

Climate Change, Glacier Response, and Vegetation Dynamics in the Himalaya

R.B. Singh • Udo Schickhoff • Suraj Mal
Editors

Climate Change, Glacier Response, and Vegetation Dynamics in the Himalaya

Contributions Toward Future Earth Initiatives

 Springer

Editors

R.B. Singh
Department of Geography
Delhi School of Economics
University of Delhi
Delhi, India

Udo Schickhoff
CEN Center for Earth System Research and
Sustainability, Institute of Geography
University of Hamburg
Hamburg, Germany

Suraj Mal
Department of Geography
Shaheed Bhagat Singh College
University of Delhi
Delhi, India

ISBN 978-3-319-28975-5 ISBN 978-3-319-28977-9 (eBook)
DOI 10.1007/978-3-319-28977-9

Library of Congress Control Number: 2016933872

© Springer International Publishing Switzerland 2016

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, express or implied, with respect to the material contained herein or for any errors or omissions that may have been made.

Printed on acid-free paper

This Springer imprint is published by Springer Nature
The registered company is Springer International Publishing AG Switzerland

Foreword

I have been working on a report for the FAO recently that is about how the mountains of the world reached the level of the United Nations that initiated a mountain chapter in the so-called Agenda 21 and with 10 mountain resolutions in the UN General Assembly between 1998 and 2014. In this report the Himalaya is playing a very important role.

In the present book, I found in 3 sections and 20 chapters having a lot of highly promising and fascinating scientific problems or approaches, which are fundamental for the future of our planet and its still growing population. In 1960 the world population was about three billion, but in 2050 only two countries, China and India, will have together three billion inhabitants, following the UN Population Division. In “the International Year of Mountains 2002”, the FAO as task manager of the mountain chapter in Agenda 21 published a report that 718 million people are living in the mountains of the world, of these 625 million in developing countries and of these 250–370 million are with food insecurity. The ICIMOD (International Mountain Centre for Integrated Mountain Development) in Kathmandu has calculated that around 1,3 billion people are living in the watersheds of the ten most important rivers from the Himalaya and the Tibet Plateau. What will be the situation at the end of century?

This question is an introduction to the first section about “Climate Change”, but as long as some big and powerful countries are not cooperating, we are confronted with very serious problems. All the same the chapters of the first section are looking very promising, and they have a high value also for the other sections. The second section with the title “Climate Change Impact on Glaciers and Hydrology” is fundamental, not only for the mountain communities, but also for the surrounding lowlands with an irrigation-dependent agricultural production. Looking at the second half of our century, when the glaciers of the “Third Pole” (Himalaya) are getting smaller and thinner and the run-off will be reduced, and then we must know that the Himalaya is the most sensitive indicator for climate change. We should never forget that water is often crossing national borders in a vast regional mountain system like the Himalaya. Lonergan said in a publication in 2005 in the UNEP Journal “Our Planet” about “Water and War”: “If there is a political will for peace, water will not

be a hindrance. If you want reasons to fight, water will give you ample opportunities". The third section with "Climate Change and Vegetation Dynamics" is not only concerning the treeline, but it is an indicator for the whole biodiversity. Different altitudinal belts represent a compression of different climatic zones in a vertical structure on a shortest possible horizontal distance. This means that the higher mountains and especially the Himalaya are indeed the "sentinels" of climate change.

From this overview with the three sections, let's go down to the 20 chapters and their authors. Where are they coming from and where are they going to? Most impressive are the mixed chapters with authors from the north and from the south. These chapters and the whole book reminded me of a speech of Kofi Annan, the UN Former Secretary-General, during the UN Millennium Declaration, valid until 2015: "What is needed is a true partnership of developed and developing countries – a partnership that includes science and technology. No nation can afford to be without science and technology capacity". It is fascinating to see the different research fields and places around the Himalaya. We hope that exactly this Springer publication will help for a north-south dialogue, but also for a science-policy dialogue and for a transboundary cooperation, as it was recommended in 2012 in the Rio+20 conference and described in the final document "The Future We Want". We select some sentences: Paragraph 210: "Mountain glaciers are retreating and getting thinner with increasing impacts on the environment and human wellbeing". Paragraph 211: "We invite States to strengthen cooperative action with effective involvement and sharing of experience of relevant stakeholders by strengthening existing arrangements and regional centres of excellence for sustainable mountain development". Paragraph 212: "We call for greater efforts towards the conservation of mountain ecosystems, including their biodiversity. We encourage States to adopt a long-term vision and holistic approaches through mountain specific policies into national sustainable development strategies". You may see that your book is fulfilling these UN declarations from 2012.

