



Kyoji Sassa · Paolo Canuti · Yueping Yin *Editors*

# Landslide Science for a Safer Geoenvironment

Volume 1

The International Programme on Landslides (IPL)



 Springer



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Volume 1: The International Programme  
on Landslides (IPL)

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*Cover Illustration:* The Loess landslide, 100 m long, 70 m wide, with a volume of 180,000 m<sup>3</sup>, occurred in Dongxiang town, Gansu Province, China, in March 2011. The landslide destroyed major roads and tens of houses, but 760 people were evacuated successfully due to early warning.

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## Foreword for *International Consortium on Landslides*



United Nations  
Educational, Scientific and  
Cultural Organization

Organisation  
des Nations Unies  
pour l'éducation,  
la science et la culture

Organización  
de las Naciones Unidas  
para la Educación,  
la Ciencia y la Cultura

Организация  
Объединенных Наций по  
вопросам образования,  
науки и культуры

منظمة الأمم المتحدة  
للتربية والعلم والثقافة

联合国教育、  
科学及文化组织

More than 200 million people are affected every year by natural hazards, and the impact is deepening—especially in developing countries, where they can set back healthy growth for years. Globally, an estimated one trillion United States dollars have been lost in the last decade alone.

We may not be able to stop disasters, but we can reduce their risks and their consequences. Mitigating the effects of natural hazards requires education, training, and capacity building at all levels. Fundamentally, it calls for new thinking—to move from reaction after disasters to action before.

Landslides are important in this regard, given the tragic loss of life and the economic disruption they cause. More than ever, we need to address landslides in ways that are integrated and coordinated internationally. This is the goal guiding the *International Consortium on Landslides* and its International Programme on Landslides, focusing on research, education, and capacity building in landslide risk reduction, working with international, governmental, and non-governmental actors.

Associated with the *International Consortium on Landslides*, UNESCO has accompanied the International Programme on Landslides from its inception, as an innovative initiative for cooperative research and capacity building in landslide risk mitigation. In the same spirit, UNESCO and Kyoto University established a University Twinning and Networking Cooperation Programme on landslide risk mitigation for society and the environment in March 2003, in order to deepen cooperation in this vital area.

This publication is an essential tool for both organizations and individuals to deepen understanding of landslide phenomena and to reduce their risks. Drawing on latest scientific developments, this volume presents a range of initiatives under way across the world and puts forward recommendations on risk mitigation. At a time when the consequences of climate change are deepening, this work provides a benchmark reference to strengthen the resilience of societies under pressure. I wish to thank all participants in the *International Consortium on Landslides* and all involved in this important work. Let me highlight especially Professor Kyoji Sassa, Chairperson of the

Consortium, for his tireless efforts. In this spirit, I look forward to further strengthening UNESCO's cooperation with the *International Consortium on Landslides*.



A handwritten signature in blue ink that reads "Irina Bokova". The signature is written in a cursive, flowing style.

**Ms. Irina Bokova**  
**Director-General of UNESCO**



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## Foreword

Landslide, floods, drought, wildfire, storms, tsunami, earthquakes, and other types of natural hazards are increasingly affecting the world. For the first time in history the world has experienced 3 consecutive years (2010–2012) where annual economic losses have exceeded \$100 billion due to an enormous increase in exposure of industrial assets and private property to extreme disaster events. During the period of 2000–2012, 2.9 billion people were affected by disasters, economic damage is equivalent of USD 1.7 trillion, and 1.2 million people were killed by disasters.<sup>1</sup>

The Global Assessment Report (GAR), a regular publication by the United Nations on disaster risk levels, trends, and analysis of the underlying causes, found that most of the small-scale recurrent disasters such as landslides are not effectively accounted for by authorities. The same report also found that while landslides and other recurrent natural hazards are responsible for only a small proportion of global disaster mortality, they account for a very significant proportion of damage to public assets, such as health and educational facilities and infrastructure, as well as to the livelihoods, houses, and assets of low-income groups.

