IHDP/Future Earth-Integrated Risk Governance Project Series

Peijun Shi · Roger Kasperson
Editors in Chief

World Atlas of Natural Disaster Risk

BNUP

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This book series, entitled "IHDP/Future Earth—Integrated Risk Governance Project Series" for the International Human Dimensions Programme on Global Environmental Change—Integrated Risk Governance Project (IHDP/Future Earth—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. Future Earth is a flagship initiative of the Science and Technology Alliance for Global Sustainability. It aims to provide critical knowledge required for societies to understand and address challenges posed by global environmental change (GEC) and to seize opportunities for transitions to global sustainability. Future Earth identifies three research themes, i.e., Dynamic Planet, Global Development and Transition toward Sustainability in its plan and adopts a new approach of "Co-designing and co-producing" to incorporate GEC researchers with stakeholders in governments, industry and business, international or intergovernmental organizations, and civil society.

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/Future Earth—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 IHDP/Future Earth—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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Editors-in-Chief
Peijun Shi
Beijing Normal University
Beijing
People's Republic of China

Roger Kasperson
Clark University
Worcester, MA
USA

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Foreword I

Economic losses as a result of disasters continue to escalate. In each of the past 3 years direct economic losses from disasters have surpassed $100 billion in the world. This trend is set to worsen unless more private and public investment strategies start to reduce the vulnerability and exposure of people and assets to natural hazards. This will require a shift from reactive approaches that manage disasters to proactive ones that, instead, manage disaster risk.

I am pleased to say that this change is underway, and in many parts of the world is gathering pace. Several countries have come a long way in reducing their disaster risk. Substantial progress has been recorded in the implementation of the Hyogo Framework for Action 2005–2015 (HFA) in all regions. Yet despite this good news, effectively addressing the underlying drivers of disaster risk, such as poverty, poor urban planning and enforcement of regulations, and the destruction of natural protective eco-systems, remains a stubbornly difficult challenge.

Understanding disaster risk and its potential impact on human lives and livelihoods as well as social, economic, and environmental assets has been shown to be crucial to strengthening resilience. Accurate, timely, and understandable information on disaster risk and losses should be integral to both private and public investment planning decisions.

This "World Atlas of Natural Disaster Risk" is one major step forward in this effort to increase understanding of hazard, vulnerability, exposure, and risk. The Atlas presents in detail the distribution of disaster risk, which, if not addressed, will undermine sustainable development in many parts of the world. The analysis of hazards such as earthquake, volcanic eruption, landslide, typhoon, flood, drought, sand-dust storm, storm surge, wildfire, heat wave, and cold wave provides countries with a greater understanding of prevailing risks.

The publication of this Atlas is timely. The world is moving towards a post-2015 international framework for disaster risk reduction that is set to highlight the importance of policies, investment planning, and local actions that are all disaster risk-informed.

The result is a truly remarkable effort of Beijing Normal University and all other associated institutions that will be very useful for disaster risk policymakers and practitioners at the national and city level. Indeed, the subsequent development of more in-depth National Atlases of Natural Disaster Risk could be appropriate for many countries.

I would like to express my sincere appreciation to all the international and Chinese experts who are represented by the Disaster Risk Scientific Research Team of Beijing Normal University, and extend my congratulation for their achievement in developing this publication.

Margareta Wahlström
United Nations Special Representative
of the Secretary-General for Disaster Risk Reduction

Foreword II

Nearly 25 years have elapsed since the initiation of International Natural Disasters Reduction Activity proposed by the United Nations in the late 1980s. Though significant achievements have been attained and this activity has received wide acclaim from countries and regions all over the world, according to reports by related organizations of United Nations, the losses and damages caused by various natural disasters still increase with fluctuation, especially those caused by catastrophes. This has been witnessed by severe natural hazards happened during recent years, such as the 2003 European heat wave, the 2004 Indian Ocean earthquake and tsunami, the 2005 Hurricane Katrina in the United States, the 2008 typhoon disaster in Burma, the 2008 Wenchuan earthquake in China, 2011 Tohoku earthquake and tsunami in Japan, as well as 2013 typhoon and tsunami in Philippines, etc. Undoubtedly, the mission of reducing worldwide natural disaster risk has been arduous.

