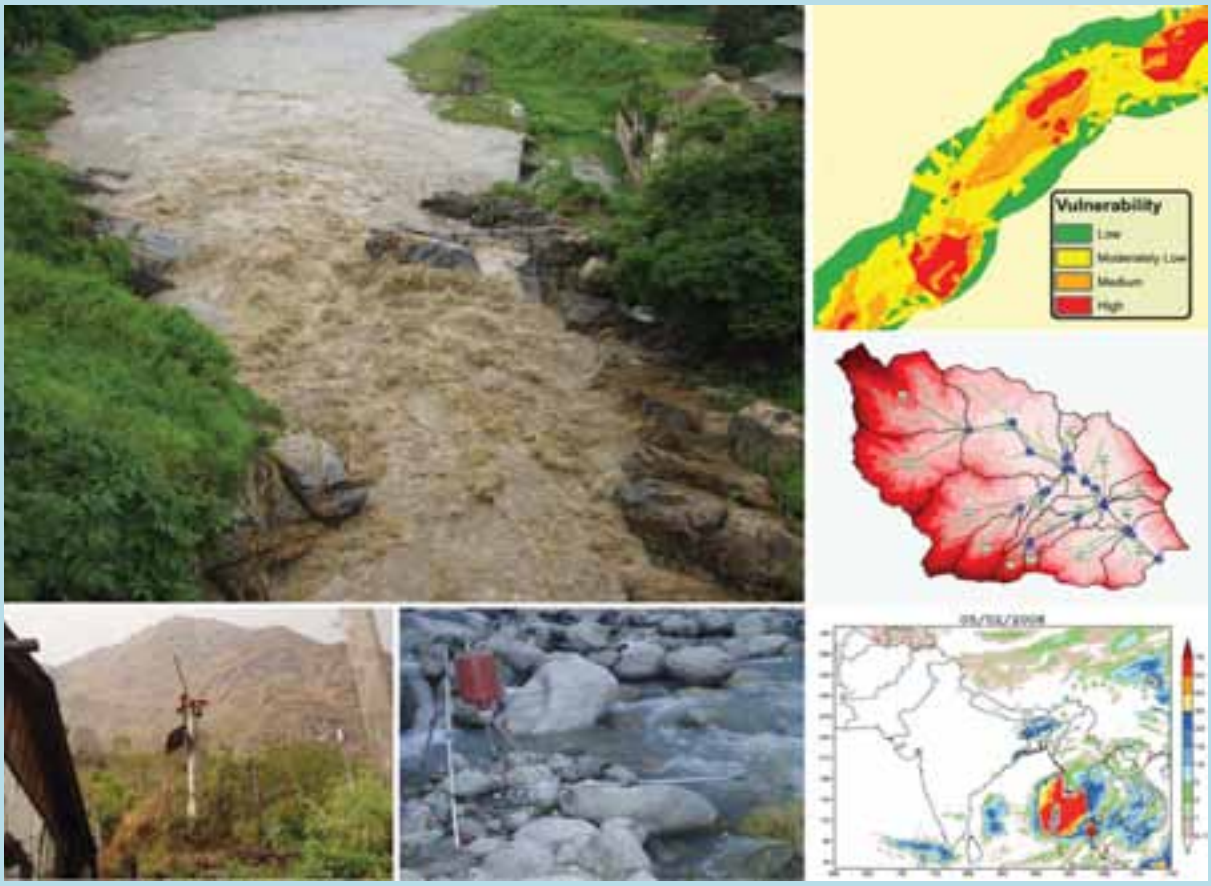
# Resource Manual on Flash Flood Risk Management

## Module 2: Non-structural Measures




Arun Bhakta Shrestha

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# About ICIMOD

The International Centre for Integrated Mountain Development (ICIMOD) is an independent regional knowledge, learning and enabling centre serving the eight regional member countries of the Hindu Kush-Himalayas – Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan – and the global mountain community. Founded in 1983, ICIMOD is based in Kathmandu, Nepal, and brings together a partnership of regional member countries, partner institutions, and donors with a commitment for development action to secure a better future for the people and environment of the Hindu Kush-Himalayas. ICIMOD's activities are supported by its core sponsors: the Governments of Austria, Denmark, Germany, Netherlands, Norway, Switzerland, and its regional member countries, along with programme co-financing donors. The primary objective of the Centre is to promote the development of an economically and environmentally sound mountain ecosystem and to improve the living standards of mountain populations.

