

A. S. Unnikrishnan
Fredolin Tangang
Raymond Durrheim *Editors*

Extreme Natural Events

Sustainable Solutions for Developing
Countries

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Foreword by Philip L. Woodworth

Two recent events have underlined the importance of extreme natural events to our planet's populations. The first event was the publication in 2021 of *The Physical Science Basis* by Working Group I (WG1) of the Intergovernmental Panel on Climate Change (IPCC). Two further reports concerned with *Impacts, Adaptation and Vulnerability* and *Mitigation of Climate Change* will be published by Working Groups II and III, respectively in 2022, thereby completing the overall IPCC's Sixth Assessment Reports (AR6). These reports provide irrefutable evidence for anthropogenic climate change during the past century and show that extreme events connected with climate change are now occurring more frequently than previously, with the largest events often impacting on developing countries. The reports provide projections of changes in many climate parameters towards 2100 and beyond, and thereby changes in the occurrence of extreme events, from which one concludes that, without mitigation and adaptation measures being taken, impacts on developing countries will be even more severe.

The second event was the 26th United Nations Climate Change Conference of the Parties (COP26) held in Glasgow during October–November 2021. Discussions at that conference underlined the need for urgency in tackling climate change, so that its impacts might be constrained as far as possible. It also demonstrated how difficult and costly that effective action will be.

For example, within my own field of sea-level science, the AR6 WG1 suggested that global average sea level could rise by 0.28–0.55 m by 2100 (relative to 1995–2014), assuming a very low greenhouse gas emission scenario, or 0.63–1.01 m, assuming a very high emission scenario. Such a rise in sea level, combined with possible changes in the frequency and intensity of storms and their associated storm surges, will require major expenditure in raising coastal defences, with sometimes consequent undesirable modifications to coastal environments. Moreover, in some cases, such as small island states, sea-level rise will represent a major threat to the people.

The AR6 and COP26 have made clear that climate change will impact every country in the world in different ways. In particular, rising temperatures and sea

levels and modifications to rainfall patterns will have major impacts on natural environments and agriculture and have many consequences for the built environment and infrastructure. A large number of these topics are discussed in this volume.

The editors are to be congratulated on assembling an excellent set of chapters which together underline the importance of the above topics. The first chapters in the volume are concerned with the provision of information on, and systems for addressing, extreme climate events. There then follow two sets of chapters dealing with extreme rainfall and thunderstorm events, which often lead to river flooding, and extreme wave and sea-level events, which can lead to coastal flooding. Further chapters discuss the extreme events associated with earthquakes and landslides, a reminder that extreme natural events are not confined to those associated with climate change. For example, recent years have demonstrated the threat posed to coastal populations by undersea earthquakes and tsunamis. Some of the chapters in the book discuss impacts of climate change on agriculture and integrated methods to reduce the impacts of disastrous events.

The chapters in this volume show that although the importance of individual types of extreme event varies between countries, they all require addressing worldwide. The chapters also demonstrate that major investment is required in infrastructure, including regional and global monitoring networks for a range of climate parameters. In addition, development is needed in new analysis and modelling techniques for the forecasting of extreme events (e.g. downscaling of global and regional climate projections to the more practically useful short spatial scales). International collaboration will be essential in network development and the use of the resulting data sets. The ultimate aim must be to provide the best possible information and advice to decision makers and the public, so that systems can be constructed by which the impacts of extreme events might be mitigated.

Therefore, it is gratifying that the chapters in this volume are written by authors from so many developing countries. I can recommend the volume as an important contribution to research into the extreme events which have such scientific and practical importance for us all.

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Introduction by Amitava Bandopadhyay

Extreme natural events such as avalanches, earthquakes, tsunamis, wildfires, floods, droughts, cyclones, volcanoes, thunderstorms and intense rainfall events occur across the world. Many of these phenomena are affected by the climate change. Various climate assessment reports have indicated that their frequency or intensity has increased, and projections show further increase in the future. Developing countries are far more vulnerable to these extreme events due to their inadequate technological, financial and logistic capabilities.