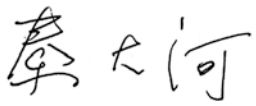
Disasters risk reduction and adaptations to global climate change play an essential role in enhancing global sustainable development. According to the IPCC-SREX report, the future impacts on many countries and regions due to global climate change will continue unabated, and weather extremes such as torrential rain, drought, typhoon, as well as heat wave will apparently mount their damages on the world. Thus, enhancing the adaptation to global climate change and improving the capacity building of comprehensive disaster prevention and reduction remain the main tasks for every country and region in the process of sustainable development.

Raising our awareness of the formation mechanism, changing pattern, and distribution of worldwide natural disaster risk is not only crucial to improve related scientific research, but also props up the implementation of natural disaster prevention and mitigation in every country. By means of systemically collating existing relevant data and compiling disasters–disaster risk atlases, we can demonstrate the regional distribution of main natural hazards and disaster risks. This job will not only be beneficial for countries and regions all over the world to plan scientific programs and schematize various projects on disaster prevention and reduction, but will also facilitate increasing public awareness of both disaster prevention and mitigation and disaster risk governance.

On the basis of systematic study of natural disaster risks in China, Beijing Normal University has organized multiple domestic and international scientific research institutions to compile the “World Atlas of Natural Disaster Risk.” This atlas is aimed to illustrate the spatial distribution of the main natural disasters in the world, which is especially commendable. Employing cartographic language in geography, this World Atlas of Natural Disaster Risk systemically depicts the global distribution of natural disasters such as earthquake, volcano eruption, landslide, typhoon, flood, drought, sandstorm, storm surge, wildfire, heat wave, and cold wave, and it clearly highlights the hot zones for these disaster risks, and thus provides important information for both global disaster prevention and reduction and integrated risk governance.

We hereby appeal to geoscience personnel, especially geographic scholars, to pay high attention to the impacts of global environmental change on mankind’s social-economical

system, to scientifically and objectively assess the risks to our social-economical systems resulting from the global change, to attach great emphasis on the worldwide undertaking science project "Future Earth," to intensify the research on Earth System Science, Global Development and Sustainable Development, to provide scientific and technological supports for comprehensive disaster prevention and reduction, and eventually to make contribution to global sustainable development. Let us advance the enhancement of capacity building for global integrated risk governance, and meanwhile accelerate the development of related subjects on disaster risk science, promote the further expansion of Earth System Science, and strive together for the betterment of mankind and realization of the global sustainable development.



Dahe Qin
Academician of Chinese Science Academy
Former Director of China Meteorological Administration
Director of State Commission of Future Earth in China
Vice President of China Science and Technology Association
Vice President of International Geographical Union
Co-Chair of Working Group I, IPCC

Preface

The year 2015 will be the 25th year of the implementation of the International Decade for Natural Disaster Reduction (IDNDR) and International Strategy for Disaster risk Reduction (ISDR) proposed by the United Nations. Great achievements have been attained in the field of global integrated disaster reduction. Disaster risk reduction, global climate adaptation, and sustainable development have become the joint responsibilities of every country in economical, social, cultural, political, and ecological construction. During these 25 years, UNIDNDR or UNISDR has worked together with governments around the world, scientific and technological groups, nongovernmental organizations, entrepreneur groups, media groups, and various relevant regional organizations, gaining effective results in alleviating human casualties, property loss, damage to resources and environment caused by natural hazards in the world, and earning a great reputation at every stratum of society as well. However, the data released by UN organizations demonstrate that the number of natural disasters is ascending in fluctuation. Though some countries and regions have obtained remarkable results in natural disaster reduction, and have reduced the impacts brought by natural hazards, the ability to cope with large-scale disaster remains insufficient. The task of natural disaster risk reduction is still arduous.