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Arun Bhakta Shrestha

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A. Beatrice Murray (Senior Editor)
Mathew Zalichin (Consultant Editor)
Susan Sellars-Shrestha (Consultant Editor)
Dharma R. Maharjan (Layout and Design)
Asha Kaji Thaku (Editorial Assistance)

**Cover photos**
Clockwise from top left: 1) Bagmati River at Chobhar, Kathmandu during the flash flood of July 2003 – *Saraju Baidya,* DHM; 2) Flash flood vulnerability map – *Arun B. Shrestha*; 3) Flash flood modelling in a mountainous catchment – *Arun B. Shrestha*; 4) Satellite rainfall estimation based on NOAA data – *Mandira Shrestha*; 5) Flow measurement in a mountain stream using dilution technique – *Arun B. Shrestha*; 6) A GLOF early warning station established in the Bhotekoshi basin, Nepal – *Arun B. Shrestha*

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# Contents

# Foreword

The Hindu Kush-Himalayan (HKH) region is one of the most dramatic physiographic features on our planet. As the youngest mountain system in the world, it has unstable geological conditions and steep topography, which, combined with frequent extreme weather conditions, makes the region prone to many different natural hazards from landslides, avalanches, and earthquakes, to massive snowfall and flooding. Among these, flash floods are particularly challenging for communities.

Flash floods are severe flood events that occur with little or no warning. They can be triggered by intense rainfall ('cloudbursts'), failure of natural or artificial dams, and outbursts of glacial lakes. The frequent occurrence of flash floods within the Hindu Kush-Himalayan region poses a severe threat to lives, livelihoods, and infrastructure, both within the mountains and downstream. Vulnerable groups – the poor, women, children, and people with disabilities – are often the hardest hit. Flash floods pose a greater risk to human life and livelihoods than do the more regular riverine floods, which build up over days when there is heavy rainfall upstream. Flash floods tend to carry with them much higher amounts of debris and, as a result, cause more damage to hydropower stations, roads, bridges, buildings, and other infrastructure.

Since its establishment in 1983, ICIMOD has explored different ways to reduce the risk of disaster from natural hazards and the physical and social vulnerability of the people in the region. These have included training courses, hazard mapping, vulnerability assessments, fostering dialogue among stakeholders, and developing materials for capacity building. Recognising the important role of flash floods, ICIMOD has recently undertaken several initiatives specifically aimed at reducing flash flood risk. An 'International Workshop on Flash Floods' organised by ICIMOD in October 2005 in Lhasa highlighted the need for capacity building in this area. Since then, ICIMOD has been working towards improving the capacity of practitioners and communities to manage flash flood risk.

Resource materials related to flash flood risk management have been compiled and developed by ICIMOD together with various partners to support the capacity development and training of planners and practitioners. After testing with different groups, these resource materials are now being published to make them more widely available. The present publication is the second module of a 'Resource Manual on Flash Flood Risk Management' and looks at technology-based, non-structural measures for managing flash floods. It was produced under the project 'Capacity Building for Flash Flood Risk Management and Sustainable Development in the Himalayas', funded by the United States Agency for International Development, Office for Foreign Disaster Assistance (USAID/OFDA). The first module focuses on community-based approaches to managing flash floods. These two modules are small, but important steps towards securing the physical security of the people of the Hindu Kush-Himalayas. We hope that they will contribute towards reducing disaster risk in this vulnerable region.

Andreas Schild
Director General
ICIMOD

# About this Module

Flash floods are among the most destructive natural disasters in the Hindu Kush-Himalayan region. They are sudden events that allow very little time to react. They often occur in isolated remote mountain catchments, where there are few, if any, institutions equipped to deal with disaster mitigation and where relief agencies are either absent or have limited presence and capacity to manage the results of natural disasters. Often the management of flash floods is done primarily by community-based organisations, local non-governmental organisations, or district and ward-level staff of governmental organisations. However, these people often lack adequate understanding of the processes causing flash floods and knowledge of flash flood risk management measures. Building the capacity of those working directly in flash flood-prone catchments will help to reduce flash flood risk in the region.