Extensive risk associated with localized, mainly weather-related hazards with short return periods. These highly localized yet frequent hazards include surface water and flash flooding, landslides, fires, and both agricultural and hydrological drought. They are exacerbated by badly managed urban development, environment degradation, and poverty.<sup>2</sup>

The *Hyogo Framework for Action 2005–2015: Building the Resilience of Nations and Communities to Disasters (HFA)*, adopted at the 2nd World Conference on Disaster Reduction (WCDR, Kobe, Hyogo, Japan, in January 2005), represents the most comprehensive action-oriented policy guidance in universal understanding of disasters induced by vulnerability to natural hazards and reflects a solid commitment to implementation of an effective disaster reduction agenda. In order to ensure effective implementation of HFA at all levels, tangible and coordinated activities must be carried out. Since 2005, we have seen many activities and initiatives developed to implement HFA in various areas. As a concrete activity in the area of landslide risk reduction, the International Programme on Landslides has maintained the momentum created in 2005 through organizing the two World Landslide Forums in 2008 in Tokyo and in 2011 in Rome, being led by the International Consortium on Landslides. It is my great pleasure to see the valuable development for the last 8 years.

There is a growing evidence of the need for a strong science basis to understand the causes and impacts of landslides as well as the most effective measures to reduce landslide risk. This book includes a number of substantive articles on landslide risk reduction. Applying science into practice is one of the key words for the global endeavour. I expect this book as well as the Third World Landslide Forum to make a substantive contribution for that purpose in the area

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<sup>1</sup> Disasters refers to drought, earthquake (seismic activity), epidemic, extreme temperature, flood, insect infestation, mass movement (dry and wet), storm, volcano, and wildfire/Data source: EM-DAT: The OFDA/CRED International Disaster Database/Data version: 12 March 2013 - v12.07.

<sup>2</sup> Global Assessment Report on Disaster Risk Reduction 2013: [http://www.preventionweb.net/english/hyogo/gar/2013/en/home/GAR\\_2013/GAR\\_2013\\_2.html](http://www.preventionweb.net/english/hyogo/gar/2013/en/home/GAR_2013/GAR_2013_2.html)

of landslide risk reduction by the promotion of exchange of experience and achievements in science and facilitating discussion on sustainable disaster risk management.

Recognizing that disaster reduction needs interdisciplinary and multi-sectoral action, we build on partnerships and take a global approach to disaster reduction. Therefore, we welcome better cooperation between government authorities and the international community including scientific community that play a critical role in helping people make life-changing decisions about where and how they live before the disaster strikes, in particular high-risk urban areas.

Once the ten-year mark has been passed in 2015, the world will have a new disaster risk reduction framework. Consultations on elements for the post-2015 framework (“HFA2”) are currently ongoing. Multi-stakeholders, including academic and scientific institutions, are encouraged to be engaged in the ongoing consultation towards HFA2, which is expected to be adopted at the Third World Conference on Disaster Risk Reduction in March 2015 in Sendai, Japan.

Scientist, international, and regional institutions have a responsibility to assist with the tools, knowledge, and capacity to understand their risk and take the most effective measures to reduce them. The knowledge on landslides is a key part of the equation and the work and outcome of The Third World Landslide Forum in June 2014 in Beijing will be important contribution to these efforts and ongoing consultation towards 2015. UNISDR is fully behind the community of practice working on landslide risk.



A handwritten signature in black ink, appearing to read 'Margareta Wahlström'.

**Ms. Margareta Wahlström**  
**Special Representative of the UN Secretary-**  
**General for Disaster Risk Reduction, Chief**  
**of UNISDR**

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## Preface: Landslide Science for a Safer Geoenvironment

The Third World Landslide Forum (**WLF3**) was held at the China National Convention Center, Beijing, China, on 2–6 June 2014. WLF is the triennial conference of the International Consortium on Landslides (**ICL**) and the International Programme on Landslides (**IPL**).

ICL (The International Consortium on Landslides) launched at the Kyoto Symposium in January 2002 is an international non-governmental and non-profit scientific organization promoting landslide research and capacity building for the benefit of society and the environment. Major activities of the ICL are the publication of a bimonthly full-colour journal “Landslides: Journal of the International Consortium on Landslides”, the International Programme on Landslides including IPL Projects in many countries/regions, and the Triennial World Landslide Forum and promotion of ICL regional and thematic networks and the World Centres of Excellence on Landslide Risk Reduction (WCoE). All activities involve cooperation by ICL-supporting organizations and other various stakeholders (national and local governments, civil society, and private sectors) contributing to landslide risk reduction.

