Council on March 26, 2008, the central finance funds of RMB 562.5 billion Yuan was allocated to the investment on “agriculture, countryside and farmers”. On the basis of existing investment of RMB 73.9 billion Yuan, an additional 25.25 billion Yuan of central finance funds was allocated to the investment on infrastructures. RMB 2 billion Yuan from the budget of the central government was allocated to investment on the infrastructures, to support the agricultural and grain production with a special focus on disaster areas.

By the end of March 2008, the normal capacities of power grids, telecommunication networks and traffic facilities had been basically restored. Damaged municipal facilities, rural water supply sources, damaged residential buildings and industrial enterprises had been restored or reconstructed by the end of June 2008. Due to the serious damages to forestry ecology and long period for forestry restoration, a 3–5 year restoration plan for the damaged forestry production was completed by the end of June 2008, and it was organized for implementation at present.

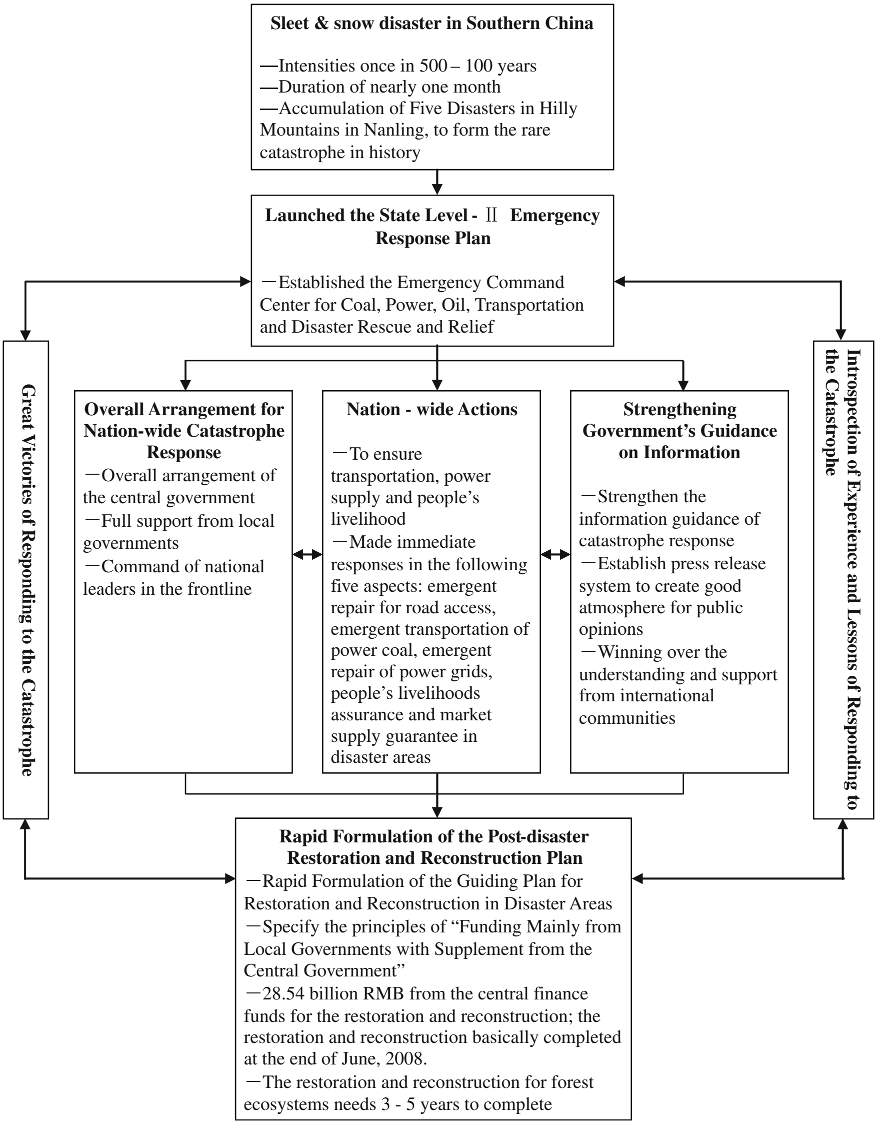

Fig. 7.4 Framework of the Chinese government's "National response to the sleet & snow catastrophe in southern China in 2008"

Figure 7.4 shows the framework of responding to the sleet & snow disaster in southern China in the beginning of 2008. From the figure, we can the successful practices that have been executed by the Chinese government's "national response to the catastrophe" as well as some aspects to be rethought and lessons to be summarized.

7.3 Lessons and Recommendations

The Chinese government achieved a great success in coping with the sleet & snow disaster in southern China. The "nation-wide response model for coping with catastrophes" has been fully promoted and affirmed by different sectors in the society and the international communities. However, the abrupt, complex and severe disasters also showed the weakness of the lifeline works such as coal, power, oil and transportations during the rapid industrialization and urbanization of China, and reflected that both disaster prevention and response capacities needed to be improved.

7.3.1 Lessons

From the perspective of China's response to the sleet & snow disaster, we can see that there are some serious problems of the emergency response in China.

7.3.1.1 Emergency Management Mechanisms Need to be Improved

Firstly, the emergency management institution establishment, especially the establishment of municipal-level and county-level management institutions, was generally backward. Secondly, the problems on linkage mechanisms and information exchange mechanisms were serious. At the early stage of the disasters, the information flow was neither smooth nor systematically organized. For example, Areas along the expressways and some main traffic hubs focused exclusively on the reduction of local traffic and population flow with no consideration of the overall interests as a whole. In addition, the information was asymmetric. As a result, deterioration of traffic jams and delay on some roads occurred, which hindered the disaster relief process. Longli County of Guizhou Province reported that the railway sector stopped a train without food and water for 44 h near Longli County Railway Station in midnight, without informing to the local government. As a result, the passengers were forced to break the train windows and searched food in the city, thereby adding to the chaos of the disaster.

7.3.1.2 Maneuverability of the Emergency Response Plans and Effective Connections Between the Plans Need to be Strengthened

The catastrophe was from the extreme weather in history. Before the disaster, local governments and sectors had established relevant emergency plans, but no dedicated plans had been made for major meteorological disasters. The disasters this time exposed the problems of lack of connections between plans, incomplete plans and weak maneuverability. In particular, some plans at grassroots level did not explicitly describe the core content, i.e. how the plans can be started and department responsibilities, and thus it was difficult to put into practice. The trainings and drills for plans were not enough.

7.3.1.3 Disaster Forecast and Early Warning Abilities Need to be Improved

Throughout the five sleet & snow weather processes, the China Meteorological Administration made comparatively accurate forecasts. However, due to limitations of monitoring measures and scientific and technological knowledge as well as insufficient studies on the formation mechanism of major meteorological disasters, many areas "misunderstood the disastrous weather forecast as meteorological disaster forecast", and lacked of general considerations on the landform conditions and climate zones involved in the disastrous weather. There were some problems of the forecasts such as short period and underestimate on the continuity and intensity of the disastrous weather, especially the catastrophe formed by accumulation of the four processes in Nanling mountain areas. Concurrently, the shortage of historical data and relevant information on professional meteorological monitoring related to power and traffic made the shortage of the damage evaluations and disaster early warnings on possible damages caused by the disastrous weather to power, traffic, economy and society.

7.3.1.4 Shortage of Emergency Rescue Facilities and Materials Reserves

During the disaster response, there was a shortage of professional rescue devices, technical measures and materials reserves in certain areas. For example, snow sweepers, tire chains, graders, forklifts, gunny bags, industrial salt and personal protective equipment were not sufficient, with the unclear original number. In some cities, satellite phones were unavailable. In other areas, the basic emergency materials reserve such as food, candles and kerosene were scare, making it difficult to guarantee the people's basic life in disaster areas.

7.3.1.5 Infrastructure Construction Levels Failed to Meet the Requirements of Disaster Prevention and Relief

Firstly, large-scale damages to the electric power lines and facilities exposed the vulnerability of the system. The disasters caused large-scale power outages in many cities (counties) of Hunan, Guizhou and Jiangxi. The power grids in some areas also suffered destructive damages. This reflected the weaknesses in power supply layout, power grid construction standards and emergency ice-melting technologies in China. Secondly, the overall transportation capacities of roads and railways are limited. Traffic jams often took place on the Guangdong Northern Section and Hunan Southern Section of the Beijing-Zhuhai Expressway, with traffic jams occurring during this disaster. In recent years, the renovation and expansion of the national and provincial highways made by the local governments processed slowly, causing the low traffic capacity of the national and provincial highways, with difficulties to manage the distribution of jammed vehicles. The limited railway transportation capacity was apparent during the Spring Festival travel rush and periods of large amount of production materials transportation every year. Lastly, the construction standards of urban public utilities such as water supply and drainage were low, with some of the utilities used beyond the service lives, with low abilities to resist natural naturals.

7.3.1.6 Risk Awareness of the Society Needed to be Improved

Firstly, some regions and sectors lack disaster risks awareness, with the fluke mind. The processes of the catastrophe were "snow landscape—lots of snow—snow disaster—snow catastrophe", which exposed that our abilities of "early discovery, early reporting, early control and early problem-solving" were weak, and the treatment in accordance with the law and scientific decision-making abilities of some leaders needed to be improved. Secondly, the public awareness of disaster prevention, reduction and avoidance was low and there was a lack of knowledge and ability for self-rescue and mutual rescue. Urban and rural dwellers were short of reserves of emergency goods for disasters such as candles and flashlights. In some regions, although disaster information was announced, numerous vehicles drove on the crowded expressways, and some drivers took over the emergency lanes of the expressways, causing the part of expressway grids completely broke down. Finally, the disaster insurance coverage was little. The catastrophe insurance claims accounted for about 4 % of the damages. The overwhelming majority of the enterprises, rural households and infrastructures were not insured and the forest insurance policy still needed to be established.

7.3.1.7 Seriously Damaged Forestry Exposed the Problems of Replanted Forest Operation and Insufficient Input for Forestry

For a long time, governments at all levels exclusively attached importance to the forest coverage index reflecting forest quantity and disregarded the index of forestland unit volume reflecting forest quality. They simply invested on forestation instead of forest operation, resulting in low forest productivity, unreasonable structures, slim trees and weak disaster resistance abilities. The decades of construction achievements in the forests of southern China suffered immensely during the catastrophe. There were risks of continuous loss expansion such as forest fire risk upgrade, tree vigor decline, increase of plant diseases and insect pests as well as rotted branches damaged by snow which would almost impossible to be used. It would take a long time to recover the forestry with difficulties. As a result, the production and life for numerous forest farmers and forestry employees would be hard.

7.3.2 Recommendations

7.3.2.1 Further Improvement of Policy Measures for Catastrophe Response

Continue to promote the national and local emergency management system construction with the core content of "revision of emergency plans as well as establishment and improvement of emergency systems, mechanisms and laws". Firstly, we need to promote the national and local emergency response systems and upgrade the meteorological disaster emergency plans to the state level. Secondly, we must promote the construction of national and local emergency management organizations and enhance the integrated coordination and united command abilities of governments at all levels. Thirdly, it is necessary to improve the emergency systems such as emergency linkage and information sharing to ensure that close contact between different levels as well as between PLAs and local governments, to conduct rapid actions and form joint forces. Finally, it is essential to strengthen the propagation and implementation of the *Law of the People's Republic of China on Emergency Response*, and to promulgate supporting implementation regulations or detailed rules for implementation by the local governments.

7.3.2.2 Improvement of Capacities for Catastrophe Forecast and Early Warning

A Weather forecast is by no means a meteorological disaster forecast or an early warning for disasters. Therefore, it is necessary to strengthen the research on early warning and forecasting technologies for extreme meteorological disasters and natural disasters with the background of global warming, to support scientific disaster prevention and reduction. It is also necessary to enhance the abilities of disaster information services and transmission.

7.3.2.3 Strengthening Emergency Security Capacity Building

Firstly, emergency materials storage should be enhanced. Secondly, the emergency teams and equipment should be enhanced. Secondly, it is advisable to establish integrated emergency teams based on fire forces, improve the volunteer system for emergency rescue, and adopt advanced emergency treatment technologies and equipment. Thirdly, the transportation guarantees capabilities, especially the integrated transportation coordination abilities of responding to catastrophes should be enhanced. Finally, the emergency platform construction should be strengthened. This platform shall guarantee the unlimited share of the emergency information and support emergency decisions and commands.

7.3.2.4 Further Improvement of Disaster Prevention and Resistance Abilities of Power Facilities and Urban Public Infrastructures

The state should fully consider the power supply problems of urban grids in terms of power supply station layout and planning, to increase or regulate emergency power supply stations. Meanwhile, the construction of power supply networks in counties (cities and districts) and countryside needs to be strengthened, and the self-protection abilities and independence of local power supply networks in counties (cities and districts) and countryside should be improved in case of failure of backbone grids. The disaster fortification standards of grids and urban infrastructures should be improved.

7.3.2.5 Improvement of Risk Prevention Consciousness and Abilities in the Society

Firstly, the officials at different levels should improve their abilities to deal with disasters and risk events. Secondly, the promotion and education of risk prevention consciousness within the entire society need to be enhanced, to strengthen the risk prevention consciousness as well as self-rescue and mutual-rescue abilities of the entire society. Finally, the insurances awareness of the public and enterprises as well as the catastrophe insurance system of the state need to be improved, with the state providing policy support for the establishment of catastrophe insurance funds and reinsurance arrangement.

7.3.2.6 Implementation of Supporting Policies for Post-Disaster Restoration and Reconstruction of Forestry

We need to consider and plan carefully, to transfer the post-disaster reconstruction as an important opportunity to build the forest ecosystems and replanted forestry operation systems in disaster areas. In the course of reconstruction, with the emphasis on the principle of "introduction of suitable trees into suitable forests", the tree species allocation should be optimized to conduct the overall improvement to the disaster resistance abilities of the forest ecosystems in disaster areas. It is also necessary to strengthen the policy support forestry restoration and reconstruction and to establish the policy insurance system for catastrophes of forestry.

7.4 Conclusions and Discussions

1. The sleet & snow disaster occurred in southern China in the beginning of 2008 was a rare catastrophe. The main cause of the catastrophe was the joint forces of the successive occurrence of the 50–100 year sleet & snow weathers as well as the low mountain and hill terrains and subtropical climate of vast Nanling areas. Moreover, the disastrous weather happened to coincide with the Spring Festival travel rush. As a result, numerous transportation and power production accidents occurred. Social security and public sanitation accidents such as stampedes in stations and water supply source pollution by deicing industrial salt occurred.
2. The national-wide response to the catastrophe by Chinese government was successful. The main experience was that it triggered the Class II State Emergency Plan timely. The central government led the overall national-wide response, clarified the response measures focusing on the principle of "ensuring the smooth transportation, power supply and people's wellbeing", strengthened the governments' information guidance, kept the correct direction of public opinions, developed scientific restoration and reconstruction plans, and organized the forces to systematically promote post-disaster reconstruction.
3. Due to the low levels of disaster fortification in local governments (especially in countryside and towns) as well as the weak risk prevention conciseness of the general public and local officials, it was difficult to response to the catastrophe and the resources consumption was high. Therefore, there were many problems exposed for local and central governments in disaster areas in responding to the catastrophe, and the lessons were impressive. For example, imperfect emergency management mechanisms and systems, no connections between the maneuverability and effectiveness of emergency plans, weak disaster early warning abilities, shortage of emergency rescue facilities and equipment as well as materials, insufficient disaster fortification of the infrastructures, and poor risk prevention consciousness of the society.
4. Aiming at the problems of Chinese government's response to the catastrophe, it is suggested to further improve the policy measures for catastrophe response and disaster fortification capacities, i.e. further promotion of the national and local emergency management system construction with the core content of "revision of emergency plans as well as establishment and improvement of emergency systems, mechanisms and laws", improvement of capacities for catastrophe forecast and early warning, strengthening emergency security capacity building, further improvement of disaster prevention and resistance abilities of power facilities and urban public infrastructures, improvement of risk prevention consciousness and abilities in the society, and implementation of supporting policies for post-disaster restoration and reconstruction of forestry.

From the perspective of the response of social ecological systems in disaster areas to sleet & snow catastrophes, it was easy for the disaster areas to be affected due to the low levels of overall disaster fortification. However, due to the action of "national-wide response to the catastrophe" of the Chinese government, the disastrous status in disaster areas were soon transferred as better status, with the catastrophe being controlled, the disaster lasting time greatly reduced and less direct and indict losses caused. In some western developed countries, with high levels of overall disaster fortification in the entire society, the disastrous weather will not cause catastrophes. However, as long as the forces of disaster formative factors exceed the fortification levels, catastrophes will be caused. Therefore, it will take a long time to transfer the catastrophe status in the disaster areas to better status, with the characteristics of "hard entry transition and slow exit transition", in contrast to the characteristics of "easy entry transition and quick transition-out" in China to respond to disasters. By comparing the catastrophe responses between China and western developed countries, we find that China shows higher efficiency and lower effectiveness of resources utilization in its response to catastrophes; while western developed countries show lower efficiency and higher effectiveness of resources utilization in their response to catastrophes. Therefore, China should learn from western developed countries, with the condition of improving disaster fortification levels in general, combine the "top (national-wide) mode to respond to catastrophes" with the "bottom (community) mode of western developed countries to respond to catastrophes", to enhance the catastrophe prevention capacities of the entire society and improve the catastrophe resources unitization efficiency.

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Chapter 8
Avoiding the Avoidable: Towards a European Heat Waves Risk Governance

Wiebke Lass, Armin Haas, Jochen Hinkel and Carlo Jaeger

8.1 Introduction

Climate change is already underway and will continue in the future. Measurements show that Global Mean Temperature (GMT) has already increased by 0.76 °C compared to pre-industrial levels, and the climate system is committed to an additional increase of 0.6 °C due to historic emissions (IPCC 2007). Given the recent growth in global greenhouse gas (GHG) emissions (GCP 2010), this temperature increase will only be the lower boundary of what the future will bring.

While national and international climate policies that aim to reduce global GHG emissions are essential in order to prevent climate change and related impacts from becoming disastrous, human societies will have to adapt to changing climatic conditions.

Climate change has many different adverse impacts, with melting ice caps and rising sea levels being most probably the most severe ones in the very long run. In the short run, weather-related disasters such as droughts, floods, and storms play an important role. Worldwide, the number of disaster losses in monetary terms (both insured and uninsured) has increased in recent years but it is still debated whether (and, if yes, to what extend) climate change has contributed to this increase (Bouwer 2011). However, climate science warns us that increasing mean values—such as GMT—come with an increased risk of weather extremes in the future:

> In a warmer future climate, there will be an increased risk of more intense, more frequent and longer-lasting heat waves. The European heat wave of 2003 is an example of the type of extreme heat event lasting from several days to over a week that is likely to become more common in a warmer future climate (IPCC 2007).

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P. Shi et al. (eds.), *Integrated Risk Governance*, IHDP-Integrated Risk Governance Project Series, DOI: 10.1007/978-3-642-31641-8_8,

This article focuses on hot spells and heat waves as pertinent disasters, and as events with a risk of higher frequencies and intensities due to climate change. Various heat wave events in the recent past, which led to numerous deaths, have raised the attention of both scientists and decision makers across the globe. Here, we examine this issue from an integrated risk governance perspective. We focus on Europe, although heat waves do frequently occur in other continents where many countries often are perceived to have much lower coping capacities. This is exactly why we find Europe a very interesting case. Usually, developing countries are perceived as being both most exposed and most vulnerable to climate change, while developed countries—despite their responsibility in terms of high actual and historic emissions—seem to be neither especially exposed nor particularly vulnerable due to their technological, organizational, and financial capacities to cope with adverse effects of climate change. In particular the heat wave events of 2003 and 2010 in Europe lead us to correct these underlying assumptions. It seems that even the most advanced countries need to rethink their existing risk governance structures.

Against this background, this article develops an integrated risk governance framework for heat waves in Europe, based upon European experiences with recent heat waves as well as with existing coping strategies. The rest of this article is organized as follows: After a characterization of heat waves, their recent occurrence, and their future developments, we look at existing coping strategies (especially early warning systems) in Europe. Based on this background, we then present a risk governance perspective and apply it to heat waves. The final section draws some conclusions and links the heat wave case to the wider picture of climate policy.

8.2 Heat Waves in Europe: Characteristics, Recent Events, and Future Trends

Heat, or anomalously hot weather, that lasts for several days, often codified as heat waves, has a clear impact on societies including a rise in mortality and morbidity. Heat waves also place an increased strain on infrastructure (power, water, and transport), with monetary damages rising continuously. This text focuses on the impacts on human health, namely mortality. One would expect European societies to be rather well prepared when it comes to climate change adaptation, but the evidence presented in this article raises some doubt about this assumption.

8.2.1 Characteristics

A heat wave is a prolonged period of excessively hot weather, which may be accompanied by high humidity. There is no universal definition of a heat wave (Souch and Grimmond 2006; Robinson 2001). The term is relative to the usual weather in the area. Temperatures that people from a hotter climate consider normal can be termed a heat wave in a cooler area if they are outside the normal climate pattern for that area. The definition recommended by the World Meteorological Organization is when the daily maximum temperature of more than five consecutive days exceeds the average maximum temperature by 5 °C (9 °F), the normal period being 1961–1990 (Frich et al. 2002). Increased summer heat does have various critical effects for natural, semi-natural, technical, and social systems[1]:

- Natural systems may come under heat and water stress, leading to losses of functions and a reduction of ecosystem service deliveries (such as water purification). Some wild living animals are more susceptible to infectious diseases under heat stress conditions (Seppälä and Jokela 2011). Despite certainly very important attempts to monetize ecosystem goods and services (Costanza et al. 1997; Millennium Ecosystem Assessment 2005), it is hard to quantify damages due to external shocks. This makes risk management strategies difficult—even if we leave aside the question of whether human intervention in largely unmanaged ecosystems can at all reduce risks.
- Semi-natural systems can experience the same or even larger stress effects, such as forest fires or crop losses.[2] This makes quantitative and monetized damage estimates much easier, and we find systems of risk management (including disaster induced crop loss insurances) already in place.
- Technical systems are vulnerable towards heat stress, and many of them are technically protected against it (for instance, cooling systems for buildings, trucks, or computers). Usually, technical systems have standard ranges of "normal" functioning, beyond of which the risk of malfunction increases. Transport infrastructures such as streets or railways are repeatedly damaged during heat stress periods.
- Social actors and systems are equally "tuned" towards normal ranges of weather patterns, including frequently occurring weather extremes. Beyond these limits, which vary from system to system and from actor to actor, they become vulnerable to damages (McMichael et al. 2006).

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[1] According to our simplified ontology we understand by natural systems mainly uncontrolled ecosystems, such as wild living animals, oceans, or wild forests; by semi-natural systems mainly controlled systems such as managed forests, agricultural systems, or the world's livestock; by technical systems such human designed and managed artifacts as houses, machines, or technical infrastructures (roads, power lines, or similar constructions); and by social systems we intend human institutions and societies, including human agents and their bodies. We are well aware that this is a somewhat arbitrary categorization, as there are gradual differences. Nevertheless we need some ideal types to clarify what we focus upon.

[2] As most human dominated ecosystems are less diverse than natural ones (the species composition of natural rain forests compared to that of nearby plantations, for example), they are less resilient and show a greater dependency on external intervention, such as provisioning of nutrients or water. This makes human-dominated ecosystems usually more vulnerable than natural ones.

Heat waves do carry sustained heat loads to the human body and have discernible impacts on human health (Kovats and Jendritzky 2006; Dhainaut et al. 2004). They affect well-being and limit the normal functioning of humans, and can stress the cardiovascular system. Unlike air pollution the effects of temperature on mortality cannot be assumed to follow a general linear form. In populations with a temperate climate, a general U- or V-shaped relationship exists between daily mortality counts and temperature, with deaths increasing as temperatures fall, as well as when temperatures rise above population-specific threshold values (Curriero et al. 2002; Hajat et al. 2010; Kovats and Hajat 2008). These stress-mortality curves vary from region to region. Despite this variance, a couple of risk factors increase heat wave damage probabilities:

- Factors affecting exposure (such as working outside or residing in a retirement home without air-conditioning);
- Factors affecting sensitivity to a given heat exposure (such as age, sex, health condition, or body mass); and
- Factors affecting access to treatment (such as lack of information or medication).

Empirical studies reveal that infants and elderly people (especially 75+) are particularly vulnerable to heat waves - mostly due to all three factors mentioned (Conti 2011; Koppe 2005; Kovats and Hajat 2008; Simón et al. 2005; Schifano et al. 2009). Vulnerability to heat wave is significantly increased due to pre-existing respiratory and cardiovascular diseases (D'Ippoliti et al. 2010; Patz et al. 2005). There is a significant social component of vulnerability. This component is an important factor for explaining some variance in mortality between different European cities during the 2003 heat wave (D'Ippoliti et al. 2010). Another empirical evidence is that women tend to be more at risk than men, although the evidence here is less clear. While U.S. studies show that low socioeconomic status is associated with higher mortality risks, data for Europe do not reveal this connection (with some exceptions: Michelozzi et al. 2005), most probably due to the better provisioning of social services in Europe.

People living in urban environments are at greater risk than those in non-urban regions. Recent studies for European cities revealed that heat waves of long duration had the greatest impact on mortality, and resulted in 1.5–3 times higher daily mortality than other periods (D'Ippoliti et al. 2010). Worldwide we live in an increasingly urbanized society, urban heat island effects underline and reinforce the relevance of heat waves for the risk management of modern societies. Thermally inefficient housing and the so-called urban heat island effect (whereby inner urban environments, with high thermal mass and low ventilation, absorb and retain heat) amplify and extend the rise in temperatures (especially overnight) (McGeehin and Mirabelli 2001).

In 2003 in Paris many nursing homes and other assisted-living and retirement communities were not air-conditioned, and elderly residents might not have been promptly moved to air-conditioned shelters and rehydrated with fluids (Dhainaut et al. 2004). Hübler et al. (2007) have made an attempt to calculate the economic damage of more summer heat days for Germany in the 2071–2100 period, with GDP losses due to reduced labor productivity being more severe than increased hospitality costs.

8.2.2 Recent Events in Heat Wave Induced Mortality in Europe

In this section, we would like to focus on the death toll of heat waves, excluding other aspects from our analysis. The reason for this focus is twofold: (1) despite some methodological difficulties that we address below, counting the victims is a rather clear cut task, and can thus be regarded as a simple but powerful metric for risk analysis; and (2) the loss of human lives is a meaningful measure for detrimental social and economic impacts of extreme weather and, possibly, climate events (Lissner et al. 2011). While one can doubt whether it is methodologically feasible and/or ethically acceptable to translate deaths into monetary equivalents, the unit "victims" can easily be understood in all societies and cultures, whether or not they are used to monetize risk. Besides the loss of human capital, dead people mean a humanitarian loss, a private tragedy, and possibly a social disaster far beyond economic evaluation. The most important recent heat wave in Europe occurred in July and August 2003. The summer of 2003 was probably the hottest in Europe since AD 1500. Temperature anomalies were 5–10 K above average summer values (Fink et al. 2004). Maximum temperatures of 35–40 °C were repeatedly recorded and peak temperatures climbed well above 40 °C (André et al. 2004; Beniston and Díaz 2004) (Figs. 8.1, 8.2).

The heat wave was accompanied by annual precipitation deficits up to 300 mm. This drought contributed to an estimated 30 % reduction in gross primary production of terrestrial ecosystems over Europe (Ciais et al. 2005). This reduced agricultural production and increased production costs, generating estimated damages of more than €13 billion (Fink et al. 2004). Unusually large numbers of heat-related deaths were reported in France, Germany, Italy, and other countries. A Pan-European research project came up with more than 70,000 additional dead people due to this event (Robine et al. 2008).

While the summer of 2006 was also very hot, a new record event was the summer of 2010, hitting Eastern Europe and Northern Asia especially hard. Many wildfires occurred in Russia, leading to heavy smoke around big cities, most notably Moscow. Daily maximum temperatures reached 40 °C, and the combined effect of heat and smoke led to 11,000 additional deaths in Moscow alone. For Russia as a whole, the death toll of the 2010 summer heat wave totaled 55,000 people (Swiss Re 2011).

The heat waves of 2003 and 2010 reveal that European societies with very different economic, social, and political settings are vulnerable to extreme weather

Fig. 8.1 Vacationers at a beach in Frankfurt Oder, Germany, 03 July 2010. (Patrick Pleul/ Imaginechina)

events. If we choose the metric of mortality, climate risks seem to pose serious problems for European societies, whatever their level of development might be.

8.2.3 Future Trends: Heat Waves and Climate Change

It is impossible to project from a single event to large-scale trends. In particular it is not valid to deduce a shift in the global climate from, say, the European heat waves of 2003 and 2010. Would these two events form our only knowledge base, climate change would be a gamy hypothesis, if not pure speculation.

But we do have much more than these mega-events to update our expectations regarding the future climate. Deeper analysis of the 2003 heat wave, using longer time series, comes to the conclusion that it can be regarded as extremely unusual under the dominant European climate conditions of the twentieth century, while under conditions of climate change it might become more frequent (Beniston and Díaz 2004). In a Bayesian breakpoint analysis, Siliverstovs et al. (2009) find that since the early 1980s return times of Swiss heat waves decreased by an order of magnitude. While Schär et al. (2004), Stott et al. (2004), and Jaeger et al. (2008) suppose a specific contribution of anthropogenic climate change for recent heat-related weather extremes, Chase et al. (2006) are more careful and try to show that such events occur regularly even under current climatic conditions.

If we focus on time development, changes seem to accelerate. Hansen et al. (2010) have already detected an increase in warm temperature anomalies in the last

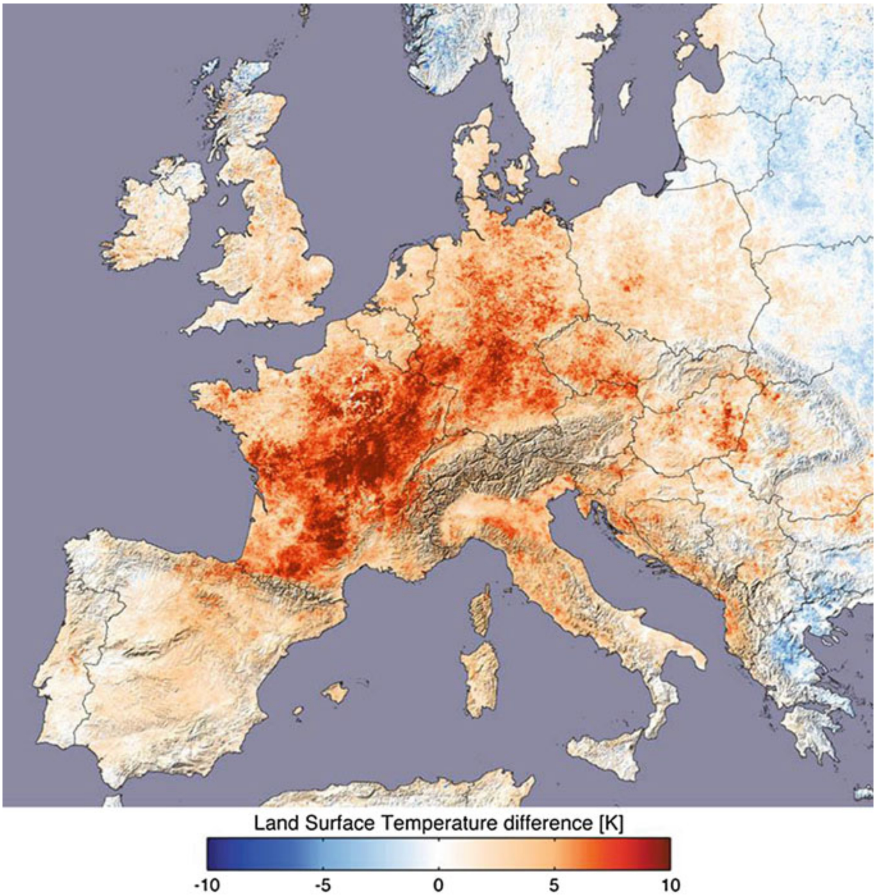

Fig. 8.2 Difference in land surface temperature between 2003 and the average of 2000, 2001, 2002, and 2004, using TERRA MODIS; data range: 20 July–20 August (Data from the MODIS instrument on the Terra satellite, http://eospso.gsfc.nasa.gov/eos_homepage/for_scientists/data_products/OurChangingPlanet/PDF/Page_53_new.pdf)

four decades. This is supported by an analysis of observational data from the 1901–2003 period on temperature extremes (Alexander et al. 2006), revealing that in most stations cold days and nights have decreased, while hot days and nights have increased during the last 100 years. These shifts in temperature patterns also shift the probabilities of extremes. In Frankfurt am Main (Germany) for example, between 1901 and 2006 the probability of a very high monthly mean temperature in August ($T > 22$ °C) has increased from 0.1 to 16.2 % (Schönwiese 2007). The majority of meteorologists and climate change experts believe that an increase of average temperatures will lead to an increase in extremes, which also holds for heat waves (Barriopedro et al. 2011; Beniston et al. 2007; Meehl and Tebaldi 2004). The extreme summer of 2003, very unusual under the climate conditions of the late twentieth century, will become a normal summer at about 2050, and a rather cold summer at around 2100. The IPCC (2007) assumes it to be "very likely" (>90 %) that the frequency of heat waves will increase over most land areas.