By the way, I have been strongly involved in the foundation of the ICIMOD and I was generously invited to its 30th anniversary in Kathmandu 2013. ICIMOD is the centre for eight Himalayan countries. I hope that transboundary cooperation with this institution will be possible in the future. I thank once more the small group of the three editors for their wonderful composition of the book, but my acknowledgements go also to all the authors of the 20 chapters for their engagement and cooperation for the highest mountain system of the world!

Ex-President, International Geographical Union
Professor Emeritus, Institute of Geography
University of Bern, Switzerland

Bruno Messerli

Foreword

There are numerous reasons why this book is important and its publication is timely. Firstly, the role of glaciers in relation to climate change is akin to the role of canaries in a coal mine. They provide one of the first signals that something is amiss. Glaciers worldwide are receding not all of them but the vast majority – and the scientific consensus is that the reason for this is global warming. But the glaciers in the Himalaya play a special role that is not well appreciated by those outside of the Indian subcontinent. The Himalaya themselves form a vertical massif that protrudes into the lower atmosphere. The heating and cooling of the surface of the Himalaya and the Tibetan plateau plays a major role in the dynamics of the atmospheric circulation and thus a major role in the climate of the Asian region. If and when the Himalayan glaciers recede, they will change the nature of the albedo, the reflected sunlight, and are thus expected to induce major changes in circulation and climate.

If and when the Himalayan glaciers recede, a possibly even more serious change will be that of the lifestyle of the population on the Indian subcontinent that rely on the waters that flow from melting glaciers. A continent that is presently well supplied with water through its fluvial system could then endure water scarcity. The likelihood is that for a region as densely populated as the Indian subcontinent, any sudden diminution of the water supply will cause social disruption if not chaos and possible armed conflict. Thus, the more we can learn about the dynamics of glaciers and vegetation in the Himalaya, the better.

Issues such as this will be studied by the new international research programme called Future Earth, which is the major new initiative of the International Council of Science (ICSU) that brings together at least three of the existing ICSU international research programmes into this new one. It seeks to examine the effects of global change on all aspects of the biosphere and anthroposphere. Although ICSU initiated this process of merging its four environmental programmes to become Future Earth, it has become a multipurpose programme cosponsored by many organizations including ICSU.

The scientific community is presently engaged in a global dialogue to determine how it can participate in and assist Future Earth. The International Union of Geodesy and Geophysics (IUGG) established a new entity, the Commission for Climate and

Environmental Change, to be the vehicle by which IUGG could co-ordinate its science in a way that would assist Future Earth, and the Commission has so far concentrated on the hydrological issues involved in the initiative known as Panta Rhei and in a study of the implications of weather, climate and food security.

Climate Change and Dynamics of Glaciers and Vegetation in the Himalaya is a topic that is of obvious importance to both of these initiatives, of importance to global change science and of importance to the future of the societies that live in the Indian subcontinent. In short it is a topic of importance to Future Earth and to the Future of the Earth.

Chair IUGG Commission for Climate and Environmental Change
Member, ICSU Committee for Scientific Planning and Review
Paris, France

Tom Beer

Contents

1	Climate Change and Dynamics of Glaciers and Vegetation in the Himalaya: An Overview	1
	Udo Schickhoff, R.B. Singh, and Suraj Mal	
Part I Climate Change		
2	Recent Climate Change over High Asia	29
	Shabeh ul Hasson, Lars Gerlitz, Udo Schickhoff, Thomas Scholten, and Jürgen Böhner	
3	Analytic Comparison of Temperature Lapse Rates and Precipitation Gradients in a Himalayan Treeline Environment: Implications for Statistical Downscaling	49
	Lars Gerlitz, Benjamin Bechtel, Jürgen Böhner, Maria Bobrowski, Birgit Bürzle, Michael Müller, Thomas Scholten, Udo Schickhoff, Niels Schwab, and Johannes Weidinger	
4	Climate Change and Hydrological Responses in Himalayan Basins, Nepal	65
	Tirtha Raj Adhikari and Lochan Prasad Devkota	
5	Spatial and Temporal Variability of Climate Change in High-Altitude Regions of NW Himalaya	87
	M.R. Bhutiyani	
6	Assessing Climate Change Signals in Western Himalayan District Using PRECIS Data Model	103
	R.B. Singh, Swarnima Singh, and Shouraseni Sen Roy	
7	Climate Change in Pindari Region, Central Himalaya, India	117
	R.B. Singh, Santosh Kumar, and Ajay Kumar	