The decade-long IHDP/Future Earth—IRG international program proposed by CNC-IHDP/Future Earth and organized by scientists around the world has been implemented for nearly 5 years. Meanwhile, the "Hazard and Risk Science Base" at Beijing Normal University supported by the Ministry of Education and the State Administration of Foreign Experts Affairs of China (111 Project, No. B08008), which is sponsored by Chinese government has also been carried out for nearly 7 years since 2008. Funded by the Chinese government, a series of scientific projects have attained enormous results and valuable references which laid a solid foundation for the compilation of this atlas, including the phrasal results and findings from the following ongoing projects: the "Relationship Between Global Change and Environmental Risks and its Adaptation Paradigm" (No. 2012CB955400)—a project supported by the special research plan of global change of the Ministry of Science and Technology of China (MOST), the creative research group "Model and Simulation of Earth Surface Process" (No. 41321001), the "Research on the Regional Agriculture Drought Adaptation Assessment Model and Risk Reduction Paradigm" (No. 41171402), and the project "the Land-use and Integrated Erosion of Soil by Wind and Water in the Eastern Ecotone of Agriculture and Animal Husbandry in North China" (No. 41271286) sponsored by the National Natural Science Foundation of China (NSFC). The atlas has also received help and data from the following completed projects: the "Geographic Transaction Zone Study on Interaction Mechanism of Human-earth System on Earth Surface" (No. 40425008)—distinguished young scientists projects, the "Integrated Natural Disaster Risk Evaluation and Disaster Reduction Paradigm Study in Rapid Urbanization Regions" (No. 40535024)—a key project of National Nature Science Foundation of China, the major international joint research program "Integrated Risk Governance—case study of IHDP—IRG Core Science Plan" (No. 40821140354), a key project of NSFC, "Global Climate Change and Large-scale Disaster Governance" (No. 2008DFA20640)—an international joint project of MOST, "the Key Technology Study and Demonstration of Integrated

Risk Prevention" (No. 2006BAD20B00)—a key science and technology pillar project of MOST, and the "Technology for Evaluating Natural Disaster Risk in the Yangtze River Delta" (No. 2008BAK50B07).

We organized all faculties and students of Beijing Normal University in the disaster risk science, and international experts who participated in the IHDP/Future Earth—IRG and "111 Project", as well as all the personnel involved in these two projects, throughout 10 years of preparation, planning, and execution, to compile this atlas, aiming to reflect the spatial patterns of major natural disaster risk all around the world. This atlas provides scientific evidence for taking effective measures of world natural disaster risk reduction by demonstrating the spatial variation from the following three spatial scales for the main natural disaster risk on the world: the grid (1km × 1km, 0.1° × 0.1°, 0.25° × 0.25°, 0.5° × 0.5°, 0.75° × 0.75° and 1° × 1°), the comparable-geographic unit (about 448334 km^2/region), and the national or regional unit (245 nations and regions).

The "Natural Disaster Hotspots" program, jointly completed by the World Bank and Columbia University (USA), has for the first time provided the major global natural disaster risk maps in small scale, which enormously inspires us in compiling this atlas. Our job has obtained desirable improvement in aspects like sorting natural disaster types, assessment method and accuracy, data upgrading, spatial comparability, temporal and spatial resolution, and results verification. Moreover, these improvements have wider and more effective applicability.

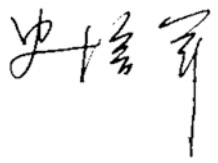
The providers of the shared data online has made great scientific contribution to world natural disaster risk reduction, which not only inspires us to make joint efforts to develop disaster risk science and compile this atlas, but will also save numerous lives, property, and the service capacity of the earth's ecological system from damage by disasters. Hence, we express our heartfelt appreciation and respect to those institutions and websites which provide related shared global data, and to those scientific personnel who devoted themselves to this grand cause.

Since 1989, BNU's integrated disaster research efforts by all its involved faculty and students have evolved in synchronization with the disaster reduction activities of the United Nations. Initiated by the establishment of "China Natural Disaster Monitoring and Prevention Research Laboratory" in 1989, a number of academic institutions and subjects have been set up, such as the "Disaster Insurance Technology Center at BNU" in 1992, "Open Laboratory for Environmental Change and Natural Disaster of Ministry of Education of China (MOE)" in 1994, "Catastrophe Insurance Technology Center at BNU" in 1998, "Key Laboratory of Environmental Change and Natural Disaster, MOE, BNU" in 1998, "Beijing Desertification and Blown-sand Control Technology Center" in 2002, the master and doctor programs of "Natural Disaster Science" which has been granted to admit students in 2003, the "Desertification and Blown-sand Control Engineering Center of MOE" in 2006, "Academy of Disaster Reduction and Emergency Management, Ministry of Civil Affairs of China (MOCA) and MOE" in 2006, and the "State Key Laboratory of Earth Surface Processes and Resource Ecology" in 2007. The BNU disaster and risk study group has enlarged from three faculties at the very beginning to nearly 100 faculties, more than 100 master students, and over 200 doctoral students today, making itself a national professional team focusing on R&D projects of natural disaster risk. Furthermore, it keeps close and excellent collaborative relationships with many top research institutions all over the world, such as Disaster Prevention Research Institute of Kyoto University in Japan, International Institute for Applied Systems Analysis in Austria, Stockholm Environment Institute in Sweden, Hazard Research Center of Clark University in the U.S., School of Sustainability Science at Arizona State University in the U. S., as well as Potsdam Institute for Climate Impact Research in the Germany, etc. Now this group is playing a significant role in integrated natural disaster risk research in the world.