Shifting climate regimes will shift annual weather patterns, which may have an effect on mortality. Mortality is high at both ends of the temperature curve: extreme cold and extreme warm conditions have their death toll. As climate change leads to both warmer winter and summer conditions, the question arises what the net effect of reduced winter and increased summer mortality will be. McMichael et al. (2006) assume the net effect to be positive in numbers, i.e. the increase in summer heat deaths will outweigh the reduction in winter mortality.[3]

An integrative research project on climate change impacts on Europe (Ciscar 2009; Ciscar et al. 2011) has also assessed the health impacts. Using a SRES A2 scenario, it states that in the 2020s, without adaptation measures and acclimatization, the estimated increases in heat-related mortality are projected to be lower than the estimated decrease in cold-related mortality. The potential increase in heat-related mortality in Europe could be over 25,000 extra deaths per year, with the rate of increase potentially higher in south Central Europe and southern European regions more generally. Physiological and behavioral responses to the warmer climate could have a very significant effect in reducing this mortality (acclimatization), potentially reducing the estimates by a factor of five to ten. By the 2080s, the effect of heat- and cold-related mortality changes depends on the set of exposure-response and acclimatization functions used. The range of estimates for the increase in mortality is between 60,000 and 165,000 (without acclimatization), again decreasing by a factor of five or more if acclimatization is included.

According to the Stern Review, the increase in average annual temperature, and in particular the increases in peak summer temperatures, will result in an increase in heat related deaths, mainly in southern Europe. Under a 2 °C scenario, the number of heat-related deaths in urban areas could increase 2–3 times. Heat-related deaths could reach 50,000 a year under the B2 scenario and 100,000 a year under the A2 scenario in 2100 (Stern 2006). So far, existing figures for heat wave-related deaths in Europe have been worrying. Given the combined effects of demographic change, urbanization, and climate change, the future will be even more alarming. Of course societies and individual actors can adapt to changing weather conditions. Once they learn from the adverse impacts of past events, they can reduce their vulnerability by a broad range of adaptive measures. Up to now, we have not explicitly addressed this important issue. It is thus time to do so in the next section.

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[3] Demographic effects will aggravate climate change risks, as the proportion of the elderly in Europe will increase dramatically. In 2004, 75.3 million of the 456.8 million EU 25 inhabitants were older than 65, and 18.2 million older than 80. In 2050, EU 25 will have about 453.8 million inhabitants, but 133.3 million will be 65+, and 49.9 million will be 80+ (DG ECFIN 2006).

8.3 European Heat Wave Coping Strategies

Heat health warning systems (HHWS) are the most prominent response to heat waves worldwide. The overall aim of an HHWS is to alert decision makers and the general public of impending dangerous hot weather and to serve as a source of advice on how to avoid negative health outcomes associated with hot weather extremes. Typically HHWS are composed of a number of elements, which include weather forecasting, a method for assessing how future weather patterns may play out in terms of a range of health outcomes, determination of heat stress thresholds for action, a system of graded alerts/actions for communication to the general population or specific target groups about a pending period of heat and its intensity, and advice to government agencies about the possible severity of health impacts.

Since the implementation of the inaugural HHWS in the city of Philadelphia, USA, in 1995, a large amount of international experience has accumulated regarding the development of HHWS. Before 2001, only one HHWS was operational in Europe (Lisbon). In 2000, the World Meteorological Organization chose Rome as a pilot city for the development and implementation of an air-mass based HHWS, which became fully operational in summer 2001. The high numbers of heat-related deaths in summer 2003 across Europe, however, resulted in an increase in the number of HHWS. By 2006, HHWS were operational in 16 countries, most of them introduced after the 2003 heat wave, and by 2009 28 HHWS were operational in Europe (Liukaityte and Koppe 2009) (Fig. 8.3).

HHWS vary significantly with respect to the methodologies and operational definitions of warning triggers (e.g., for critical temperature thresholds), both worldwide and in Europe, leaving room for improvement and more coordination (Bassil et al. 2007; Kalkstein et al. 2009; McGregor et al. 2010; NHS 2006; Nogueira 2005).

Hajat et al. (2010) examined 4 commonly used trigger-setting approaches: (1) synoptic classification; (2) epidemiologic assessment of the temperature–mortality relationship; (3) temperature–humidity index; and (4) physiologic classification. They applied each approach in Chicago, Illinois; London, United Kingdom; Madrid, Spain; and Montreal, Canada, to identify those days expected to be associated with the highest heat-related mortality. They found little agreement on which days were identified as most dangerous among the various approaches. In general, days identified by a temperature–mortality approach have been associated with the highest excess mortality.

Heat health warning systems are often part of a wider heat plan. These heat plans embrace the HHWS itself, but additionally consider a whole set of strategy elements: education and awareness raising; heat event preparedness and guidance on heat avoidance actions and heat risk governance; a communication plan, a program of evaluation; a health surveillance system; and advice on longer term strategies for reducing heat risk. European heat plans vary widely in structure, partner agencies, and specific interventions. The majority of the existing

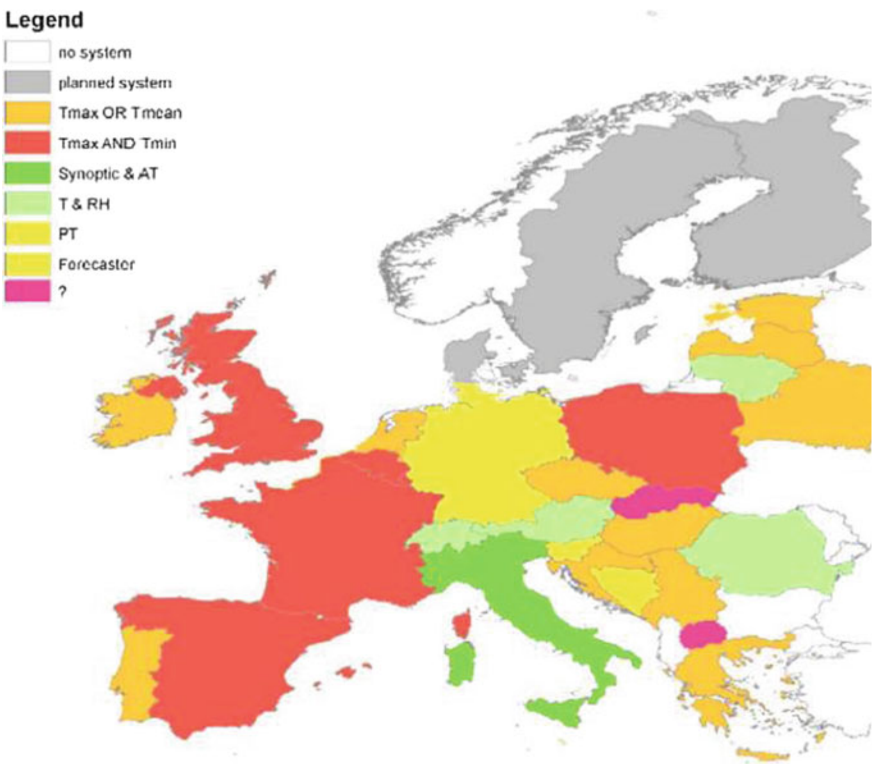

Fig. 8.3 Operational Heat Health Warning Systems (HHWS) in Europe (status 2009); The figure shows the different methodological thresholds used for initialization of early warning. (Legend: *Tmax* maximum temperature; *Tmean* mean temperature; *Tmin* minimum temperature; *AT* apparent temperature; *T* Temperature; *RH* relative humidity; *PT* perceived temperature; *?* not known) (Liukaityte and Koppe 2009)

heat-health action plans are organized on a national level (England, France, Portugal, and Hungary) with regional components. But several are implemented on a regional and local level (Catalonia, Spain; Lazio, Italy; Federal States of Germany). Almost all systems were initiated and designed by the ministry of health as the lead agency and all had an official link to the national meteorological service. The systems in Italy, France, and Hungary had a legal basis and Hungary, England, and Catalonia described a link to the national disaster plan. Most heat health warnings in Europe are issued by the national meteorological offices. The communication campaigns are mostly the responsibility of the ministries or departments of health, or institutes of public health, in collaboration with the health services. Behavioral and medical advice is launched through health services, general practitioners, and pharmacies. Hospital and care home managers, as well as their staff, ensure the implementation of specific measures in their facilities. General practitioners and health centers, as well as social services, are often

Table 8.1 Measures and strategies in existing heat health warning systems (HHWS) and heat plans

Measures, strategy	Level of implementation	Comments
Media announcements (radio, television)	***	Provide general advise on heat stress avoidance to general public
Bulletin or webpage	***	Maybe restricted access to relevant professionals or accessed by anybody
Leaflet	**	General advice, and advice for nursing home managers. Often distributed at beginning of the summer via health centers, and places where vulnerable people may be.
Telephone help-line	**	Either a dedicated telephone service is opened (e.g. Heatline on Portugal) or people are encouraged to phone a pre-existing general health advice line(e.g. NHS Direct in U.K)
Opening of cooling centers	**	Some evidence that cooling centers not used by high-risk individuals, but used by low-risk individuals.
Alert to hospital emergency rooms, ambulance services	*	Used to improve operational efficiency (e.g. if need to deploy extra staff). Needs to be based on local information and carefully evaluated.
Home outreach visits to vulnerable persons	*	Important but usually expensive. Use pre-existing networks of volunteers (e.g. Buddy system in Philadelphia). Or professions (e.g. social workers). Requires some registry of vulnerable people
Outreach to homeless	*	High-risk group in southern U.S (11 homeless people died in heatwave in Phoenix, July 2005)
Electricity companies cease disconnection for non-payment	***	Utility companies have initiated and financially supported HHWS in the US. Most important where population relies heavily on air conditioning (as in the US)
Water companies cease disconnection for non-payment	*	
Fan distribution	**	Fans are effect when they circulate cooler air, but not about temperatures ~37 °C

[*] rarely implemented
[**] often implemented
[***] very often implemented
Source Kovats and Ebi 2006

the main partners responsible for the care of people at risk (Matthies and Menne 2009). Table 8.1 gives an overview of different measures and strategies that existing HHWS and heat plans include.

While it is difficult to assess the efficiency of these systems, some agencies report about their interventions at the end of the summer season. A case study of the French early warning system, comparing the mortalities of the 2006 heat wave to that of 2003 concludes that the implementation of HHWS in France after the 2003 event did contribute to a reduction in the numbers of victims (Fouillet et al. 2008). In contrast, the death toll of the summer 2006 heat wave in many other European countries with HHWS in place shows that there are still gaps in implementation and that many European countries have not yet developed sufficient actions (WHO Europe 2008a).

Triggered by the European heat wave in 2003, several research projects have been launched that do address heat wave impacts—among other climate change impacts—on European societies and their ecosystems. One of these projects, EuroHEAT, was coordinated by the Global Change and Health program of the WHO Regional Office for Europe and co-funded by the EU Directorate General for Health and Consumers. The project quantified the health effects of heat in European cities and identified options for improving the preparedness and response of health systems to protect health from heat waves. Its activities contributed to the implementation of the Declaration of the Fourth WHO Ministerial Conference on Environment and Health and of the European Commission's Environment and Health Action Plan.

One of the core findings of the project was that the adverse health effects of heat waves are largely preventable if certain conditions are met (WHO Europe 2008b). One outcome of these activities is the web-based heat wave forecasting tool called EuroHEAT (http://www.euroheat-project.org/dwd/index.php). This tool is based on the Ensemble Prediction Systems (EPS) of the European Centre for Medium Range Weather Forecasts (ECMWF) and consists of a 50 member ensemble. EPS simulates possible initial uncertainties by adding, to the original initial conditions, small perturbations within the limits of uncertainty of the initial data. This creates an ensemble of slightly different initial conditions. Each ensemble member is then used as starting point for a forecast. Instead of one forecast with a specific starting date and lead time, an EPS produces an ensemble of forecasts. The skill of the EPS forecast is very good for short lead times, but decreases significantly with increasing lead times.

EuroHEAT is a good example of a social learning process derived from recent heat waves. It is European in scope, and integrates different weather forecast models. There is no heat action plan underlying the heat early warning system, but with respect to a Pan-European heat wave risk governance structure this could be changed.

8.4 Towards Heat Wave Risk Governance

As we have seen in the previous sections, heat waves already pose a serious threat to European societies, and it is expected that climate change will increase the frequency and the intensity of European heat waves. Many agencies, including weather forecasting organizations, have reacted and developed heat health early warning systems. In principle, the heterogeneity of methods and procedures followed is not a problem. Regional and local conditions vary and lead to different vulnerabilities. In addition, there is always some path dependency in the development of HHWS, given the traditions and the capacities of national weather services. Against this background, the plurality of warning systems in Europe is an asset, and one can refer to principles of subsidiarity and federalism[4] in order to justify it. Coordination, cooperation, and learning have to be improved, however, in order to avoid additional heat wave deaths. In addition, forecasting and warning systems have to be based on a comprehensive risk analysis, as weather baselines can be expected to shift due to climate change, and as societies have to get prepared in order to assess realistically the potential damages of more frequent heat waves.

Thus the question arises: How might an improved heat wave risk governance architecture for Europe look like that capitalizes on the flexibility of systems and variety of national approaches, one that at the same time ensures comparability, cooperation, and a comprehensive analysis of changing risk conditions? First of all, we think it appropriate to characterize what we mean by risk governance, and why we assume it to be indispensable in the case of heat waves in Europe, before we give an outline of such an architecture.

8.4.1 Risk Governance

While risk management refers to all measures that deal with a given risk, the term risk governance explicitly takes into account the complexity of risks as well as the heterogeneity of the social institutions and organizations that deal with them. We have outlined the necessity of such a governance approach to risk in programmatic terms in another paper (Shi et al. 2010). Here we would like to apply the approach to heat waves. Risk governance deals with the identification, assessment, management, and communication of risks in a broad context (IRGC 2005, 2008; Shi et al. 2010). It includes the totality of actors, rules, conventions, processes, and a mechanism involved in managing risks, is concerned with how relevant risk information is collected, analyzed, and communicated, and evaluates how management decisions are taken. It applies the principles of good governance (such as transparency, effectiveness, efficiency, and acceptability) to the domain of risk research and risk management (Jaeger et al. 2001).

The benefits of good risk governance are quite clear. It avoids inequitable distribution of risks and benefits between countries, organizations, and social

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[4] We refer to the European notion of federalism that focuses on the decentralist perspective of a federal structure, as for example realized in Germany, in contrast to a centralist political and administrative tradition, for which in Europe France still provides a good example.

groups, deals with different approaches to assessing and managing the same risk, considers political boundary conditions and trade-offs, and takes into account economic costs and public perceptions.

On a national scale, governance describes structures and processes for collective decision making involving governmental and nongovernmental actors (Nye and Donahue 2000). Governing various choices in modern societies is seen as an interplay between governmental institutions, economic organizations, and civil society actors (such as NGOs). At the global level, governance embodies a horizontally organized structure of functional self-regulation that encompasses state and non-state actors and brings about collectively binding decisions without superior authority (Rosenau 1992). In this perspective, non-state actors play an increasingly relevant role and become more important, since they have decisive advantages of information and resources compared to single states.

But governance is not confined to strictly political issues or levels. The important point for our analysis is that governance approaches are meaningful and necessary if simple coordination measures of political bodies do not suffice, but nonpolitical actors are essential for the problem definition and solving. Heat waves transcend the capacity of government agencies, as knowledge and information providers (science, weather services), and economic and other social actors are required in order to generate and provide relevant knowledge as well as to design and implement meaningful action. We thus argue that risk governance is necessary for coping with heat waves in Europe.

8.4.2 Risk Governance Framework for Heat Waves

Risk governance includes five major elements: a pre-assessment of risk, risk appraisal, risk judgment, risk management, and risk communication (IRGC 2005, 2008). It is important to link these elements in a meaningful and sequential way (Fig. 8.4). While these steps do have a clear time sequence, it is also important to see that recursive loops are necessary as well.

We start from the sequential loop of the above mentioned elements, and enrich them with respect to heat wave risks as we have discussed above. It is worth noting that risk governance sits at the interface of analysis and understanding on the one hand, and decision making and action on the other. This holds in particular when scientific questions play a key role in understanding specific issues. In the case of heat waves, climate change induced risk amplification is a good example.

1. **Heat Wave Risk Pre-Appraisal**

The first step for any analyst of risk is to come up with a scoping of heat wave risks in the context of other risks, and a qualitative assessment of the framing of heat waves. Given the fact that heat wave risk analysis has become a research and, in part, an action area in its own right, this step might seem superfluous. But as it is always helpful to rethink routine assumptions of certain communities, it is

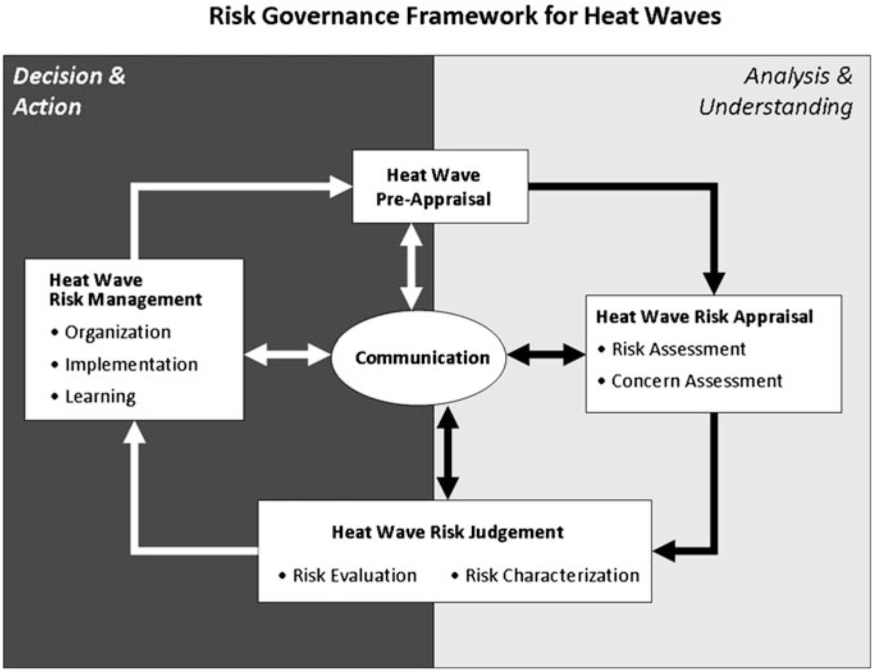

Fig. 8.4 Schematic elements of a heat wave risk governance framework (Modified after IRGC 2005)

necessary to readjust the underlying risk definitions for heat waves from time to time, to compare them with other risks (not only those associated with climate change), and to find out how important social stakeholders (for example policy branches, business communities, NGOs) understand the issue and how they want to deal with it. In the same line of thought, existing regulations for heat wave management have to be briefly (and repeatedly) reviewed in order to adapt risk governance schemes to new developments.

This would already hold if heat waves could be perceived as natural climate variations exclusively, as some extreme events in the range of "normal" stochastic extremes might shift the way decision makers or the wider public perceives them (for example shifting from nuisance to disaster). This prospect is even more likely as heat waves become more frequent and intense due to anthropogenic climate change, and as risk baselines will shift measured either as a frequentist return period or as a Bayesian prior belief.[5]

[5] Frequentists define probabilities on the basis of historical frequencies (e.g. tumbling a dice ideally an infinite number of times), where as Bayesians define them as subjective measures of un certainty. There is, therefore, a frequentist and a Bayesian concept of probability.

For that same reason, a heat wave pre-appraisal also needs to identify the climate discourse of a given region or country.[6] It makes a huge difference whether, for example, the climate discourse is focusing on the attribution question—is there anthropogenic climate change or not—, or whether it has moved to a next phase in which different solutions are debated (Reusswig 2010). In that sense, one can argue that the European heat wave of 2003 has helped to bring about such a new climate change discourse, and that the establishment of heat health warning systems in many parts of Europe took place under the auspices of this new climate change discourse.

In contrast, we find that in Russia climate change is much debated and more controversial—as it is in the U.S.—and that this oil and gas exporting country finds it difficult to accept officially the ongoing anthropogenic global climate change as a risk. Instead, leading Russian politicians as well as some Russian climate scientists either neglect climate change altogether, or assess it as having a net beneficial effect on the Russian economy. After the severe heat wave that hit Russia in summer 2010 the perception may change: Still Russian meteorologists, looking at instrumental records in Moscow of the last 130 years and a Gaussian probability distribution, came to the conclusion that this extreme event would occur only every 5,000 years; but on the other hand prominent politicians and experts put the extreme event in the context of anthropogenic climate change (Shuster 2010).

2. **Heat Wave Risk Appraisal**

Risk appraisals are the cognitive core elements of any risk governance scheme. The appropriate assessment of what is creating the risk, and how, is a central prerequisite for any practical risk management strategy. There are two major aspects we would like to highlight here: risk assessment and concern assessment.

The risk assessment component deals with questions of probability and potential damage, or adverse effects. The systematic screening of historical records of heat waves in particular regions is crucial, but scientific findings that test for future developments, changing baselines, and interactions of different risks are also imperative. Case studies of historic events provide important insights into the vulnerability of particular systems, regions, and social groups. They help to establish a common knowledge base for cause-effect relations that have to be addressed when it comes to designing management options.

An important question is what scientific, technical, and analytical approaches, knowledge, and expertise should be used to (better) assess the adverse impacts of heat waves. In this context it is important to remember that existing heat wave management practices can be seen as "incorporated knowledge," schemes that are

[6] "A climate change discourse is a thematically focused and (more or less) coupled sequence of publicly visible arguments in various contexts (or framings) that different social actors are engaged in, in order to influence (1) one another, (2) specific boundary conditions of social action (such as politics), and (3) the general public so that the resource endowments, interests and worldviews of the speaking actors have a higher chance to prevail in the social interpretation and individual or collective decision making processes" (Reusswig and Lass 2010, p. 158).

based upon some underlying risk assumptions that are not necessarily made transparent, may be because most agents take them for granted. If baselines for heat waves shift due to climate change, such taken-for-granted assumptions underlying management practices have to be reviewed critically, and tested against scenarios for different futures. In this respect it is crucial to become aware of the theories, organizations, and persons that—for any given region—are or may become relevant to assessing the risk of heat waves, such as climatologists, medical specialists, social workers, key administrative staff, and social scientists. Providing a flexible and adaptive knowledge base is crucial for risk governance—both with respect to theoretical concepts and to organizations and persons.

In Europe, the 2003 heat wave triggered much research as well as the establishment of different early warning systems at the national and local levels. Despite a flurry of activities concerning climate change and a growing interest in the research community, heat wave risk assessments remain fragmented, and basic tools for facilitating good decision making are lacking (Corfee-Morlot et al. 2011). A Europe wide approach to improve the knowledge base for heat wave related risk appraisal is needed. We suggest an initiative to integrate the empirical findings and, most of all, the methods of short-term research, assessment, and monitoring activities (Fink et al. 2004; Koppe et al. 2004; Kosatsky and Menne 2005; Michelozzi et al. 2005; Robine et al. 2008) into existing institutionalized activities, whereby sectoral and standardized assessments have to be accelerated in specific domains (Lissner et al. 2011). We suggest the International Disaster Database (EM-DAT) at the Center for Research on the Epidemiology of Disasters (CRED) at the School of Public Health in Louvain's University to be the best suited institution for this purpose (http://www.emdat.be/). The European Union seems the most appropriate organization to fund the integration of findings and the transfer methods of leading European research groups into the EM-DAT monitoring scheme. It could also usefully fund consulting and outreach capacities at CRED in order to provide national and local risk managers with relevant information of how to create regionally adapted risk-related information bases. It is important to involve WHO Europe with its head office in Copenhagen in the creation of such an activity for capacity building in order to improve the salience of health-related information.

Risk assessments deal with probabilities and potential damages, but they do not cover the whole range of a comprehensive risk appraisal. We additionally suggest a concern appraisal, addressing the social representation of heat wave risks. While from a purely natural science point of view it might seem unnecessary or even detrimental to ask for social concerns in addition to the classical dimensions of risk, from a risk governance perspective it is crucial to do so. What are the public's concerns and perceptions of heat waves? What is the social response to heat wave risks? Is there the possibility of political mobilization or potential conflict? What roles do existing institutions, governance structures, and the media play in defining public concerns? Which socioeconomic damages can be expected from heat waves? Questions such as these have to be answered in order to design a viable management strategy. They reflect the fact that the results of climate science do not influence a society's climate discourse per se. Only what passes the filter of social amplification or downplay, for which the mass media representation of (past) heat waves and climate change in general is crucial, meaningfully affect public discourse and understanding of the problem.

Thus we contend that the CRED updated monitoring and outreach activity should be accompanied by a mass media analysis unit that collects and critically analyzes European mass media coverage of heat wave-related events. In cases of mass media misrepresentation of facts and causal attributions, CRED could also inform local and national risk managers about improved information strategies.

3. **Heat Wave Risk Judgment**

While risk assessments make up the core of the scientific analysis and understanding of risks, risk judgments are situated at the interface between analysis and action. The term judgment explicitly refers to the dimension of valuation in all assessments and aims at a more conscious, systematic, and transparent mode of risk evaluation. Risk judgment has two major components: risk characterization and risk evaluation.

Risk characterization, lending itself more to the analytical side, focuses on the health and socioeconomic effects of heat waves and tries to qualify different qualitative and quantitative profiles of risk situations. As we have seen, hot spell and heat wave mean different things for different locations, depending on the existing adaptive capacity of established behaviors and infrastructures. This means that heat wave risk profiles differ across and between regions.

As risk profiles are area specific, their realization depends on area profiles that identify the vulnerable regions, sectors, and groups in a given region. This again requires a sound book-keeping with respect to past heat wave events in the same region. For this purpose official statistics, past mass media reports, and oral or other reports from people affected or responsible for risk management are helpful. At the same time, comparisons with past experiences of other regions deliver valuable insights, as climate change will shift the baselines for risk assessments. The method of climate analogies is a very useful tool here (Hallegatte et al. 2007; Hallegatte and Corfee-Morlot 2011).

This also means that heat wave management schemes in place elsewhere are also relevant for assessing and improving a specific area's risk profile. There are many studies available–again most of them triggered by the 2003 heat wave–that compare early warning systems and other heat wave management systems. In order to enable risk managers to learn from good practice, the European Union should fund a continuous effort to compare these systems in a coherent manner, building upon existing experience both from European research projects and from specialized organizations such as WHO. We propose to institutionalize such a heat wave management monitoring activity at The Monitoring and Information Centre (MIC), a branch under the auspices of the European Commission's Mechanism for Humanitarian Aid and Civil Protection (http://ec.europa.eu/echo/civil_protection/civil/prote/mic.htm).

Risk evaluation makes up the second pillar of risk judgment, lending itself more to the decision and action side of risk governance. Here normative and evaluative aspects do come explicitly to the fore. What are the values at risk in case of heat waves? What ethical problems or conflicts arise? Which potential damages are tolerable and acceptable, and for whom? What does a disaster mean for particular sectors or groups, especially for vulnerable individuals and communities who are often neglected, such as the homeless or tourists? What costs—in a wider sense, including not only monetary but also organizational and psychological costs—are attached to particular risk reduction options, and who will have to bear them? Are there any co-benefits from heat wave risk reduction options, and where/to whom do they accrue?

It is important to deal with these questions in an open, transparent manner at this stage of the risk governance process. If these political questions are not addressed early enough—and many scientists tend to leave them to politicians—conflicts over management priorities and the allocation of scarce resources will become much more difficult later.

As a result of risk characterization and risk evaluation, the feasible management option space for a given region should become clear. This option space should not only cover what could be done in case of upcoming heat waves, but also determine what are the most effective and efficient measures with which to cope with climate perturbations.

4. **Heat Wave Risk Management**

The management of heat waves clearly is the practical core of risk governance, and the reason and goal for the whole operation. Risk management involves the design and implementation of the actions and remedies required to avoid, reduce, transfer, or retain the risks. Questions of organization, implementation, and learning are at its heart. Risk management includes the generation, assessment, evaluation, and selection of appropriate risk reduction options as well as implementing the selected measures, monitoring their effectiveness, and reviewing the decision if necessary.

As a first step, the definition and set-up of the risk management process and the involved actors and organizations are crucial. Who should be involved, who can bring in specific competences and responsibilities, and what will be the lines of decision making and communication? In this domain it becomes clear why the term "risk governance" is more appropriate than "risk government." Government processes refer to more or less hierarchical structures in public agencies, where the assigned staff and its communication and decision lines are clear—at least in principle. While government bodies (such as municipal departments or the police) do play an important role in risk management, they are not the only relevant actors. In the case of managing heat wave risks, the required set of agents comprises hospitals, medical doctors, retirement home managers, landlords, urban planners, facility managers, entrepreneurs, civil society organizations, and active citizens at large. It is impossible to organize these heterogeneous actors in a top-down manner, as government organizations typically do. Instead, cooperative forms of coordinated action are required, combining elements of top-down control with those of motivation, consultation, and voluntary cooperation. The handling of these hybrid forms of coordinated action requires skills in governing (not commanding and controlling) social networks rather than heading a single agency. Experienced individual agency heads may very well be qualified to govern these networks, but mostly due to additional skills acquired through long-term, on-the-job experience.

Heat wave risk management needs an early warning system. As we have seen, such systems operate in most European countries. Yet they are based on different methods. Heat waves can occur locally, and heat wave vulnerabilities vary considerably between cities and regions. It is thus reasonable to follow different approaches across Europe. But in view of trans-boundary heat waves, as well as in view of the allocation of European organizational capacity and funds, a coherent European early warning culture has to emerge.

National weather services have been the major drivers of existing heat wave early warning systems, and their respective meteorological approaches have shaped the multitude of currently co-existing event risk definitions and thresholds for specific actions. While plurality may be a strength, fragmentation is not. Needed is a nested European early warning system that evolves from existing systems, accompanying the other integrative governance efforts we have mentioned so far. The Europe-wide, web-based prognostic tool EuroHEAT, based upon ensemble predictions for heat waves, could be the nucleus for the final integration version of these efforts. It is crucial that the development process of a Pan-European heat wave early warning system is not driven by meteorological considerations (and agencies) alone. It is essential to keep in mind that an early warning system is not primarily an addon service of meteorological offices, but the first step in a disaster management process. As such, other actors must be involved, bringing in all aspects of relevant information, timelines, degree of details, necessary supporting data and interpretation materials, and understandable communication.

