Dilanthi Amaratunga
Richard Haigh
Nuwan Dias *Editors*

Multi-Hazard Early Warning and Disaster Risks

Springer

Multi-Hazard Early Warning and Disaster Risks

Dilanthi Amaratunga · Richard Haigh · Nuwan Dias
Editors

Multi-Hazard Early Warning and Disaster Risks

Springer

Editors
Dilanthi Amaratunga
Global Disaster Resilience Centre
University of Huddersfield
Huddersfield, UK

Richard Haigh
Global Disaster Resilience Centre
University of Huddersfield
Huddersfield, UK

Nuwan Dias
Global Disaster Resilience Centre
University of Huddersfield
Huddersfield, UK

ISBN 978-3-030-73002-4 ISBN 978-3-030-73003-1 (eBook)
https://doi.org/10.1007/978-3-030-73003-1

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

In memory of Prof. Samantha Hettiarachchi, for his tireless commitment to the development of disaster risk knowledge, and taking science to practice

International Scientific/Peer Review Committee

Mr. Asitha de Silva, Global Disaster Resilience Centre, School of Applied Sciences, University of Huddersfield, UK

Prof. Boyko Ranguelov, Professor Mining and Geology, University Bulgaria

Dr. Chathuranganee Jayakody, Postdoctoral Researcher, Global Disaster Resilience Centre, School of Applied Sciences, University of Huddersfield, UK

Dr. Chaminda Bandara, Senior Lecturer, Department of Civil Engineering, University of Peradeniya, Sri Lanka

Dr. Chamindi Malalgoda, Senior Lecturer, School of Art, Design and Architecture, University of Huddersfield, UK

Prof. Champa M. Navaratne, Professor, Department of Agricultural Engineering, University of Ruhuna, Sri Lanka

Prof. Champika Lasanthi Liyanage, Professor in Facilities Management, School of Engineering, University of Central Lancashire, UK

Dr. Chandana Siriwardana, Senior Lecturer, Department of Civil Engineering, University of Moratuwa, Sri Lanka

Prof. Charlotte Kendra Gonzales, Programme Manager, Climate Change and Disaster Risk, Ateneo Institute of Sustainability; Associate Professor, Department of Environmental Science, Ateneo de Manila University

Dr. Crisanto M. Lopez, Department Chairperson, Department of Biology, Ateneo De Manila University, Philippines

Prof. Dilanthi Amaratunga, Professor of Disaster, Risk Reduction and Management, Co-director, Global Disaster Resilience Centre, School of Applied Sciences, University of Huddersfield, UK

Dr. Gayan Wedawatta, Senior Lecturer, Senior Lecture in Engineering Systems and Management, Aston University, Birmingham, UK

Dr. Harkunti Rahayu, The International Oceanographic Commission of UNESCO (IOC-UNESCO), ICG/IOTWMS WG 1 on Tsunami Risk

Mr. Ignacio Aguirre Ayerbe, Researcher, Environment Hydraulics Institute, IH Cantabria, Spain

Dr. Kanchana Ginige, Senior Lecturer, Department of Architecture and Built Environment, Northumbria University, Newcastle, UK

Prof. K. D. N. Weerasinghe, Professor Emeritus, Faculty of Agriculture, University of Ruhuna, Sri Lanka

Ms. Kinkini Hemachandra, Global Disaster Resilience Centre, School of Applied Sciences, University of Huddersfield, UK

Dr. Maheshika Sakalasuriya, Global Disaster Resilience Centre, School of Applied Sciences, University of Huddersfield, UK

Mr. Malith Senevirathne, Global Disaster Resilience Centre, School of Applied Sciences, University of Huddersfield, UK

Dr. Niraj Thurairajah, Associate Professor, Department of Architecture and Built Environment, Northumbria University, Newcastle, UK

Dr. Nishara Fernando, Senior Lecturer, Head of the Department of Sociology, University of Colombo, Sri Lanka

Dr. Nuwan Dias, Research Fellow in Disaster Resilience Global Disaster Resilience Centre, School of Applied Sciences, University of Huddersfield, UK