This manual provides resource materials for understanding the problem and managing the risk. The manual is prepared in two modules. The first concerns community-based flash flood risk management. This second module concerns technology-based non-structural flash flood risk management. Chapters 1 and 2 of this module introduce the natural setting of the region: topography, geology, climatic systems, and so on. Chapter 3 describes three major types of flash flood that occur in the region: intense rainfall floods, landslide dam outburst floods, and glacial lake outburst floods, supplemented by examples and case studies. Chapter 4 explains ways to assess flash flood risks. Chapter 5 describes general, non-structural flash flood risk management measures. Chapter 6 provides insight into some hazard-specific measures.

This module is designed for professionals from both social science and physical science backgrounds. Its objective is to build the capacity of district-level disaster mitigation and relief workers, professionals from community-based and non-governmental organisations such as hydrologists, meteorologists, engineers, and so on. The tools and models selected here are simple, but important, requiring relatively little data. Users with higher technical skills can also benefit from these tools as a first approach and use higher-level models to further enhance their analysis.

**Note:** Remote sensing images of the Himalayan region use ESRI as the map source with data from ICIMOD. The Hindu Kush-Himalayan outline shows an approximate boundary based on an ICIMOD working definition of mountain/hill areas linked to the mountain ranges that stretch from the Hindu Kush to the Himalayas.

# Acknowledgements

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* IDNDR (1997) *Guiding Principles for Effective Early Warning*. Geneva: United Nations International Decade for Natural Disaster Reduction (IDNDR)

# Acronyms

| | |
|---|---|
| ADPC | Asian Disaster Preparedness Center |
| CRU | Climate Research Unit |
| DHM | Department of Hydrology and Meteorology (Nepal) |
| DPTC | Disaster Prevention Technical Centre (Nepal) |
| DWIDP | Department of Water Induced Disaster Prevention (Nepal) |
| ESRI | Environmental Systems Research Institute |
| EWS | early warning system |
| FHM | flood hazard mapping |
| GIS | geographical information system |
| GIS-IDC | Geographical Information System Integrated Development Centre |
| GLOF | glacial lake outburst flood |
| HEC | Hydraulic Engineering Center (USA) |
| HF | high frequency |
| HKH | Hindu Kush-Himalayas/n |
| HMS | Hydrologic Modelling System (HEC) |
| ICIMOD | International Centre for Integrated Mountain Development |
| IDNDR | International Decade for Natural Disaster Reduction (UN) |
| IFFM | integrated flash flood management |
| ILWIS | The Integrated Land and Water Information System (ITC) |
| ISDR | International Strategy for Disaster Reduction (UN) |
| ITC | International Institute for Geo-Information Science and Earth Observation (The Netherlands) |
| ITCZ | Inter-tropical Convergence Zone |
| IWRM | integrated water resource management |
| LDOF | landslide dam outburst flood |
| masl | metres above sea level |
| MWRS | monitoring warning and response system |
| OFDA | Office for Foreign Disaster Assistance (USAID) |
| RGSL | Reynolds Geoscience Limited (UK) |
| SCS | Soil Conservation Service (now Natural Resources Conservation Service, USA) |
| TU | Tribhuvan University (Nepal) |
| UN | United Nations |
| USACE | United States Army Corps of Engineers (USA) |
| USAID | United States Agency for International Development |
| USGS | United States Geological Survey |
| VHF | very high frequency |
| WECS | Water and Energy Commission Secretariat (Nepal) |
| WWF | World Wildlife Fund/Worldwide Fund for Nature |

# Some Key Terms

The definitions provided here are based on the UN/ISDR Glossary[1], UNDP/BCPR (2004), ISDR (2004), and UNU-EHS (2006).

## Climate, flood and related terms

**Weather and climate:** Weather is a term that encompasses phenomena in the earth's atmosphere, usually referring to the activity of these phenomena over short periods such as hours or days. Average atmospheric conditions over significantly longer periods of time are known as climate.

**Precipitation:** Precipitation is the discharge of water, in a liquid or solid state, from the atmosphere, generally upon a land or water surface. Rainfall is precipitation occurring in a liquid state.