The next broad step is to develop locally/regionally adopted measures to reduce exposure to heat waves. As many victims die before they reach the hospital, such a step is crucial in order to reduce mortality. There are multiple ways of reducing individual heat exposure. This includes individual behavioral measures, short-, medium-, and long-term housing measures, and long-term improved urban planning, building design, and transport and energy policies. Short-term measures include advice on behavior, provisioning of access to cool spaces, as well as the allocation of mobile evaporation coolers and room air conditioners. Medium-term measures include increasing the albedo of the building envelope, external shading, insulation, decreasing the internal heat load, the provisioning of passive cooling technologies, and efficient active cooling. Long-term measures encompass the adaptation of building regulations, urban planning, land-use changes, and mitigation of climate change (Matthies and Menne 2009; U.S. EPA 2006; WHO Europe 2008a, b).

It is clear that this very broad package of measures not only asks for the coordination of a multitude of actors, but also for the integration of heat wave risk management into other policy and planning areas. This implies that different processes and timelines are involved. While information campaigns for triggering behavior changes can be implemented rather rapidly and need but a small network of agents, changing building legislations and codes may take several years, and requires the involvement of national agencies, governments, political parties, and parliaments, among others. Here again, a European focal point for heat wave risk governance could help to push national legislations, e.g. by providing facts, experience, and future impact scenarios.

While a general information campaign is indispensable, more specialized and probably more personalized information is needed in order to reach particular target groups, such as isolated elderly or homeless people. Social scientists and communication specialists will be needed to tailor information to their needs and capacities, and other actors relevant to the everyday life practices of those groups (health care organizations, health insurance agencies, social assistance agencies, local nodal points, such as shelters, shopping centers, or meeting rooms) must be engaged in the effort. Mass media campaigns not only require sound information, they also need to be communicated by credible and accepted people; the same holds true for personalized information, in which case a specialized staff needs extra training.[7]

A next necessary step is to develop emergency plans for those instances when a particular threshold of the early warning process has been passed. Again, the relevant actor network has to be first defined, and communication and decision procedures, together with responsibilities, have to be agreed upon. An affected region or city has to identify and assign cooling rooms that the general public can easily access (such as public buildings); it has to design and implement emergency action plans for hospitals, retirement homes and kindergartens; it should suspend shut-offs of utilities for individuals during heat events; and it should reschedule public events to avoid large outdoor gatherings when possible.

Businesses in the region whose employees work outside should also develop behavior guidelines and implement emergency plans. Public authorities should install (and communicate) phone hotlines, and national weather services, together with telecommunications operators, should offer specialized information for mobile phones.

This bundle of measures will not only vary from region to region, according to the outcomes of the risk judgment phase. It will also vary over time, given the learning process due to implementation experiences and new ideas from elsewhere. Monitoring the outcomes of management plans and the provisioning of learning capacities (for instance extra staff members, or extra time reserved for

[7] If funds for heat wave risk management do not allow for specialized permanent staff, it might be equally effective to train other staff that communicates with vulnerable target groups on a regular basis.

evaluation exercises) is a necessary step towards a resilient, learning network of heat risk governance agencies.

5. **Risk Communication**

Finally, the critical importance of communication should be emphasized briefly—last but not least. Its role has already been mentioned several times in this article. This is not accidental. In fact, communication is an essential factor for successful risk governance (Renn 2008) as well as for many climate change adaptation situations (Hinkel et al. 2009). This holds for two sets of reasons. On the one hand, the heterogeneity of actors at various scales makes it essential to communicate in order to create and maintain action capacity. On the other hand, the variety of agencies and publics that heat risk governance has to address requires flexible forms of communication in order to get heard and understood.

One might call the first aspect internal communication (within the actor network), while the second one refers to external communication with those institutions and groups that provide necessary information or are addressed as potential users. While it might be impossible to institutionalize these two strands in a separate organization, it is indispensable that all actors involved in the governance network should be aware of the necessity to get the communication side right.

8.5 Conclusion

The study of recent evidence of heat wave-related mortality data indicates that while economic wealth and technological capacity might be a necessary condition for adequately coping with adverse climate change effects, they are hardly sufficient. The death toll of recent heat waves in developed countries has been remarkably high, contradicting the common assumption that scoring high in economic and technological indicators automatically leads to low vulnerability to weather extremes. Due to climate change, heat waves can be expected to become more frequent, adding to the challenge posed by climate impacts and raising the question of the adaptive capacity of even the developed countries to climate change.

After the 2003 heat wave, many European countries underwent a remarkable process of social learning and implemented heat health warming systems. But phenomena like the death toll of the summer 2006 heat wave in many European countries with heat health warning systems in place demonstrates that there are still gaps in implementation, and that many European countries have not yet developed sufficient action plans and responses.

Questions of awareness, preparedness, organizational issues, and actor networks have to be addressed in a proactive and focused manner in order to decrease future heat wave damages considerably. We propose practical consequences for heat wave adaptation measures by adopting a risk governance framework that can be universally applied as it is sufficiently flexible to deal with the multi-level and often fragmented reality of existing coping measures. The proposed risk governance framework can give structure to processes of social learning that decrease the vulnerabilities of societies to weather extremes, whatever their future frequency may be.

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Chapter 9
Hurricane Katrina: A Teachable Moment

Qian Ye and Michael H. Glantz

9.1 Introduction

In one of NOAA's technical reports, it states that "Hurricane Katrina is the most costly natural disaster ever to strike the United States, and the deadliest since the Lake Okeechobee disaster (hurricane) of September, 1928. In addition, Katrina was one of the strongest storms to impact the coast of the United States during the last 100 years" (Graumann et al. 2005).

Unlike other anomalous "natural events", however, for which usually only number of victims and degree of economic damages attract the attention both from general public and governments, Hurricane Katrina has been now investigated heavily, not only by natural scientists in USA for its relationship with global warming (Trenberth 2007) and its impacts on local ecosystems (National Research Council 2006), but also by social scientists from psychology, political science, anthropology, geography and economics (check the website http://understandingkatrina.ssrc.org for more details), as well as engineers (Seed et al. 2005), popular sciences media (Fischetti 2006), and politicians (Sandalow 2005). The Hurricane Katrina situation is viewed as a mix of "natural" and "human-made" as well as "technological" factors and as a historically conditioned process (for example, Brunsma et al. 2007; Colten 2006; Hartman and Squires 2006).

Many excellent researches and reports on Hurricane Katrina have been published for the past 4 years. The purpose of this working is trying to generate more discussions on the research questions initiated by the IRG Project working group. After summarizing the background information about Hurricane Katrina, including

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P. Shi et al. (eds.), *Integrated Risk Governance*, IHDP-Integrated Risk Governance Project Series, DOI: 10.1007/978-3-642-31641-8_9,

the meteorological facts and its social and economic impacts based on reports from various official sources, we will present our thoughts on fallacies or misconceptions about the Hurricane Katrina and New Orleans situation. We summarize our thoughts by proposing some research questions which may require attention from the IRG Project.

9.2 Background Facts

As reported by US National Climate Center,[1] Hurricane Katrina was one of the strongest storms to impact the coast of the United States during the last 100 years. With sustained winds during landfall of 125 mph (110 kts) (a strong category 3 hurricane on the Saffir-Simpson scale) and minimum central pressure the third lowest on record at landfall (920 mb), Katrina caused widespread devastation along the central Gulf Coast states of the US. Cities such as New Orleans, LA, Mobile, AL, and Gulfport, MS bore the brunt of Katrina's force and will need weeks and months of recovery efforts to restore normality.

In addition, Katrina was one of the strongest storms to impact the coast of the United States during the last 100 years. At landfall, sustained winds were 127 mph (a strong Category 3 hurricane on the Saffir-Simpson scale—see Fig. 9.2), and the minimum central pressure was the third lowest on record (920 mb). Katrina caused widespread, massive devastation along the central Gulf Coast states of the U.S. The flooding of New Orleans, LA following the passage of Katrina was catastrophic, resulting in the displacement of more than 2,50,000 people, a higher number than during the Dust Bowl years of the 1930s. As of early August 2006, the death toll exceeded 1,800 and total damages/costs were estimated to be around $125 billion."

9.2.1 Meteorological Facts

HISTORY: On August 23rd, 2005, Hurricane Katrina developed as a tropical depression (TD #12 of the season) in the southeastern Bahamas. The next day, it strengthened into Tropical Storm Katrina. On August 25th, Katrina strengthened to become a category 1 (wind speeds of 75 mph or greater) hurricane. The first landfall occurred between Hallandale Beach and North Miami Beach, Florida, with wind speeds of approximately 80 mph (70 kts). Gusts of above 90 mph (78 kts) were measured as Katrina came ashore. Then, the storm moved southwest across the tip of the Florida peninsula and quickly re-intensified shortly after

[1] The information in this section is summarized based on the material presented at http://lwf.ncdc.noaa.gov/oa/climate/research/2005/katrina.html.

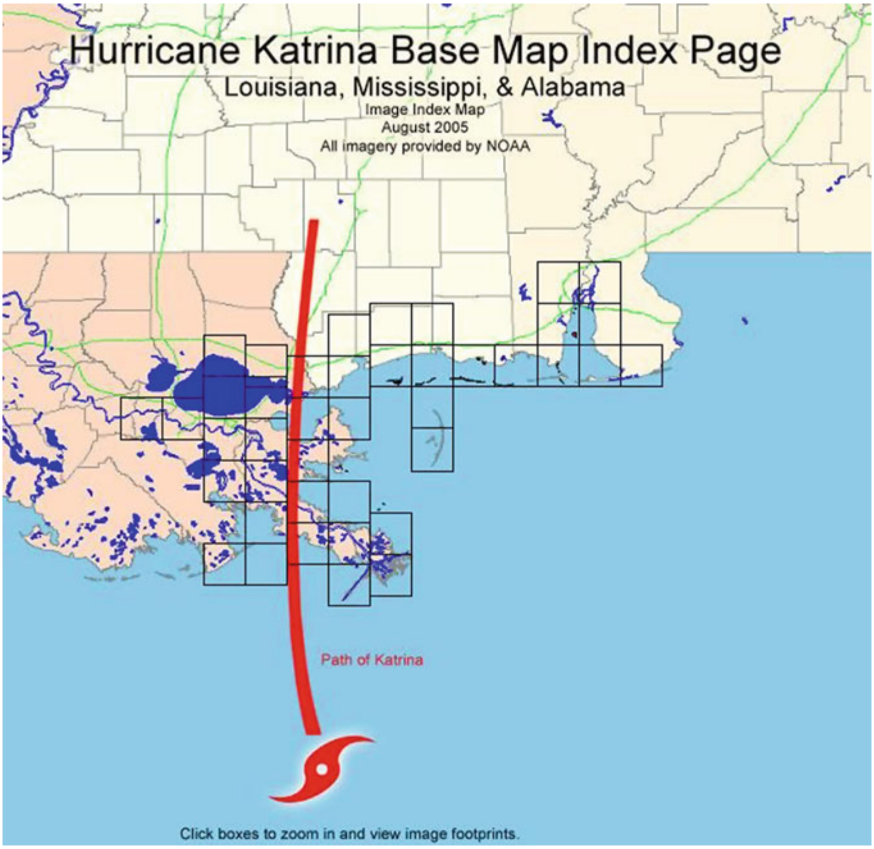

Fig. 9.1 Hurricane Katrina base map index page (From NOAA http://ngs.woc.noaa.gov/katrina/KATRINA0000.HTM)

moving over the warm waters of the Gulf of Mexico. Atmospheric and sea-surface conditions (an upper level anticyclone over the Gulf and) were conducive to cyclone's rapid intensification, which lead to Katrina attaining 'major hurricane' status on the afternoon of the 26th and it reached maximum wind speeds on the morning of Sunday August 28th of over 170 mph (150 kts, category 5), and its minimum central pressure dropped that afternoon to 902 mb—the 4th lowest on record for an Atlantic storm (Fig. 9.1).

Katrina remained a strong category 4 strength hurricane despite the entrainment of dryer air and an opening of the eye wall to the south and southwest before landfall on the morning of the 29th. Land falling wind speeds at Grand Isle, LA were approximately 125 mph (110 kts) (strong category 3 intensity) with a central pressure of 920 mb—the 3rd lowest on record for a land falling Atlantic storm in the US.

RAINFALL: During its initial landfall in southern Florida, Katrina generated over 5 inches of rainfall across a large area of southeastern Florida. Rainfall from Katrina's outer bands began affecting the Gulf coast well before landfall. As Katrina came ashore on August 29th, rainfall exceeded rates of 1 inch/hour across a large area of the coast. NOAA's Climate Reference Network Station in Newton, MS (60 miles east of Jackson, MS) measured rainfall rates of over an inch an hour for 3 consecutive hours, with rates of over 0.5 inch/hour for 5 h during August 29th. Precipitation analysis from NOAA's Climate Prediction Center shows that rainfall accumulations exceeded 8–10 inches along much of the hurricane's path and to the east of the track.

WINDSPEEDS: Wind speeds over 140 mph were recorded at landfall in southeastern Louisiana while winds gusted to over 100 mph in New Orleans, just west of the eye. As the hurricane made its second landfall on the Mississippi/Louisiana border, wind speeds were approximately 110 kts (125 mph). Gusts of over 80 mph were recorded in Mobile and 90 mph in Biloxi, MS.

As the storm moved inland and weakened to a tropical storm on the 29th, rainfall became the primary impact. Rainfall amounts exceeded 2–4 inches across a large area from the Gulf coast to the Ohio Valley. As a result, flood watches and warnings were common across these regions. Rain bands from Katrina also produced tornadoes causing further damage in areas such as Georgia.

9.2.2 Impacts

LOSS OF LIFE: From the Gulf states (principally Louisiana and Mississippi), the loss of life is unknown but will likely reach well into the hundreds and possibly higher. It is clearly one of the most devastating natural disasters in recent US history. From Katrina's first landfall in Florida, while it was at category one strength, initial estimates suggest 11 deaths resulted.

FLOODING: The loss of life and property damage was worsened by breaks in the levees that separate New Orleans from surrounding lakes. At least 80 % of New Orleans was under flood water on August 31st, largely as a result of levee failures from Lake Pontchartrain. The combination of strong winds, heavy rainfall and storm surge led to breaks in the earthen levee after the storm passed, leaving some parts of New Orleans under 20 ft of water. Storm surge from Mobile Bay led to inundation of Mobile, Alabama causing imposition of a dusk-to-dawn curfew for the City. Large portions of Biloxi and Gulfport, Mississippi were underwater as a result of a 20–30+ foot storm surge which flooded the cities (Fig. 9.2).

OIL INDUSTRY: A major economic impact for the nation was the disruption to the oil industry from Katrina. Preliminary estimates from the Mineral Management Service suggest that oil production in the Gulf of Mexico was reduced by 1.4 million barrels per day (or 95 % of the daily Gulf of Mexico production) as a result of the hurricane. Gasoline had reached a record high price/gallon as of Monday August 30th with concerns over refinery capacity apparently driving the increase.

Fig. 9.2 Homes remain surrounded by floodwaters from Hurricane Katrina 4 September 2005 in New Orleans. (David J Phillip/Imaginechina)

POWER OUTAGES: Over 1.7 million people lost power as a result of the storm in the Gulf States, with power companies estimating that it will take more than several weeks to restore power to some locations. Drinking water was also unavailable in New Orleans due to a broken water main that serves the city. Power was lost to 1.3 million customers in southeastern Florida from the initial landfall on August 24th.

COST: Estimates for damages for Hurricane Katrina are still extremely preliminary and properly assessing losses will take many months. However, the total losses as a result of Katrina are estimated to exceed $100 billion with over $34 billion in insured losses.

TRAVEL: Both of New Orleans' airports were flooded and closed on August 30th and bridges of Interstate 10 leading east out of the city were destroyed. Most of the coastal highways along the Gulf were impassable in places and most minor roads near the shore were still underwater or covered in debris as of August 30th. Katrina also disrupted travel as it headed inland, with more than 2 inches of rain falling across a large area from the coast to parts of Ohio during the 48 h after Katrina made landfall.

9.3 Fallacies (Myth or Misconceptions)

Fallacies are statements that some people have said or may think are true but for the most part are either not true at all or is partly true in certain circumstances. For the Hurricane Katrina, the following fallacies were then and are still now around:

9.3.1 Poor People Choose to Live in Dangerous Places

People live in places that are at elevated risk to natural hazards for a variety of reasons, many of which are beyond their personal control. Some do it because of the view. These people generally speaking have funds available that allows them to rebuild if their property is damaged. They also have the wherewithal to "get out of town in a hurry" if they have to do so. For example, on TV news channels the lines of cars and trucks were leaving New Orleans the day before the hurricane was expected to hit. But, many of the city's residence could not leave: No available cash in hand, No access to cash to flee, no money for gasoline, no way to move possessions, no where to go, and so forth. Making the response of those at-risk to Katrina even more difficult was the fact that there had been hurricane warnings and close calls before in recent times (such as Hurricane Georges in 1998). For a while there was still some uncertainty as to the exact location of landfall and the impacts were not expected to be very threatening from the hurricane itself. So, many "stayed the course" to a tragic end. The combination of psychological, financial and political factors combined with a direct hit of Hurricane Katrina and the cascade of disasters that followed (the breakdown of the levees) underscored the vulnerabilities of the poor, the elderly, kids and racial minorities (nationally speaking). It also underscored the importance of educating people about the range of the local hazards that they may have to face. Many of the at-risk people living along the gulf coast do not choose to live in harm's way; they are forced to do so by circumstances they cannot control.

9.3.2 Technology is the Answer

In current fast development of technologies, people in developed countries such as Americans in general tend to have a blind faith in technology. That means that if there is a problem, a hi-tech solution can be found that can save us from the impacts of that problem. And to date technology has frequently come to rescue. Sometimes, however, technological fixes are often used as band-aids, meaning that they are only temporary solutions to chronic major underlying problems. They do not erase the problem but help us to circumvent it … at least for a while. A famous economist once suggested that technology actually helps to increase the total amount of misery because when the problem does reappear there are more people around to be negatively affected by its impacts.

Technology is actually neutral. What determines whether is a positive or a negative tool is how and whether it is used effectively. As we are seeing, once the emergency response phase to Hurricane Katrina ends and reconstruction begins debates will ensue about whether the levees should have been reinforced according to plans that were not only on the table but were already being undertaken. Clearly, the need to shore up the levees had been recognized at all government levels, local to national. Technology may prove to be the answer, but one must ask "what is the question?" Should that question be about decision making related to the use of technology?

9.3.3 Forewarned is Forearmed

"Forewarned is forearmed" is an old adage that speaks well to early warnings and to knowledge in general. It is based on the popular belief that more information about the future enables one to prepare for it at least to some extent, if not fully.

The projections and speculation about Hurricane Katrina's category, location of landfall, potential damage from a variety of sources, of the intensity and storm track for Katrina were in essence forewarnings. However, they were not heeded by those with the power to encourage, entice or force people to move out of harm's way by evacuating their homes and their cities along the Gulf coast. Warnings are not enough. Actions must take place in response to them.

As an example, Mark Fischetti wrote an excellent report on New Orleans in Scientific American Magazine in 2001 (Fischetti 2001). In his report, he not only warned and explained why New Orleans is a disaster waiting to happen, but also discussed the potential serious economic and environmental consequences as well as the cultural loss due to the drowning of New Orleans. Unfortunately, what he described became reality and the early warning became late lessons.

9.3.4 The Third World is More Vulnerable to Hazards Than the Rich Countries

There has been a prevailing view among climate scientists and policy people, both those who believe in global warming and those who don't, that developing countries are more vulnerable to climate change impacts than are the industrialized countries. The Hurricane Katrina case demonstrated that this belief—that developing countries are more vulnerable—is unrealistic. This fallacy relates more to the self-deception of people in rich countries who are surrounded by technologies that they believe can protect them, technologies that those in developing countries can only dream about.

For the people living in USA, they have watched from a distance as "superstorms" of one kind or another have impacted societies in developing countries. The killer tsunami (not weather related) in the Indian Ocean on 26 December 2004 when hundreds of thousands perished, and Hurricane Mitch in late 1998 (over 17,000 dead) are two good examples. A sad difference between poor and rich countries is that people in poor countries are accustomed to adversities and are often left on their own to cope with natural and other disasters. In the rich countries, the people expect and usually get help from their governments because they have the resources to cope with the problem and to pay for the solution, an option that many poorer countries do not have. Rich countries, however, have much lower thresholds of tolerance for inconvenience.

This argument has been difficult to prove about the relative vulnerability of rich versus poor countries; difficult to prove… until Hurricane Katrina in late August 2005 slammed into the Gulf of Mexico coasts of Louisiana, Mississippi and Alabama and exposed how vulnerable all societies are, regardless of level of technological development.

9.3.5 The Impacts Associated with Hurricane Katrina were the Result of a Natural Disaster

Hurricane Katrina reached Category 5 level at or about the time it made landfall in Louisiana, Mississippi and Alabama. It was called a massive hurricane, a top-strength storm, an incredibly strong storm and one webmaster referred to it as a superstorm. That is the natural hazard that was sure to have brought about death and destruction at some expectable level. However, the damage from this event was much higher than even the experts expected. A lot of the reason for extreme levels of death, destruction and human misery rests with society's contribution to the adverse impacts of the naturally occurring hurricane. The poor, for example, often end up living in locations that are at high risk to whatever the local natural hazard happens to be. The levees in the New Orleans area were known to be in need of repair as well as upgrading. The impacts of a Category 5 hurricane were projected in many scenarios over the years (one FEMA Exercise called Hurricane Pam was done only one year before the Hurricane Katrina, http://www.fema.gov/news/ newsrelease.fema?id = 13051). This event was not wanted but was expected to occur at some time. In fact there had been several near hits in the past few decades. So, that raises the question about what part of the disastrous impacts of a natural disaster (death, destruction, and misery) can be correctly blamed on nature and what part on societal, especially political, decision making. To be sure there will be considerable discussion, finger pointing and blame, as well as spin doctoring and claims of success, but in America there is the expression that the "buck stops at the US President's desk".

9.4 Summary

In Sum, the reason for pointing out what we consider to be fallacies (myths or misconceptions) is that, even if such views are proven to be incorrect, the actions taken by individuals and governments based on them will be real and therefore will have real consequences. When it comes to disaster, people have to careful about the generalizations they make because people will not necessarily evaluate them for their validity. Myths and fallacies, like unfounded rumors, are very misleading and can have dangerous long-lasting consequences for societies as well as for the victims of natural-hazard-related disasters in the distant as well as near future.

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Chapter 10
The Great Tangshan and Wenchuan Earthquakes in China: A Preliminary Comparison and Lessons Learned

Guoyi Han, Wei Xu, Jifu Liu and Peijun Shi

Natural hazards triggered disasters are products of both natural variability and human–environment interactions. Natural disasters are thus inherently linked to resilience and development of the coupled human–environment systems. While natural disasters have always been part of the human history, our relationship with natural disasters has been profoundly changing as humans becoming an increasingly powerful force influencing both the hazards and our vulnerability to them. Natural disasters can lead to important changes in human-environment systems, yet by far there has been little research on the characteristics and processes of such change (Birkmann et al. 2010).

In recent decades, particularly since the 1990s, the dramatic increase of losses due to natural disasters has brought notions of vulnerability and resilience to the central stage of natural disaster risk reduction. From the International Decade for Natural Disaster Reduction (IDNDR) to the International Strategy for Disaster Reduction (ISDR), to the Hyogo Framework of Action, disaster risk reduction has been calling for commitment and new approaches that focus on vulnerability reduction and resilience building, and the integration with the pursuit of sustainable development.

The close linkage between natural disaster and development has been widely recognized (DFID 2005). Resilience thinking addresses the dynamics and development of complex social-ecological systems (SES) (Folke et al. 2010). In the context of natural disasters, resilience is the capacity of a SES to continually change and adapt yet remain within critical thresholds. There are three key components for resilience of SES—amount of shock it can endure, the degree of

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P. Shi et al. (eds.), *Integrated Risk Governance*, IHDP-Integrated Risk Governance Project Series, DOI: 10.1007/978-3-642-31641-8_10,

self-organization, and the capacity for learning and adaptation. To all of those key components of resilience, disasters offer "window of opportunity" for learning. Transformability is the capacity to cross thresholds into new development trajectories (Folke et al. 2010). Research has shown that crisis such as natural disaster can be used as window of opportunity to navigate a prepared SES for transformation. Both resilience building by enhance learning and adaptability and transformation to break vulnerable state and open new path for resilience building lay in the heart of integrated disaster risk governance.

It is in the above broad context, this paper examines the changing vulnerability and disaster resilience, as well as learning through a comparative study of the great earthquakes of Tangshan in 1976 and Wenchuan in 2008, China.

10.1 Comparison of the Wenchuan and Tangshan Earthquakes

The great 1976s Tangshan (Fig. 10.1) and 2008s Wenchuan earthquake (Fig. 10.2) are the two deadliest since the founding of the People's Republic of China in 1949. A comparative case study of the two is particular interesting for several reasons. First, the nature of the hazard is similar, which sets a base for a possible comparative study where vulnerability and resilience of the affected human–environmental systems are the central focus. Second, the timing of the two earthquakes marked a period (i.e. 1976–2008) during which transformative changes have happened in China. It thus offers a unique opportunity to examine how vulnerability and resilience to disasters have changed since the "open and reform" era in China. Thirdly, a solid case study of the two great earthquakes provides a valuable entry to the "large-scale disaster case-base" that currently under construction at Beijing Normal University for disaster studies and education.

10.1.1 Basic Information

The Wenchuan Earthquake happened at 14:28:04 on May 12, 2008. It has been the earthquake with the highest magnitude, the widest coverage and the biggest destruction in China since the founding of the People's Republic of China, except the Tibetan Motuo Earthquake of M8.5 on August 15, 1950 and the Qinghai Kunlaishan Earthquake of M8.1 on November 14, 2001. The epicenter of Wenchuan Earthquake was at 30.986°N and 103.364°E, with a focal depth of 14 km and an epicentral intensity of XI. The earthquake was felt all throughout China to various extents. As of 25 September, 2008, the quake had killed in total (including the missing people) 87,100 people, injured 375,000 people, and caused the direct economic loss of 845.1 billion Yuan (http://baike.baidu.com/view/1587662.htm).

Fig. 10.1 Severely destroyed buildings in the Wenchuan Earthquake (Imaginechina)

Fig. 10.2 Building collapse in the Tangshan Earthquake (Imaginechina)

The Tangshan M7.8 Earthquake happened at 03:42:54 on July 28, 1976, with the epicenter at 39.60°N and 118.20°E, a focal depth of 22 km, and an epicentral intensity of XI. The intensity range of the earthquake covered 14 provinces (Including municipalities directly under the central government and autonomous regions), almost one-third of the total area of China. The earthquake killed 242,500 people, injured 708,000 people, and caused a direct economic loss of 13.275 billion Yuan (1976 price).

10.1.2 Geophysical Environment

The Wenchuan Earthquake took place on the seismic tectonics of Southwest China. In the earthquake disaster areas, geological structures are complex with fractures interlaced. Most of the disaster areas are mountainous and hills, with complex terrains. The Tangshan Earthquake took place on the seismic tectonics of Northern China. In this particular seismic area, the topography is simple and mostly plain.

10.1.3 Hazard

As outlined above, for the main geophysical parameters of the hazard event, the Wenchuan and Tangshan earthquakes are rather similar. The magnitude of Wenchuan Earthquake was M8.0, slightly higher than that of the Tangshan Earthquake (M7.8). The epicentral intensity of both earthquakes was XI. In terms of focal depths, the Wenchuan Earthquake is 14 km and the Tangshan Earthquake is 22 km, which make both the so-called shallow earthquake. Nevertheless, since Wenchuan Earthquake had a higher magnitude and a shallower focal depth, it had a greater destructive force.

In terms of the fault movement, the fault movement duration of the Tangshan Earthquake was 12.9 s, and the upper plate subducted. During the Wenchuan Earthquake the upper plate rose up, and the fault movement duration was 22.2 s. The longer the movement duration is, the longer time people experience the strong effects of the earthquake. Therefore, the swing duration of buildings in the Wenchuan Earthquake was longer than that of the Tangshan Earthquake.

In terms of aftershocks, at 18:45 on the same day when the Tangshan Earthquake happened, an M7.1 aftershock took place at Luanxian County about 40 km away from Tangshan. On November 15 of the same year, Ninghe was hit by an M6.9 aftershock. Strong aftershocks persisted until the spring of 1977. After the Wenchuan Earthquake, frequent aftershocks were also observed. According to the measurement of the China Earthquake Networks Center, as of 12:00, July 26, 2010, the Wenchuan Earthquake recorded more than ten thousand aftershocks, including 316 aftershocks of a measurement of M4.0 and above. The biggest aftershock was the M6.4 aftershock hitting Qingchuan of Sichuan at 16:21 on May 25 (http://www.csi.ac.cn/sichuan/index080512001.htm). In general, both the Tangshan and Wenchuan Earthquakes had a relatively non-uniform decay process and a long period of aftershocks.

In terms of the secondary disasters, as the disaster areas of the Wenchuan Earthquake were mostly mountainous and hilly terrain, the quake resulted in many landslides, collapses and mud-rock flows. Additionally, many quake-lakes were formed due to jammed rivers created by landslides. Secondary geological hazards caused many buildings and houses to collapse. Some villages were instantly buried by huge landslides. A large number of infrastructures such as roads, railways, bridges and communication facilities were destroyed. Many large-scale barrier lakes caused a big threat to millions of people in downstream Mianyang City. On the other hand, the Tangshan Earthquake took place mainly in plain regions, where aftershocks caused many fire but no other significant secondary disasters. Furthermore, it is interesting to note that, in comparison, there were almost no fire disasters caused by the Wenchuan Earthquake, largely due to the differences in climatic conditions and seasonality.

10.1.4 Exposure

The disaster areas of the Wenchuan Earthquake were mainly rural regions and small cities and towns with relatively developed economies. And a lot of counties and towns were scattered within the valleys, of which many had only one road for connection with the outside world. The disaster area included the most important home region for the Qiang ethnic minority group in China and the Wolong Natural Conservation Zone, the most important biodiversity region in China and the home of the big pandas (the national treasure of China). The seismic areas of the Tangshan Earthquake were primarily located in the city area of Tangshan, adjacent to major cities such as Beijing and Tianjin.

In terms of population, industrial structure and economy in general, the disaster affected areas of the Wenchuan Earthquake are mainly mountainous and remote, poverty-stricken ethnic minorities with underdeveloped agriculture-based economy. Yet there was also a high-tech industry cluster district along the line of Chengdu–Deyang–Mianyang. Before the disaster, the population was 3,667,000 and the regional GDP was 62.735 billion Yuan (data of 10 counties with extremely severe disasters in 2007). In comparison, Tangshan was the heavy machinery and energy (mainly coal) industry base in China. Before the quake, Tangshan city proper and its surrounding counties had a population of over 1,220,000 and the regional GDP of 2.195 billion Yuan (the data of 1975, at the current-year price).

In terms of the building code situations in disaster areas, most agricultural residences in the Wenchuan Earthquake areas were soil-stone structures, without consideration of fortification. Most of the urban buildings were built after 1989, with the seismic fortification of VII designed according to the *Code for Seismic Design of Buildings* (GBJ11-89). In the Tangshan Earthquake areas, nearly all high-rise buildings were built after 1949. The soil-stone houses with courtyards were built before 1949, without any consideration to seismic fortification.

10.1.5 Impact and Loss

In terms of the seismic affected area, except Heilongjiang, Jilin and Xinjiang, the Wenchuan Earthquake was felt throughout all of China and even in Vietnam, Thailand, Philippines and Japan. The quake was experienced in nearly half of the Asian continent. The area of the Wenchuan Earthquake with the intensity equal to or higher than level VII was 126,000 km^2, while the severe disaster area covered over 100,000 km^2. In comparison, the Tangshan Earthquake had smaller affected areas and was felt in 14 provinces. The area of the Tangshan Earthquake with the intensity equal to or higher than level VII was about 43,000 km^2 and the severe disaster area covered 30,000 km^2.