Prof. Ranjith Dissanayake, Professor of Civil Engineering, University of Peradeniya, Sri Lanka

Prof. Richard Haigh, Professor of Disaster Resilience, Co-Director, Global Disaster Resilience Centre, School of Applied Sciences, University of Huddersfield, UK

Dr. Roshani Palliyaguru, Senior Lecturer in Quantity Surveying, University of Vocational Technology, Sri Lanka

Dr. Ruben Paul Borg, Associate Professor, Construction and Property Management, Faculty for the Built Environment, University of Malta, Malta

Dr. Senaka Basnayake, Director, Climate Resilience Department, Asian Disaster Preparedness Centre, Thailand

Ms. Shavindree Nissanka, Global Disaster Resilience Centre, School of Applied Sciences, University of Huddersfield, UK

Dr. Shiromani Jayawardena, Deputy Director (Forecasting and Decision Support), Department of Meteorology, Colombo 07, Sri Lanka

Prof. Siri Hettige, Professor Emeritus of Sociology, University of Colombo, Sri Lanka

Mr. Thushara Kamalrathne, Global Disaster Resilience Centre, School of Applied Sciences, University of Huddersfield, UK

Prof. W. L. Sumahipala, Professor Emeritus, The Open University of Sri Lanka

Dr. Zin Mar Lwin, Remote Sensing Department, Mandalay Technological University, Myanmar

Preface

During the time period in which this book was being written, countries around the world have been tackling the COVID-19 global pandemic. Never in human history have so many people recognised and started to understand the importance of disaster risk.

In the short term, countries have been dealing with rapidly rising infection rates and excess deaths associated with COVID-19. In the longer term, there will be a devastating legacy on health as vital resources have been diverted away from other essential health services and specialist treatments.

The economic impacts of the pandemic are also going to have a devastating impact on our attempts to alleviate poverty. In order to combat the spread of the infection, many governments have engineered a deliberate slowdown in the economy to manage the health risks. This approach has generally involved closing borders, introducing social distancing and quarantine measures, and prohibiting specific activities. Recent estimates suggest that the impact of this economic disruption due to the COVID-19 pandemic could cost 21 trillion US dollars.

As well as in these direct and indirect impacts, the COVID-19 pandemic has also brought to the forefront the concept of systemic risk and the need for a multi-hazard approach to disaster risk reduction and early warning.

Systemic risks are those of high complexity that are interconnected. Cascading impacts, of the type many countries and people have experienced during the pandemic, are often inadequately understood and rather unpredictable in terms of cause and effect. They are often transboundary in nature, challenging our decision-makers as they do not easily fit into existing international, national, or sub-national administrative or sectoral structures.

The pandemic has also exposed existing vulnerabilities, including weaknesses in existing healthcare and support structures, but also disproportionately affecting the poorest members of our communities. Underlying drivers of disaster risk have been exposed, including human rights, poverty, inequality, and global supply chains.

Having a common framework to cope with such complex disasters can make it easier for decision-makers and other actors, including people at risk, to understand the cascading effects and therefore where to prioritise in their efforts to prepare and mitigate for disaster risk.

The need for this multi-hazard approach is set out in The Sendai Framework for Disaster Risk Reduction 2015–2030 (Sendai Framework), which was signed in 2015 and became the first major agreement of the post-2015 development agenda. It provided the Member States with concrete actions to protect development gains from the risk of disaster.

The Sendai Framework works hand in hand with the other 2030 Agenda agreements, including The Paris Agreement on Climate Change, The Addis Ababa Action Agenda on Financing for Development, the New Urban Agenda, and ultimately the Sustainable Development Goals. It was endorsed by the UN General Assembly following the 2015 Third UN World Conference on Disaster Risk Reduction (WCDRR), and advocates for *The substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries.*

The Sendai Framework recognises that the state has the primary role to reduce disaster risk, but that responsibility should be shared with other stakeholders including local government, the private sector, and other stakeholders.

During the negotiations for the Sendai Framework, countries and partners highlighted the need to:

1. Continue to invest in, develop, maintain, and strengthen people-centred, end-to-end early warning systems;
2. Promote the application of simple and low-cost early warning equipment and facilities;
3. Broaden the dissemination channels for early warning information to facilitate early action.