The IPL is a programme of the ICL. It is developed in partnership with ICL-supporting organizations. The programme is managed by the IPL Global Promotion Committee including ICL and ICL-supporting organizations: the United Nations Educational, Scientific and Cultural Organization (UNESCO), the World Meteorological Organization (WMO), the Food and Agriculture Organization of the United Nations (FAO), the United Nations International Strategy for Disaster Risk Reduction (UNISDR), the United Nations University (UNU), the International Council for Science (ICSU), the World Federation of Engineering Organizations (WFEO), and the International Union of Geological Sciences (IUGS). The IPL contributes to the United Nations International Strategy for Disaster Reduction.

ICL-IPL invites relevant organizations and programmers to promote Landslide Science for a Safer Geoenvironment.

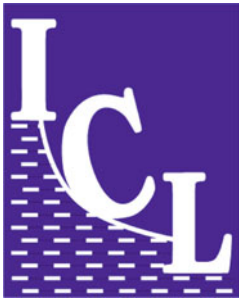
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### The International Consortium on Landslides (ICL)

- ICL was established by adopting its statutes in January 2002. The headquarters was registered as a legal body under the Japanese law for non-profit-making organizations (NPO) in the Kyoto Prefectural Government, Japan, in August 2002.
- ICL established the UNITWIN (University Twinning and Networking) Cooperation Programme on Landslide Risk Mitigation for Society and the Environment with UNESCO and Kyoto University in March 2003. The UNITWIN Headquarters Building was constructed by ICL and Kyoto University at the Kyoto University Uji Campus in September 2004. The programme was developed to promote landslide and water-related disaster risk management for society and the environment in November 2010.
- ICL founded “*Landslides*”: *Journal of the International Consortium on Landslides* in 2004. It was established as a quarterly journal published by Springer Verlag. It was approved as an ISI journal in 2005 and moved to a bimonthly journal from Vol. 10 in 2013.
- ICL founded the International Programme on Landslides (IPL) in partnership with seven global stakeholders by adopting the 2006 Tokyo Action Plan. It exchanged MoU to

promote IPL with the United Nations Educational, Scientific and Cultural Organization (UNESCO), the World Meteorological Organization (WMO), the Food and Agricultural Organization of the United Nations (FAO), the United Nations International Strategy for Disaster Reduction (UNISDR), the United Nations University (UNU), the International Council for Science (ICSU), and the World Federation of Engineering Organizations (WFEO) in 2006.

- The IPL Global Promotion Committee (IPL-GPC) was established following the 2006 Tokyo Action Plan to manage IPL activities including IPL projects, the World Landslide Forum (WLF) every 3 years, and the World Centres of Excellence for Landslide Risk Reduction (WCoEs) to be identified at WLFs.
- ICL headquarters in Kyoto, Japan, was approved as a scientific research organization (No. 94307) which can receive scientific grants from the Ministry of Education, Culture, Sports, Science and Technology (MEXT), Japan, in March 2007 and registered in the cross-ministerial research and development management system of all ministries of Japan in May 2008.
- ICL was approved as an NGO having operational relations with UNESCO in April 2007. It was reclassified as an NGO with consultative partnership with UNESCO in March 2012.
- ICL-IPL organized the First World Landslide Forum (WLF1) at the United Nations University, Tokyo, in November 2008.
- ICL-IPL organized the Second World Landslide Forum (WLF2) at the Food and Agriculture Organization of the United Nations, Rome, in October 2011.
- ICL-IPL is organizing the Third World Landslide Forum (WLF3) at the China National Convention Center, Beijing, in June 2014.
- ICL-IPL will organize the Fourth World Landslide Forum (WLF4) in Ljubljana, Slovenia, in May 29–June 2, 2017.



The symbol of ICL was designed as below.

**I** is a symbol of cultural heritage at landslide risk

**C** symbolizes the moving landslide mass

**L** is a symbol of retaining wall to stop landslides for its risk reduction.

The greatest discussion on C whether the Consortium should stand still or might be inclined during dynamic motion.

