

## **Impact of Global Changes on Mountains: Responses and Adaptation**

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## Impact of Global Changes on Mountains: Responses and Adaptation

Edited by Velma I. Grover, Axel Borsdorf, Jürgen Breuste, Prakash Chandra Tiwari, and Flavia Witkowski Frangetto. Boca Raton, FL: CRC Press, 2015. ix + 517 pp. £ 103.00. Also available as an e-book. ISBN 978-1-4822-0890-0.

Mountains are important. They cover around a quarter of Earth's land mass and provide the space for about an eighth of its population. They are home to ice caps and thousands of glaciers and, in their role as water towers, provide freshwater to almost half of the world's population. They play significant roles in driving global climate change, provide ecosystem services, and are the global focus of agricultural resources and tourist activity.

Apart from the possible exception of the Arctic, mountains are places where the effects of climate change are most apparent, driving glacier recession, glacier lake development, and permafrost melting. This association of climate change with cryospheric change means that there have been attempts to link glacier hazards to global warming. Such detection and attribution assessments are important for policy-makers in supporting climate mitigation and adaptation schemes and in driving efforts to reduce greenhouse gas emissions; they are also important if we are to develop climate justice and litigation protocols to help developing nations and remote communities pay for the impacts that climate change will bring. However, although detection and attribution of the impacts of climate change on glacier recession have recently been established, other causal chains linking climate change with natural hazards such as glacial lake outburst floods and rock avalanches have not been made. This is partly because the

observational data are not robust enough to make the statistical association and partly because the relationships between extreme glacier hazards and climate change are highly nonlinear and, in some cases, stochastic, involving a range of nonclimate variables such as geological structure and changes in debris supply to glacier surfaces. In other cases, the attribution studies have not been undertaken.

Understanding what future climate and environmental change might do to mountain regions is hampered by major limitations in our ability to successfully model mountain systems. Our numerical climate models have too coarse a resolution to model small-scale mountains, valleys, and associated features. Even current regional climate models, which are downscaled from global climate models, are routinely run with grid square resolutions of 10 to 50 km. Thus, the problems of modeling glaciers less than 1 km in width, the behavior of small lakes, or the evolution of small ecosystems are clear.

With recent international agreement to keep the rise of atmospheric temperatures to less than 2°C above preindustrial levels, and with the intention to aim even lower, it is a highly opportune time to assess the nature of global change in the world's mountains. This book achieves this by bringing together a large number of international researchers to detail the nature of change in the world's mountains in response to atmospheric warming, land use change, and socioeconomic drivers. The book comprises 22 chapters in 5 sections. The first 4 sections outline many of the wider issues concerning climate and environmental change, policy, sustainability, and governance that are common to many of the world's mountain regions. Section 1 starts with 2 useful chapters, by Jack Ives and Velma Grover, reviewing the nature of global change and the special place that mountains hold in

this debate. Section 2 focuses on the impact of global changes on mountains. It consists of a useful review chapter by Axel Borsdorf and others on the impacts of global change in mountains, covering aspects of glacier and permafrost melting, biodiversity, soil erosion, and shifts in human uses of mountain systems such as agriculture and tourism. Section 3 has 3 chapters on models and strategies for adaptation and mitigation of climate and environmental change. Several of these focus on the development of international policy on ecosystem services and of protocols for sustainable development in mountain regions, and they provide useful case studies of where this has been attempted. Section 4 covers governance and legal issues in mountains. Its 4 short chapters include a discussion of the 1991 Alpine Convention on the protection of the European Alps and one on international conventions and treaties, both by Rosario. The final section of the book comprises 15 chapters as case studies illustrating some themes developed in previous sections: land use change, natural hazards, community relations, ecosystem services, and sustainable tourism from a range of mountain regions.

At times, the book is a little repetitive; for instance, there are 2 chapters on climate change in the Rocky Mountains. Climate change is an enormous issue, but this is introduced in several of the chapters; better editing might have concentrated the basics into one main chapter and allowed the regional specifics to be covered elsewhere. There is also concentration on the Hindu Kush–Himalaya, which is understandable given the region's importance, but there are only 2 chapters covering the Andes, whose cultural, political, and environmental importance is also enormous. It is great to see other regions included; the chapters on Sri Lanka and the High Tatras show that all mountain

regions have similar challenges. I would also have liked to see discussion on the agenda of climate change litigation and climate justice, a debate in which the importance of detection and attribution plays a significant part and one that brings governance to the fore.

Despite these minor caveats, the book is a triumph. It brings together a disparate range of scientists, social scientists, policy-makers, practitioners, and development experts to focus on the remarkable range of landscapes and services that mountains provide. As a single resource for those interested in environmental and development policy, the book is

invaluable, with a set of excellent and wide-ranging bibliographies, and it will be of great interest to everyone concerned with mountain landscapes and their evolution.

We are living in a world of enormous change, and it is a telling thought that this may be the last period of deglaciation for geological periods. With current and likely future atmospheric concentrations of greenhouse gases, and with the nature of climate sensitivity, it is quite clear that most mountain glaciers will undergo prolonged recession and most will eventually disappear. Our understanding of atmospheric physics means we can predict with some

confidence that renewed glaciation will not happen for millennia. This book provides an excellent reminder of the importance of this crucial issue and the implications of change in the world's mountains.

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