Countries also called for the further development of and investment in effective, nationally compatible, and regional multi-hazard early warning mechanisms. To address these needs, global target (g) of the Sendai Framework was adopted, namely to "substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments to the people by 2030".

Around the world, meteorological and hydrological services have developed and implemented multi-hazard early warning systems (MHEWS) for weather and climate-related hazards. A MHEWS has the ability to address several hazards and/or impacts of similar or different type in situations where hazardous events may occur alone, simultaneously, cascading or cumulatively over time, and taking into account the potential interrelated effects.

To be effective, a MHEWS should include the participation of different stakeholders and actively involve the people and communities at risk, in order to ensure that the system has an enabling environment, which incorporates the appropriate technology, regulatory and legal frameworks, adequate operational capacities, as well as to clearly defined roles and responsibilities for all participating agencies including communities.

There is now increasing recognition that efforts on MHEWS must expand to address a wider array of hazards, including biological such as epidemics and pandemics, as well as cascading impacts. A multi-hazard approach can be common for all hazards and is therefore more likely to become trusted so everyone can understand and use as a basic element of their efforts towards disaster risk reduction.

In reflecting upon these efforts, this book brings together a collection of empirical research, case studies, discussion, and insights on the need for and challenges associated with developing multi-hazard early warning systems, as well as wider perspectives on disaster risk reduction.

The chapters are primarily drawn from contributions to an international symposium on multi-hazard early warning and disaster risk reduction that was originally scheduled for March 2020, to be held in Colombo, Sri Lanka. The event was postponed due to the global pandemic, and instead held online, in December 2020. The event was jointly organised by:

- State Ministry of National Security, Home Affairs and Disaster Management, Sri Lanka
- Disaster Management Centre, Sri Lanka
- Global Disaster Resilience Centre, University of Huddersfield, UK
- University of Moratuwa, Sri Lanka
- Asian Disaster Preparedness Centre (ADPC), Thailand.

The organisers were supported by a wide range of national and international partners representing disaster-related actors from government, non-governmental organisations, universities, and research projects as follows:

- The International Oceanographic Commission of UNESCO (IOC-UNESCO), Intergovernmental Coordination Group for the Indian Ocean Tsunami Warning and Mitigation System (ICG/IOTWMS) ICG/IOTWMS WG 1 on Tsunami Risk, Community Awareness and Preparedness
- IOC-UNESCO IOTWMS, WG 1 on Tsunami Risk, Community Awareness and Preparedness
- United Nations Office for Disaster Risk Reduction (UNDRR)
- International Union for Conservation of Nature (IUCN), Sri Lanka
- Department of Meteorology, Sri Lanka
- Association of Disaster Risk Management Professionals in Sri Lanka (ADRiMP)
- University of Peradeniya, University of Colombo, University of Ruhuna, Sri Lanka
- REbuildinG AfteR Displacement (REGARD) project
- Capacity Building in Asia for Resilience EducaTion (CABARET) project on fostering regional cooperation for more effective multi-hazard early warning and increased disaster resilience among coastal communities
- Improving COVID-19 and pandemic preparedness and response through the downstream of multi-hazard early warning systems project
- Bandung Institute of Technology (ITB), Indonesia
- Regional Dialog of Asian Preparedness Partnership (APP)
- The United Nations World Food Programme
- The United Nations Development Programme (UNDP)

- The Japan International Cooperation Agency (JICA)
- ChildFund Sri Lanka.

Many of the chapters reflect the original venue for the symposium and provide contemporary insights into the challenges in Sri Lanka for developing and implementing a multi-hazard approach to early warning and wider efforts on disaster risk reduction.

Sri Lanka experienced devastating effects when there are inadequate early warning systems. The lack of a tsunami early warning system and poor preparedness of communities resulted in the death of over 30,000 people in Sri Lanka and the displacement of many more. Sri Lanka was not alone in these failings, as the Indian Ocean did not have the type of tsunami early warning system that had been operating in the Pacific since the 1960s. As a result, communities along the surrounding coasts of the Indian Ocean were severely affected, and the tsunamis killed an estimated 227,898 people in 14 countries. The direct results caused major disruptions to living conditions and commerce, particularly in Indonesia, Sri Lanka, India, and Thailand.