In terms of death toll, the Wenchuan Earthquake killed a total of 87,100 people (including those missing) and injured 375,000 people (as of 25 September, 2008). Most of the people died in counties (cities) including Beichuan, Wenchuan, Dujiangyan, Pengzhou, Mianzhu and Qingchuan. The Tangshan Earthquake killed 242,500 people, injured 167,000 people severely and 541,000 people less severely. In the Tangshan city proper, nearly 149,000 people were killed. In the surrounding counties of over 69,000 people were killed and in other areas over 20,000 people died.

In terms of damaged houses and economic losses, the Wenchuan Earthquake caused the collapse of 7,780,000 houses and damages to 24,590,000 houses (as of 25 June, 2008), with a direct economic losses of 845.1 billion Yuan. The Tangshan Earthquake caused the destruction of 6,293,800 houses as well as damages to 1,396,000 houses and 1,493,800 industrial and public buildings, with the direct economic losses of 13.3 billion Yuan (1976 price).

10.2 Earthquake Disaster Response

10.2.1 Emergency Response and Rescue Operation

Upon the occurrence of the Wenchuan Earthquake, the Central Committee of Communist Party of China (CPC) and the State Council immediately took effective rescue measures. Two hours after the earthquake, Premier Jiabao Wen was on the plane to the disaster areas to started a Grade I national disaster relief response and established the State Council's Earthquake Rescue and Relief Headquarters.[1] The concept of "putting people first" was practiced during the entire process of earthquake rescue and relief. With vulnerable lives in the ruins, the CPC Central Committee made rescue people the top priority. Premier Wen repeatedly emphasized that "one second can make a difference between life and death for a person whose life is endangered", "as long as there is the slightest hope, we will never relax our efforts" and "do not hesitate to adopt any method and pay any price".

Under the leadership of the State Council's Earthquake Rescue and Relief Headquarters, the Wenchuan earthquake rescue and relief had been conducted

[1] China has a national emergency response system that divides the types of the responses into Grade I to IV according the severity of the emergency, with Grade I being the most severe.

with the most rapid rescue speed, the widest range of mobilization, and the biggest input in the history of China. Maximum effort was expended to save the greatest number of lives and to minimize the losses due to the disaster. 84,017 people were saved from the ruins, 1,490,000 trapped people were rescued, and over 4,300,000 injured and ill people received prompt medical treatment. More than 10,000 severely injured people were rapidly transferred to 375 hospitals in 20 provinces nationwide. There were 146,000 People's Liberation Army (PLA) and armed policemen as well as 75,000 militiamen of reserve duty participating in the rescue. People all over China provided great support. The whole country put forth all possible efforts towards earthquake rescue and relief.

By 25 September, 2008, the Ministry of Civil Affairs dispatched 1,579,700 tents, 4,866,900 quilts, 14,101,300 pieces of clothing, 4,146,000 tons of fuel oil and 8,858,000 tons of coal. 677,131 temporary houses (mobile plank houses) were installed. Till then, A total of 80.936 billion Yuan were used for rescue and relief from governments of all levels, of which 73.457 (about 91 %) billion Yuan from the central government (33.132 billion Yuan for emergency rescue and disaster relief and 40.325 billion Yuan for post-disaster restoration and reconstruction). The local finance deployed 7.479 billion Yuan.

In comparison to the swift national and international responses to the Wenchuan earthquake, the national response to the Tangshan earthquake was seriously delayed and the international community was largely kept in the dark. It took more than a half day only to verify the exact location of the epicenter.[2] It took the central government 7 days to send the condolences group to the Tangshan disaster areas to comfort the people in the severely affected disaster areas. The Tangshan Earthquake took place in the late "Cultural Revolution" in China, the guiding principle for earthquake rescue and relief was "to conduct both earthquake rescue and revolution". The Chinese government wanted to prove its self-reliance and international assistance was never sought for the earthquake rescue and relief.

Based on the above-mentioned analysis, Table 10.1 shows the comparison of the basic conditions of the Wenchuan and Tangshan Earthquakes.

10.2.2 Post-Disaster Restoration and Reconstruction

Upon the incident of the Wenchuan Earthquake, the State Council passed the *Regulations on Post-Wenchuan Earthquake Restoration and Reconstruction* (hereinafter referred to as the *Regulations*) on 4 June 2008 and promulgated for implementation on 8 June 2008. According to the *Regulations*, and based on the quick scientific evaluation of the range, the extent and the carrying capacity for restoration and reconstruction of the Wenchuan Earthquake disaster, the Central

[2] The information was passed on to the central government in Beijing by someone who drove all way from Tangshan to Beijing.

Table 10.1 Comparison of the basic conditions of the Wenchuan Earthquake and the Tangshan Earthquake

Compared items	Tangshan Earthquake	Wenchuan Earthquake
Geophysical environment	Northern seismic tectonics, seismic active area, plain region	Southwestern seismic tectonics, seismic active area, mountainous and hilly region
Magnitude	M7.8	M8.0
Epicenter	39.60°N, 118.20°E Yuehe village, Kaiping district, Tangshan city, Hebei province	30.986°N 103.364°E Yingxiu town, Wenchuan county, Sichuan province
Focal depth	22 km	14 km
Epicentral intensity	XI	XI
Timing of the occurrence	03:42, July 28, 1976	14:28, May 12, 2008
General environment setting	Densely populated urban center on plain	Vast rural mountainous area with densely populated towns and small cities
Timing and residents' daily activity pattern	In early morning when most of people are in sound sleep. Extremely high 'indoor' percentage and small intra-population variability,	In early afternoon when most of children are in the classroom and people are at work. High intra-population variability depending on occupation and where they work/study.
Population before quake	Over 1,220,000 in Tangshan city and its counties (1975)	3,667,000 in 10 extremely severe disaster counties (2007)
GDP before quake	2.159 billion Yuan of Tangshan city (price in 1975)	62.735 billion Yuan of 10 extremely severe disaster counties (price in 2007)
Building code	Almost all the high-rise buildings built after 1949, without consideration of seismic fortification; some of the courtyard houses of soil-stone structure built before 1949, without seismic fortification	Agricultural residences mostly of soil-stone structure, without consideration of fortification, and many of the urban buildings built after 1989, with the seismic fortification of VII designed according to the standard of GBJ11-89.
Building-owner	Almost all state-owned	Almost all private-owned
Economic structure and major industries	Coal mine, heavy machinery production; power generation	Agriculture/Fertilizer production
Felt range (provinces, municipalities and autonomous regions)	14	Over 30
Affected area (above VII)	42,787 km^2	125,536 km^2
Area of severe disaster areas	Approx. 30,000 km^2	Over 100,000 km^2
Death toll	242,500	87,100 (including the missing population, as of 25 September, 2008)

(continued)

Table 10.1 (continued)

Compared items	Tangshan Earthquake	Wenchuan Earthquake
Injured population	708,000 (including 167,000 severe injured people)	375,000 (as of 25 September, 2008)
Direct economic losses (current-year price)	13.3 billion Yuan	845.1 billion Yuan
Collapsed building	Destroying 6,293,800 houses, damaging 1,386,000 houses as well as 1,493,800 industrial and public buildings	7,780,000 houses collapsed and 24,590,000 houses damaged (as of 25 June, 2008)
Aftershocks and secondary disasters	Many aftershocks, but few secondary disasters	Many aftershocks, leading to a large number of secondary disasters such as landslides, mud-rock flows and barrier lakes
Emergency response and rescue	Relatively slow, short of resources and large lifting machinery and other rescue equipment	Quick and integrated
Relocation	–	15,100,000 people
Major rescue organizations	Nationwide efforts without any international support and participation	Nationwide efforts with international support and participation
Relief expenses (current-year price)	0.5 billion Yuan	53.6 billion Yuan
Information release and transparency	Confidential and not published	Timely, adequate, open and transparent
Restoration and reconstruction period	1976–1986	2008–2011
Investment for reconstruction	5 billion Yuan (1976–1986)	1 trillion Yuan (2008–2011)
Fund sourcing for reconstruction	Mostly central government	Central government, local governments, supporting provinces and municipalities, social donation and international organizations

Data Source Statistical yearbooks from relevant research areas; Shi et al. (2008), Disaster Information Department of National Disaster Reduction Center of China (2008), Wen et al. (2010), Zhou (2000), and Zhou and Yin (2010)

Government passed the *Directive on Counterpart Assistance Plan for Post-Wenchuan Earthquake Restoration and Reconstruction* on 11 June 2008, passed the *Suggestions of the State Council on Post-Wenchuan Earthquake Restoration and Reconstruction* on 29 June 2008, formulate the *Guiding Opinions of the State Council on Post-Wenchuan Earthquake Restoration and Reconstruction* on 3 July 2008, and promulgated the *Overall Plan for Post-Wenchuan Earthquake Restoration and Reconstruction* (hereafter referred to as the *Overall Plan*) on 19 September 2008, as the programmatic document of restoration and reconstruction for the disaster areas. In order to ensure the successful implementation of the *Overall Plan* and to accelerate the restoration and reconstruction, in October and November of 2008, the National Development and Reform Commission (NDRC) and other related ministries and commissions successively issued the

> Special Plan on Urban and Rural Housing Construction for Post-Wenchuan Earthquake Restoration and Reconstruction, the Special Plan on Urban System for Post-Wenchuan Earthquake Restoration and Reconstruction, the Special Plan on Rural Construction for Post-Wenchuan Earthquake Restoration and Reconstruction, the Special Plan on Public Service Facilities Construction for Post-Wenchuan Earthquake Restoration and Reconstruction, the Special Plan on Infrastructure Construction for Post-Wenchuan Earthquake Restoration and Reconstruction, the Special Plan on Productivity Layout and Industrial Adjustment for Post-Wenchuan Earthquake Restoration and Reconstruction, the Special Plan on Market Service System for Post-Wenchuan Earthquake Restoration and Reconstruction, the Special Plan on Disaster Prevention and Reduction for Post-Wenchuan Earthquake Restoration and Reconstruction, the Special Plan on Ecological Rehabilitation for Post-Wenchuan Earthquake Restoration and Reconstruction, and the Special Plan on Land Use for Post-Wenchuan Earthquake Restoration and Reconstruction,

proposed specific targets and tasks for restoration and reconstruction in relevant fields, and extended and specified the targets and tasks of the *Overall Plan* in specific fields.

Comparing to the speedy recovery and reconstruction, the process for the rebuilding of Tangshan, in terms of both planning and implementation, was a much slower one.

After the Tangshan Earthquake, the state approved, in principle, the *Overall Urban Planning for the Tangshan Municipality of Hebei Province* in May 1977, and improved the *Overall Urban planning for the Tangshan Municipality* for implementation in September 1979, and adjusted the *Overall Urban planning for the Tangshan Municipality* and formulated the *Adjustment Program for Implementation of Contraction Policy for the Restoration and Reconstruction of the Tangshan Municipality* on 13 January 1982, almost 6 years after the earthquake.

10.3 Experience and Lessons

Through the comparison of the two great earthquakes, various lessons can be learned relating to the changing vulnerability and disaster resilience since the open and economic reform in the late 1970s.

10.3.1 Seismic Buildings Code

Despite the fact that Wenchan Earthquake was stronger and more powerful than the Tangshan Earthquake in terms of higher intensity and shallower focal depth, life loss in the Tangshan Earthquake was significantly higher than that of

Wenchuan. While there are range of factors contributed to this difference (e.g., densely settled urban area vs. vast rural area; the timing of earthquake; the speed of rescue actions), a major reason was the different seismic resistance standards for buildings and structures. The Tangshan Earthquake predominantly affected the industrial city area, and many of the buildings were civil structures, without seismic fortification standards. In other words, there was no seismic building code required for the city of Tangshan then. Thus, destruction occurred in almost all civil buildings in Tangshan City, with the urban and rural building destruction rates high as 96 and 91 %, respectively. The disaster areas of the Wenchuan Earthquake were mainly in mountainous terrains, but many of the buildings, especially those in small cities, had been fortified according to seismic standards. Except for particular towns on the fracture zone such as Beichuan County Town and Yingxiu Town with housing collapse rates of over 70 %, much less buildings were collapsed than those collapsed in Tangshan earthquake.

Lessons, particularly from the Wenchuan earthquake, have been learned on the importance of protecting public facilities such as schools and hospitals. After Wenchuan Earthquake, the central government, relevant ministries and commissions and local governments attached great importance to the fortification of public facilities such as schools and hospitals. During the restoration and reconstruction, the new fortification was one grade higher than the seismic protection standards required. These public facilities were built as shelters for future disasters such as earthquakes.

However, it should be noted that there has been major difference on the building codes regulation vs. the supervision and implementation of the codes. In the case of Tangshan Earthquake, while city was not required with seismic building code (i.e. lack of regulation), there was a strong compliance along the command line from central to local in the old strict centrally planned economy. In comparison, almost the opposite can be observed in the Wenchuan case, that is, while a major advance has been observed in terms of laws and regulations including updated seismic building code, compliance and the enforcement of those regulations were revealed from the Wenchuan Earthquake as a major problem. This raises various issues concerning the central and local relation, role of government vs. the role of market, and their linkages to disaster vulnerability of the human–environment systems.

10.3.2 Mobilization of Social Forces

The post-disaster recovery and reconstruction has been much faster in the case of Wenchuan comparing to that of Tangshang. This is partly attributed to a much stronger economic power of China in 2008 as compared to what it had in 1976, and partly due to the strong mobilization of social forces and innovative supporting mechanisms for quickly and effectively generating the resources required for recovery and rebuilding. One such mechanism is the so-called “counterpart support”, by which each of the severely affected counties is paired up with a province or a city outside of the disaster affected areas. The “counterpart support” mechanism has not only provided the needed financial support to the affected area, but also strengthened its overall capacity for recovery and indeed re-development in terms of transforming the local economy through economic partnerships. It took Tangshan 8 years before its GDP recovered to the pre-disaster level. In comparison, after the Wenchuan Earthquake, the GDP growth in Sichuan province did not decreased.

With a much more open, transparent and public information system (see section below), the quick response and recovery of the Wenchuan Earthquke has also benefited from wide support from civil society, NGOs, general public, as well as international community. In comparison, with the country still under the “Cultural Revolution”, the Tangshan Earthquake was largely kept as secrete in 1976, even within China. Consequently, in addition to a very weak state economic power, the response and recovery process of Tangshan received very limited external support. It is clear through this comparison that, in terms of responding to large-scale disasters, it will not only rely on the national power, but also require an open system to mobilize the forces from all walks of life to play their roles.

10.3.3 Open Information

During the Tangshan Earthquake, the *People’s Daily* reported the disaster in the form of news compiled and edited by the Xinhua News Agency, with the title of “A Strong Earthquake Hit the Areas of Tangshan and Fengnan in Hebei Province/ the People in the Disaster Areas Conducted the Earthquake Rescue and Relief with the Revolutionary Spirit of “Man can Conquer Nature” under the Guidance of Chairman Mao’s Revolutionary Route” (Quan 2010). The coverage of the news on the earthquake disaster’s effects was relatively concise, the forewords contained an outline statement of a dozen of words describing the cause. Nothing was reported for the most important information of the disaster effects such as how many houses collapsed and how many people were killed. Instead, there was only one sentence of “the epicentral area suffered losses of different extents”. The focus was on the struggle between man and disaster: how Chairman Mao, CPC Central Committee and governments at different levels cared for people in disaster areas and how they led the people in disaster areas for earthquake rescue and relief. Thus, the disaster effects were hided and the right for the public to know about the earthquake was deprived by the media. It was 3 years later at the meeting for the establishment of the Seismological Society of China (held from November 17–22 of 1979) when the specific death toll of the Tangshan Earthquake was disclosed. On November 23, the second day after the meeting ended, the *People’s Daily* published the news from the meeting “Tangshan Earthquake Killed More Than 240,000 People” (Zhou 2000). The news shocked the world, especially because people had nearly forgotten about the event and the news was essentially “outdated”.

From the moment the Wenchuan Earthquake happened, the central and local governments as well as all the media including television, radio, newspapers and internet made great efforts to conduct the timely, fully and vivid coverage for the earthquake effects and earthquake rescue and relief. Chinese and foreign journalists had access to disaster areas to gather news. Sichuan Provincial Government and the State Council Information Office held press conferences every day, where the relevant executives announced the current seismic conditions and the latest information of earthquake rescue and relief, the numbers of killed, injured and missing people, the relocation of affected people, and the difficulties and problems encountered in earthquake rescue and relief; and answered, without reservation, the questions raised by Chinese and foreign journalists. The information release was unprecedentedly open, public and transparent. The media was closely related to the national people, and played an important role in gathering people, encouraging combat spirit, enhancing the governmental public credibility and promoting the nation and the world to learn of the earthquake effects.

10.3.4 Scientific and Technological Support

The role of scientific and technological support in both Tangshan and Wenchuan earthquakes are also distinctively different in several aspects. First, the post-disaster support seemed much stronger in the case of Wenchuan. In response to the Wenchuan Earthquake, two high level scientific and technological support bodies were established. One is the Expert Group for Earthquake Rescue and Relief established by the Ministry of Science and Technology and the National Disaster Reduction Commission the day after the earthquake. The Expert Group then organized nationwide teams to conduct rapid assessments of disaster affected areas as well as the losses, providing timely support for emergency response. The other, based on the Expert Group, is the National Scientific Committee for Wenchuan Earthquake established by the State Council's Earthquake Rescue and Relief Headquarters to further provide scientific and technological support to disaster areas on recovery and reconstruction. Tremendous amount of work have been done through thousands of professional drawings, data on disaster effects, planning reports as well as strategies and suggestions submitted to the State Council's Earthquake Rescue and Relief Headquarters. Those strong and timely scientific and technological supports have no doubt contributed to the effective response and speedy recovery processes post-Wenchuan earthquake, played critical role in reducing live and property losses.

Second, in comparison, the availability, involvement, and extent of the scientific and technological support in the Tangshan earthquake case was much limited. Except that the earthquake professionals went to disaster areas for investigations, there was almost no timely and effective scientific support to guarantee the central and local governments' rapid treatment of the large-scale disaster. As a result, the emergency rescue was delayed, and the post-disaster recovery and reconstruction was seriously affected.

Third, while there was no early warning for the Wenchuan earthquake, there have been rich literatures concerning the political concealment of the early warnings for the Tangshan earthquake. This has raised, at least to some extent, the question of the role of science in earthquake monitoring and early warning, which has changed considerably since the Tangshan earthquake. In many ways, Tang-shang earthquake occurred at the peak of the so-called “mass prevention and mass monitoring”, a system China adopted since the 1960s for earthquake monitoring and warning. It was the practice of “pooling the wisdom and efforts of everyone” by mobilizing mass participation and establishing monitoring spots in schools, factories, coal mines, etc. (Bennett 1979). Many have attributed the successful forecast and early warning of the M7.2 earthquake in Haicheng in 1975 to this system. Prior to the Tangshan Earthquake, warning information was available, but due to political reasons, it did not draw adequate attention from the government to issue an official warning (Zhang 2006). Since the late 1970s, this system was criticized for being “unscientific”. Along with rapid economic development and increased investment in new scientific technology, this system of practice has been completely substituted with the strong belief and reliance on “real science and technology”. Which system is better and more effective? Would it be possible that the “mass prevention and mass monitoring system”, by combining public awareness raising and risk communication, is actually much more effective in coping with natural hazards such as earthquake where science still cannot make accurate prediction?

10.4 Discussion

With the Wenchuan Earthquake and the Tangshan Earthquake as examples, this paper made a comparison study in terms of hazard, exposure, disaster impacts and losses, disaster rescue and relief as well as recovery and reconstruction. Based on it, we summarized the existing problems and experience obtained.

From the mainstream perspective of disaster risk reduction, we summarized three key lessons from the responses to the two earthquakes, especially the response to Wenchuan Earthquake:

The most importantly one is the clear definition of roles, responsibilities, as well as coordination among key actors, including governments (central and local), private sectors and public institutions. This is even more so in the Chinese context with rapid transition from a centralized planning economy to an increasing market based one, from rural to urban, from a very egalitarian to a society in which disparities among social groups and regions in increasingly a major concern.

The second lesson is the awareness of disaster risk and development for both government and public. While China has the right strategic orientation for disaster risk reduction (i.e. prevention and mitigation as foundation, combined with relief and assistance), mainstreaming such a strategy into development planning still has a long way to go.

The third one, perhaps, is a question rather than a clear lesson. While China is capable of powerful and massive mobilization in disaster emergency response due to the powerful central government, how such approach would feature scientifically remain to be a question, i.e. the cost and benefits of such practices needs to be carefully examined. That is to say, we need to learn from the internationally advanced experience in order to simultaneously improve the resources utilization efficiencies and effectiveness for disaster prevention and reduction. The key measure is to improve the disaster fortification abilities in an overall manner, and to establish an integrated disaster prevention paradigm combined the "top–bottom mode" with "bottom–top mode".

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Chapter 11
Comparative Study on Sleet and Snow Disaster in Southern China and Hurricane Katrina Disater in USA

Ming Wang, Lili Lu and Peijun Shi

Based on the recent research on definitions of catastrophes (Shi and Liu 2009), a disaster can be determined as a catastrophe if it conforms two or more than two standards among the following four standards: (1) Fatality exceeds 10,000; (2) Direct economic losses exceed 100 billion Yuan (about 10 billion Euros); (3) Affected area exceeds 100,000 km^2; and (4) Return period of hazards exceeds 50 years. The sleet & snow disaster in southern China in 2008 affected 21 provinces (municipalities directly under the central government and autonomous regions), and it caused the urgent evacuation of 1,660,000 people. The direct economic losses were over 151.6 billion Yuan (National Bureau of Statistics of China 2009). The affected area was approximately 1,000,000 km^2. The US Hurricane Katrina had a severe impact on four states, and it caused the emergent relocation of 770,000 people. The direct economic losses were over 100 billion dollars (DOC 2005), and the affected area was approximately 400,000 km^2. Both of these events can be considered as catastrophes according to the definition (Shi et al. 2009).

In the International Human Dimensions Program on Global Environmental Change—Integrated Risk Government (IHDP-IRG), an “entry transition” of a disaster is defined as the transition period during which a given socio-ecological system (SES) in a certain society switches from normal mode into emergency or crisis mode when dealing with natural or man-made disasters. Although it is usually difficult to find a straightforward way to define a timeframe for emergency or crisis mode in a disaster, the entry transition can be interpreted as the transition process starting from the time when a disaster begins to form and impacts the SES and ends at the time of disaster rescue in an all-around manner. Not all the severe hazards cause a catastrophe and common hazards also have the potential to cause a

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P. Shi et al. (eds.), *Integrated Risk Governance*, IHDP-Integrated Risk Governance Project Series, DOI: 10.1007/978-3-642-31641-8_11,

Fig. 11.1 Emergency repair of power grids collapsed in the snowstorm (Changmin Liu/Imaginechina)

catastrophe. It, to a great extent, depends on the "entry transition" process of a disaster and the response during the process.

The objective of this paper is to understand the "entry transition" of catastrophes by conducting a comparative case study of the sleet & snow disaster in Southern China in 2008 (Fig. 11.1) and the US Hurricane Katrina in 2005 (Fig. 11.2), to analyze the coping measures and decisions of governments during the events, and to explore the effective way to reduce the losses and impacts of catastrophes.

11.1 Factors to Determine the Entry Transition of Catastrophes

11.1.1 Intensities of Hazards and Regional Vulnerabilities

In 2008, there were 5 snowfall processes during the sleet & snow disaster in southern China, and the event lasted for 28 days. Phase I was from Jan. 10 to 16 (7 days); Phase II was from Jan. 18 to 22 (5 days); Phase III was from Jan. 25 to 29 (5 days); Phase IV was from Jan. 31 to Feb. 2 (3 days) and Phase V was from Feb. 4 to 6 (3 days) (Shi et al. 2009).

We took Hunan province as an example and selected the meteorological data from its four base stations during the same period (from (Jan. 10 to Feb. 6, 28 days in total) from 1950 to 2008, so as to view the historical levels of relevant meteorological elements.

From Figs. 11.3, 11.4 and 11.5, we can see that the return period of the average daily mean and minimum temperature in 2008 event is about 18 years, which is not rare in historical records. However, the duration of the freezing temperatures and amount of snowfall in the 2008 event is the highest since 1950. From the perspective of meteorological elements, the sleet & snow disaster in 2008 is not extreme.

Fig. 11.2 The flood disaster in urban area of New Orleans caused by Hurricane Katrina (Imaginechina)

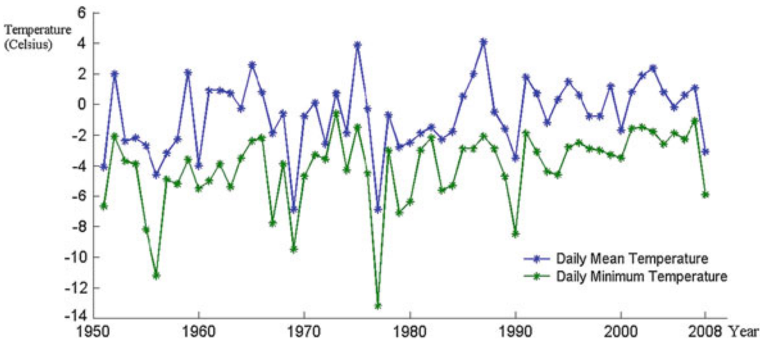

Fig. 11.3 The daily mean temperature and daily minimum temperature profile of hunan province from 1950 to 2008

However, from the perspective of hazards combination, the 2008 event is the first time in the meteorological records in China.

It is known to all that the winter in southern China is warmer than that in northern China. In southern China, although the amount of rainfall is abundant and the temperature can be extremely cold at times, it is rare to have lasting chilly weather

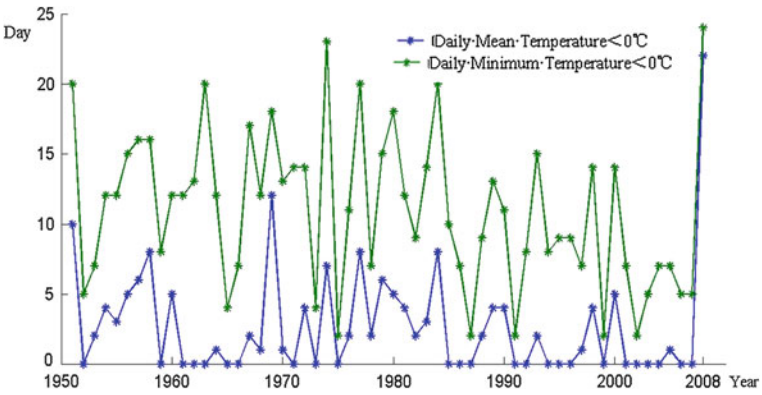

Fig. 11.4 The days of daily mean temperature and daily minimum temperature <0 °C of hunan during 28 days from 1950 to 2008

and long period of snowfall. Government and people in southern China focused little on how to cope with disasters like the 2008 event. As a result, once the disaster occurred, the shortage of equipment, emergency response plans and experience significantly limited the efficiency and effectiveness of the disaster response.

People in northern China are generally more prepared for snow disasters, and more facilities (i.e., deicing vehicles) are available for emergencies. Due to different climate conditions, the power grids are also designed differently in southern and northern China, with the power density in southern China smaller than that in the northern China. Low power density causes low heat dissipation of grids, which makes the grids prone to get frozen in lower temperatures. Without considering the problem of grids getting frozen, the grid loads in southern China are designed to be less than that in northern China. What is worse, when the grids were covered with ice in southern China in the 2008 event, there was a shortage of ice-melting facilities and equipment. Therefore, the practice shows that, if the high-intensity hazards impact the vulnerable areas, it is prone to cause catastrophes.

The case of Hurricane Katrina further confirms the point that a disaster which happens in a vulnerable area is prone to transit into a catastrophe. Hurricane Katrina was not the strongest hurricane (Category 3 during the second landing) which hit the USA, yet still caused the highest economic losses and casualties in the history of the USA since the Hurricane San Felipe-Okeechobee.

From Fig. 11.6, we know that many hurricanes stronger than Hurricane Katrina had far less disastrous effects than that of Hurricane Katrina. Take Hurricane Audrey and Hurricane Camile as examples, Hurricane Audrey of Category 4 landed in the south of Salt Lake City of Texas in 1957, which killed 390 people and caused the economic losses of 390,000,000 dollars. Hurricane Camille, with the central pressure of the second strongest in the recorded history of U.S., landed

[1] 1ft = 0.3048 m, similarly hereinafter.

Table 11.1 Comparison of intensities of hazards and regional vulnerabilities between the sleet & snow disaster in southern china in 2008 and the Hurricane Katrina in the USA in 2005

Catastrophes	Intensities of hazards	Regional vulnerabilities
Sleet & snow disaster in Southern China	A single meteorological factor and a single snowfall process were not extreme. But multiple meteorological factors and the combination of five snowfall processes formed the "once in a hundred years" hazards	The climate in winter was relatively warm. It lacked of the experience of coping with sleet & snow disasters and responding plan. The infrastructures were extremely vulnerable in the long duration of sleet & snow process
Hurricane katrina	When the hurricane was landed, it was Category 3. The hurricane itself was not rare in history, but it caused the extreme storm surge and flooding event	The city was a high-risk area due to its geographical location and terrain. The infrastructures were old, with shortage of upgrade and maintenance, which were extremely vulnerable in front of the extreme storm surges and flooding

in the mouth of Mississippi River on Aug. 17, 1992. It killed 323 people and caused the economic losses of 1.42 billion dollars (Wikipeida). Although the hazards of Hurricane Audrey and Hurricane Camille were stronger than those of Hurricane Katrina, the death toll from the two hurricanes was 22 % of that in Hurricane Katrina, and the economic losses from the two hurricanes were 2 % of that in Hurricane Katrina. So what are the causes for Hurricane Katrina to became a catastrophe?

The key is that Hurricane Katrina hit the most vulnerable area, New Orleans. New Orleans is in the region of the Gulf of Mexico, which is frequently hit by hurricanes. However, for the city, the greatest threat from hurricanes is not the wind, but the storm surge and the flooding. New Orleans is built on the swamp of the delta of the Mississippi River. The terrain of New Orleans area resembles the shape of a bowl. The downtown of New Orleans is at the bottom of the bowl, which has an average elevation of 6 ft[1] below the sea level. The Mississippi River and Lake Panchartrain in New Orleans have an average elevation of about 14 and 1 ft above the sea level, respectively. The concrete floodwalls and levees along Lake Pontchartrain and other main waterways built after Hurricane Betsy are designed to protect this city from flooding. However, once the flood fortification systems are broken by a hurricane, the terrible results will occur immediately. In short, the geographic location and terrain of New Orleans explains the fact that it is highly vulnerable to extreme storm surges and flooding disasters. Unfortunately, when Hurricane Katrina caused the super strong storm surge and broke many important levees such as the St. Bernard Levee, immediately after it landed, and led to the flooding which may never happened in the last 100 years (Table 11.1).

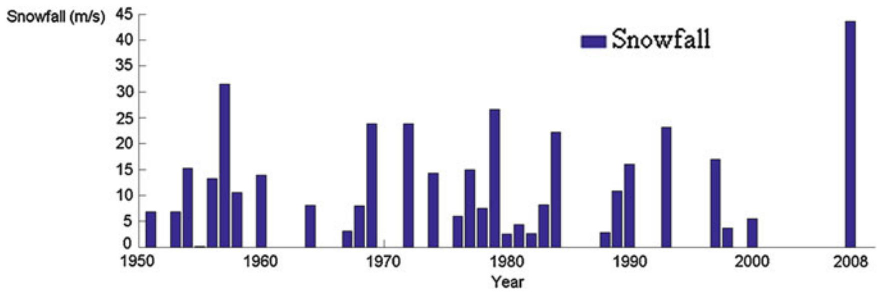

Fig. 11.5 The snowfall of hunan province during the 28 days of the same period from 1950 to 2008

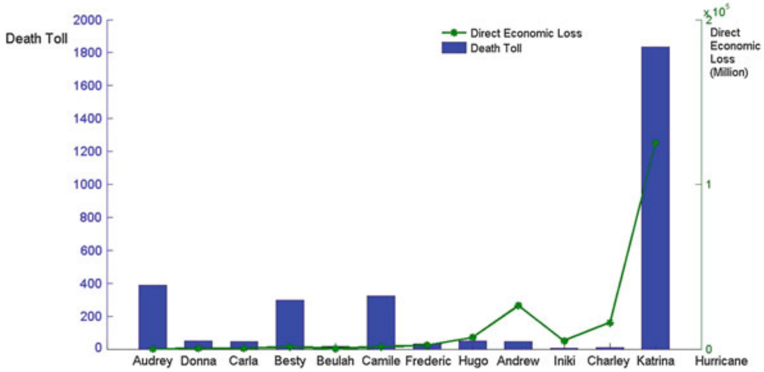

Fig. 11.6 The death toll and economic losses of Hurricane Katrina and Hurricanes stronger than category 4

11.1.2 Active and Passive Modes of Emergency Response Plans of the State

In China, local and province governments are the first to respond to disasters. Moreover, the State Council divides disasters into four grades according to their severity with Grade 1 being the highest. If necessary, in accordance with the *Emergency Response Law of the People's Republic of China,* the State Council sends their working team to lead disaster response and disaster relief, and commands the People's Liberation Army, Chinese People's Armed Police Force and Militia to take part in the disaster response (Shi et al. 2009). This response system is called the active-style national emergency response plan.