Part II Climate Change Impacts on Glaciers and Hydrology

- 8 Glacier Variations in the Trans Alai Massif and the Lake Karakul Catchment (Northeastern Pamir) Measured from Space** 139
Nicolai Holzer, Tim Golletz, Manfred Buchroithner, and Tobias Bolch
- 9 Heterogeneity in Fluctuations of Glacier with Clean Ice-Covered, Debris-Covered and Proglacial Lake in the Upper Ravi Basin, Himachal Himalaya (India), During the Past Four Decades (1971–2013)** 155
Pritam Chand, Milap Chand Sharma, and Ram Nagesh Prasad
- 10 Current and Future Glacial Lake Outburst Flood Hazard: Application of GIS-Based Modeling in Himachal Pradesh, India** 181
Simon K. Allen, Andreas Linsbauer, Christian Huggel, S.S. Randhawa, Yvonne Schaub, and Markus Stoffel
- 11 Estimating Recent Glacier Changes in Central Himalaya, India, Using Remote Sensing Data** 205
Suraj Mal, R.B. Singh, and Udo Schickhoff
- 12 Instability Processes Triggered by Heavy Rain in the Garhwal Region, Uttarakhand, India** 219
Manish Mehta, D.P. Dobhal, Tanuj Shukla, and Anil K. Gupta
- 13 The Need for Community Involvement in Glacial Lake Field Research: The Case of Imja Glacial Lake, Khumbu, Nepal Himalaya** 235
Teiji Watanabe, Alton C. Byers, Marcelo A. Somos-Valenzuela, and Daene C. McKinney
- 14 Understanding Factors Influencing Hydro-climatic Risk and Human Vulnerability: Application of Systems Thinking in the Himalayan Region** 251
Gourav Misra, Harekrishna Misra, and Christopher A. Scott

Part III Climate Change and Vegetation Dynamics

- 15 Climate Change and Treeline Dynamics in the Himalaya** 271
Udo Schickhoff, Maria Bobrowski, Jürgen Böhner, Birgit Bürzle, Ram Prasad Chaudhary, Lars Gerlitz, Jelena Lange, Michael Müller, Thomas Scholten, and Niels Schwab

16 Treeline Responsiveness to Climate Warming: Insights from a Krummholz Treeline in Rolwaling Himal, Nepal 307
Niels Schwab, Udo Schickhoff, Michael Müller,
Lars Gerlitz, Birgit Bürzle, Jürgen Böhner,
Ram Prasad Chaudhary, and Thomas Scholten

17 Dendroecological Perspectives on Climate Change on the Southern Tibetan Plateau 347
Achim Bräuning, Jussi Grießinger, Philipp Hochreuther,
and Jakob Wernicke

18 Spatially Variable Vegetation Greenness Trends in Uttarakhand Himalayas in Response to Environmental Drivers 365
Niti B. Mishra and Gargi Chaudhuri

19 Impact of Glacial Recession on the Vegetational Cover of Valley of Flowers National Park (a World Heritage Site), Central Himalaya, India 377
M.P.S. Bisht, Virendra Rana, and Suman Singh

20 Snow Cover Dynamics and Timberline Change Detection of Yamunotri Watershed Using Multi-temporal Satellite Imagery 391
Manish Kumar and Pankaj Kumar

Contributors

Tirtha Raj Adhikari Central Department of Hydrology and Meteorology, Tribhuvan University, Kirtipur, Kathmandu, Nepal

Simon K. Allen Department of Geography, University of Zurich, Zurich, Switzerland

Institute for Environmental Sciences, University of Geneva, Geneva, Switzerland

Benjamin Bechtel CEN Center for Earth System Research and Sustainability, Institute of Geography, University of Hamburg, Hamburg, Germany

M.R. Bhutiyani Defense Terrain Research Laboratory, Defense Research & Development Organization, New Delhi, India

M.P.S. Bisht Department of Geology, HNB Garhwal University, Srinagar (Garhwal), Uttarakhand, India

Maria Bobrowski CEN Center for Earth System Research and Sustainability, Institute of Geography, University of Hamburg, Hamburg, Germany

Jürgen Böhner CEN Center for Earth System Research and Sustainability, Institute of Geography, University of Hamburg, Hamburg, Germany

Tobias Bolch Institut für Kartographie, Technische Universität Dresden, Dresden, Germany

Geographisches Institut, Universität Zürich, Zürich, Switzerland

Achim Bräuning Institute of Geography, Friedrich-Alexander-University Erlangen-Nürnberg, Erlangen, Germany

Manfred Buchroithner Institut für Kartographie, Technische Universität Dresden, Dresden, Germany

Birgit Bürzle CEN Center for Earth System Research and Sustainability, Institute of Geography, University of Hamburg, Hamburg, Germany

Alton C. Byers Institute of Arctic and Alpine Research, University of Colorado at Boulder, Boulder, CO, USA

Ram Prasad Chaudhary RECAST Research Centre for Applied Science and Technology, Tribhuvan University, Kathmandu, Nepal

Gargi Chaudhuri Department of Geography and Earth Science, University of Wisconsin-La Crosse, La Crosse, WI, USA

Pritam Chand Centre for the Study of Regional Development, Jawaharlal Nehru University, New Delhi, India