In the process of compiling and publishing this atlas, as well as in the evolution of Disaster Risk Science of BNU, we received strong support and help from many institutions at home and abroad. We would like to express our gratitude to the following centers, academic

institutions, and state-owned enterprises for their help in related references, data, and technological guidance and guarantee: National Climate Center of China Meteorological Administration, National Remote Sensing Center of China Ministry of Science and Technology of the People's Republic of China, National Disaster Reduction Center of China, Ministry of Civil Affairs, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Science (CAS), Cold and Arid Regions Environmental and Engineering Research Institute, CAS, Research Center for Eco-Environmental Sciences, CAS, Institute of Tibetan Plateau Research, CAS, Institute of Earth Environment, CAS, Institute of Mountain Hazards and Environment, CAS, Institute of Atmospheric Physics, CAS, Institute of Geology and Geophysics, CAS, College of Urban and Environmental Sciences of Beijing University, School of Geography and Ocean Sciences of Nanjing University, College for Global Change Studies of Tsinghua University, School of Geography and Planning of Sun Yat-Sen University, Faculty of Geo-Science of East China Normal University, College of Earth and Environmental Sciences of Lanzhou University, School of Resource and Environmental Sciences of Wuhan University, People's Insurance Company of China, and China Reinsurance Company. Many world-recognized universities and academic institutions, who keep close academic collaborative relationship with us, have also supplied us with substantial data and references, as well as the theoretical support regarding assessing methodology. They are University of Maryland in the USA, Nanyang Technological University in Singapore, University Wien in Austria, Oxford University in the UK, University of Stuttgart in Germany, University of California-Berkeley in the USA, Risk Management Solution (RMS), Swiss Re, Munich Re, and Aon Benfield. UNISDR, UNISDR Asia-Pacific Office and UNISDR-Global Assessment Report on Disaster Risk Reduction (GAR) have also offered us great supports and detailed guidance. Star Map Press (Beijing) has provided great supports in editing the maps, and Beijing Normal University Press and Springer-Verlag have jointly provided the ideal conditions for the publishing of this atlas.

We also owe an incalculable debt of gratitude to the following notable scientists and experts for their guidance to this atlas: Academician Guanhua Xu, Dahe Qin, Zhisheng An, Changming Liu, Xueyu Lin, Xiaowen Li, Yong Chen, Zongjin Ma, Xinshi Zhang, Rixiang Zhu, Tandong Yao, Bojie Fu, Prof. Yanhua Liu, Jun Chen, Ms. Margareta Wahlström, Dr. Fenmin Kan, Sujit Mohanty and Pedro Basabe. Ms. Margareta Wahlström and Academician Dahe Qin also wrote prefaces for this atlas. Here, we would like to express our sincere appreciation to all of the leaders and experts. At the same time, we are looking forward to a greater achievement in worldwide disaster prevention and reduction, and a significant improvement of integrated disaster risk governance capability in the near future. Restricted from limited references and data, it is regrettable to give an incomplete evaluation to some countries and regions. We wish that the insufficiency will be revised and perfected in our further work. Comments and suggestions from peers and readers will be highly welcome and appreciated.



Professor Peijun Shi
State Key Laboratory of Earth Surface Processes and Resource Ecology
Key Laboratory of Environmental Change and Natural Disaster, MOE
Academy of Disaster Reduction and Emergency Management, MOCA and MOE
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