In the United States, local and state governments are the first to respond to disasters. If the state becomes overwhelmed by disasters, it can seek help through the Emergency Management Assistance Compact (EMAC) which is an interstate mutual aid agreement. If the state government deems that EMAC is not enough to cope with disasters, it can request additional assistance from the federal

Table 11.2 Comparison of the first authority to response to disasters between China and the USA

Country	The first authority to response to disasters	The first authority to response to catastrophes
China	Local and provincial governments	The state council as the core, supplemented with local and provincial governments
The USA	Local and state governments	The local and state governments as the core, with the assistance divided into 3 levels according to the severity: (1) Assistance from other states (2) Assistance from federal government (3) The active assistance from federal government

government before or after disasters. This federal government assistance system which can only be obtained by applications from state governments is called the passive emergency response plan. However, if disasters are too severe for governments of first respond to send the request (e.g., in the case of communication disruption), the federal government may actively provide assistance to the sates (U.S. Federal Government 2006).

In China, once a catastrophe occurs, the central government conducts the necessary assistance and military action immediately after the disaster. However, in the United States, the federal government usually waits for a request from the state. If the state does not request assistance in time, or simply does not ask for assistance, delays will postpone the relief process. Although in some special cases, the federal government can actively provide their help when the president promulgated catastrophe decrees. However, once the government underestimates the severity of the catastrophe, both the federal government and state government will be passive during the disaster response. Although the efficiency of active mode is considered to be lower than that of the passive mode in terms of utilization of materials, personnel and energy, the active mode can give rescue and relief to more affected people in a limited time.

From Table 11.2, we can see that in China, once the local and provincial governments are overwhelmed by a disaster the State Council will become the first authority to respond to the disaster, to dispatch the human and material resources in the country to rapidly respond to the disaster. However, in the USA, the local and state governments have to firstly complete the assessments in terms of the indexes such as self-response abilities, assistance abilities from other states and intensities of the disaster formative factors, and based on the assessments, request the assistance of corresponding levels from federal government. Only when the federal government fully realizes the severity of the disaster, it will actively provide the assistance, which means if the disaster is underestimated and the responding abilities are overestimated by people who make the assessment, the rescue schedule will be delayed, and the disaster rescue effectiveness will be reduced.

11.2 Comparison of Early Warning and Emergency System

11.2.1 Disaster Research and Judgment as well as Response at the Early Stage

At the beginning of the sleet & snow disaster in southern China, the National Meteorological Center issued an "orange" early warning[2] for snow disasters on Jan. 10 (Phase I), a "red" early warning for snow disasters on Jan. 27 (Phase III), and an "orange" early warning for snow disasters on Jan. 28 (Phase III). Hunan Province, the severely affected area by the sleet & snow disaster, issued a "blue" early warning for snow disasters on Jan. 13 (Phase I), a "yellow" early warning for snow disasters on Jan. 15 (Phase I), and an "orange" early warning for snow disasters on Jan. 26 (Phase III); and issued a "red" early warning for highway icing on Jan. 13 (Phase I), an "orange" early warning for highway icing on Jan. 28 (Phase III) and a "red" early warning for highway icing on Jan. 29 (Phase III). Although Hunan Province issued the "red" early warning for highway icing on Jan. 13, the length of the stranded vehicles on the Beijing-Zhuhai Expressway was over 5 km. There were three reasons for it: Firstly, people failed to obtain the road early warning information timely. Secondly, the early warning scope was too wide and sometimes even ambiguous. Even if there was a traffic jam in Beijing-Zhuhai Expressway, the drivers from other highways which appeared to be smooth usually misjudged the situations in Beijing-Zhuhai Expressway. Thirdly, people had no choice, and they had to get through Beijing-Zhuhai Expressway if they wanted to go to the destinations. Phase III (Jan. 25 to 29) was the worst period during the sleet & snow disaster in southern China. There were about 11,000 vehicles and approximately 4000,000 people stranded on the Beijing-Zhuhai Expressway as of Jan. 28. However, the National Meteorological Center decreased early warning grades from the "red" warning for snow disasters to "orange". According to the issued early warning for snow disasters, we can see that the early warnings attached importance to the extremity of meteorological factors in a short period, with little consideration of the potential influence on the society in a longer period. The disconnection between early warnings and monitoring of the dynamic change of disaster impact led to the failure of providing timely information for authorities, and the underestimation of the disaster's impact on the social system.

From the curve of the population affected (Fig. 11.7), we can see that during phase III, when the number of people affected rose significantly, the Ministry of Civil Affairs issued the Level III Emergency Response on Jan. 25 and rose it as Level I 3 days later. The National Disaster Reduction Commission and the Ministry of Civil Affairs issued a Level IV Emergency Response on Jan. 26

[2] The early warnings for snow disasters are classified into four grades, i.e. the blue early warning, the yellow early warning, the orange early warning and the red early warning from the low to the high grade.

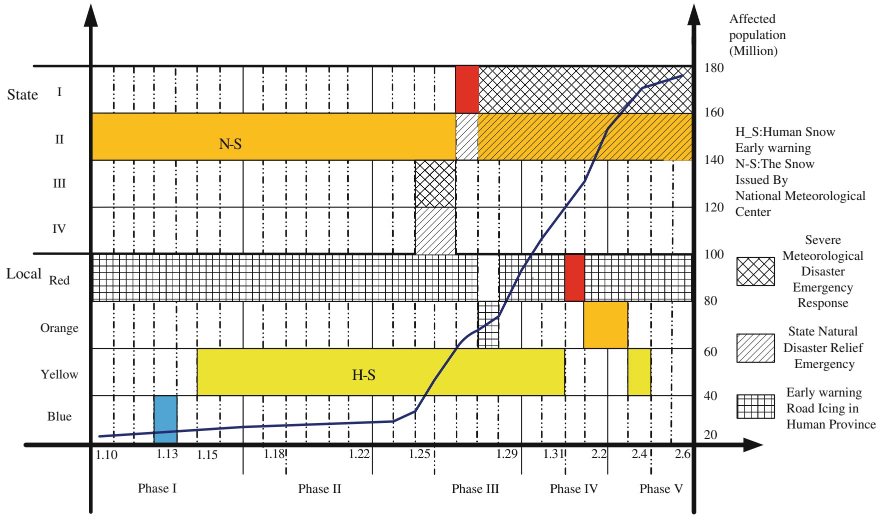

Fig. 11.7 The warning system of China during the sleet & snow disaster in southern China in 2008

(the second day of Phase III) and a Level II Emergency Response on Jan. 29 (the last day of Phase III). In general, the government well judged the disaster development trend and conducted emergency responses measures to assist the affected people. However, the local government of the Hunan Province did not correctly estimate the severity of the disaster. Throughout Phase III, the local government only issued a yellow early warning for snow disasters according to the snowfall intensity and did not pay attention to the accumulated effects of consecutive snowfall. When the disaster entered into Phase IV (nearly the end of the catastrophe), as the increase of the snowfall density, the Hunan province only issued a red early warning for snow disasters on Feb. 1. If the early warning issuing was conducted by taking consideration of both hzard intensities and the social impact of hazards, the red early warning for snow disasters should have been issued on Phase III, which was the phase for the rapid entry-transition of the catastrophe. Therefore, the relatively low level of emergency early warning issued by the local government indicates that the ultimate impact of the sleet & snow disaster was significantly underestimated.

As forecasted by the National Hurricane Center of the USA (NHC), Hurricane Katrina firstly landed in Florida. NHC forecasted the place and time of its second landing precisely on Aug. 26 and warned that the hurricane would land around New Orleans, with the possibility to break the levees. President Bush issued a federal emergency declaration for Louisiana on Aug. 27. Although NHC forecasted that hurricane Katrina would land in New Orleans, the city issued a mandatory evacuation order 2 days after the warning, making many people's failure to evacuate out of the severely affected areas. In contrast, Hancock County issued a mandatory evacuation order at 17:00 on Aug. 27, nearly 6 h earlier than New

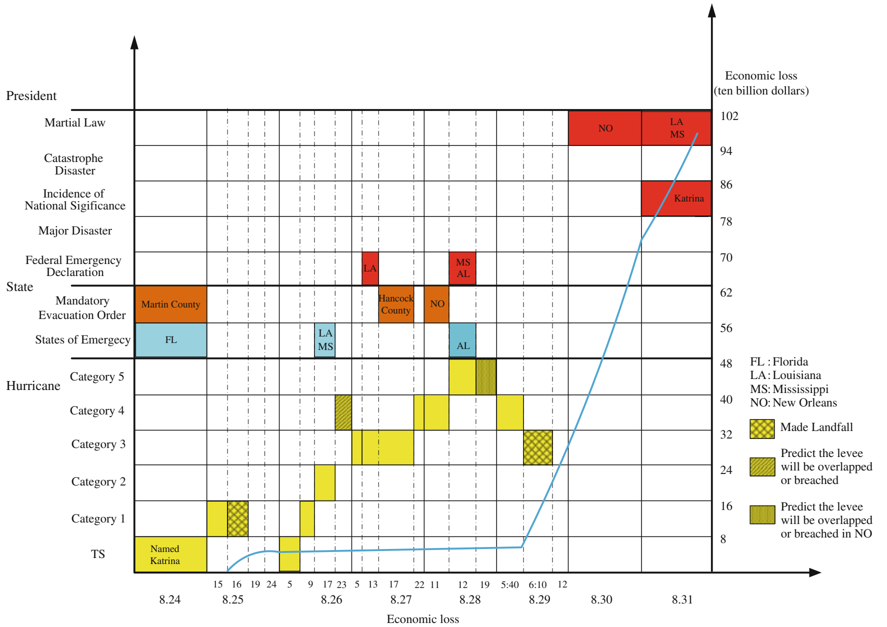

Fig. 11.8 The preparedness system for hurricane katrina of the united states

Orleans. The area, which suffered the most from the disaster and should have paid attention to the meteorological early warnings, failed to adjust the emergency plans wisely. Part of the reasons was the underestimation to the severity of the hurricane.

Although the mandatory evacuation order was issued on Aug. 27 in New Orleans, the government failed to provide sufficient assistance to citizens, especially the people with special needs and the people who did not own private vehicles for the evacuation. In New Orleans, there were about over 100,000 residents without their own automobiles. Although churches had implemented "Brothers' Mutual Help Program" to assist to evacuate those without transportation vehicles, many people who failed to be evacuated by vehicles were sent to shelters which were damaged to different extent in the hurricane. Moreover, before the hurricane landed, there were not enough military force to handle emergencies in New Orleans (Fig. 11.8).

Although the US government has made a series of preparations before the landing of Hurricane Katrina, it is still not sufficient for coping with such a catastrophe. After the hurricane landed, local and state governments were overwhelmed. New Orleans ordered a mandatory curfew on Aug. 30 to maintain social security on the night of the second day of the hurricane's landing. The Chertoff, the Secretary of the Department of Homeland Security, declared that Hurricane Katrina striking Louisiana and Mississippi was the national emergency, and issued the curfew order in Louisiana and Mississippi on Aug. 31, nearly 43 h after

Table 11.3 Differences of early warning systems and emergency systems between China and the USA

Catastrophes	Early warning system	Emergency system
Sleet & snow disaster in Southern China	Meteorological factors: be able to accurately forecast the changes of meteorological factors within 48 h, without paying attention to the accumulative effect of meteorological factors Social impact: Little consideration of the impact on social system caused by the hazards	Little preparation before the disaster; Paid attention to the united and overall deployment and coordination during the response process.
Hurricane Katrina	Meteorological factors: be able to accurately forecast the hurricane path and severity Social impact: be able to forecast the possible impact. Paid attention to the social impact possibly caused by the hurricane with timely information release to public.	Full preparation before the disaster, the adjustment and decisions making process during disaster appeared to be not efficient or timely enough.

Hurricane Katrina's second landing. Although the rescue was conducted in timely manner, the response to Hurricane Katrina was not effective and its severity was not correctly assessed, compared with the response of Hurricane Rita (which was determined as the "national emergency" 2 days before its landing). Due to the delayed response to the disaster, shortage of policemen and sharp increase of criminals in the disaster areas, the American government gave the affected people the impression of "a government not caring for people". The government though it was "well" prepared, but it underestimated the power of Hurricane Katrina.

From Table 11.3, we know that the meteorological early warning system in China primarily focuses on the development process and severity of meteorological elements, with little consideration on meteorological events' impact on the society. Thus the social impact of extreme meteorological events was usually underestimated, and emergency response may not be sufficient in the early stage of a catastrophe. The early warning system in the case of Hurricane Katrina showed a good example in term of forecasting of hazard development and assessment of potential impact. It accurately forecasted the development process and severity of meteorological elements, and released the possible impact the disaster may have on the social system through multiple media channels, to make the governments and individuals to arrange the response plans accordingly. Therefore, the early warning system is crucial for governments and individuals to act effectively to reduce the possibilities of catastrophes' entry transition (For example, in Hancock, the government timely evacuated people to reduce casualties, based on the received early warning information.) However, it is not enough to have only the effective early warning system. The government should also make adjustment according to the actual situations and dynamics of the disaster, in order to enhance the efficiency of disaster respond and the effectiveness of the disaster rescue.

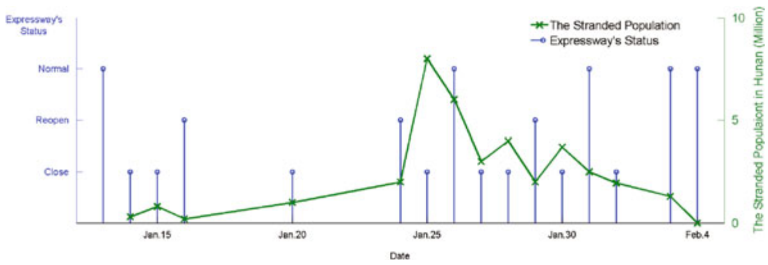

Fig. 11.9 People stranded in beijing zhuhai expressway in hunan province and the situation of the expressway. (Data Source: http://www.ce.cn/cysc/jtys/gonglu/200801/31/t20080131_14421574.shtml)

11.2.2 Comparison of Emergency Response

In the sleet & snow disaster in southern China in 2008, the number of casualties was relatively small although millions of people had been affected. The coordination of governments at all levels and the military forces played a critical role in minimizing the losses. The troops with over 6,000 people and militia forces with 120,000 people moved to disaster areas immediately after the central government issued a Level 2 Emergency Response. In the United States, the government underestimated the severity of the hurricane, and did not fully use the forecast information to respond to the disaster, even though the hurricane had been forecasted accurately. Two days after Hurricane Katrina's landing, the federal government issued an "national emergency" and conducted the overall disaster rescue. The number of national guards and active duty people was only 7,522 on Aug. 29 when New Orleans was flooded. The number of people increased to 16,113 on Sept. 1. In contrast, the case of the Chinese provided a good example of speedy and effective emergency response through efficient coordination between military and central and provincial governments.

As for the case of China in emergency response, the decision-making of the government sectors has the direct impact on the development of the disaster effects. The Beijing-Zhuhai Expressway is an extremely important expressway connecting North China and South China, with the total length of approximately 2,310 km. The Beijing-Zhuhai Expressway section in Hunan Province begins at the Yanglousi Toll Station of Yueyang, and ends at the Yizhang Toll Station of Chenzhou, passing through six cities in Hunan, with the total length of 531 km.

As shown in Fig. 11.9, during Phase I and Phase II (from the Jan. 10 to 22), the number of people stranded on the Beijing-Zhuhai Expressway increased steadily no matter what decisions were made on the expressway. The most difficult period for the Beijing-Zhuhai Expressway was Phase III. When the road reopened on Jan. 24 after it was closed for a short time, the vehicles poured onto the expressway was stranded again because the road conditions were not fully recovered and not all of

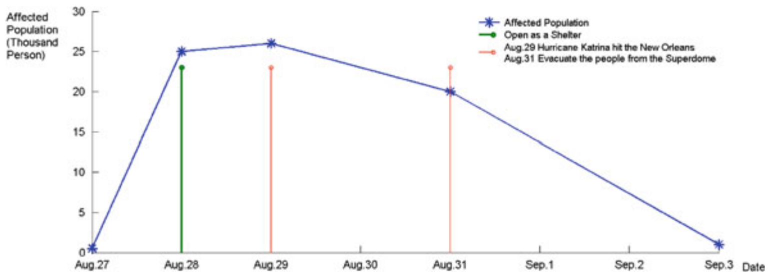

Fig. 11.10 The relationship between the stranded population in Superdome and the decision of government

the previously stranded vehicles and people were evacuated. On Jan. 26, the road conditions were recovered steadily, which reduced the number of people stranded. However, when the road was reopened on Jan. 29, the number of people stranded increased due to the entrance of excessive number of vehicles. During Phase IV (from Jan. 31 to Feb. 2) and Phase V (from Feb. 4 to Mar. 6), the road conditions were improving, and the number of stranded people decreased gradually. During the consecutive five phases of the event, the closure of expressway would reduce the stranded people while the reopening would significantly increase traffic jams due to continuously poor road and weather conditions. When the relevant government sectors, especially at the local level, made decisions, they sometimes did not conduct the overall dynamic assessment of the road conditions combined with the weather forecasting for the next 48 h. For example, in this case, the road conditions were improving by Jan. 24, and the local government authority reopened the expressway. However, the road conditions worsened in the following days, and the government closed the road immediately. If the government had made a decision by considering all related factors in an integrated way, they would have been able to control the number of vehicles which poured into the expressway, and alleviated the traffic jam on the expressway. Therefore, the decision-making sectors should not to solve problems temporarily. They should cooperate with relevant sectors including the meteorological sector, to obtain the information on the development of hazards and to conduct reasonable plans. Meanwhile, as the trans-provincial expressway connecting many provinces, the weathers and traffic conditions of the expressway sections in other provinces should be fully incorporated into the decision-making process of the local government.

In the case of Hurricane Katrina, on Aug. 28, the government of New Orleans decided to open the Superdome as a shelter strictly for the people with special needs and as a "shelter of last resort" for the general population. Although the American Red Cross thought the Superdome did not met their safety standards, the mayor insisted that the Superdome could be used as a shelter to accommodate 50,000–70,000 people. However, as the number of people in the Superdome significantly increased and the deterioration of the weather conditions, the requests for additional assistance sent by the working group to federal government were not satisfied. For example, the working group requested 180,000 liters of water and 4,109,440 meals for the Superdome. However, the working group only obtained 90,000 L of water and 43,776 meals due to the impact of high wind and storm surge. After the landfall of Hurricane Katrina, the population at the stadium continued to grow as thousands of people migrated there from their flooded homes. However, the floodwaters cut off access to the Superdome and made the restock of supplies extremely difficult. Some of the roof sections of the Superdome were stripped away by high wind; sewage and draining systems and communication and power lines were incapacitated. Conditions at the stadium became increasingly difficult due to the increase of people and shortage of food and water. In the morning of Aug. 30, the U.S Department of Health and Human Services assessed the Superdome as "uninhabitable". However, it took more than 48 h for Governor Blanco to reach an agreement with Texas Governor Rick Perry to evacuate people from the Superdome to the Houston Astrodome. By Sept. 3, approximately 92 % of people had been evacuated from the Superdome, leaving approximately 2,000 people (Fig. 11.10).

11.3 Conclusion

1 Extreme hazards occurring in the most vulnerable areas amplified the severity of disasters and formed catastrophes. Although the meteorological elements of the sleet & snow disaster in 2008 and Hurricane Katrina were not the most extreme cases in the historical records, the combinations of multiple hazards and the chain effects of disasters caused huge losses and significant influence.

2 There was a critical gap between the early warning system and the response system in China. The early warnings issued by the meteorological sector only focused on meteorological elements and did not emphasize the possible impact of hazards on the social system, which caused the serious disconnection between the meteorological early warnings and the actual dynamic development of disaster impact during the sleet & snow disaster in southern China.

3 The United States failed to prepare and adjust the emergency rescue plan for the disaster based on the reliable and relatively accurate forecast. Although the meteorological forecasts and pre-disaster forecasts about Hurricane Katrina were very accurate, the efficiency of emergency response and disaster rescue was not high due to the underestimation of the disaster impact amongst decision makers.

4 The decision-making process of governments in the entry-transition process could amplify or mitigate the severity of disasters. Inappropriate decisions could

speed up the number of stranded people on the expressway, and could leave the affected people in the Superdome a nightmare as well.

A better understanding of regional disasters' spatial–temporal distributions and risk patterns is crucial at the stage of emergency response for catastrophes. The spatial–temporal distributions and patterns are also changing under the background of global climate change. Many regions may face severe disasters they have never experienced before. Therefore, the social and physical vulnerabilities at different scales should be re-evaluated, especially the vulnerabilities of key infrastructures. During the early stage of the "entry-transition" of a catastrophe, rapid evaluation of the impact of hazards on the socio-ecological system, combined with forecasting and early warning systems, would be crucial for governments authorities to make more efficient and effective emergency plans. Finally, the disaster response of government at all levels and scales ought to seek an integrated approach in which the effective mechanism of collaborative operations from a systemic perspective is established.

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Chapter 12
Chinese Paradigm of Catastrophe Risk Governance

Peijun Shi, Weihua Fang, Wenjie Dong, Ning Li, Wei Xu and Shi Chen

Up until now, there has not been a unified international standard for large-scale disaster or catastrophe. Many scientists from different disciplines have proposed definitions of catastrophe from their respective angles. Experts from geoscience disciplines usually use human casualties and property losses due to disaster formative factors or affected scope as the standard for classifying a catastrophe. For example, Ma et al. (1994) regard any disaster causing deaths of more than 10,000 people or a direct economic loss of over 10 billion Yuan RMB, as an extraordinarily serious disaster. Mohamed Gad-El-Hak (2008) identifies any disaster causing the death of over 1,000 people or affecting an area of over 100 km^2 as an enormous disaster, disaster causing the death of over 10,000 people or affecting an area of over 1,000 km^2 as a Gargantuan Disaster. Those experts in insurance and financial management business usually determine a catastrophe according to the value of affected insured properties. American Insurance Service Office (ISO) defines catastrophe as an event that results in direct loss of at least 25 million US dollars for the insured properties and affecting a certain number of insurers and policy holders. Swiss Re names losses of 38.7 million US dollars as a threshold, whilst according to Munich Re, if, when any natural disaster takes place, the affected area cannot rely on its own strength to restore itself but shall depend on regional or international assistance; such natural disaster is classified as a catastrophe (Yao 2007). Therefore, a catastrophe may represent any event that has a low probability of occurring but will result in drastic losses, with its major characteristics of causing numerous human casualties, huge property losses and wide affected scope. In view of the serious catastrophe cases occurred in China in recent years, such as the Tangshan Earthquake in Hebei in 1996, the flood in the mid and

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P. Shi et al. (eds.), *Integrated Risk Governance*, IHDP-Integrated Risk Governance Project Series, DOI: 10.1007/978-3-642-31641-8_12,

downstream regions of the Changjiang River in 1998, the SARS (Severe Acute Respiratory Syndromes) in 2003, the sleet & snow disaster in southern China and the Wenchuan Earthquake in 2008, this paper defines catastrophe as: any serious disaster causing profound human casualties and huge property losses with wide areas impacted due to disaster formative factors with a return period of one hundred years and which, upon happening, cannot be managed by the affected area through its own efforts but with the assistance of external forces. Generally, such a catastrophe will kill more than 10,000 people or result in a direct economic loss of over 100 billion (equal to 10 billion Euros), or affected areas of over 1000,000 km^2.

By definition, catastrophe risk is a disaster caused by catastrophes which usually form a disaster chain. Therefore, governance of catastrophe risks requires the integrated catastrophe risks governance system of a region and country, including pre-catastrophe preparation, catastrophe emergency response, and the organization and commanding system, institutional assurance system, material assurance system, technical support system, emergency rescue system and social mobilization system for post-disaster restoration and reconstruction. By summarizing and reviewing the experience and lessons of China in coping with recent catastrophes, this paper has organized China's "whole nation paradigm" for catastrophe risk governance, evaluated its advantages, analyzed its existing problems and concluded it as the "Chinese Paradigm of Catastrophe Risk Governance".

12.1 Political and Institutional Bases of China for Coping with Catastrophe Risks

12.1.1 The Social Characteristics of the Country

China conducted a socialist market economy with the state ownership (ownership by the whole people) of resources and socialist public ownership of the means of production, under the unified leadership of the central authorities. China is one of the countries in the world with the longest history of a united multi-national state created jointly by all nationalities in China. According to the *Constitution of the People's Republic of China*,

> the People's Republic of China is a socialist state under the people's democratic dictatorship led by the working class and based on the alliance of workers and peasants. The socialist system is the basic system of the People's Republic of China. The state organs of the People's Republic of China apply the principle of democratic centralism. The National People's Congress and the local people's congresses at different levels are instituted through democratic elections. They are responsible for the people and subject to their supervision. The division of functions and powers between central and local state organs is guided by the principle of giving full consideration to the initiative and enthusiasm of local authorities under the unified leadership of central authorities.

The *Constitution of the People's Republic of China* also stipulates that "the basis of the socialist economic system of the People's Republic of China is socialist public ownership of the means of production, namely, ownership by the whole people and collective ownership by the working people". "Mineral resources, water, forests, mountains, grassland, un-reclaimed land, beaches and other natural resources are owned by the state, that is, by the whole people" "Land in cities is owned by the state. Land in rural and suburban areas is owned by collectives except for portions which belong to the state in accordance with the law; house sites and private plots of cropland and hilly land are also owned by collectives. The state may in the public interest take over land for its use in accordance with the law." "The state practices a socialist market economy." "State-owned enterprises have decision-making power in operation and management within the limits prescribed by law." "Collective economic organizations have decision-making power in conducting independent economic activities, under the condition that they accept guidance from the state plan and abide by the relevant laws." The *Constitution of the People's Republic of China* also specifies that "Armed forces of the People's Republic of China belong to the people. Their tasks are to strengthen national defense, resist aggression, defend the motherland, safeguard the people's peaceful labor, participate in national reconstruction, and work hard to serve the people."

12.1.2 The Structure of the State

The Structure of the State is composed of the National People's Conference, the State Council, the local people's conference and local people's governments at various levels, the Chinese People's Political Consultative Conference and the National Committee of the Chinese People's Political Consultative Conference. According to the *Constitution of the People's Republic of China*, "The National People's Congress of the People's Republic of China is the highest organ of state power. Its permanent body is the Standing Committee of the National People's Congress." "The National People's Congress and its Standing Committee exercise the legislative power of the state." "The National People's Congress exercises the following functions and powers: amend the Constitution, supervise the enforcement of the Constitution, enact and amend basic statutes concerning criminal offenses, civil affairs, the state organs and other matters, elect the President and the Vice-President of the People's Republic of China, decide on the choice of the Premier of the State Council upon nomination by the President of the People's Republic of China, and decide on the choice of the Vice-Premiers, State Councilors, Ministers in charge of Ministries or Commissions and the Auditor-General and the Secretary-General of the State Council upon nomination by the Premier, elect the Chairman of the Central Military Commission, the President of the Supreme People's Court and the Procurator-General of the Supreme People's Procuratorate, examine and approve the plan for national economic and social development and report on its implementation, examine and approve the state budget and report on its implementation; approve the establishment of provinces, autonomous regions, and municipalities directly under the Central Government." Also according to the *Constitution of the People's Republic of China*, "The Standing Committee of the National People's Congress exercises the following functions and powers: interpret the Constitution and supervise its enforcement, when the National People's Congress is not in session, decide on general mobilization or partial mobilization, decide on the enforcement of martial law throughout the country or in particular provinces, autonomous regions or municipalities directly under the Central Government, and exercise such other functions and powers as the National People's Congress may assign to it". The *Constitution of the People's Republic of China* further specifies: "The State Council, that is, the Central People's Government of the People's Republic of China, is the executive body of the highest organ of state power; it is the highest organ of state administration." "The State Council is composed of the following: the Premier; the Vice-Premiers; the State Councilors; the Ministers in charge of Ministries; the Ministers in charge of Commissions; the Auditor- General; and the Secretary-General. The Premier has overall responsibility for the State Council. The Ministers have overall responsibility for respective ministries or commissions under their charge." "The State Council exercises the following functions and powers: adopt administrative measures, enact administrative rules and regulations and issue decisions and orders in accordance with the Constitution and the statutes, submit proposals to the National People's Congress or its Standing Committee, allocate tasks and responsibilities for the ministries and commissions of the State Council, exercise unified leadership over the work of the ministries and commissions and direct all other administrative work of national character which does not fall within the jurisdiction of the ministries and commissions, exercise unified leadership over the work of local organs for state administration at different levels throughout the country, and distribute the detailed division of functions and powers between the Central Government and the organs of state administration for provinces, autonomous regions and municipalities directly under the Central Government, draw up and implement the plan for national economic and social development and the state budget, and decide on the enforcement of martial law in parts of provinces, autonomous regions and municipalities directly under the Central Government in accordance with laws." "The State Council is responsible, and reports on its progress, to the National People's Congress or, when the National People's Congress is not in session, to its Standing Committee. The Chairman of the Central Military Commission is responsible for the National People's Congress and its Standing Committee." "Local people's governments at different levels are the executive bodies of local organs of state power, as well as the local organs of state administration at their corresponding level. Local people's governments at different levels practice the system of "overall responsibility by governors, mayors, county heads, district heads, township heads and town heads". The *Constitution of the Chinese People's Political Consultative Conference* specifies that "The Chinese People's Political Consultative Conference is the patriotic united front organization of Chinese people, the main organ for multi-party cooperation and political consultancy under the leadership of the Communist Party of China and the main entity to execute socialist democracy in the political life of China. Unity and democracy are the two major subjects of the Chinese People's Political Consultative Conference."

12.1.3 Communist Party of China and State Power

The Communist Party of China is the core of leadership for the cause of socialism with Chinese characteristics. According to the Constitution of the Communist Party of China, "The Communist Party of China is the vanguard both of the Chinese working class and of the Chinese people and the Chinese nation. It is the core of leadership for the cause of socialism with Chinese characteristics and represents the development trend of China's advanced productive forces, the orientation of China's advanced culture and the fundamental interests of the overwhelming majority of the Chinese people." "In leading the cause of socialism, the Communist Party of China must persist in taking economic development as the central task, making all other work subordinated to and serve this central task. We must lose no time in speeding up economic development; implement the strategy of rejuvenating the country through science and education and that of sustainable development, and give full play to the role of science and technology as the primary productive force. We must take advantage of the advancement of science and technology to improve the quality of workers and work hard to push forward the economy with good results, high quality and high speed." "The Communist Party of China leads the people in developing the socialist market economy. It unwaveringly consolidates and develops the public sector of the economy and unswervingly encourages, supports and guides the development of the non-public sector." "The Communist Party of China leads the people in promoting socialist democracy. It integrates its leadership, the position of the people as masters of the country, and the rule of law, takes the path of political development under socialism with Chinese characteristics, expands socialist democracy, improves the socialist legal system, builds a socialist country under the rule of law, consolidates the people's democratic dictatorship, and builds socialist political civilization. It upholds and improves the system of people's congresses, the system of multiparty cooperation and political consultation under its leadership, the system of regional ethnic autonomy, and the system of self-prevention at the primary level of society." "China persists in its leadership over the People's Liberation Army and other armed forces of the people." "The Party must be determined to meet the following four essential requirements: First, adhering to the Party's basic line; second, persevering in emancipating the mind, seeking truth from facts and keeping up with the times; third, persevering in serving the people wholeheartedly; fourth, upholding democratic centralism."