## The International Programme on Landslides (IPL)

- The United Nations World Conference on Disaster Reduction was held on 18–22 January 2005 in Kobe, Japan. At this conference, the ICL proposed the organization of a thematic session to develop the IPL within the WCDR, and it was approved by the United Nations Secretariat for the International Strategy for Disaster Risk Reduction. With financial support from the Cabinet Office of Japan, the Ministry of Education, Culture, Sports, Science and Technology of the Government of Japan (MEXT), and the Disaster Prevention Research Institute of Kyoto University, the thematic conference Session 3.8 “New International Initiatives for Research and Risk Mitigation of Floods (IFI) and Landslides (IPL)” was organized together with ICL-supporting organizations and also the flood group.
- The thematic session 3.8 was opened with the addresses by Koichiro Matsuura (Director-General of UNESCO), Michel Jarraud (Secretary-General of WMO), and others. The session was chaired by Hans van Ginkel (Rector of UNU). The ICL proposed a **Letter of**

- Intent** to promote further joint global activities in disaster reduction and risk prevention through “Strengthening research and learning on ‘Earth system risk analysis and sustainable disaster management’ within the framework of the ‘United Nations International Strategy for Disaster Reduction’ (ISDR)”. This Letter of Intent was agreed and signed by heads of seven global stakeholders of UNESCO, WMO, FAO, UNISDR, UNU, ICSU, and WFEO.
- Based on this Letter of Intent, ICL, UNESCO, WMO, FAO, UNISDR, UNEP, UNU, and Kyoto University jointly organized the Round Table Discussion (RTD) “Strengthening research and learning on earth system risk analysis and sustainable disaster management within UN-ISDR as regards landslides—towards a dynamic global network of International Programme on Landslides (IPL)” on 18–20 January 2006 at Elizabeth Rose Hall of the United Nations University, Tokyo, Japan. The RTD was cosponsored by Japanese and international governmental and non-governmental organizations. The 2006 Tokyo Action Plan was adopted as the result of RTD.
  - The 2006 Tokyo Action Plan decided to develop the International Programme on Landslides (IPL) which is managed by IPL Global Promotion Committee. It is formed by ICL member organizations, ICL-supporting organizations which have exchanged the Memorandum of Understanding with ICL to promote ICL, and organizations which provide Subvention to IPL.
  - The ICL exchanged the Memoranda of Understanding with each of seven global stakeholders: UNESCO, WMO, FAO, UNISDR, UNU, ICSU, and WFEO to promote the 2006 Tokyo Action Plan within 2006. Then, IPL was formally launched as a programme of the ICL in partnership with ICL-supporting organizations aiming at organizing work in response to the ICL goals.
  - The logo of IPL in Fig.1 is a simple design of ICL and ICL-supporting organizations which have exchanged MOU with ICL to promote ICL-IPL.



**Fig. 1** Logo of the International Programme on Landslides (IPL)

## The World Landslide Forum

### The First World Landslide Forum: Implementing the 2006 Tokyo Action Plan on the International Programme on Landslides (IPL)

WLF1 was organized at the United Nations University, Tokyo, in November 2008. It was a global cross-cutting information and cooperation platform for all types of organizations from academia, United Nations, governments, private sectors, and individuals that are contributing to landslide research and education and who are willing to strengthen landslide and other related earth system risk reduction.

- Plenary sessions were (1) Open forum “Progress of IPL Activities”, (2) Plenary symposium “Global Landslide Risk Reduction”: A special Report and four keynote lectures, (3) Public Forum on “Protection of Society and Cultural and Natural Heritage, (4) “Landslides for Children”, (5) High-level panel discussion “Landslides in Global Change—How to mitigate risk? Toward the Second World Landslide Forum in 2011”.
- Parallel sessions were (1) A look from space, (2) Case Studies and National Experiences, (3) Catastrophic slides and avalanches, (4) Climate change and slope instability, (5) Landslides threatening heritage sites, (6) Economic and Social Impact of Landslides, (7) Education, Capacity Building and Public Awareness for Disaster Reduction, (8) Environmental Impact of Landslides, (9) Landslides in General, (10) Landslides and multi-hazards, (11) Mapping: inventories, susceptibility, hazard and risk, (12) Monitoring, prediction and early warning, (13) Policy and Institutional framework for Disaster Reduction, (14) Rainfall, debris flows, and wildfires, (15) Landslide Disaster Mitigation Engineering Measures, (16) Watershed and Forest Management for Risk Reduction, (17) Landslides in Dam Reservoirs.
- One full-colour book—Landslides-Disaster Risk Reduction—including all papers in plenary sessions and introduction of all parallel sessions was published, two monocolour proceedings for full papers were accepted for parallel sessions, and papers accepted for poster papers were printed and also are uploaded in the ICL web in full colour.
- 430 people from 48 countries and several other international organizations participated (175 from Japan, and 255 from abroad).

