ICIMOD

Formation of Glacial Lakes in the Hindu Kush-Himalayas and GLOF Risk Assessment

ISDR
International Strategy for Disaster Reduction

GFDRR
Global Facility for Disaster Reduction and Recovery

THE WORLD BANK

FOR MOUNTAINS AND PEOPLE

Formation of Glacial Lakes in the Hindu Kush-Himalayas and GLOF Risk Assessment

Jack D. Ives
Rajendra B. Shrestha
Pradeep K. Mool

International Centre for Integrated Mountain Development, Kathmandu, May 2010

Foreword

Director General
International Centre for Integrated Mountain Development

Glaciers are believed to have persisted in the Hindu Kush-Himalayas since the last Ice Age (which ended about 10,000 years ago). At present, world glacial ice cover is most widely distributed in Antarctica and Greenland. Nevertheless, the Hindu Kush-Himalayan region is one of the most heavily glacierized areas in the world outside the polar regions. Glacier ice covers approximately 33,000 square kilometres in the Himalayan range alone. Thus, explorers, mountaineers, scientists, researchers, developers, and planners, have been attracted to the area for the last 200 years. The extensive permanent ice and snow cover forms the headwater supply of some of the world's largest rivers. This in turn is vital for the provision of life-supporting water and hydroelectricity for almost one-third of the world's population, living in the lower river basins beyond the mountains. However, the combination of extremely high mountains, high seismic activity, and steep slopes is also responsible for a wide range of natural hazards, including landslides, flash floods, avalanches, and glacial lake outburst floods.

It has been widely recognised that global climate change is causing the shrinkage or retreat of glaciers throughout the world. The Hindu Kush-Himalayan region is no exception. This has resulted in the formation of a large number of glacial lakes, many of which can become unstable as their volume increases or they are subjected to surge waves as a result of ice and rock avalanches striking their surface that cause them to overtop their end moraine dams. A number of glacial lake outburst floods (GLOFs) have occurred in the Hindu Kush-Himalayas in recent years, some of which have caused considerable damage across international borders. Lives have been lost, livelihoods destroyed, and extensive damage to infrastructure has occurred.

Monitoring ice and water resources, promoting community resilience and preparedness for disaster risk reduction, and ensuring the sharing of upstream-downstream benefits are priority areas in ICIMOD's programme. As glaciers and glacial lakes are related both to water resources and to water-related natural hazards, they need to be mapped and monitored.

While glaciological research has been carried out in the Hindu Kush-Himalayan region by many institutions and individuals (principally academic) over more than a century, the research has been intermittent with no systematic or coordinated long-term basis. Given the vast area involved and problems of accessibility and high altitude, and despite many invaluable results, the entire region remains little known compared to such areas as the European Alps, Scandinavia, and western North America. ICIMOD is attempting to bridge the knowledge gap by undertaking a systematic inventory of glaciers and glacial lakes, and identifying those lakes that could represent a threat. This large programme, heavily dependent on remote sensing, has been developed in collaboration with ICIMOD's country partners. More than 8,000 glacial lakes have been identified. While the great majority of these are very small and have formed in remote areas, up to 200 may be potentially dangerous.

The potential for serious losses due to GLOFs is likely to increase as climate warming progresses through the 21st century; new lakes are forming and existing ones are enlarging. Hence, a standardised glacial lake inventory is being prepared for the entire Hindu Kush-Himalayan region and will be used as a basis for GLOF risk assessment, supported by the Swedish International Development Cooperation Agency, the Norwegian Ministry of Foreign Affairs, and the World Bank.

We hope that the present report, which provides a detailed background to the present situation, will help fulfil the requirement for regional knowledge about glacial lakes and GLOF risk. In this way, planners and policy makers, as well as development scientists, will have a tool to facilitate regional collaboration aimed at reducing the glacial lake hazard.

On behalf of ICIMOD, I would like to thank the Swedish International Development Cooperation Agency, the Norwegian Ministry of Foreign Affairs, and the World Bank for their support. The assistance in preparation of this report provided by the United Nations International Strategy for Disaster Reduction (UNISDR) and the Global Facility for Disaster Reduction and Recovery (GFDRR)/World Bank is gratefully acknowledged.

Andreas Schild
Director General
ICIMOD

Foreword

Special Representative of the Secretary-General for Disaster Risk Reduction
United Nations International Strategy for Disaster Reduction

and

Vice President
South Asia Region, World Bank

Himalaya is a Sanskrit word that translates as 'abode of snow'. Today, this glacial abode, forming the largest body of ice outside the polar latitudes, is shrinking. Though the rate of melting and retreat varies, and glacier advance is occurring in some areas, the overall negative trend is evident. The wider Himalayan system extends across eight countries: Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan and supports ten river systems – the Amu Darya, the Brahmaputra, the Ganges, the Indus, the Irrawaddy, the Mekong, the Salween, the Tarim, the Yangtze, and the Yellow. These river systems provide water and sustain food supplies for over 1.3 billion people.