Following the disaster, the Intergovernmental Oceanographic Commission (IOC) of UNESCO was given the mandate to develop and implement the Indian Ocean Tsunami Warning and Mitigation System (IOTWMS). The Intergovernmental Coordination Group (ICG) for the IOTWMS was established as a primary subsidiary body of the IOC by its July 2005 Assembly (Resolution XXIII-12). Further mandates were given to UNESCO/IOC by the UN General Assembly through Resolutions 61/132 and 62/91.

After 8 years of international collaboration and development, facilitated and coordinated by UNESCO/IOC, the IOTWMS became fully operational on 31 March 2013 with Tsunami Service Providers (TSPs) established by Australia, India, and Indonesia.

An end-to-end tsunami warning system begins with the upstream rapid detection of a tsunami wave, including detection, verification, threat evaluation, and forecasting. It ends with a well-prepared community that is capable of responding appropriately to a warning, including delivery of public safety messages, risk assessment and management, initiating national countermeasures, and preparing and implementing standardised reactions.

As illustrated by the 2018 Sunda Strait and Central Sulawesi tsunami events in Indonesia, it is also vital to address the challenge of cascading hazards that pose a tsunami risk and the importance of linking tsunami early warning to a multi-hazard environment. Moving towards a multi-hazard environment is complex and poses many challenges, but can bring significant benefits in terms of efficiencies and also in recognising the links between hazards, such as cascading threats.

Reflecting the multiplicity of the challenges and the need for a diversity of scientific perspectives and methodological approaches, the book's 56 chapters address a range of important topics, many of them drawing upon experiences and results from Sri Lanka.

The chapters are spread across five broad themes. The opening nine chapters address the Sendai Framework and Sustainable Development Goals, including the importance of wider policy coherence. The need to draw synergies between climate change, disaster risk, and sustainable development is also reflected in many of the seventeen chapters that focus on disaster risk reduction and eight on disaster preparedness. Seventeen chapters focus more directly on the development of effective early warning systems, including better communications and need for multi-hazard approaches. The final five chapters address the need to integrate health into disaster risk reduction, including some early reflections on COVID-19 and the need to address epidemic and pandemic threats in preparedness planning.

As editors, it is our hope that this important collection of scientific results, discussion, and insights provides a useful point of reference that reflects upon our progress to date in tackling disaster risk in Sri Lanka, but also across the wider region and globally. We also hope it sets out some of the challenges and opportunities that lay ahead of us if stakeholders are to successfully develop a common framework that will help our communities to better prepare for and tackle complex, multi-hazard threats.

Huddersfield, UK
December 2020

Prof. Dilanthi Amaratunga
Prof. Richard Haigh
Dr. Nuwan Dias

Contents

About the Editors

Prof. Dilanthi Amaratunga holds the chair in Disaster Risk Management at the University of Huddersfield, UK. She is a leading international expert in disaster resilience with an extensive academic career that has a strong commitment to encouraging colleagues and students to fulfil their full potential. She provides expert advice on disaster resilience to national and local governments and international agencies including the United Nations Office for Disaster Risk Reduction. She is engaged in many significant research engagements around the world, in partnership with key academic and other organisational stakeholders. To date, she has produced over 400 publications, refereed papers and reports, and has made over 100 keynote speeches in around 30 countries. Among many leadership roles, she is the joint chief editor of the International Journal of Disaster Resilience in the Built Environment and the chair of the International Conference on Building Resilience (ICBR) series, which she co-created. She is a member of the European Commission and UNDRR's European Science and Technology Advisory Group representing the UK, a member of the Steering Committee of the UNISDR "Making Cities Resilient" Campaign, and a Steering Committee member of the Frontiers of Development programme, a Collaborative Programme of The Royal Academy of Engineering, The Academy of Medical Sciences, The British Academy and The Royal Society. She is a fellow of the Royal Institution of Chartered Surveyors (RICS), a fellow of The Royal Geographical Society, a fellow, and a chartered manager of the Chartered Management Institute, UK. She can be contacted on: d.amaratunga@hud.ac.uk.