12.1.4 Legal Basis for Emergency Response

The legal basis for China's emergency response is the *Emergency Response Law of the People's Republic of China*. On August 30 of 2007, at its 29th meeting, the Standing Committee of the 10^{th} National People's Congress passed the *Emergency Response Law of the People's Republic of China* (hereinafter referred to as the *Emergency Response Law*)˙

In accordance with the *Emergency Response Law*, emergencies include "natural disasters, calamitous accidents, public health accidents and public security incidents, which occur abruptly and cause or may potentially cause serious social harm and for which measures for handling emergencies need to be adopted.", and according to the degree of social harm done and the extent of repercussions and other factors, emergencies are classified in four grades: especially serious, serious, relatively serious and common.

Activities in response to emergencies include "prevention and emergency preparedness, monitoring and warning, emergency handling and rescue, post-disaster rehabilitation and reconstruction". It is designated that "the State establishes a system for administration of emergency response, which is characterized by unified leadership, all-round coordination, control according to grades, responsibility at different levels and, chiefly, territorial jurisdiction." "The State Council shall, under the leadership of the Premier, study, decide on, and make deployment for, response to especially serious emergencies; it shall, in light of actual need, establish a national command for emergency response, which shall be responsible for work in this respect; and when necessary, it may send a work team to guide the relevant work." "The Chinese People's Liberation Army, the Chinese People's Armed Police Force and the militia shall participate in emergency rescue, relief and handling in accordance with the provisions of this Law and of the relevant laws, administrative regulations and military regulations, as well as the orders issued by the State Council and the Central Military Commission." "The State Council shall be responsible for making the overall precautionary plans in response to national emergencies and organizing the making of special precaution plans in response to specific national emergencies; and the relevant departments of the State Council shall, in compliance with their respective duties and the relevant precautionary plans made by the State Council, be responsible for making their departmental precautionary plans in response to national emergencies.

Local people's governments at all levels and the relevant departments of the local people's governments at or above the county level shall, in accordance with the relevant laws, regulations, rules, and the precautionary plans in response to emergencies made by the people's governments at higher levels and their relevant departments and in light of the actual local conditions, make appropriate precautionary plans in response to emergencies."

It is also stipulated in the *Emergency Response Law* that "The State Council shall establish a unified national information system for emergencies." "Local people's governments at various levels shall, in compliance with the relevant State regulations, submit information on emergencies to the people's governments at higher levels." "The State establishes a sound emergency monitoring system." "The State establishes a sound early warning system for emergencies. According to degree of urgency of an emergency, its trend of development and the extent of damage it may cause, the early warnings about natural disasters, calamitous accidents and public health incidents that may be forewarned shall be classified in four grades: Grade 1, Grade 2, Grade 3 and Grade 4, which shall be indicated respectively in red, orange, yellow and blue, Grade 1 being the highest one. The standard for classifying the grades of early warnings shall be established by the State Council or the departments designated by the State Council."

It is also further in the *Emergency Response Law* that "after an emergency occurs, the people's government that performs the duty of unified leadership or organizes the handling of the emergency shall, in light of the nature, characteristics and degree of damage of the emergency, immediately organize the relevant departments, deploy the emergency rescue teams and people from different sectors of the society, and take measures for handling the emergency in accordance with the provisions in this Chapter and the provisions of the relevant laws, administrative regulations and rules." The people's government should take measures for post-emergency rehabilitation and reconstruction.

The provisions of relevant laws, regulations and rules in the above three aspects have laid a solid institutional foundation for the Chinese government to conduct the "nationwide catastrophe governance", and have also specified job divisions and duties for the central and local governments in preventing catastrophe risks as the administrative organs of the state. Figure 12.1 shows the institutional framework for the Chinese Government to execute the "nationwide catastrophe governance". Figure 12.1 shows the institutional framework for the nationwide catastrophe governance adopted by the Chinese government. From Fig. 12.1, we can see that the "paradigm of the nationwide catastrophe risk governance" of Chinese government is determined by the socialist political institution of the state, specified by the *Constitution of the People's Republic of China*, endowed by the National People's Congress, selected by the CPC National Congress and regulated by the *Emergency Response Law of the People's Republic of China*.

12.2 Economic, Social and Cultural Bases for China to Cope with Catastrophe Risks

12.2.1 Reform and Opening-Up Policy

China has changed from a highly centralized planned economic system to a socialist market economic system. On December 18, 1978, the 3rd Plenary Session of the 11th CPC Central Committee was held in Beijing, starting a new historical

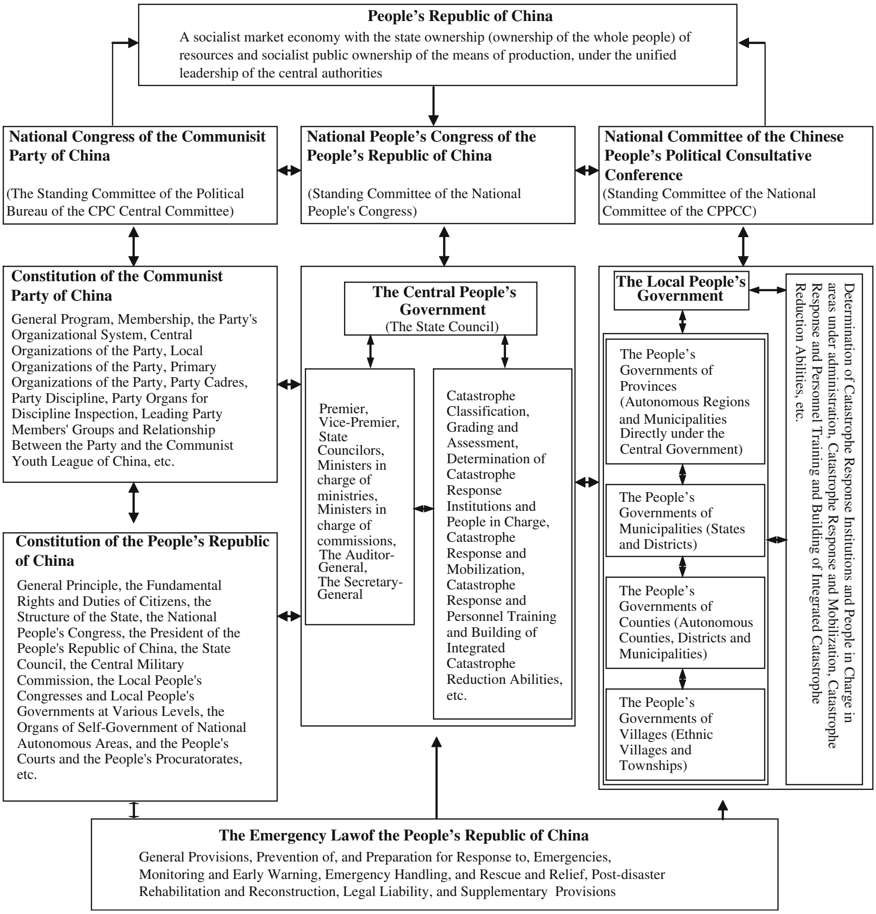

Fig. 12.1 Political system for the "Nationwide Catastrophe Risk Governance" of Chinese government

period of reform and opening-up in China. Under the leadership of the CPC, all Chinese nationals started a great revolution under new historical conditions. Under the leadership of the general designer Deng Xiaoping, a guideline of "emancipating the mind, seeking truth from facts, setting wits to work and uniting as one to move forward" was defined and a historical decision was made to shift the work focus of the CPC and the state to economic construction and to recognize reform and opening-up. Hence, the "liberation of thoughts, development of economy, flourishing of politics, rising of education, and flourishing of culture" happened in China (Hu 2008a). Again, with hope and vigor, the CPC and the state have embarked on the journey of identifying socialist modernization. The CPC leads the Chinese people to undertake reform and opening-up with the purpose of liberating and developing a social productive force and understanding the modernization of the state for the benefit of the Chinese people and the development of the nation, encouraging self-improvement and development of the socialist institution in China and endowing socialism with new enthusiasm and construct and develop socialism with Chinese characteristics.

Over the last three decades, by stimulating system reform in different aspects, China has achieved a great change from a highly centralized system of planned economy to a vigorous system of socialist market economy. China continues to build and improve the system of a socialist market economy, establishes the rural dual-level operation system based on family contracted operation and integration of generalization and separation, from the basic economic institution with public ownership as the core part and joint development of a multi-ownership economy, from the allocation institution as per labor and allow the co-existence of different allocation modes, and forms the economic management institution with the market allocating the resources under the macro control of the state. While continually deepening the reform of the economic system, China continually develops the reform of the political, cultural, social and other systems, and continually forms and develops vigorous new systems and new mechanisms in compliance with contemporary national conditions of China, to provide the energetic institutional assurance for the economic flourishing and development as well as social harmony and stability of the state.

12.2.2 Overall National Strength

Over the last three decades, China has continued to expand the opening up for construction and accelerated the development of an open economy. From establishing special economic zones to opening up the coasts, rivers, frontiers and inland and the accession to WTO, from the large-scale "brining in" to the initiative "going out", China has improved its standard of utilizing international and domestic markets and resources as well as enhanced its international competitiveness. From 1978 to 2008, China's total import and export increased from 21.1 billion dollars to 2.5616 trillion dollars, making it ranked the third in the world. China's import and export accounted for 0.8 % of the world trade in 1978, but it rose to 7.7 % in 2007. China's import and export was only 6.4 % of that of the USA and 8.0 % of that of Germany in 1978, but it increased to 68.4 and 91.1 %, respectively, in 2007, with the gap between e USA and Germany reduced apparently. From 1978 to 2008, China's foreign exchange reserves increased from 1.6 billion dollars to 1.9460 trillion dollars and broke the record of 1 trillion dollars by the end of 2006 to reach 1.0663 trillion dollars, ranking first in the world by surpassing Japan (Hu 2008a).

Over the last three decades, by maintaining the focus of economic construction, the overall national strength of China has moved on to a new stage. From 1978 to 2008, China's GDP increased sharply from 364.5 billion Yuan to 30.0670 trillion Yuan, making it the fourth highest in the world, with an annual average growth of approximately 10.0 %, being higher than the average growth of 6.1 % from 1953 to 1978 and being higher than the world's average growth of 3.0 % in the corresponding period (National Bureau of Statistics of China 1979, 2009). China has steadily and independently resolved the food problem for a population of 1.3 billion. The financial strength of the state is constantly enhanced. The national financial revenue was only 113.2 billion Yuan in 1978, but it reached 5.1322 trillion Yuan in 2007 (being the primary tax revenues, excluding the duties, farmland use tax and contract tax), with an annual average growth rate of 14.1 % from 1979 to 2007. A change has also taken place in the structure of primary, secondary and tertiary industries. The proportion of primary, secondary and tertiary industries was 28.2 %, respectively 47.9 and 23.9 %, respectively, in 1978, which changed as 11.3, 48.6 and 40.1 %, respectively, in 2007, showing a major change in the proportions of primary, secondary and tertiary industries (National Bureau of Statistics of China 2008a). Urbanization has been accelerated, achieving the change from urban and rural separation to urban and rural coordination and mutual development. Over the last three decades, the proportion of the urban population in the total population has increased year by year and urbanization level has increased from 17.9 % in 1978 to 45.7 % in 2008, up by 27.8 % points. Additionally, by 2008, China ranked first in the world in terms of output of agricultural products and industrial products; Major scientific and technological innovations with advanced levels in the world have been achieved; The high-tech industry has developed rapidly; Breakthrough progress has been accomplished in infrastructures such as water conservancy, energy, transportation and communications; Development of ecological civilizations was promoted; Urban and rural appearances has been updated (National Statistical Bureau of China 2009).

12.2.3 People's Standard of Living

The people's standard of living has been improved gradually, with a moderately prosperous life in general. The people's China has the largest population in the world, with the natural resources per capita ranking low in the world. Therefore, great and long-term efforts are required to improve the people's standard of living. Over the last three decades, while the national strength increased, the government has focused on improving people's wellbeing. From 1978 to 2008, national per capita disposable income of urban residents increased from 343 to 15,781 Yuan, with an actual growth of 7.0 times; per capita net income of peasants increased from 134 to 4,761 Yuan, with an actual growth of 6.7 times (National Statistical Bureau of China 2008a, 2009). The rural poverty-stricken population decreased from 250,000,000 to 14,000,000 (National Statistical Bureau of China 2008a). Per capita GDP increased from 381 Yuan in 1978 to 18,934 Yuan in 2007, with a growth of nearly 10 times, excluding the price factor, showing an annual average growth of 8.6 %. Per capita national income also achieved a rapid growth, from 190 dollars in 1978 to 2,360 dollars in 2007. According to the classification standard of the World Bank, China has jumped from a country of low income to a country of medium–low income (National Statistical Bureau of China 2008a).

Over the last three decades, social security and cultural environments have been constantly improving for people. The state has greatly developed a socialist advanced culture and the increasing demand of people for spiritual culture has been properly satisfied. Social harmony and stability has been consolidated and developed. The urban and rural free nine-year compulsory education has been implemented, with the higher education scale as well as the total number of students in primary and middle schools and universities ranking first in the world. Education quality has been constantly improved. The social security system building has been accelerated and the social security system covering urban and rural residents has been formed initially. The public health service system and basic medical service system have been constantly improved and the new rural cooperative medical system has reached coverage for the entire country. Social management has been constantly improved and the social situation has been stabilized (National Statistical Bureau of China 2008b).

12.2.4 Cultural Tradition

The Chinese traditional culture determines the disaster prevention and reduction culture being "harmony between nature and men", "truth, kindness and beauty" and "one party in trouble being assisted by others". As a country with a long history of ancient civilization, China has, in the historical period of five thousand years, formed a tradition of Confucian culture profoundly influencing the Chinese people. The concepts of "integration of nature and men" and "nature between heaven and men" have illustrated the harmonious relationship between men and the natural environment system. Meanwhile, China has also formed the outlook on life of "hard work and bravery", "truth, kindness and beauty", the outlook on the world of "harmonious but different", "seek common points while reserving difference" and "complementation with multiple factors" as well as the value of "a gentleman is open and poised". With the impact of these Confucian traditional cultures of "harmony with nature, kind with man, and common ground with society", a cultural atmosphere of "one party in trouble being assisted by others" has been formed for the society to cope with catastrophes. Facing the catastrophes, people from all over the country's ethnic groups are closely related to the people in disaster areas. They are fearless of hardships and undaunted by repeated setbacks, fully showing the Chinese nation's characteristics of constantly striving to become stronger and trying hard for victories. They persist in putting people first and respect science, fully showing the Chinese nation's characteristics of caring for life and advocating rationality. Human life being the priority, all people of one mind and uniting as one fully show the Chinese nation's characteristics of work together with one heart and uniting for striving (Hu 2008b).

From the above analysis, it can be seen that the reform and opening-up has played a decisive role in the rapid increase of the country's overall strength, while the focus on economic construction has moved the overall national strength to a new stage, laying a material foundation for the Chinese Government to implement the "nationwide catastrophe risk governance". With the living standards of people being improved, the people's awareness of safety fortification increased year by year and their awareness of risk prevention has also been enhanced, imposing new requirements for the "nationwide catastrophe risk governance". The cultural tradition has created civilized merit of "one party in trouble being assisted by others" passed by people from generation to generation, which builds up a spiritual support for the "nationwide catastrophe risk governance". However, while the enhanced overall national strength and the spiritual support of responding to catastrophes created by cultural traditions have increased the national capacity to cope with catastrophes, the medium–low per capita income level has affected the state to increase capacity of disaster risk governance. In the vast economically underdeveloped regions and regions with comparatively high disaster risks, the safety fortifications cannot meet the requirements of the nation's sustainable development strategy; while frequent disasters in some regions are still the biggest barrier for building a harmonious society. Figure 12.2 outlines the economic, social and cultural system of China to prevent catastrophe risks. As a whole, the economic base for the nationwide catastrophe risk governance has been enhanced, but from the perspective of different regions nationwide, the urban and rural gap is obvious; the cultural foundation for the nationwide catastrophe risk governance is solid, but the social foundation is still weak. It is still a hard task for the state to be able to increase the per capita income, improve and enhance the awareness of disaster risk governance and increase disaster safety fortification levels for the whole society, especially for the economically underdeveloped regions and vast rural areas.

12.3 "Chinese Paradigm" for Catastrophe Risk Governance

From the discussion in the preceding two parts, we can observe some institutional, economic, social and cultural foundations of the Chinese government with regard to catastrophe risk governance as well as the specific content of system, mechanism and legality during "nationwide response".

12.3.1 Firm Command of the Central Government

The firm command of the central government plays a core role in catastrophe response. When a catastrophe happens each time, it directly or indirectly affects the whole nation. Therefore, as the executing organ of the state supreme power,

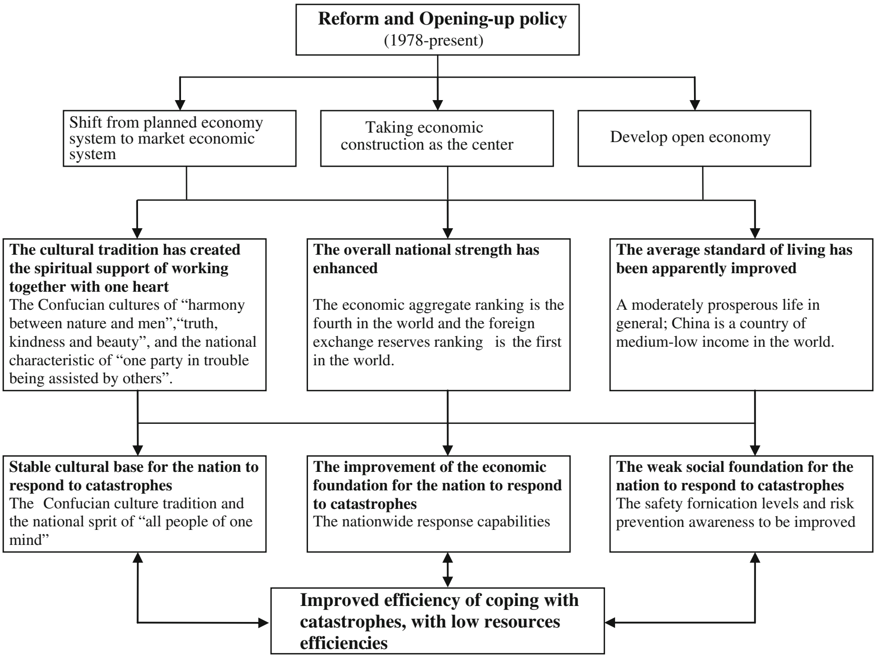

Fig. 12.2 Economic, social and cultural foundation framework for the Chinese government's "Nationwide Catastrophe Risk Governance"

the State Council undertakes the major task of leading, organizing and commanding response to catastrophes. In accordance with the *Constitution of the People's Republic of China* and *Emergency Response Law of the People's Republic of China*, and in terms of the scope of any catastrophe, and the casualties and property losses thereof, based on the permanent organizations of coping with disasters, temporary organizations should be established to cope with any catastrophe, such as the "Headquarters of the State Council for Coal, Power and Oil Transport and Disaster Rescue and Relief" established to cope with the sleet & snow disaster in southern China in early 2008, the "Headquarters of the State Council for the SARS Prevention and Treatment" established to cope with SARS in 2003 and the "Headquarters of the State Council for Earthquake Rescue and Relief" established to cope with the Wenchuan earthquake of May 12, 2008. These temporary organizations for coping with catastrophes were headed by the leaders of the State Council. The establishment of temporary organizations to cope with catastrophes has integrated central and local forces, and though the relevant offices under the organizations, the forces can be promptly gathered to lead, organize and command catastrophe response, reflecting the firm leadership of the "nationwide catastrophe response". These organizations become the core force in coping with catastrophes.

12.3.2 Full Devotion of the Peoples' Army

The people's army plays a core role in catastrophe response. The armed forces of the People's Republic of China belong to the people. Each time a catastrophe happens, under the leadership of the Chairman of Central Military Commission acted by President of the State, the people's army deemed the disaster effects as the command, goes to disaster areas immediately, and joins the governments at different levels and people in disaster areas to form a emergency armed force for disaster rescue and relief. Facing each catastrophe, officers and soldiers of PLA and armed police, staff of the reserve forces and policemen take responsibilities and play a role of mainstay and commandos. The people's army care for people in disaster areas and respond to the expectations of the party and the people. From senior generals to ordinary soldiers, they have a fighting spirit of bravery, tenaciousness, fearlessness of sacrifice and continuous combat. They undertake the most emergent, tough and dangerous tasks for disaster rescue and relief.

12.3.3 Support of Powerful National Strength

The support of powerful national strength is a guarantee for catastrophe response. As an emergent transition country in the world, China has gradually implement the overall reform and opening up policy since 1978, making the national strength increased obviously within three decades. As an important part of the socialist approach with Chinese characteristics, the socialist market economy system being steadily improved in compliance with the national conditions of China shows brilliant development prospects. Based on this, by absorbing all advanced knowledge of human civilization and cooperating extensively with foreign governments and people throughout the world, the Chinese government and the Chinese people have further improved the basic economic system with the public sector remaining dominant and diverse sectors of the economy developing side by side, to make the Chinese socialist economy to develop further. Due to the enhancement of national strength, the materials reserves for catastrophe response have been gradually increased, disaster safety fortification levels have been improved, the emergency management system has been improved, the capacity of disaster rescue and relief has been strengthened, the system for catastrophe risk transfer has been established and gradually optimized and the system of integrated disaster risk governance has been principally set in place, playing a powerful role of assurance in catastrophe response.

12.3.4 National Active Participation

The national active participation plays a positive role in catastrophe response. Facing with each catastrophe, upon the order from the central government, the whole nation is encouraged to participate in disaster rescue and relief. During the days and nights in disaster rescue and relief, people from all over the country's ethnic groups are worried, and they united in a concerted effort to share the same destiny. "Universal Love in the World in spite of Ruthless Disasters; Come on, disaster areas; Come on, China" become the strongest voice echoing throughout China. Numerous volunteers come from all over China, numerous people approach the blood-donation points spreading over China to donate their blood, numerous people contribute and donate to disaster areas, and millions of the party members render special party membership fees to the party organization. Numerous medical and health personnel, with the spirit of saving lives, work day and night to save life and control epidemic diseases. The journalists went to the frontline to deliver the voice of the central government and report on the disaster and progress of disaster rescue and relief, reflecting the heroic deeds of the party, governments and people's disaster rescue and relief and providing strong public opinion support for catastrophe respond. The science and technology workers and engineering constructors cooperated to provide disaster rescue and relief with knowledge, technological and engineering support. Art workers enthusiastically eulogized the spirit of disaster rescue and relief, providing disaster rescue and relief with strong spiritual encouragement. By actively participating, all the nationals formed a strong coherence in coping with catastrophe and energetically motivated the process of the nationwide catastrophe respond.

12.3.5 Media Guidance

The media guidance plays a significant role in cohesion of people in catastrophe response. China's political system has created an excellent base for media to organize and guide public opinions in coping with catastrophe. Each time, the temporary organizations for Chinese government's catastrophe response as well as the permanent organs of the Party and governments responsible for news propaganda are as important organizations to participate. Among the permanent organs for disaster response, propaganda sectors of governments play an important role as well. For instance, with the concurrent position of the Deputy Head of China National Disaster Reduction Committee, the Deputy Director of the Central Propaganda Department plays a key role. Under the overall arrangement of the temporary catastrophe response organizations of the central government, the media published timely, accurate and authoritative information. The Press Office of the State Council regularly published different authoritative information regarding the progress of disaster rescue and relief and timely replied to questions from different journalists and social sectors; It also published different bulletins in *People's Daily*, CCTV, Xinhua.net and People.net, to timely publicize measures of catastrophe response as well as advanced stories and people, to encourage people

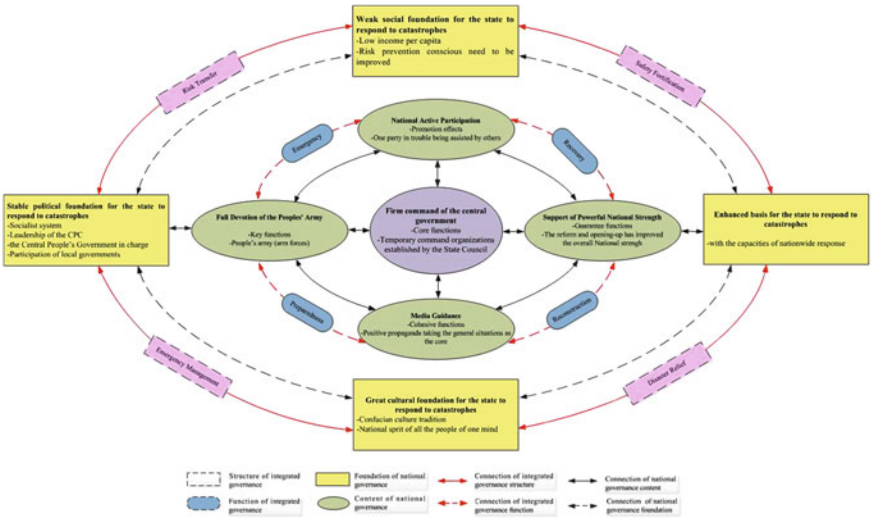

Fig. 12.3 The Chinese government's paradigm for the "Nationwide Catastrophe Risk Governance" (Chinese paradigm for catastrophe risk governance) (Shi et al. 2009)

and inspire the fighting spirit, with the guidelines of taking disaster rescue and relief as the center, adhering to unification and stability and encouraging positive propaganda. Under the general coordination and guidance of the Central Propaganda Department, Press Office of the State Council and local administrations of propaganda and press, for the purpose of meeting the overall requirements for "the nationwide catastrophe response" as the main target, the media adopt various methods such as live broadcast and live interviews, to exchange the information between disaster areas and non-disaster areas and to play a role as mind cohesion as well as resources and force integration.

To sum up, Fig. 12.3 represents the main features of the "Chinese Paradigm" for catastrophe risk governance, from which we can see that: the basis for the Chinese government's nationwide catastrophe governance is the political advantage of Chinese socialist system to concentrate force to solve big issues, the excellent characteristics of the Chinese nation, the continuously improving overall national strength, the political features of the people's army and the firm leadership of the central government. The content of the Chinese Government's whole nation's catastrophe governance is a national system of integrated catastrophe risk governance composed of the core role of the central government, the crucial role of the people's army, the assurance role of powerful national strength, the promoting role of nationwide participation and the cohering role of the media guidance, as well as the structural and functional system of national catastrophe risk governance supported by these five factors (Shi et al. 2009).

12.4 Conclusion and Discussion

This paper illustrated the political, economic, social and cultural basis of China's governance of catastrophe risks, exhibited the mode of whole nation's catastrophe response by analyzing the two cases of the sleet & snow disaster in southern China in early 2008 and the Wenchuan earthquake on May 12 of 2008, and established the Chinese paradigm for catastrophe risk governance. Therefore, the conclusions are as follows:

1. The Chinese government's paradigm of the "whole nation's catastrophe risk governance" is determined by the socialist political system of the state, stipulated by the *Constitution of the People's Republic of China*, endowed by the National People's Congress, selected by the CPC National Congress and regulated by the *Emergency Response Law of the People's Republic of China*.
2. The policy of reform and opening up has greatly enhanced national strength and laid a foundation the "nationwide catastrophe risk governance". As the improvement of living standards, people require higher levels of disaster safety fortification year by year. People's awareness of risk governance has been enhanced, and propose new requirements for the "whole nation's catastrophe risk governance". The accumulation of cultural traditions formed the civilized virtue of "one party in trouble being assisted by others", to construct the spirit support for the paradigm of the "nationwide catastrophe risk governance".
3. The Chinese government's paradigm of the "nationwide catastrophe risk governance" can be explained in the following perspectives: Firstly, the basis, i.e. the political advantage of Chinese socialist system to concentrate force to solve big issues to establish the temporary national emergency command organizations in accordance with law, the continuously improving overall national strength, the excellent characteristics of the Chinese nation, and the firm leadership of the central government; secondly, the content, i.e. the core role of the central government, the crucial role of the people's army, the assurance role of national strength, the promoting role of nationwide participation and the cohering role of media guidance; and thirdly, the system, i.e. the structural system of national integrated disaster risk governance composed of "safety fortification, disaster rescue and relief, as well as emergency management and risk transfer" and the functional system of national integrated disaster risk governance composed of "disaster preparation, emergency as well as restoration and reconstruction".

China is a large country, with great natural, social and economic gaps between regions. China has a large population, with the per capita income still at the medium–low level of the world. Therefore, the disaster safety fortification level of basic communities is rather limited. Except some economically developed metropolitans and cities in the eastern coastal areas, in the vast central and western regions and especially parts of the poverty-stricken regions, the capacity for disaster safety fortification is weak, with limited disaster defense level. Due to the weak national awareness of disaster risk governance and the lack of necessary coping techniques, “small disasters causing big destructions” often occurs, and big disasters result in huge destructions. Therefore, while increasing the overall national strength, increasing the per capita income is a hard task for the central and local governments to respond to catastrophes (Shi et al. 2009). But only by doing so can it become possible to improve the overall efficiency and effectiveness of resource utilization for the whole nation‘s catastrophe response, and to improve the Chinese paradigm of catastrophe risk response, i.e. (1) learning from foreign countries the experience of establishing catastrophe risk transfer, to develop catastrophe insurance and reinsurance; (2) enhancing the infrastructure fortification and ecological system service capacities; (3) increasing national awareness of catastrophe risk governance and basic techniques of escape; and (4) improving emergency plans, information integration networks and command platforms for catastrophe response. Therefore, the efficiency of resource utilization for catastrophe response can be increased in an all-round manner.

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Chapter 13
The Community Model of Integrated Natural Disaster Risk Governance in China

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Communities are the smallest unit of government administration and the foundation for disaster prevention and reduction and risk governance. Community integrated risk governance lies at the core of improving regional and national integrated risk governance abilities. It is also an important part in improving "top down" and "bottom up" integrated risk governance modes. To summarize the Chinese government's efforts against the sleet and snow disaster in southern China in 2008 and the Wenchuan Earthquake in 2008, we have proposed the "nationwide catastrophe response" mode (the top down mode), i.e. "two bases, five actions and two systems" (Shi and Liu 2009). With respect to the weak ability of disaster prevention and reduction in local regions throughout China, i.e. the status quo of shortage of "bottom up" risk governance measures and abilities, this paper proposed the community model of integrated natural disaster risk governance in China, to strengthening disaster prevention and reduction and integrated risk governance in China, especially to improve the catastrophe risk governance abilities, according to the "Hyogo Framework for Action" of the United Nations (UNISDR 2005).

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P. Shi et al. (eds.), *Integrated Risk Governance*, IHDP-Integrated Risk Governance Project Series, DOI: 10.1007/978-3-642-31641-8_13,

13.1 Theoretical Basis for the Construction of the Community Integrated Natural Disaster Risk Governance Mode

Natural disaster risk governance is a complicated and comprehensive human system project requiring the integration of multiple resources and the consideration of their functions. Therefore, in constructing the community natural disaster risk governance mode, we have three theoretical bases, i.e. the principle of "harmony between nature and men" and "integration of nature and men", the principle of sustainable development and the principle of regional disaster systems.