**Discharge:** The volume of water per unit of time that passes through a specified section of a channel is called discharge and is commonly denoted by the letter Q. Discharge can be measured in cubic metres per second ($m^3/s$), sometimes referred to as cumecs. In the English system discharge is measured in $ft^3/sec$ or cusec. A cusec is 35.29 times smaller than a cumec.

**Flood:** Significant rise of water level in a stream, lake, reservoir, or coastal region.

**Flash flood:** Flash floods are severe flood events triggered by extreme cloudbursts; glacial lake outbursts; or the failure of artificial dams or dams caused by landslides, debris, ice, or snow. Flash floods can have impacts hundreds of kilometres downstream, although the warning time available is counted in minutes or, at the most, hours.

**Annual flood:** The highest instantaneous peak discharge in a stream that occurs within a hydrological year is called annual flood.

**Design flood:** Design floods are hypothetical floods used for planning and management. As a design flood is defined by its probability of occurrence, it represents a flood that has a particular probability of occurring in any one year. For example, the 1% annual excedence probability (AEP) or 1 in 100 average recurrence interval (ARI) flood is a best estimate of a flood which has 1 chance in 100 of occurring in any given year.

**Flood magnitude:** The size of flood peak in discharge units (e.g., $m^3/s$, $ft^3/s$, etc.).

**Inundation:** The state of being submerged under water due to flood is called inundation. The depth of water at a particular location is called inundation depth, and the area under submergence is called area of inundation.

**Return period:** Return period, also known as recurrence interval, is the average interval of time within which the given flood will be equalled or exceeded once. For example, a flood of 10 years return period is likely to occur on average once in every ten years.

## Hazard, risk and related terms

**Hazard[2]:** A potentially damaging physical event, phenomenon, or human activity that may cause the loss of life or injury, property damage, social and economic disruption, or environmental degradation. Hazards can include latent conditions that may represent future threats and can have different origins: natural (geological, hydro-meteorological, biological) or human-induced (environmental degradation and technological hazards).

[1] http://www.unisdr.org/eng/library/lib-terminology-eng.htm (Accessed June 2007)
[2] See Chapter 4 for a detailed description of hazard, vulnerability, and risk.

Hazards can be single, sequential, or combined in their origin and effects. Each hazard is characterised by its location, intensity, frequency, and probability.

**Vulnerability[2]:** The capacity (or lack of capacity) of a society to anticipate, cope with, resist, and recover from the impact of a natural hazard. A society's vulnerability is determined by a combination of factors that determine the degree to which life, property, infrastructure, and services are put at risk by a discrete and identifiable event.

**Risk[2]:** The chance of loss of life or property, or of injury, damage, or disruption to economic activity due to a particular event for a given area and reference period. Risk is the combination of hazard and vulnerability.

**Acceptable risk:** The level of loss a society or community considers acceptable given existing social, economic, political, cultural, technical, and environmental conditions.

**Mitigation:** Sustained actions taken to reduce or eliminate a long-term risk to people, infrastructure, and property from hazards and their effects; measures taken in advance of disaster to decrease or eliminate its impact on society and the environment.

**Preparedness:** Activities to ensure that people are ready for a disaster and respond to it effectively. Preparedness requires deciding what will be done if essential services break down, developing a plan for contingencies, and practising the plan.

**Prevention:** Activities designed to provide permanent protection from disasters. These include engineering and other physical protective measures, and also non-structural measures (like legislation, incentives, awareness raising, information dissemination) controlling land use, and urban planning.

**Recovery:** Reconstruction activities carried out after a disaster. They include rebuilding homes, businesses, and public facilities; clearing debris; repairing roads, bridges, and other important infrastructure; and rebuilding sewers and other vital services.

**Coping and adaptation strategies:** Short- and long-term strategies developed by communities to avoid, minimise, accommodate and/or spread the negative impacts of natural hazards on livelihoods, property and infrastructure, and life.

**Structural measures:** Action to reduce the effects of floods by physical interventions (like retention basins, embankments, dredging, diversions, dams, levees, floodwalls, elevating buildings, flood-proofing).

**Non-structural measures:** Action to reduce the effects of floods using non-physical solutions (like land use planning, floodplain zoning, forecasting, advance warning systems, flood insurance).

[2] See Chapter 4 for a detailed description of hazard, vulnerability, and risk.