Prof. Richard Haigh is a professor of Disaster Resilience and a co-director of the University of Huddersfield's Global Disaster Resilience Centre in the UK. His research interests include multi-hazard early warning, disaster risk governance and resilience in the built environment. He is the editor-in-chief of the International Journal of Disaster Resilience in the Built Environment and the co-chair of the International Conferences on Building Resilience, which started in 2008. He is an expert member of Working Group 1 of Intergovernmental Coordination Group on the Indian Ocean Tsunami Warning and Mitigation System (ICG/IOTWMS). He and his team won the Newton Prize for Indonesia, celebrating the best research innovation partnership for the project Mainstreaming Integrated Disaster Risk Reduction and Climate

Change Adaption Strategies into Coastal Urban Agglomeration Policy. He has led and successfully delivered research grants funded by the UK Natural Environment Research Council, the European Commission's Horizon 2020, Erasmus+, Framework Seven Programme, Lifelong Learning, Asia Link and European Social Fund, the UK Newton Fund, the UK Foreign and Commonwealth Office, British Council and UK Parliamentary Under Secretary of State for Business, Energy and Industrial Strategy. Many of these projects were carried out in close collaboration with government, non-government organisations, and industry partners. He has published widely, including an edited book by Wiley Blackwell, fifteen edited chapters and forty-five peer-reviewed journal articles, the majority of which are in ISI or SCOPUS indexed journals. He has delivered over 80 invited speeches and keynote presentations for audiences in twenty-five countries across North America, South America, Europe, Asia, Africa, and Australasia.

Dr. Nuwan Dias is a research fellow in Disaster Resilience at the Global Disaster Resilience Centre, University of Huddersfield, UK. His research interests include multi-hazard early warning, integration of climate change adaptation to disaster risk reduction, and resilience in urban planning and design. He has delivered over 10 invited speeches and keynote presentations for audiences in Europe, South Asia, and South East Asia. He has chaired over 20 sessions in international conferences and presented his research work in more than 30 international audiences. Further, Nuwan has published two edited chapters and 12 peer-reviewed journal articles. He is involved in developing research impact case studies for the UK Research Excellence Framework (REF2021) under the Unit of Assessment 13, Architecture, Built Environment and Planning for the University of Huddersfield. He has worked in many international research projects funded by the European Commission's Horizon 2020, Erasmus+, Lifelong Learning, and the Global Challenges Research Fund in different capacities. In his different roles, he has worked with multi-stakeholders including government, non-government organisations, and industry partners. He earned his Ph.D. in Urban Design from the University of Huddersfield, UK, his master's degree from the University of Salford, UK, and the undergraduate degree from the University of Moratuwa, Sri Lanka. Further, he is a fellow member of the Higher Education Academy of the UK. He can be contacted on: n.dias@hud.ac.uk.

List of Figures

Role of the Built Environment in Rebuilding Displaced and Host Communities

Strategy for the Establishment of Local Disaster Risk Reduction (DRR) Plans in Sri Lanka: A Study on Its Effectiveness and Challenges Through a Pilot Programme

Disasters, Climate Change and Development Nexus: Food Security Sector in Asia

The Role and Challenges for Local Governments in Achieving the Resilience of Critical Infrastructure

Local Responsiveness to Changes in Climate: A Case of Underutilized Marine and Aquatic Resources

Natural Versus Manmade Disasters: Impact of Disasters on Small Holder Agricultural Systems in Gem Mining Areas of Sri Lanka

A Site Specific Study on Peacock and Human Conflict—A Case Study from Jayanthipura Grama Niladhari Division, Polonnaruwa—Sri Lanka

Inventory Survey of Slope Failures in Sri Lanka

Plant Selection Criterion for Nature-Based Landslide Risk Management

Impact of Tsunami on Heterogeneous Economic Sectors: The Case of Sri Lanka

Synoptic and Mesoscale Background of the Disastrous Heavy Rainfall in Sri Lanka Caused by a Low Pressure System