13.1.1 The Principle of "Harmony Between Nature and Men" and "Integration of Nature and Men"

In ancient Chinese philosophy, the important ideas for dealing with conflict between man and nature are "harmony between nature and men" and "integration of nature and men". In constructing the community disaster reduction and governance and integrated disaster risk governance mode, we should reflect the great philosophical ideas in ancient China. The core idea of "harmony between nature and men" is to handle the coordination relationship between various natural, human and economic elements within the earth surface system. That is to say, human activities should be in line with natural patterns and laws, to recognize the goal of a harmonious coexistence of human and natural patterns. The community is an important unit in the earth surface system. Human activities, which are closely related to natural environments, construct the human–earth interaction landscape systems with land resources of the earth, and construct the earth–air interaction climate system, regional landscape system and climate system (i.e. regional earth surface systems with the interactions of regional elements, the physical foundation of communities) with regional climate and environment. Therefore, the construction of a community natural disaster risk governance mode cannot be separated from the material basis of the existence of communities. The evolution of various natural elements of the earth, where communities are located, is closely related to human development processes. That is to say, the inter-annual changes and the inter-monthly changes of the earth surface as well as the annual and monthly human development processes consist of the human–earth interaction dynamic evolution process on earth surface. This process is also the regional earth surface evolution process and the dynamic evolutions process of the physical basis to support the existence of communities. Therefore, to construct a community natural disaster risk governance mode, we must follow the rules of the development of the physical basis which supports the existence of communities. The process and pattern of human–earth interaction on the earth's surface influence the scale and the intensity of mankind's exploitation of nature at any moment, and also determine the methods and levels of regional disaster prevention and reduction.

This is an important principle for the development of a community integrated natural disaster governance mode.

13.1.2 The Principle of Regional Sustainable Development

At present, the principle of sustainable development is an important principle for solutions to the conflict between human development and its living environments throughout the world and also an important basis for the construction of a regional disaster prevention and reduction and integrated disaster risk governance mode. In the battles against natural disasters in past years in China, the important experience has been summarized as "combining disaster elimination with benefit promotion", which is in line with the strategic framework of integrating regional disaster prevention and reduction and risk governance into regional sustainable development of the current society. As subjects of regional natural resource development and utilization, communities must ensure safe resource development and utilization to reduce the risk of natural disasters. Disaster incidences arising from resource development and utilization need to be prevented. When constructing a chemical plant along a river, the pollution of the water resources needs to be strictly controlled. (After the explosion of aniline workshops in Jilin Chemical Plant which located in Jilin Province, it discharges harmful chemicals into the Songhuajiang River, causing serious pollution of the water and giving rise to water supply risk along the river.) The conflict between "resource development and disaster prevention and reduction" needs to be addressed on a community level. While enhancing the safety fortification of communities, special attention needs to be paid to the main infrastructures and the lifeline and production line systems to ensure operation safety. This not only ensures normal production and life, but also substantially reduces community losses from disasters. "Disaster elimination" shall aim at "benefit promotion" and "benefit promotion" must have "disaster elimination" as its purpose, thus scientifically coordinating the conflict between "development and disaster" and realizing possibilities for sustainable development at the community level. Therefore we must follow the principle of regional sustainable development when constructing a community integrated natural disaster risk governance mode.

13.1.3 The Principle of Regional Disaster Systems

A regional disaster system is an abnormal change system on the earth surface consisting of regional disaster formative factors, disaster affected bodies and disaster formative environment, and is the direct target for community disaster prevention and reduction and integrated disaster risk governance. For the construction of a community natural disaster risk governance mode, we give full consideration to various natural disaster formation factors in communities and secondary disaster factors caused thereof, i.e. various disaster types and disaster chain problems; We also fully evaluate the vulnerabilities of the social and economic system in the community to community disaster formative factors; we fully recognize the sensitivity of community resources and environmental systems to community disaster formative factors as well as the dependence on community resources and the environmental systems. The community resources and environmental systems are the basis for community development as well as disaster prevention and reduction. By developing community resources and using and protecting the environment, the productivity within the community as well as its disaster prevention and reduction ability is increased and its vulnerability to disaster formative factors is reduced. However, the resources and environmental systems in which the community is located also provide the conditions to form various natural disaster formative factors and to develop disaster chains. Communities on rivers have a convenient access to water resources, but also a high risk of flooding if the river surface rises to the level higher than the fortification level. Communities on plains can benefit from convenient traffic and fertile soil. However, when rainstorms exceed the standard, the risks of waterlogging and traffic interruption are high. Therefore, when constructing the community natural disaster risk governance mode, we shall obey the principles of the regional disaster system and give full consideration to the relationship between "disaster causing and disaster formation", the relationship between "development and fortification" and the relationship between the "environment and disaster incubation".

Therefore, we shall construct a regional integrated disaster risk governance mode of "adapting to community environment, ensuring community development and reducing community risks" on the basis the three above-mentioned principles.

13.2 Case Analysis of Community Integrated Natural Disaster Risk Governance

13.2.1 International Safe Community

The Youth Park in Huaiyin District, Jinan City of Shandong is the first "International Safe Communities Network Membership" named by the World Health Organization (WHO) in mainland China (http://www.phs.ki.se/csp/index.htm). Huaiyin District is one of the central city districts in Jinan City, with an area of 151 square kilometers, and a resident population of 378,000, 12 sub-district offices and 2 towns. The Youth Park is a sub-district office of Huaiyin District, with a population of about 25,000 (20,760 in 2005). In June 2002, the community applied to the WHO Collaborating Centre on Community Safety Promotion for the formal start of the community safety promotion project. Through nearly five years' efforts, according to the WHO standard on safe communities and the goal of "having community

Fig. 13.1 The street scene of Youth Park of Huaiyin District (from The Youth Park Sub-district Office)

residents feel the atmosphere of safety at any moment in the community and receiving uninterrupted safety intervention", a work mode of "government guidance, overall planning, resources integration, diversified participation, community intervention, feature driving, dynamic positioning and long-term operation" has been gradually formed. A work safety network in which the government, health service institutions, volunteers' organizations, enterprises and individuals jointly participate has been established, and substantial development has been achieved in terms of fire control safety, AIDS prevention, self-rescue and mutual rescue, anti-domestic violence and safety production. Therefore, on Feb. 10, 2007, the WHO Collaborating Centre on Community Safety Promotion formally confirmed Youth Park as the first "International Safe Communities Network Membership" in mainland China and the 97th in the world, named by the WHO, thus becoming a flagship for safe communities in China (Figs. 13.1, 13.2).

As a paragon for Chinese safety communities meeting the international standards, Youth Park of Huaiyin District, Jinan City of Shandong has the following characteristics:

Firstly, it follows the WHO idea of "safety promotion", strictly implements six standards for "safe community" (Ding 2006), and operates according to the project management model, forming the "macro-safety" concept in line with actual situations of the community.

Secondly, it fulfills the scientific outlook on development, highlights the "putting people first" to be in power for the people, ensures the community residents' rights for survival and health, substantially reduces and effectively prevents residents' exposure to risks, and receives support from residents.

Thirdly, it implements the national strategy for sustainable development, constructs a safety network ensuring development within the community for economic and social development, substantially reduces production accidents, safeguards normal operation of production and life, improves utilization efficiency and effectiveness of various disaster reduction resources within the community, stabilizes the society and further promotes development.

Fig. 13.2 The emergency response drill organized by Youth Park of Huaiyin District (from The Youth Park Sub-district Office)

Fourthly, it upgrades fortification abilities to cope with various risks, from the enhancement of safety awareness, training of emergency response skills, and improvement of public security facilities to the improvement of community comprehensive safety levels, government comprehensive management abilities and community efficiency. Positive elements of various aspects are integrated to eliminate various hidden troubles for safety and to make the community safer, more harmonious and more developed.

The case of the “safe community” of Youth Park in Huaiyin District, Jinan City of Shandong highlights “public safety”, forming a community integrated risk governance mode of centering on “public safety”, which fully reflects the WHO principle and objective for establishing “safe communities”. However, from the perspective of constructing a community integrated disaster risk governance mode, and in accordance with the above-mentioned principle to be followed for constructing a community integrated disaster risk governance mode, this “international safe community” mode lacks profound understanding as well as necessary measures and actions for “community development”, and lacks consideration for the “combination of disaster elimination and benefit promotion”, fundamentally solving “conflict between men and nature” and the “integrated disaster prevention and reduction structure and function optimizing system” which must be included in establishing integrated disaster risk governance. Therefore, we shall improve and upgrade it to accomplish greater and better goals of community risk governance.

13.2.2 Integrated Disaster Reduction Demonstration Community

The *National Plan for Comprehensive Disaster Reduction in the Eleventh Five-Year* has put forward the task of strengthening community disaster reduction abilities. “We shall improve the urban and rural community emergency plans, and organize community residents to take an active part in disaster reduction activities and emergency plan drills. We shall keep improving rural and urban community disaster reduction infrastructures and construct resident disaster reduction settlement projects. We will strengthen disaster reduction and refuge function, and establish refuge areas in urban and rural communities susceptible to disasters. We shall build a disaster information personnel team. We will strengthen preparation for disaster prevention and reduction in residents' families of urban and rural communities and establish a community vulnerable group protection mechanism in time of emergencies. We shall improve the urban and rural integrated disaster resistance ability in an all-round manner". (The State Council of the People's Republic of China 2007).

The standards for the construction of a national "integrated disaster reduction demonstration community" are as follows in terms of the ten aspects: sound organization and management mechanisms, carrying out disaster risk evaluations, preparing integrated disaster and emergency rescue plans, often carrying out disaster reduction publicity, education and training activities, disaster prevention and reduction infrastructures all ready, upgrading residents' disaster reduction awareness as well as refuge and self-rescue skills, extensively carrying out community disaster reduction mobilization and participation activities, a sound management assessment system, standard archival management and distinctive features of community integrated disaster reduction. (China National Disaster Reduction Commission Office 2008a, b).

By the end of 2010, the number of "national integrated disaster reduction demonstration communities" selected and accredited by the National Disaster Reduction Committee Office according to the above standards had reached 1562, and the goal of the *National Plan for comprehensive Disaster Reduction in the Eleventh Five-Year* was achieved. The communities acquiring qualifications for "national integrated disaster reduction demonstration communities" are classified as urban and rural communities, with the following common features:

Firstly, highlighting the guidance of "integrated disaster reduction", integrating disaster preparation, emergency response as well as restoration and reconstruction, integrating safety fortification, disaster relief, emergency management and risk transfer, and forming an "integrated disaster prevention and reduction structure and function system" on the community level;

Secondly, highlighting the purpose of "putting people first" of community management, and constructing a new pattern of community disaster prevention and reduction by the three major measures of "strengthening leadership and organizational structure, preparing systems and fulfilling work responsibilities, strengthening management and building volunteer teams";

Thirdly, highlighting the principle of giving priority to training of awareness of community disaster prevention and reduction, creating an overall climate of community disaster prevention and reduction by "paying attention to the three aspects" such as "paying attention to activity propaganda, activity training and carrier propaganda";

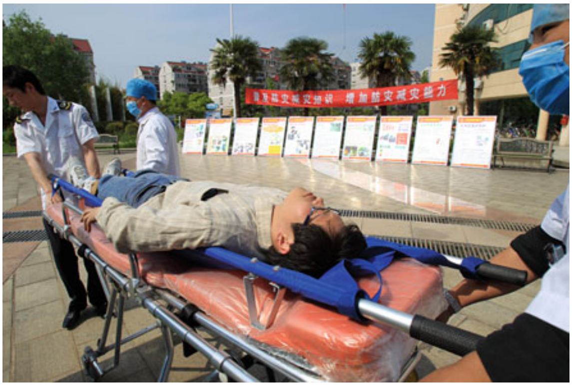

Fig. 13.3 Integrated risk reduction demonstration community activities—integrated drill for disaster prevention and reduction in Nantong Community of Jiangsu (Congjun Xu/Imaginechina)

Fourthly, highlighting the objective of upgrading community disaster prevention and reduction abilities, and implementing "three connections" such as "establishing a public security and defense system in connection with joint defense for public security, improving disaster governance and self-rescue abilities in connection with daily drills and establishing emergency rescue and refuge centers in connection with materials preparation".

The above four characteristics of "integrated disaster reduction demonstration communities" fully display China's action outline for implementing the integrated disaster reduction strategy and fully reflect the goal of the national integrated disaster reduction plan at the community level. However, in comparison to the three basic principles to be followed in constructing the community integrated disaster risk governance mode, the "integrated disaster reduction model community" mode fails to reflect the win–win ideology of "development and disaster reduction" and the goal of "combining disaster elimination and benefit promotion" or to realize the establishment of a structured and functioning system of regional integrated disaster risk governance. It also fails to re-construct the mode of "integrating development and disaster reduction" based on a communities economic and social development and adaptation to community resources and environment (Fig. 13.3).

13.3 Chinese Community Model of Integrated Natural Disaster Risk Governance

The United Nations held the Second World Disaster Reduction Conference in Kobe City of Hyogo, Japan from January 18 to January 22, 2005, and adopted the "Hyogo Framework for Action 2005–2015: Building the Resilience of Nations and Communities to Disasters", which stressed the necessity of building up resilience of nations and communities to disasters, determined various action measures in terms of strategy and system, and provided a platform for experience exchange among countries across the globe. The strategic objective established in this

Fig. 13.4 The reconstructed city hall of Greensburg (From Imagine China)

framework for action was: "The disaster risk reduction should be integrated into sustainable development policies, plans and actions. Emphasis should be given to disaster governance, reduction, preparation and reduction of vulnerabilities. Various disaster reduction organizations, mechanisms and abilities shall be developed and strengthened in various social circles, especially communities, to promote disaster reduction. Various measures for disaster reduction shall be organically applied to disaster areas, to improve and implement community emergency preparation, response measures as well as restoration and reconstruction plans." The actions as priorities are: "Ensure that disaster risk reduction is a national and local priority with a strong institutional basis for implementation. Identify, assess and monitor disaster risks and enhance early warnings. Through knowledge propaganda, innovation and education, cultivate risk reduction awareness in the society. Reduce underlying risk factors. Strengthen disaster preparation and conduct active response."

With regard to the UN strategic goals and action priorities in strengthening national and community disaster resistance abilities, drawing on the experience in the above case, according to the three basic principles to be followed for constructing the community integrated disaster risk governance mode, and with reference to the "sustainable development" principle in the restoration and reconstruction plan of Fort Green of Kansas, US, we have built the Chinese community model of integrated natural disaster risk governance—the "re-development mode" (Fig. 13.4).

13.3.1 Constructing the "Development and Disaster Reduction Integration" System

China shall integrate development and disaster reduction at the community level, i.e. to achieve the overall promotion in the following five aspects: Firstly, make efficient use of resources, substantially improve the environment and combine disaster elimination with benefit promotion. Secondly, avoid high risk areas, improve fortification levels and reduce community risks. Thirdly, build new

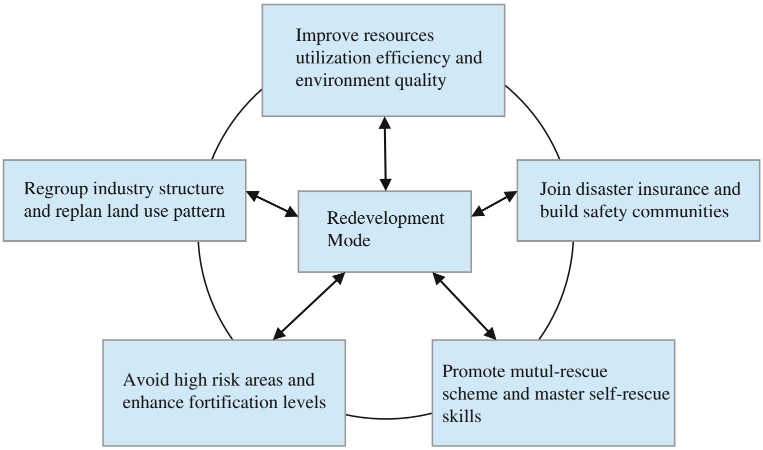

Fig. 13.5 Community "development and disaster reduction integration" system

industrial structures and reconstruct land use patterns, to adapt to community risk levels. Fourthly, participate in disaster insurance, build safe communities and ensure community development. Fifthly, improve mutual rescue organizations, grasp self-rescue skills and improve risk governance abilities (Fig. 13.5).

13.3.2 Construction of the "Integrated Disaster Prevention and Reduction" Systems

At the community level, the sound integrated disaster prevention and reduction systems need to be formed, i.e. to construct two systems by depending on two bases and implementing five actions.

The two bases are to fully rely on the rouses and environment carrying capacities as well as social and economic development levels. The five actions are to improve the community resource use effectiveness and to improve environmental quality, to restructure community industrial structures and to reconstruct community land use patterns, to strengthen community fortification levels and to improve the community's ability to cope with disaster risks, to improve mutual rescue and self-rescue systems and to establish safe communities and integrated risk governance systems.

The two systems are the community disaster prevention and reduction structural system integrating "safety and fortification, disaster rescue and relief, emergency management and risk transfer" and the disaster prevention and reduction functional system integrating "disaster preparation, emergency response as well as restoration and reconstruction" (Fig. 13.6).

Fig. 13.6 Integration of community integrated disaster prevention and reduction structure and function system

13.4 Conclusion and Discussion

We proposed the principle of "harmony between men and nature" and "integration of men and nature", the principle of regional sustainable development and the principle of regional disaster systems, which should be complied with in construction of a community integrated natural disaster risk governance. On the basis of analyzing the WHO "international safe community" and the "integrated disaster reduction demonstration community" by the China National Disaster Reduction Commission, this paper proposed the Chinese community model of integrated natural disaster risk governance—the "re-development mode", integrated the community "development and risk reduction integration" system with the "integrated disaster reduction" system, i.e. the community "development and risk reduction integration" system composed of "making efficient use of resources, substantially improving the environment, building new industrial structures, reconstructing land use patterns, participating in disaster insurance, building safe communities, avoiding high risk areas, improving fortification levels, improving mutual rescue organizations and grasping self-rescue skills", the community structural system of risk reduction and prevention formed by the integration of "safety fortification, disaster rescue and relief as well as risk transfer", and the community "integrated disaster reduction" system formed by the integration of community functional disaster reduction and prevention systems which are formed by the integration of "disaster preparation, emergency response as well as restoration and reconstruction".

The Chinese community integrated disaster risk governance mode we have proposed is based a large amount of experience in integrated disaster prevention and reduction and disaster risk governance community construction at home and abroad, which still needs to be improved in practice. Also, a large amount of comparative research on the community disaster prevention and reduction and risk governance mode is needed, to draw experience and lessons to expand and develop our mode with the guidance of the IHDP-IRG Project scientific plan.

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Appendix A
Proposal for Establishment of IHDP-IRG Project

A.1 Significance

The global change due to the natural and human dimensions and the influence thereof has been reflected in various aspects. The abnormal climatic phenomena occurring in different parts of the world in recent years have been a reflex of such influence, including Hurricane Katrina in the southern part of America, draught in Chongqing regions of Southwest China and frequent sand storm in Asia. As per the IPCC 4th Assessment Report, the impact of the global warm-up on mankind is not only extensive, but also very profound. These impacts thereof such as abnormal climate and frequent disaster weather are enough to cause huge risks over the sustainable development of mankind and the entire terrestrial life system (WMO and UNEP 2007). As per estimate, during the period of 1984–2003, the population influenced by the natural disasters exceeds 4 billion. The losses due to disasters during 1990–1999 exceed that during 1950–1959 by 15 times (World Bank 2006a). Increase of losses due to disasters is related to the socio-economic factors, but as per some observations, the exceptional climate change also becomes an important reason (Emanuel 2005). Therefore, it may be deemed that to discuss on the formation mechanism of different disaster risks due to the global change and search the appropriate countermeasures is of extremely important significance for deepening the understanding of the impact of global impact on mankind and for scientific design of the sustainable development model for different regions in the world.

A.1.1 Increase of Global Risks Due to Global Environmental Change

The global climate warm-up due to the natural and human activities has become a fact beyond dispute. No matter how much the natural or human dimensions contribute or if the trend of future change will continue or change in direction,

P. Shi et al. (eds.), *Integrated Risk Governance*, IHDP-Integrated Risk Governance Project Series, DOI: 10.1007/978-3-642-31641-8,

this basic fact of global environmental change attracts the governmental decision makers at all levels, manufacturers and scientists to start their high concern over the relation between global environmental change and disaster risks, especially the contribution of global warm-up to the increase of disaster risks.

In recent years, the increased frequency of exceptional weather and climate due to the global warm-up has intensified the disaster risks, as has been gradually demonstrated in the meteorological observation data from all over the world (Emanuel 2005). The IPCC 4th Assessment Report has also demonstrated further the increased frequency of exceptional weather and climate due to the climate warm-up, including the expansion of drought frequency and scope, increase of heavy rainfalls and increase for frequency of strong tropical cyclone in some of the regions (WMO and UNEP 2007).

The global climate warm-up not only leads to the frequent exceptional weather and climate, but also influences the normal operation of some infrastructures in world and increases the production accident risks. For instance, in some regions with a shortage of electricity, due to high temperature in summer, the electricity consumption of interior air-conditioning increases obviously, causing overload of power and damage to the power grid and leading to a series of production accidents. In recent years, this phenomenon is quite common in the vast eastern region of China, including the Zhujiang River Delta, Changjiang River Delta and Jing-Jin-Tang region. For another instance, the increase of heavy winter snowfalls in European region in recent years not only intensifies the traffic disaster risks, but also damages the power grid in some regions and impacts the normal power supply, resulting in the further expansion of disaster risks.

The global warm-up has also impacted the service capacity of the earth ecological system. As per primary observation results, the occurrence of recent large-scale infectious diseases such as SARS and bird's flue is closely related to the poor health status of the global ecological system, especially the damage to the diversity of bios. It also indicates that the global environmental change is in certain association with the risk increase in the world ecological system and population health.

As a conclusion of the above, the global environmental change is closely related to the increase of global risks. Proclaiming the formation mechanism and process of this association is of the extremely important value for stipulating IRG countermeasures as well as of very important role in deepened understanding of the impact of global change over the mankind.

A.1.2 The World-Wide Dissemination of Different Risks Due to Globalization is Being Strengthened

In recent years, in the process of global change, globalization is accelerated. The number of countries joining WTO increases continually. Especially since China with one fifth of the world's population joined WTO, globalization has obviously speeded up. As per guest and estimate, the market-based extent of China has reached over 73.8 %, while her GDP has shown an annual average growth of over 8 % over the last five years. China has become a country with the most prominent influence scale over the global economy and trade (Li 2006).

With globalization in progress, regionalization is also accelerated. The worldwide inter-country and inter-region economic, trading and governmental cooperation organizations have been continually enhanced, including “ASEAN Ten Countries”, “ASEAN Ten Countries + 1” and “ASEAN Ten Countries + 3”, APEC, EU, Alliance of America, Canada and Mexico, etc. Accelerated development and strengthened contact between these regionalized organizations has also enhanced the special dissemination and diffusion of different risk factors.

Due to different disaster insurances and re-insurance services established by some countries, the regions of influenced caused by disaster risks have been obviously expanded. For instance, such international re-insurance companies as Swiss Re-insurance Company and Munich Re-insurance Company have recently permitted successively to undertake re-insurance businesses in China, while some international insurance companies are also allowed to undertake insurance businesses in China. All these have transferred different risks of China to other countries of world through international insurance and re-insurance businesses. In the rapid development of China’s market economy, these international insurance and re-insurance companies have obtained shares in China’s insurance and re-insurance market as well as undertaken the liabilities of different risks from China.

The rapid development of Internet has not only accelerated economic and social globalization, but also initiated huge risks. For some governmental work systems and corporate and commercial systems depending on Internet, once Internet breaks down, it will cause serious impacts and even huge losses. For instance, at the end of 2006, the strong earthquake in the South Pacific caused a serious impact on the sea-bed optical cable through the South Pacific and suspended the internet of Mainland China and Taiwan with USA and other American countries for a period of three weeks. It has seriously impacted the exchange between governments the online businesses of enterprises and different academic and cultural activities, causing an estimated loss of billions of US dollars.

Besides, the accelerated development of globalization has also influenced to some extent the process of urbanization in countries and regions all over the world. In China, due to joining WTO, the industry-intensive regions with high dependence on the international market have speeded up the urbanization, such as the coastal regions with comparatively developed economy in Eastern China: regions like the Zhujiang River Delta, Changjiang River Delta and Jing-Jin-Tang region have all shown an obviously accelerated urbanization. Due to the promotion by WTO, the accelerated circulation of some important strategic goods and materials including energy and mineral resources like petrol in countries and regions all over the world has urged accelerated special dissemination of different risks and expanded of influence scope. Formation of the world’s high-risk regions is not only related to the frequent natural disaster factors in these regions, but also associated with the internationalization standard of these regions in their economic and social development (Dilley et al. 2005).

As indicated, as an important component of global change, globalization has been obviously accelerated in recent years due to the promotion of such economic and trade organizations like WTO. China and India with the biggest proportion of the world's population have become the important factors of accelerating the globalization. The accelerated development of globalization has enhanced obviously the special dissemination of different risks through cooperative approaches of trade, finance and technology (World Bank 2006b).

A.1.3 For the World's Sustainable Development, it is Required to Accelerate the Development of IRG Science and Technology

In the process of promoting the international disaster reduction, UN has convened two world disaster reduction conferences respectively in Japanese Yokohama (1994) and Kobe (2005) and issued the Yokohama Declaration and Kobe Declaration. The former declaration has a target to build a 21st century keeping the world safer, stress on mobilizing all mobilizable forces and promote the realization of UN-IDNDR. Based on the former strategy and action assessment, the latter declaration has further elaborated the relation between promotion of the world's sustainable development and reduction of disaster risks and called on all UN member countries to show high concern over the frequent occurrence and increase of different disaster risks possibly due to the global environmental change and tremendous obstacles for realizing the target of global sustainable development. It is hereby observed that the development of IRG science and technology plays an important role in realizing the world's sustainable development. In its thousand-year development target, UN has also taken it as an important measure to reduce the impact different disasters and raise the capacity of responding to different disaster risks.

Sixth IHDP Open Science Conference held at Bonn, Germany in 2005 has taken up the subject of global safety as its theme to discuss, in different dimensions, the policy, economic, social and technical approaches for the sustainable development and reduction of disaster risks. The International Disaster Reduction Conference held at Davos, Switzerland in 2006 has also taken it as its major subject to promote the regional sustainable development and reduction of disaster risks and has especially stressed on the recovery and rebuilding of the ecological system as the national and regional important infrastructures for construction so as to relax, in a macro scale, the aggravation of different disaster risks and reduce the frequency of disaster risks. To realize the strategy of disaster reduction and sustainable development, UNISDR (United Nations International Strategy for Disaster Reduction) states clearly that it is necessary to establish the social system with coexistence of risks and emphasizes to start with raising the capacity of communities for risk resistance and to promote the regional sustainable development (UNISDR 2004).

Meanwhile, from UNISDR, it is observed that through some typical regional integrated disaster risk governance cases, it can also realize the regional sustainable development model for regional development and disaster risk reduction (UNISDR 2005). As for the developing countries, it is extremely important to stress on development and strengthen IRG. Due to the influence of global environmental change, especially the influence of global warm-up, some developing countries on small islands and coastal areas have higher vulnerability for disaster risks that they have weak capacity of recovering from and adapting the disaster recovery and consequently undertake more serious risks of global environmental change. Therefore, the ability to develop the IRG work in these regions appears to be extremely important.

According to some research workers, the financial and insurance approaches can be taken to reduce different risks, especially disaster risks in the regions of the kind (Linnerooth-Bayer et al. 2005). Additionally, by strengthening the integrated risk management, it is of an important guiding role for the regions to establish the development model adapting different risks. The "three-base fish pond" for land utilization developed in the Zhujiang River Delta of China has played an important role in relaxing the flood and drought disasters in the region. The land utilization model of terrace and silted land dyke in China's loess plateau has also played an important role in reducing the soil erosion and drought risks in the region (Shi 2003).

As indicated above, the establishment of regional sustainable development model and promotion for the world's sustainable development not only requires for IRG, but also in the process of strengthening IRG is beneficial to optimize the regional land utilization pattern and industrial structure for formation of regional production, livelihood and ecological system so as to raise the global and regional and local-dimension capacity of adapting the global environmental change.

A.2 Major Targets and Key Scientific and Technological Issues

In view of the core scientific program established by IHDP, with consideration of IHDP, WCRP and DIVERSITAS and the core scientific programs of relevant researches established by ESSP, in view of the striving target defined in UNISDR and with reference to some major scientific, technical and managerial issues concerned recently by the organizations related to the study of relevant risk problems, the core scientific program has planned the major target in the following three dimensions starting from the overall target of IHDP. This overall target needs to be further defined with several discussions of experts.

A.2.1 In View of the Multi-Discipline Integration Analysis, Deepen the Understanding of Risk Formation Mechanism and Dissemination Behavior Under the Background of Global Environmental Change

Under the integral motivation of mankind and nature, the complexity of global environmental change has been increasingly known to the mankind, including the gradual change of global environment like global warm-up, emergent events such as exceptional weather and climate events and a series of disaster risk events arising thereof (flood, landslide, mud-rock flow, infectious bio disaster risk events). Because the human factors in the process of global environmental change become increasingly complex and enhanced in strength, the formation mechanism of different disaster risks arising thereof also tends to be complex. In view of the above, the core science program must take the multi-discipline integration analysis to deepen the understanding of risk formation mechanism under the background of global environmental change and dissemination behavior in the globalization system. In this regard, it is planned to undertake the profound studies in the following aspects.

- Mutual function of mankind and nature and formation mechanism of disaster risks under the global opening system
- Development trend of the world's disaster risks and the changing trend of its space-time pattern under the background of global warm-up
- Predictability of global environmental change and space-time change of natural disaster risks
- Predictability of global environmental change and space-time change of ecological disaster risks
- Globalization and global dissemination and diffusion mechanism of disaster risks
- Feedback mechanism for impacts of tremendous disaster events on the regional and even global environment
- Disaster risk assessment model system in line with the different space-time dimensions and formation mechanism
- Integrated disaster risk simulation analog tool in line with different situations (different space-time dimension, difference in formation mechanism, vulnerability of objects suffering the disasters and prominent difference in recovery, different political and economic systems of the regions with disaster risks, etc).

A.2.2 In View of the Discipline Crisscross (Natural Sciences, Social Sciences and Human Sciences and Technology), Deepen the Understanding and Raise the Capacity of Human Society to Adapt the Global Environmental Change

Due to the coexistence of the current different risks and human development in the world, it is impossible and is not scientific to try to eliminate fundamentally the risks. As long as mankind exists, there will be accordingly risks. However, the mankind can relax the influence of risks by different means and by raising the capacity of adapting the risks.

The design of risk governance system is the most common measure to raise the capacity of mankind to adapt risks. The technological progress not only plays an important role in deepening the understanding the risk formation and especially raising the capacity for supervision and forecast of disaster risks, but also plays a promoting role in reducing the influence of risks and raising the capacity of mankind to adapt the risks.

Economic development is not only the source of different risks, but also the fundamental force to improve and reduce the influence of risks. Adjustment of the economic structure and development speed and scale can, on the one hand, reduce the frequency of risks as well as their influence and on the other hand can raise the capacity of adapting the risks. Meanwhile, adoption of different financial means such insurance and re-insurance can also transfer the risks worldwide. The total loss arising thereof is not reduced, but the pressure on the influenced enterprises for recovery and rebuilding can be relaxed to a great extent. From the viewpoint of economics, it provides a new approach to undertake and operate the "ventures".

Strengthening the governance consciousness of different risks and undertaking risk management education is of important value in reducing the influence of risks on mankind, adapting the risks and building the safety cultural system in coexistence with risks (Morioka 2007). Therefore, the research can be deepened in the following dimensions:

- System design adapting different risks under the global environmental change
- Technology of reducing risks with different space-time dimensions and different reasons for formation
- Safety building of enterprises and communities and integrated risk management system
- Financial system and mechanism of promoting huge risk insurance and re-insurance
- Trans-system design and technology development for improving the global-dimension huge disaster emergency and salvage system.
- Financial salvage mechanism for improving the construction of IRG infrastructures for high-risk regions

- Organization mechanism for promoting and improving the volunteer system for huge disaster emergency response
- Construction mechanism for promoting and improving the public financial support system of risk education.