Lochan Prasad Devkota Central Department of Hydrology and Meteorology, Tribhuvan University, Kirtipur, Kathmandu, Nepal

D.P. Dobhal Centre for Glaciology, Wadia Institute of Himalayan Geology, Dehradun, Uttarakhand, India

Lars Gerlitz Section Hydrology, GFZ German Research Centre for Geosciences, Potsdam, Germany

Tim Golletz Institut für Kartographie, Technische Universität Dresden, Dresden, Germany

Jussi Griebinger Institute of Geography, Friedrich-Alexander-University Erlangen-Nürnberg, Erlangen, Germany

Anil K. Gupta Wadia Institute of Himalayan Geology, Dehradun, Uttarakhand, India

Shabeh ul Hasson CEN Center for Earth System Research and Sustainability, Institute of Geography, University of Hamburg, Hamburg, Germany

Philipp Hochreuther Institute of Geography, Friedrich-Alexander-University Erlangen-Nürnberg, Erlangen, Germany

Nicolai Holzer Institut für Kartographie, Technische Universität Dresden, Dresden, Germany

Christian Huggel Department of Geography, University of Zurich, Zurich, Switzerland

Ajay Kumar Department of Geography, Delhi School of Economics, University of Delhi, Delhi, India

Manish Kumar Department of Geography, Kalindi College, University of Delhi, Delhi, India

Pankaj Kumar Department of Geography, Delhi School of Economics, University of Delhi, Delhi, India

Santosh Kumar Department of Geography, Delhi School of Economics, University of Delhi, Delhi, India

Jelena Lange Institute of Botany and Landscape Ecology, University of Greifswald, Greifswald, Germany

Andreas Linsbauer Department of Geography, University of Zurich, Zurich, Switzerland

Department of Geosciences, University of Fribourg, Fribourg, Switzerland

Suraj Mal Department of Geography, Shaheed Bhagat Singh College, University of Delhi, Delhi, India

Daene C. McKinney Department of Civil, Architectural & Environmental Engineering, University of Texas at Austin, Austin, TX, USA

Manish Mehta Wadia Institute of Himalayan Geology, Dehradun, Uttarakhand, India

Niti B. Mishra Department of Geography and Earth Science, University of Wisconsin-La Crosse, La Crosse, WI, USA

Harekrishna Misra Institute of Rural Management Anand, Anand, Gujarat, India

Gourav Misra International Water Management Institute, Anand, Gujarat, India

Michael Müller Department of Geosciences, Chair of Soil Science and Geomorphology, University of Tübingen, Tübingen, Germany

Ram Nagesh Prasad Centre for the Study of Regional Development, Jawaharlal Nehru University, New Delhi, India

Virendra Rana Department of Geology, HNB Garhwal University, Srinagar (Garhwal), Uttarakhand, India

S.S. Randhawa State Centre on Climate Change, Himachal Pradesh, India

Shouraseni Sen Roy Department of Geography and Regional Studies, University of Florida, Miami, FL, USA

Yvonne Schaub Department of Geography, University of Zurich, Zurich, Switzerland

Udo Schickhoff CEN Center for Earth System Research and Sustainability, Institute of Geography, University of Hamburg, Hamburg, Germany

Thomas Scholten Department of Geosciences, Chair of Soil Science and Geomorphology, University of Tübingen, Tübingen, Germany

Niels Schwab CEN Center for Earth System Research and Sustainability, Institute of Geography, University of Hamburg, Hamburg, Germany

Christopher A. Scott Udall Center for Studies in Public Policy/School of Geography & Development, University of Arizona, Tucson, AZ, USA

Milap Chand Sharma Centre for the Study of Regional Development, Jawaharlal Nehru University, New Delhi, India

Tanuj Shukla Centre for Glaciology, Wadia Institute of Himalayan Geology, Dehradun, Uttarakhand, India

R.B. Singh Department of Geography, Delhi School of Economics, University of Delhi, Delhi, India

Suman Singh Department of Geology, HNB Garhwal University, Srinagar (Garhwal), Uttarakhand, India

Swarnima Singh Department of Geography, Delhi School of Economics, University of Delhi, Delhi, India

Marcelo A. Somos-Valenzuela Department of Civil, Architectural & Environmental Engineering, University of Texas at Austin, Austin, TX, USA

Markus Stoffel Institute for Environmental Sciences, University of Geneva, Geneva, Switzerland

Dendrolab.ch, Institute of Geological Sciences, University of Berne, Berne, Switzerland

Teiji Watanabe Faculty of Environmental Earth Science, Hokkaido University, Sapporo, Hokkaido, Japan

Johannes Weidinger CEN Center for Earth System Research and Sustainability, Institute of Geography, University of Hamburg, Hamburg, Germany

Jakob Wernicke Institute of Geography, Friedrich-Alexander-University Erlangen-Nürnberg, Erlangen, Germany