Extreme events are likely to push millions in the developing world into poverty and reduce the prospects for sustainable development. Such events are likely to have a significant impact both on human growth and economics. Variations in the frequency, severity and duration of some extreme weather events increase risks to children's mental health and impact their development from infancy to adolescence. Similarly, these extremes will primarily impact economic growth of a nation through damage to property and infrastructure, loss in productivity, mass migration and security threats.

Solutions developed in technologically-advanced countries often cannot be simply applied in the developing world. It is thus imperative that the natural and social scientists and engineers in the developing world improve their ability to forecast and manage these extreme events in order to reduce the economic, social (human) and environmental impacts. Adaptation to these extreme natural events must be an integral part of the national policy of the developing countries dealing with disaster management.

This book in its seventeen chapters intends to explore the challenges of the developing countries to understand and manage the risks of extreme natural events. The book brings together scientific communities from Ghana, India, Indonesia, Malaysia, Philippines, Sri Lanka, South Africa and Venezuela to share their experience and expertise in different aspects of managing extreme natural events, particularly those related to climate.

In this connection, I am proud to mention that in the past the NAM S&T Centre has made significant contributions in capacity building and exchange of knowledge

among its member countries on the subject of extreme natural events in partnership with various S&T institutions and agencies by organizing international workshops, roundtables, symposiums and training programmes and bringing out relevant scientific publications that are of significant interest to the global south.

I am extremely delighted that the NAM S&T Centre has reached another milestone by publishing its next scientific monograph titled *Extreme Natural Events: Sustainable Solutions for Developing Countries*. I gratefully acknowledge the contributions made by eminent experts from various countries on different themes on extreme natural events including climate extremes, *such as extreme rainfall events and thunderstorms, extreme waves, extreme sea-level changes, storm surges and coastal inundation, earthquakes and landslides, impact assessment and integrated disaster risk reduction*. I may mention here that the subject of “Lightning” as an important component of extreme natural events has not been included in the scope of this monograph as NAM S&T Centre has published a separate monograph titled *Lightning: Science, Engineering, and Economic Implications for Developing Countries* in August 2021 through Springer Nature, Singapore.

I am thankful to the editorial team of this book: Dr. A. S. Unnikrishnan (Former Chief Scientist, Physical Oceanography Division, CSIR-National Institute of Oceanography, Goa, India), Prof. Fredolin Tangang (Chairman and Professor, Department of Earth Sciences and Environment, Faculty of Science and Technology, Universiti Kebangsaan Malaysia, Kuala Lumpur) and Prof. Raymond J. Durrheim (South African Research Chair in Exploration, Earthquake and Mining Seismology, University of the Witwatersrand, Johannesburg, South Africa) for the scientific evaluation of the manuscripts and ensuring the best selection of the contents for dissemination of scientific knowledge on the subject in the developing world.

In addition, I am also grateful to some of the invited reviewers from India : (i) Dr. Umesh Chandra Kulshrestha (Professor, School of Environmental Sciences, Jawaharlal Nehru University, New Delhi); (ii) Dr. Someshwar Das (Former Adviser/Scientist ‘G’, Ministry of Earth Sciences, Government of India, New Delhi); (iii) Dr. M. R. Ramesh Kumar (Former Chief Scientist, Physical Oceanography Division, National Institute of Oceanography, Dona Paula, Goa); (iv) Dr. Kalachand Sain (Director, Wadia Institute of Himalayan Geology, Dehradun, Uttarakhand); (v) Dr. Smitha V. Thampi (Scientist F, Space Physics Laboratory, Vikram Sarabhai Space Centre, Indian Space Research Organisation, Trivandrum, Kerala); (vi) Prof. Bimal Kumar Roy (Head, R. C. Bose Centre for Cryptology and Security, and Former Director, Indian Statistical Institute, Kolkata) and (vii) Prof. Subimal Ghosh (Institute Chair Professor, Department of Civil Engineering and Convener, Interdisciplinary Program in Climate Studies, Indian Institute of Technology Bombay, Mumbai) for extending their support to the Centre in bringing out this valuable publication.

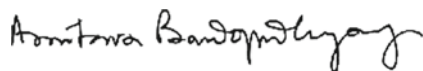
I express my sincere gratitude to Dr. Philip L. Woodworth, Former Director of the Permanent Service for Mean Sea Level at the National Oceanography Centre, Liverpool, UK, for kindly agreeing to write the “Foreword” of the monograph.