A.2.3 *In View of Research to Practice, Improve as a Whole the IRG Model for Reducing the Risk Influence and Promoting the World's Sustainable Development*

The building of IRG model not only needs the aforementioned scientific research on the risk issues under the global environmental change and the technology development for risk governance and design of different systems, but also more importantly the way to put into practice the mutual function mechanism of global environmental change and risks and technology and policy achievement for risk governance.

At the World Disaster Reduction Conference held in 2005 at Kobe, Japan, scientists and technological experts from different countries all over the world all held in esteem to put the research achievements of disaster reduction into the practice of disaster reduction (UNISDR 2007). As for reduction of different risks due to the global change, it is not only required to deepen the understanding of the formation mechanism and dissemination behavior and to raise the capacity of reducing and adapting risks, but more importantly collect the successful experiences in different countries and promote energetically the same in the regions suitable for such promotion. As indicated in the available practice and experiences, establishment of IRG information-sharing platform plays an important role in risk governance. DRH-Asia (Disaster Reduction Hyperbase-Asia) promoted by Japan has obtained a prominent progress in this aspect. By selecting some practical technologies for disaster reduction and risk governance, it has promoted the promotion and extensive application of these technologies through the information-sharing platform (Kameda 2006). Meanwhile, since SARS broke out in 2003, China has also been strengthening the building of the information-sharing platform for integrated risk management and emergent response. The completed public health information platform and disaster reduction information platform have played a better role in risk prevention.

The regional sustainable development IRG model integrated of regional development and disaster reduction has also to some extent promoted energetically the integration and application of the available risk governance policies and technologies: e.g., China's regional demo project for preventing and controlling the wind-sand disaster risks and China's demo project for preventing and controlling the landslide and mud-rock flow disaster risks. Countries like Japan and Turkey have established the building demo projects for preventing and controlling the earthquake disaster.

Additionally, the huge disaster insurance projects developed in recent years have also energetically promoted the construction of capacity for reducing risks:

e.g., the flood insurance project developed by America in the flooded areas, the bond scheme for huge disaster governance advocated by Swiss Re-insurance Company and the "climate index insurance scheme" advocated by Munich Re-insurance Company. Therefore, it is intended to carry out the in-depth studies in the following aspects.

Construction of information service platform for preventing the risks due to the global environmental change

Standard system suitable for different countries and regions to prevent different risks

Global-dimension model for sustainable development and IRG

Classification of high-risk regions and integrated model for risk governance

Financial and insurance model and demonstration for huge disaster risk governance

Comparison of community IRG models under different cultural backgrounds (collection, promotion and application of local experiences for traditional risk governance)

Aid model of risk governance for weak regions to risks arising from the global environmental change

Adapting model for island countries to prevent the global warm-up risks.

A.2.4 Key Scientific, Technological and Managerial Issues for Realizing the Major Targets of IHDP-IRG Core Science Program

For the purpose of realizing the major targets of aforementioned IHDP-IRG core science program, the prior concern and arrangement should be given to the scientific, technological and managerial issues:

How to measure the integrated risk problems on the premise of global environmental change: i.e., the improvement of theories and methodologies for integrated risk measurement

How to probe the system design problem for IRG under the background of globalization: building of the legal system and administrative system for IRG

Formation mechanism (dynamics) for integrated risks under the background of global change and the theory and technology for its model and analog: i.e., risk dynamics and its model and analog

IRG model and its promotion and application for the high-risk regions under the background of globalization: i.e., selection, promotion and application of typical successful cases of IRG

Construction of information-sharing platform for global, regional and local-dimension integrated risks under the multi-lingual and cultural environment and building of the integrated risk information and effective technical service system: i.e., integration of risk information and capacity building for public and commercialized services

Global-dimension promotion of sustainable development and building of IRG model: i.e., build the demo regions integrated with sustainable development and IRG adapting the global environmental change.

A.3 Available Work Bases

There are certain available bases for undertaking the scientific researches and technical development of global environmental change and IRG. In addition to the seven available science programs already established by IHDP Scientific Committee that can be taken as reference, some relevant activities developed by some relevant international organizations and regional academic organization can also provide supports to the said core science program and participation in the core science program is also possible. Chinese National Committee for IHDP (CNC-IHDP) has already established CNC-IHDP-RG. All these have laid certain base for establishment of IHDP-IRG Core Program.

A.3.1 The Implementation System of UNISDR Attaches High Attention to Promote the World's Sustainable Development Through Disaster Reduction and Risk Management

UN International Decade for National Disaster Reduction (IDNDR) launched the International Strategy for Disaster Reduction, with the aim to build the disaster-resistant society by regarding it as the important component of sustainable development to raise the consciousness of disaster reduction and accordingly reduce the factors of natural disasters and the human, social, economic and environmental losses due to the relevant technical and environmental factors.

Therefore, the World Disaster Reduction Conference held at Kobe, Japan from January 17–22, 2005 issued the Kobe Declaration upon completing the execution assessment of Yokohama Strategy and Plan of Action for a safer world and adopted the new strategic plan: i.e., Hyogo Framework for Action 2005–2015: Building the Resilience of Nations and Communities to Disaster (HFA), specifying to associate the disaster reduction and IRG closely with the sustainable development and contribute to the thousand-year target proposed by UN. UN-HFA has laid a strategic foundation for IHDP-IRG Core Scientific Research Plan (UNISDR 2005).

A.3.2 Some International Organizations and Institutions Attach High Attention to the Disaster Deduction and Risk Management and Carried Out Scientific and Technical Preparation for Establishment of IHDP-IRG Core Science Plan

Giving attention to risks has become one important public behavior and commercial activity in the society today. Therefore, since the last 1980s, when the world-wide studies on global environmental change started, people have started to care for the risk prevention and transfer, while the academic circle has attached high attention to the conventional environmental and health risk studies, protection of ecological system health and management of integrated disaster risks.

The earliest academic institution related to the risk management is the Risk Management Association (RMA) founded in 1914, with its headquarters located in Philadelphia, USA, with the aim to provide commercial services based on the principle of risk sources. It has now over 3,000 institutional members and over 17,000 professional risk management staffs. In addition to the local office in USA, it has also established branches in Hong Kong, Singapore, Melbourne, Sydney and London (RMA 2007). Secondly, Society for Risk Analysis (SRA) was founded in 1980 with the aim to raise the risk analysis technology and the application knowledge and understanding capacity. In addition to its head office in Washington of USA, the Society has established branches in Europe and Japan (SRA 2007). The Society is of important influence world-wide. Its 25 year International Journal of Risk Analysis leads the future of the risk analysis. The third important international institution is the International Risk Governance Council (IRGC) founded in 2003 at Geneva, Switzerland. The main target of the Council is to improve the global and systematic risk governance measures. In 2005, it officially published the white paper of risk governance, introducing a complete new system for risk classification: i.e., simple risk, complicated risk, indefinite risk and unspecified risk (IRGC 2007).

In addition to the aforementioned three international institutions, World Bank also attaches great attention to the studies on risks and has organized successively experts from different countries and regions in completing a number of very influential books on risk governance (World Bank 2007): e.g., High-risk Region of Natural Disasters—Global Risk Analysis (Dilley et al. 2005), Establishment of Safe Cities—Future of Disaster Risks (Kreimer et al. 2003), Risk Management of Developing Countries (Claessens 1993), Management of Disaster Risks in Emergency Economy (Kreimer and Arnold 2000) and Manage Huge Disaster Risks by Applying Risk Financial and Fund Insurance Means (Pollner 2001).

OECD has also given special attention to the influence of huge disasters on the financial and commercial activities and advocated the commercial activities of insurance and re-insurance for huge disasters (OECD 2007). OECD has established the Committee of Senior Experts for Huge Disaster Risks and will hold in Indian Hyderabad the Seminar on Financial Management of Huge Disasters, probing the new approaches for global transfer of huge disaster risks from February 26–27, 2007 (OECD 2007). Six sessions of Forum on Integrated Disaster Risks jointly sponsored and organized by IIASA—DPRI have been held up to now, with the aim to undertake the comprehensive analysis on different disaster risks and discuss on the effective methods to manage the integrated disaster risks (Shi et al. 2006a).

Additionally, all the established core science programs IGBP, IHDP, WCRP, DIVERSITAS and ESSP have been involved, to different extents, in the risk governance, especially the studies on the governance of natural disasters and ecological and environmental disaster risks.

A.3.3 IRG Studies in China

With SARS breaking out in 2003, the Chinese Government has attached great importance to the emergency management of the public security and has greatly raised the concerns on prevention of different risks accordingly. In terms of the institution building, introduction of different related planning and plans, science, education and culture, it has accelerated the governance of different risks, especially showing the high attention to the governance over the possible public safety problems arising from the global environmental change. In view of the public safety problems arising from different risks in China, the Chinese Government has classified the public safety problems into four major categories: natural disaster, production accident, public sanitation and social order and has integrated the prevention of different risks and sustainable development closely in the national "11th Five-year Plan" and increased the governance studies on different risks to a great extent in the development plan for science and technology, attaching special attention the comprehensive studies on risks possibly arising from the global environmental change (MOST 2007).

In 2005, the Chinese Government promulgated the emergency program for the central government, its departments, local governments and large state-owned enterprises (Xinhua News Agency 2007). The national meteorological planning has also stressed especially to attach attention to the global climate change and reduce the meteorological and climate disasters and raise the national capacity of defending meteorological disaster risks (China Meteorological Administration 2007). The National Disaster Reduction Committee has not only emphasized on the comprehensive defense of different natural disasters but also compiled especially the National 11th Five-year Year Comprehensive Disaster Reduction Planning (National Disaster Reduction Center of Ministry of Civil Affairs of China 2007). The State Council Emergency Office and State Development and Reform Commission have jointly organized the compilation of National 11th Five-year Planning for Emergency System Construction of Public Events.

Meanwhile, the Chinese Government has attached great importance to the IHDP activities and has established officially CNC-IHDP in 2005 which has successively set up seven core work groups. CNC-IHDP-RG is one of these core work groups. Since its establishment, the group has not only completed China Risk Management Study Report (CNC-IHDP 2007), but also assisted in organizing several international seminars. By publishing a number of research achievements, the members of CNC-IHDP-RG have played an active role in promoting the Chinese government, enterprises, communities and public to attach attention on the global environmental change and reduce the influence of different disaster risks (Liu et al. 2005; Shi et al. 2006a, b). With the support of Ministry of Science and Technology, PRC, China National 11th Five-year Science and Technology Support Program—IRG Key Technology Study and Governance undertaken by the main institutional members of CNC-IHDP-RG was officially actuated. Nearly research fellows from Ministry of Civil Affairs, China Insurance Regulatory Commission and other research universities and institutions have participated in the program. China Insurance Regulatory Commission have also published China Risk Governance Report (Wu 2006).

To sum up the above, under the guidance of IHDP Scientific Committee, a fine foundation has been laid for establishment of Core Science Program for global environmental change and IRG research and development. With the extensive discussions by relevant experts, it is completely feasible as well as possible to stipulate a core science program leading the world's global environmental change and IRG. However, we must be aware that the relevant international organizations and institutions have undertaken a large number of researches on risk governance and disaster reduction, but it is just a start to really integrate close the global environmental change and IRG and carry out the in-depth studies on such frontier academic issues as weakness/recovery capacity, threshold value/transformation, management and learning/application in view of carrying out UN's thousand-year development target and implementation of the world-wide strategy for sustainable development. Only based on the completed works and by organizing the extensive discussions of experts interested in this field and under the guidance of IHDP Scientific Committee can we possibly complete the compilation of IHDP—IRG Core Science Plan. Nevertheless, we think that it is ready and inevitable to complete this task.

A.4 Preliminary Work and Time Table

A.4.1 Preliminary Work

1. In 2005, the newly established CNC-IHDP-RG started to discuss on how to develop one IHDP-IRG Core Science Plan. Upon careful discussion, CNC-IHDP-RG formulated a primary program which it deems necessary to submit to CNC-IHDP.

2. On the occasion of IHDP China Regional Workshop organized CNC-IHDP in Beijing from the first ten days of November 5–7, 2006, Professor Quansheng Ge, secretariat of CNC-IHDP submitted officially to Professor Oran R Young Chairman of IHDP Scientific Committee the proposal for establishing the IHDP-IRG Core Science Program. At IHDP China Regional Workshop, Professor Peijun Shi, team leader of CNC-IHDP-RG introduced about the assumption for establishment of the Core Science Program. Afterwards, taking the advantage of ESSP Open Science Conference held in Beijing October 9–12, 2006, Professor Peijun Shi held further discussion with Oran R. Young Chairman of IHDP Scientific Committee. Professor Oran R. Young, Chairman of IHDP Scientific Committee gave important guidance and specified that the setup of the Core Science Program should prominently reflect the relation between the global environmental change and risk governance and should be obviously different from the current core science programs, showing characteristic and multi-discipline involvement and reflect the contribution made to the realization of UN Thousand-Year Objective. It is required to submit a proposal for establishment of the said Core Science Program at the conference of IHDP Scientific Committee to be held in Brazil from March 15–18, 2007.
3. From November 2006 to January 2007, Professor Peijun Shi, team leader of CNC-IHDP-RG communicate with several international experts with various experts in the field. In November 2006, at the ESSP Beijing Meeting, he held detailed discussion with Professor Roger Kasperson from America Clark University. In his opinion, to establish the Core Science Program, it is to focus especially on the integrated governance of environmental risks, reflect thoroughly the crisscross of multiple disciplines, undertake the in-depth study on global environmental change and IRG in the field of risk science, technology and management and absorb different experiences to form an IHDP—IRG Core Science Program. During the period from February 13–14, 2007, at International Seminar on Risk and Sustainable Development Education held in Osaka (Japan), Professor Peijun Shi also held detailed discussions with Professor Norio Okada from Hazard Resistance Institute of Kyoto University and Professor Tohru Morioka of Osaka University, stating that it is extremely important to set up the International Core Science Program under IHDP and proposing for special attention to the theoretical and practice combination in the integrated risk studies, emphasis on service to UN's sustainable development target and stress on its capacity building, especially the education promotion for risk management. At the conference in Japan, Professor Peijun Shi held discussions with Professor Shoji Tsuchida, President of SRA Japan and Japanese Kansai University, David M. Hassenzahl, Chairman of SRA Education Committee and Professor of University of Nevada (USA), Professor Rosalyn Mckeown, Director of Geographical and Environmental Education Center of University of Tennessee (USA), Professor John Watt, Director of Decision Analysis and Risk Management Center of British Middlesex University and Professor Dongchun Shin, Director of Environmental Study Center of South Korean Yonsei University. They unanimously viewed

that strengthening the study on global environmental change and IRG is beneficial to promote the realization of UN Millennium Development Goals and stressed to strengthen the multi-discipline study, focus on resolving different disaster risks arising from global warm-up that the world is facing today, enhance the education on environment and disaster risks and promote the world-wide sustainable development. The discussion concluded also that SRA Japan and Beijing Normal University will jointly convene Asian Risk Assessment and Management Seminar founded in 1998 (which is held every two years: the first seminar was held at Beijing Normal University, China, in 1998, the second at Kobe University, Japan, the third at South Korean National Environment Institute and the fourth to be held at Beijing Normal University, China, in August 2008), with the subject of global environmental change and Asian IRG. During this period, CNC-IHDP-RG communicated through letters with Joanne Linnerooth-Bayer and Aniello Amendola, the experts of IIASA-Integrated Risk Research Group set up in Austria. The two experts have both expressed their support to this program and also suggested to especially stress on disaster risk of different disaster weathers and climates possibly arising from the global environmental change so as to probe the approaches of utilizing the financial and commercial insurance and strengthen the governance of huge disasters. Letters were written to Professor Ben Wisner working at American Oberlin Institute, who has also expressed his support to the establishment of the program and stressed on IRG and risk education of weak schools.

4. For the proposal for establishment of IHDP—IRG Core Science Program to submitted by CNC-IHDP-RG at the end of February 2007, the secretariat of CNC-IHDP organized some members of CNC-IHDP Senior Science Advisor Committee for discussion, who have expressed full support to the establishment of the Core Science Program and put forward a series of suggestions for modification. Based on this, CNC-IHDP-RG made further revision and improvement and formed the proposal for Establishment of IHDP-IRG Core Science Program to be submitted to IHDP Scientific Committee to be held in Brazil from March 15–18, 2007.

A.4.2 The Schedule for Further Work

1. Attend Brazil Conference of IHDP Scientific Committee (March 15–18, 2007) and request for views from IHDP Scientific Committee and its acceptance so as to undertake the further action.
2. Formulate the time schedule for “IHDP-IRG Core Science Program”

   (a) In June 2007, convene in Beijing the first international seminar on IHDP-IRG Core Science Program (the planned experts for participation: 25–30 persons, including about 10 foreign experts and experts of CNC-IHDP-RG); the meeting will be for two days to make the first draft of IHDP-IRG Core Science Program.

(b) During the period from July to August 2007, the network is used to obtain extensively the views from relevant experts to improve further the first draft of IHDP-IRG Core Science Program and form the second draft of IHDP-IRG Core Science Program.
(c) In August 2007, on the occasion of International Disaster Reduction Conference to be held in Ha'erbin, China (August 21–25, 2007), organize a special seminar on integrated risk management, at which it is to further discuss and revise the second draft and form the third draft of IHDP-IRG Core Science Program.
(d) In September 2007, on the occasion of the Seventh IIASA—DPRI Seminar to be held in Italy (September 19–21, 2007), organize a special seminar on integrated risk management, at which it is to further discuss and revise the third draft and form the fourth draft of IHDP-IRG Core Science Program.
(e) At the second international seminar on IHDP-IRG Core Program to be held in Beijing in December 2007, improve further the fourth draft of IHDP-IRG Core Science Program and form the fifth draft of IHDP-IRG Core Science Program.
(f) In January 2008, submit the program to 2008 Conference of IHDP Scientific Committee for review and approval and expect to announce the launch of the Core Science Program.

A.4.3 Financial Solutions for Establishment of IHDP-IRG Core Science Program

1. In the early, the payment will be mainly from China National "11th Five-year" Science and Technology Support Program – "IRG Key Technology Study and Governance" undertaken by the main institutional members of CNC-IHDP-RG will undertake the expenses for.
2. During the period for formation of IHDP-IRG Core Science Program, in addition to the support from the aforementioned project, application will be made to the secretariat of CNC-IHDP for certain support.
3. Once IHDP Scientific Committee approves the application for establishment of IHDP-IRG Core Science Program, application will be made to Ministry of Science and Technology, PRC for steady support for the implementation of the Core Science Program through the support to CNC-IHDP in the name of international cooperation project. Therefore, it is suggested that the execution office of the program will be set up at CNC-IHDP and undertaken by Beijing Normal University, superior unit of CNC-IHDP-RG, which provides the office for the implementation of the program and salaries and relevant welfares for 2 or 3 international management staffs. The particular execution can be done by Disaster Reduction and Emergency Management Institute of Ministry of Civil Affairs and Ministry of Education set up in Beijing Normal University.

A.5 Drafting Committee List of IHDP—IRG Suggestion

A.5.1 Scientific Advisers of Drafting

Honglie Sun Academician of Chinese Academy of Science, Chairman of CNC-IHDP advisory committee. **CHINA**

Dadao Lu Academician of Chinese Academy of Science, administrative commissioner of the CNC-IHDP. **CHINA**

Yanhua Liu Academician of Asia-Eurpe Academy of Science, Chairman of CNC-IHDP.**CHINA**

Roger Kasperson Academician of America Academy of Science, Life Professor of Clark University.**USA**

Norio Okada Director of Disaster Prevention Research Institute, Kyoto University. **Japan**

A.5.2 Drafting Committee

Chairmen

Peijun Shi Administrative commissioner of CNC-IHDP, leader of the CNC-IHDP-RG Workgroup; Vice dean of Academy of Disaster Reduction and Emergency Management, China; Vice President, Professor of Beijing Normal University. **CHINA**

Members

Quansheng Ge Administrative commissioner and secretary general of CNC-IHDP; Director and researcher of Institute of Geographical Science and Natural Resources Research, Chinese Academy of Science. **CHINA**

Xiubin Li Vice leader of CNC-IHDP-RG committee; Vice director and researcher of Institute of Geographical Science and Natural Resources Research, Chinese Academy of Science. **CHINA**

Ming Zou Vice leader of CNC-IHDP-RG committee; Administrative vice-director and Professor of National Disaster Reduction Committee Center, the Ministry of Civil Affairs of the P. R. **CHINA**

Chongfu Huang Member of CNC-IHDP-RG; Director of the Risk Analysis Council of China Association for Disaster Prevention. **CHINA**

Qinghai Yao	Member of CNC-IHDP-RG; Chief of Department of Agency Management Institution, China Insurance Regulatory Commission. **CHINA**
Xiulan Zhang	Member of CNC-IHDP-RG; Director and Professor, Institute of Social Development and Public Relationship, Beijing Normal University. **CHINA**
Ning Li	Member of CNC-IHDP-RG; Vice-director of Risk Research Center, SwissRe-BNU, Associate Professor, Institute of Disaster and Public Security, Beijing Normal University. **CHINA**
Jing'ai Wang	Professor, School of Geography, Beijing Normal University.
Jianjun Wu	Secretary General of the CNC-IHDP-RG; Associate Professor, Institute of Disaster and Public Security, Beijing Normal University. **CHINA**

A.5.3 Experts in Discussion or in Suggestion Via Internet

Linnerooth-Bayer,J	Professor, Leader of IIASA Risk and Vulnerability Group. **AUSTRIA**
Shoji Tsuchida	Professor, Director of EAMT, Osaka University, **Japan**
Johru Morioka	Professor, President of the Society for Risk Analysis Japan-Section, Kansai University. **JAPAN**
David M. Hassenzahl	Associate Professor, Chair, Department of Environmental Stndies Greenspum College of Urban Affairs, University of Nevada, Las-Vegas. **USA** Chair, Education Commission, Society of Risk Analysis, **USA**
John Watt	Professor, Director of Center for Decision Analysis and Risk Management, Middlesex University. **UK**
Dongchun Shin	Professor and Chair, Department of Preventive Medicine and Public Health College of Medicine, Institute for Environment Research, Yonsei University. **KOREA**
Guoyi Han	Research Associate, Stockholm Environment Institute. **SWEDEN**
Gopalakrishnan Chennal	Professor, Department of Natural Resources and Environmental Management, University of Hawaii at Manoa. **USA**
Ben Wisner	Professor, Oberlin Colleg. **USA**

Appendix B
International Human Dimensions Programme on Global Environmental Change (IHDP)

International Human Dimensions Programme on Global Environmental Change (IHDP) is one of the four major programmes of Earth Science System Partnership (ESSP). IHDP is an interdiscipline and non-governmental international science programme, with the aim to promote and jointly coordinate in studies on the issue of global change. IHDP was first sponsored by the International Social Science Council (ISSC) in 1990, as "Human Dimensions Programme (HDP). In February 1996, International Council of Scientific Unions (ICSU) and ISSC became the cosponsors of the programmed of which the name was changed from HDP to IHDP, with its secretariat set up in Bonn, Germany. IHDP consists of five major plates: Secretariat, Scientific Committees, Core Science Project and Cooperative Core Science Project, National Committees and Information-sharing Platform. The firmer chair of IHDP Scientific Committee was Professor Oran Young of USA University of California, Santa Barbara and the current chair is Professor Sir Partha Dasgupta of UK Cambridge University; the former executive director of IHDP was Professor Andreas Rechkemmer and the current executive director is Anantha Kumar Duraiappah. The 8 science projects in process include: Earth System Governance (ESG), Global Land Project (GLP), Integrated History and Future of the People on Earth (IHOPE), Integrated Risk Governance (IRG), Industrial Transformation (IHDP-IT), Land-Ocean Interaction in the Coastal Zone (LOICZ), Urbanization and Global Environmental Change (UGEC) and Knowledge Learning and Social Change (KLSC); the 4 cooperative science projects in process include Global Carbon Project (GCP), Global Environmental Change and Food Security (GECAFS), Global Environmental Change and Human Health (GECHH) and Global Water System Project (GWSP); the three science projects completed include Global Environmental Change and Human Security (GECHS), Institutional Dimensions of Global Environmental Change (IDGEC) and Land-Use and Land-Cover Change (LUCC) (organized jointly with IGBP).

P. Shi et al. (eds.), *Integrated Risk Governance*, IHDP-Integrated Risk Governance Project Series, DOI: 10.1007/978-3-642-31641-8,

Website of IHDP: http://www.ihdp.unu.edu

IHDP
International Human Dimensions Programme
on Global Environmental Change

Appendix C
Chinese National Committee for the International Human Dimensions Programme on Global Environmental Change (IHDP)

Chinese National Committee for the International Human Dimensions Programme on Global Environmental Change (CNC-IHDP) was founded in 2004 upon approval of the China Association for Science and Technology (CAST) and Ministry of Science and Technology of PRC, with Professor Yanhua Liu (then acting as the Vice Minister of Science and Technology) elected as its first chair, Academician Honglie Sun appointed as the first chair of its Consultative Committee and Research-fellow Quansheng Ge as its first Secretary-General.

CNC-IHDP sets up Secretariat and 8 branches: working groups of International Transformation, Global Environmental Change and Human Security (GECEH), Urbanization Project (UP), Risk Governance (RG), Land-Ocean Interactions in the Coastal Zone (LOICZ) and Land Change Science (LCS) and information Center for Global Environmental Change Studies. CNC-IHDP Secretariat is set up at Institute of Geographical Sciences and Natural Resources Research, Chinese Academy of Sciences. Through academic exchange platform and network service capacity building, CNC-IHDP organizes Chinese research force of national human dimensions on global environment change to activley participate in IHDP academic exchange and research of core science projects and strives to make contributions to the field of sustainable development and the development of earth system sciences. Additionally, CNC-IHDP actively participates different academic activities of IHDP so as to internationalization of Chinese human dimensions research on global environmental change and represent the research characteristics of China as well as to make contributions to the research on global environmental change.

Website of CNC-IHDP: http://www.ihdp-cnc.cn

P. Shi et al. (eds.), *Integrated Risk Governance*, IHDP-Integrated Risk Governance Project Series, DOI: 10.1007/978-3-642-31641-8,

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CMA (China Meteorological Administration): http://www.cma.gov.cn.

CNC-IHDP: http://www.ihdp-cnc.cn.

DIVERSITAS: http://www.diversitas.org.

DRH: http://www.mext.go.jp.

ESSP: http://www.essp.org.

IGBP: http://www.igbp.kva.se.
IHDP: http://www.ihdp.uni-bonn.de.
IRGC: http://www.
MOST (The Ministry of Science and Technology of the People's Republic of China): http://www.most.gov.cn.
OECD: http://www.oecd.org.
RMA: http://www.
SRA: http://www.sra.org.
UNISDR: http://www.unisdr.org.
WCRP: http://www.wcrp.wmo.int.
World Bank: http://www.worldbank.org.
Xinhua Net: http://www.xinhuanet.com.

Postscript

With the efforts of nearly five years made by Chinese and foreign scientists, International Human Dimensions Programme on Global Environmental Change—Integrated Risk Governance Project (IHDP-IRG) was eventually declared for kick-off on the third National Disaster Prevention and Reduction Day of China. Executive Director of IHDP, Professor Anantha Kumar Duraiappah, and Counselor of the State Council of PRC, Chair of Chinese National Committee for International Human Dimensions Programme on Global Environmental Change (CNC-IHDP), form Vice Minister of Science and Technology of PRC and Professor of Institute of Geographical Sciences and Natural Resources Research, Chinese Academy of Sciences Yanhua Liu delivered enthusiastic speeches at the kick-off meeting of IHDP-IRG Project. The co-chairmen of the project, Professor Peijun Shi of China Beijing Normal University and Professor Carlo Jaeger of German Potsdam Institute for Climate Impact Research respectively chaired the kick-off meeting of the core science project introduced about the major parts of IHDP-IRG Project. From this day, the one-decade catastrophe risk research on global environmental change started for worldwide. The execution of the science project is not only to find out the answers on learning and discussing how to handle the risk exceeding the current response capacity, but also to lay a solid theoretical foundations for establishing and development disaster risk science.

To present the primary achievements made in the preparatory work of the science project over the last five years, upon obtaining the consent from Professor Anantha Kumar Duraiappah, Executive Director IHDP Secretariat, IHDP-IRG Project Office officially published IHDP-IRG Science Project in the series collections of IHDP-IRG. In the meanwhile, the current volume of the collections also includes the primary achievements of the integrated catastrophe governance studies by the relevant experts of China Beijing Normal University and German Potsdam Institute for Climate Impact Research, according to the primary framework of IHDP-IRG Science Project, during the course of drafting and revising

P. Shi et al. (eds.), *Integrated Risk Governance*, IHDP-Integrated Risk Governance Project Series, DOI: 10.1007/978-3-642-31641-8,

IHDP-IRG Science Project. Furthermore, in order to record the proposals the Integrated Risk Governance Science Project (IRG) in IHDP made by the Working Group of Risk Governance (RG) for CNC-IHDP (CNC-IHDP-RG) at the ESSP Opening Conference held in Beijing in October 2006, the volume also includes the project proposal for setting up IHDP-IRG Project presented by CNC-IHDP-RG to the meeting of IHDP Scientific Committee held in Brazil in March 2007.

IHDP-IRG Science Project has been set up with great support, guidance and assistance from various institutions and experts. IHDP Secretariat at Bonn, Germany has provided systematic guidance and assistance for completion of IHDP-IRG Science Project Plan. International Cooperation Department of Ministry of Science and Technology of PRC, Earth Science Department of National Natural Science Foundation of China, China Beijing Normal University and German Potsdam Institute for Climate Impact Research has provided the precious financial sponsorship for completion of IHDP-IRG Science Project Plan; Professor Oran Young of USA University of California, Santa Barbara (former Chairman of IHDP Scientific Committee), Professor Andreas Rechkemmer of German University of Cologne (former executive director of IHDP Secretariat), Mr. Falk Schmidt (former director IHDP Secretariat Core Science Projects), Professor Anantha Kumar Duraiappah (Executive Director of IHDP Secretariat), Professor Yanhua Liu of Institute of Geographical Sciences and Natural Resources Research, Chinese Academy of Sciences (Chair of CNC-IHDP and Counselor of the State Council of PRC), Research-fellow Quansheng Ge (Secretary-general of CNC-IHDP and Deputy Director of Institute of Geographical Sciences and Natural Resources Research, Chinese Academy of Sciences), Director Xiaoming Jing, Deputy Director Linhao Chen and Division Director of International Cooperation Department of Ministry of Science and Technology of PRC, Research-fellow Yucheng Chai (Executive Director of Earth Science Department of National Natural Science Foundation), Research-fellow Changqing Song (Deputy Director of Earth Science Department), Research-fellow Suying Leng (1st Division Director of Earth Science Department), members of IHDP-IRG Committee, anonymous reviewers of the HDP-IRG Project, and Professor Walter J. Ammann (President and CEO GRF Davos) have also provided guidance and assistance in this regard. For their efforts and contribution made to IHDP-IRG Science Project, we express our sincere appreciation.

Here, we also extend our sincere appreciation to State Key Laboratory of Earth Surface Processes and Resource Ecology, Beijing Normal University, Key Laboratory of Environmental Change and Natural Disaster, Ministry of Education of China, Beijing Normal University and Academy of Disaster Reduction and Emergency Management, Ministry of Civil Affairs and Ministry of Education undertaking the work of the secretariat, during the preparatory work of the project, as well as German Potsdam Institute for Climate Impact Research and Secretariat of European Climate Forum. This volume of the collections has been published with the sponsorship from Key International (Regional) Cooperation Project of National Natural Science Foundation of China (40821140354), International Cooperation Project of Ministry of Science and

Technology (2008DFA20640, 2010DFB20880) and Beijing Normal University Publishing Group.

IHDP-IRG Project Offices (Beijing and Potsdam)
May 12 2011