Accelerated glacial melt increases the risk of avalanches and floods, and causes lakes formed from melting glaciers to expand. Many Himalayan basins report fast growing lakes greatly increasing the threat of glacial lake outburst floods (GLOFs). Glacial lakes bursting their banks can have catastrophic consequences for people, agriculture and hydropower infrastructure downstream.

It is estimated that there are over 8,000 glacial lakes in the Hindu Kush-Himalayan region with more than 200 of them identified as potentially dangerous. A GLOF event of 1985 originating from Dig Tsho, a glacial lake in the Khumbu Himal, Nepal, destroyed the nearly completed Namche Small Hydel Project and caused extensive damage downstream. GLOFs have caused damage across national borders; outbursts originating in China have impacted areas in Nepal, India, and Bhutan.

Glacial lakes pose a threat to their downstream communities, but they are also a potential source of water storage for sustaining agriculture and forest-based livelihoods. The challenge is to minimise the risk of outburst and to reduce the vulnerability of nearby communities while securing the potential benefits of the lakes. Scientific information about existing glacial lakes, enhanced by monitoring and early warning systems, and mitigation measures to reduce the impact of glacial melting is essential.

The South Asia programme of the Global Facility for Disaster Reduction and Recovery (GFDRR) in partnership with the United Nations International Strategy for Disaster Reduction (UNISDR) has given high priority to the sub regional issues of GLOFs. This technical assessment study of GLOF risks in the Hindu Kush-Himalayan region, by the International Centre for Integrated Mountain Development (ICIMOD), pays special attention to the impact of GLOFs and their transboundary nature. It aims to encourage inter-country dialogue, to develop appropriate policies, and to generate the required investments.

We hope that this will be a step towards achieving greater regional cooperation and consensus for effective GLOF risk reduction and mitigation in the South Asia region.

Margareta Wahlström
Special Representative
of the Secretary-General for Disaster Risk Reduction,
United Nations International Strategy for Disaster Reduction,
Geneva

Isabel M. Guerrero
Vice President,
South Asia Region, World Bank

Executive Summary

This report contains an assessment of the threat facing the Hindu Kush-Himalayan region from the recent (post-1950s) and rapid formation of meltwater lakes on the surface or at the end of a large number of the region's glaciers. There is no doubt that the driving force is the current climate warming. Individual case studies of the catastrophic outburst (glacial lake outburst floods or GLOFs) from such glacial lakes are introduced. The potential for acceleration of extensive downstream damage and loss of life is high. Equally, there have been many occasions in the news media, and even in the scientific literature, where the threat has been exaggerated to the point of becoming melodrama. An attempt is made here to modify this potentially damaging misrepresentation.

Early responses up to the present are described together with the methods employed, including remote sensing and geophysical field investigations. A list is provided of the several institutions with responsibility for assessing the GLOF problem within their own prescribed sections of the region. Already, several bilateral and trilateral associations have evolved, with ICIMOD playing the role of facilitator.

The critical importance of continued and extended application of a wide variety of remote sensing techniques is underlined. However, it is also stressed that once a realistic ranking of the glacial lakes in order of their perceived degree of danger is firmly in place, detailed glaciological and geophysical field investigation will be required. Remote sensing application is the primary tool to achieve this in view of the serious challenges posed by high altitude, vast areal extent, and difficult accessibility. Enough is known already, such that action does not need to await lengthy scientific investigation. Nevertheless, it is emphasised that precise identification of the timing and magnitude of potential outbreak of glacial lakes cannot be achieved with the present state of knowledge. Consequently, the report aims to present a preliminary assessment as a basis for future action.

As understanding of the hazard advances, effective warnings should reach every person at risk in a timely manner. Likewise, mitigation measures applied to reduce the loss of life and property from the GLOF risk should be such that they should not create or increase the risk during and after the time that the proposed mitigation measures are being put in place. The early warning systems that have been installed in Nepal and Bhutan are described and warning systems employed in other countries are also mentioned. Similarly, examples of mitigation measures taken in Nepal and Bhutan are discussed.

Regional collaboration among or between the governments in the event of transboundary disasters such as GLOF risk assessment and mitigation, as well as sharing of data and information for GLOF risk management, is essential. Also, there is a need to accelerate inter-governmental collaborative research on glacial hazards and GLOF risk management. The importance of national policy development in GLOF risk management is also emphasised. Regional centres of excellence such as ICIMOD can play a critical role in bringing knowledge to guide policy making on GLOF risk reduction. A regional convention involving relevant government authorities and expert groups is proposed to develop the next steps in GLOF risk management.

Contents

Dig Tsho glacial lake, Nepal, in April 2009 (after August 1985 GLOF)