### The Second World Landslide Forum: Putting Science into Practice

WLF2 was organized at the Headquarters of the Food and Agriculture Organization of the United Nations (FAO) on 3–9 October 2011. It was jointly organized by the IPL Global Promotion Committee (ICL, UNESCO, WMO, FAO, UNISDR, UNU, ICSU, WFEO) and two ICL members in Italy: the Italian Institute for Environmental Protection and Research (ISPRA) and the Earth Science Department of the University of Florence with support from the Government of Italy and many Italian landslide-related organizations.

- 864 people from 63 countries and several international organizations participated. Attendance was larger than expected, and twice the attendance at the First World Landslide Forum 2008 in Tokyo.
- 25 Technical sessions were held, and 465 full papers were submitted. All accepted papers were edited in seven full-colour volumes titled as “**Landslide Science and Practice**” as below.
  - Vol. 1 Landslide inventory and susceptibility and hazard zoning
  - Vol. 2 Early warning, instrumentation and monitoring
  - Vol. 3 Spatial analysis and modelling
  - Vol. 4 Global environmental change (420 pages)
  - Vol. 5 Complex environment (520 pages)
  - Vol. 6 Risk assessment, management and mitigation (430 pages)
  - Vol. 7 Social and Economic Impact and Policies (430 pages)



## **The Third World Landslide Forum: Landslide Risk Mitigation Toward a Safer Environment**

WLF3 will be organized on 2–6 June 2014 in Beijing, China.

Three full-colour volumes (Vol. 1–Vol. 3) will be published by Springer, titled as Landslide Science for a Safer Geoenvironment. 303 papers will be published in three full color volumes. One monocolour proceedings which contains 123 full papers and an abstract volume will be published by the Chinese Organizing Committee. Volume 1 includes Plenary lectures, and selected papers from the side events. Volume 2 includes papers accepted in sessions for methods of landslide studies. Volume 3 includes papers accepted for methods of landslide studies. Front matters include two Forewords from Ms. Irena Bokova, Director-General of UNESCO and Ms. Margareta Wahlström, Special Representative of the UN Secretary General for Disaster Risk Reduction, Chief of UNISDR, and Preface by Kyoji Sassa (Executive Director), Paolo Canuti (President) and Yueping Yin (Incoming President) of ICL. Back matters include “Landslide Technology and Engineering in Support of Landslide Science” and “ICL Structure”.

Plenary sessions are:

1. High-Level Panel Discussion toward a Safer Geoenvironment
2. Plenary Lectures “Progress in Landslide Science”
  - Runqiu HUANG: Progress in Large-Scale Landslide Studies in China
  - Farrokh NADIM: Progress in Living with landslide risk in Europe
  - Rex BAUM: Progress in Regional landslide hazard assessment
  - Kyoji SASSA: Progress in Landslide Dynamics
3. Round Table Discussion “Major achievement in WLF3 and development toward WLF4”

Parallel sessions are:

Special Sessions

A1 International Programme on Landslides, A2 Thematic and Regional Networks on Landslides, A3 Policy, Legislation and Guidelines on Landslides, A4 Climate & Landuse Change Impacts on Landslides, A5 Recognition and Mechanics of Landslide, A6 General Landslide Studies

Sessions for Methods of Landslide Studies

B1 Physical Modeling and Material Testing, B2 Application of Numerical Modeling Techniques to Landslides, B3 Remote Sensing Techniques for Landslide Mapping and Monitoring, B4 Hazard Mapping, B5 Monitoring, Prediction and Warning of Landslides, B6 Risk Assessment, B7 Remedial Measures & Prevention Works, B8 Risk Reduction Strategy, B9 Inventory and Database

Sessions for Targeted Landslides

C1 Debris Flows, C2 Rock-Slope Instability and Failure, C3 Earthquake-Induced Landslides, C4 Rain-Induced Landslides, C5 Landslides in Cultural/Natural Heritage Sites, C6 Urban Landslides, C7 Landslides in Cold Regions, C8 Landslide in Coastal and Submarine Environments, C9 Natural Dams and Landslides in Reservoirs

Side Events

D1 Student Session, D2 Landslide Teaching tools, D3 Dialogues on Country Landslide Issues

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## **Other ICL-IPL Activities**

**Other ICL-IPL activities** include (1) IPL Projects, (2) ICL Regional and thematic networks, (3) World Centre of Excellence on Landslide Risk Reduction, (4) ICL Landslide Teaching Tools.