I am thankful to Dr. Loyola D’Silva, Executive Editor, Springer Nature, Singapore, for considering this book for publication through the reputed publishing house Springer Nature, and Ms. Vinothini Elango, Project Coordinator, Springer Nature,

for monitoring and streamlining the publication process. I am confident that our association with “Springer” would lead to many more such valuable collaborative endeavours in future.

My sincere thanks are also due to the entire team of the NAM S&T Centre, especially to Mr. M. Bandyopadhyay, Senior Adviser and Ms. Jasmeet Kaur Baweja, Programme Officer and Contributing Staff Editor, NAM S&T Centre for facilitating this project. I am also thankful to Dr. Ranadhir Mukhopadhyay, Former Chief Scientist, CSIR-National Institute of Oceanography (NIO), Goa, for helping to bring out this publication. I also record my appreciation for the assistance rendered by my colleagues Mr. Rahul Kumra and Mr. Pankaj Button towards bringing out this publication.

I am sure that this book would be a valuable reference material for the scientists, researchers and other professionals working in the areas of extreme natural events, particularly those related to climate.



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Preface

Extreme events of atmospheric, coastal, hydrological and geological origins (e.g. intense rainfall events, droughts, hurricanes, storm surges, floods, earthquakes, landslides) cause fatalities, property damage and socio-environmental disruption. The disasters occurring all over the globe have affected millions of people, causing loss of life and inflicting huge financial loss. Natural disasters the world over have been increasing due to global warming.

This state of affairs is particularly daunting for low-income developing countries, since they lack the resources to prepare, respond and mitigate. These extreme events represent major development impediments for low-income countries, as they hamper access to shelters, clean water, sanitation, cause food/nutritional shortage and increase the threat of communicable diseases.

Extreme events inflict considerable economic burden. The additional funding required for reconstruction and economic recovery efforts, particularly for developing countries, demonstrates the need to link the efforts for emergency disaster response to long-term development projects to sustain recovery. Hence, adapting and mitigating extreme events become a priority for governments the world over. The first step for achieving this is to understand these events, their occurrences in the past and changes that have been happening in recent years. It is also important to understand how climate-related disasters can be influenced by climate change in future periods.

The present monograph provides a comprehensive description of some of the major extreme events in atmosphere, ocean and land. Though the list may not be complete, a good attempt has been made to cover a wide spectrum of events covering different countries in many regions. The contributed articles are from authors belonging to various countries in the Non-Aligned Movement (NAM). The articles, in general, describe extreme events in the regions surrounding these countries. Developing countries are more vulnerable to the impacts of these events, because of lack of preparedness, lack of adequate adaptation and mitigation practises. Moreover, the high cost of mitigation also adds to the slow progress in implementation. We hope that this volume will be useful for improving the understanding of the

extreme events in region-wise basis so that various governments and policymakers can develop long-term strategies for tackling these events.

Some articles in the present monograph focus on the scientific understanding of extreme events, while some are on adaptation and mitigation strategies to tackle these extremes. *The seventeen articles are divided into five parts.* Part I deals with a description of climate extremes. Part II covers extremes atmospheric events, such as intense rainfall and thunderstorms. Part III deals with a description of extremes waves, sea level and coastal flooding. Part IV deals with articles on earthquakes and landslides. Part V has only one article that deals with impact assessment, and Part VI deals with adaptation and mitigation approaches dealing in particular with hydroclimatic extreme events.

We believe that this volume will enhance public awareness and promote educational efforts to increase understanding of these events and their management, which will be the first step for planning, adaptation and mitigation. The Intergovernmental Panel on Climate Change (IPCC) published the Sixth Assessment Report (AR6) of WG I in 2021 and the reports of WG II and WG III are expected to be published in 2022. These reports provide comprehensive descriptions of the past changes and future projections of extreme events due to climate change and their impacts, vulnerability and mitigation. The present monograph provides a description of some of these events and adaptation practises followed in selected regions. A unique feature of the monograph is that it covers many regions in different continents such as Asia, Africa, North and South America. This will provide information on extreme events in different regions for various governments and policy makers. We hope that this monograph will generate a lot of public awareness and be useful for educational purposes. It is hoped that the monograph will complement AR6 reports of IPCC.

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