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Preparing for Flood Disaster

Mapping and Assessing Hazard in the Ratu Watershed, Nepal

Hindu Kush-Himalayan friend

Narendra R. Khanal
Mandira Shrestha
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About the Organisations

The **International Centre for Integrated Mountain Development** (ICIMOD) is an independent 'Mountain Learning and Knowledge Centre' serving the eight 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 extended Himalayan region. ICIMOD's activities are supported by its core programme donors: the governments of Austria, Denmark, Germany, Netherlands, Norway, Switzerland, and its regional member countries, along with over thirty project 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.

The **International Hydrological Programme** (IHP) is UNESCO's cooperative programme in water research, water resources management, education, and capacity-building, and the only broadly-based science programme of the UN system in this area. In existence for over 30 years now, IHP is committed to developing the science of hydrology at the service of society. Its primary aim is to draw together scientists worldwide in order to establish the scientific and technological bases for the rational management of water resources with respect to water quantity and quality.

The **Hindu Kush-Himalayan Flow Regimes from International Experimental and Network Data project** (HKH-FRIEND), is a regional network for hydrological research and data exchange. It is one of the eight research groups in the International FRIEND Project under UNESCO's International Hydrological Programme (IHP). The project evolved through a series of regional consultations initiated jointly by UNESCO, ICIMOD, and regional countries since 1989 and was formally established in 1996. ICIMOD has provided the Secretariat for HKH-FRIEND since its inception and also houses its Regional Hydrological Data Centre (RHDC). HKH-FRIEND works through collaboration and partnerships – national, regional, and international – and has received financial support from UNESCO/IHP; the German IHP/OHP National Committee; World Meteorological Organization (WMO); Federal Institute of Hydrology, Germany; Department for International Development (DFID) and Centre for Ecology and Hydrology (CEH), UK; and ICIMOD.

The data and information exchange will facilitate research on the hydrology and water resources of the Hindu Kush-Himalayan region and contribute towards improved management of water resources, such as flood forecasting, climate change impacts on water resources, hydropower development, and assessment of fresh water resources, and contribute towards sustainable development of water resources for poverty alleviation in the region.

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Photo credit: Women involved in flood disaster preparedness in the Ratu Khola – *Mandira Shrestha*

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Foreword

The devastating impacts of floods on local Himalayan communities as well as downstream residents has been an enduring concern for both ICIMOD and UNESCO as well as our partners. Riverine and flashfloods cause more damage to lives, livelihoods, and infrastructure annually than any other natural calamities in the Himalayan region. This has led both ICIMOD and UNESCO to encourage regional collaboration in the study and sharing of mitigation measures on floods as well as river systems and the interaction between the mountain and plains that these rivers induce. One of the platforms that we have created to forge regional cooperation in the region is the HKH FRIEND. Since its inception in March 1996, HKH-FRIEND has been contributing to improve the understanding of the regional water resources and their behaviours in the HKH region.

The advancement in computer-aided and space-based technology such as geographic information systems (GIS) and remote sensing (RS) has proved very useful in studying and mapping the flood-hazards and developing measures that can be useful to the local communities as well.

This study documents the use of flood-hazard mapping as a way of helping communities to devise plans that would help them develop warning and response systems. This allows communities to prepare a management plan that will boost their resilience to mitigate damages and salvage their livelihoods to the extent possible. This is especially critical for the women and poor within these communities who are the ones to suffer the greatest and the ones with the least ability to recover their meager assts.

This study and flood-hazard mapping of the Ratu Khola watershed in Nepal seeks to encourage others to undertake similar work. The results obtained were of direct use to the communities concerned. More importantly, they illustrate an approach that can be used more widely.

This study has been published at a time when the HKH FRIEND has been put through an evaluation and efforts are underway to revamp and reorganise this regional set up.

ICIMOD and UNESCO-New Delhi were pleased to work together in this important project. We hope the study will not only save lives and livelihoods in Ratu Khola but also provide a basis for replication throughout the Himalayan region.

J. Gabriel Campbell
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The Study Team

Executive Summary

Flood hazards, their impact, and the resilience of communities have been assessed here on three spatial scales – national at macro-level, watershed at meso-level, and village development committee/municipality at micro-level. At national level, the impacts from different environmental hazards have been assessed, whereas at watershed level the focus was on hazard, risk, and vulnerability mapping. The Ratu Watershed in the Central Terai (Mahottari and Dhanusa districts) was selected for mapping. At micro-level, the focus was on enhancing the resilience of local people to cope with and recover from flood hazard. Rajbas in the upstream area and Jaleshwar municipality in the downstream area were selected for micro-level activities. The study was coordinated by the International Centre for Integrated Mountain Development (ICIMOD) with support from the United Nations Education, Scientific and Cultural Organization (UNESCO), New Delhi, India.

Floods occur repeatedly in Nepal and cause tremendous losses in terms of property and life, particularly in the lowland areas of the country. Hence, they constitute the main hazard. Floods that cause substantial devastation in Nepal are triggered by five different mechanisms: continuous rainfall and cloudbursts, glacial lake outbursts, landslide dam outbursts, failure of infrastructure, and sheet flooding or inundation as a result of excessive rain, bank overflow, or obstruction to the flow from infrastructural development. Nearly 77% of the total losses caused by water-induced disasters – floods, landslides, and avalanches – occur in the Terai region where the main water-induced disasters are floods. An extremely rugged, diverse, and dynamic mountain landscape; the fact that the country is landlocked; inaccessibility; dispersed human settlements; and a high rate of territorial mobility among the population are the main causes of extreme physical and locational vulnerability to floods and landslide disasters. Moreover, socio-economic conditions characterised by a poor human development profile, low level of economic growth, mass poverty, and a great disparity in the distribution of productive assets and income, in addition to inadequate provision of services and lack of political stability, commitment, and accountability, increase the vulnerability to natural disasters and constrain appropriate response and augmentation of resilience to disasters.

Flood-hazard, risk, and vulnerability mapping in the Ratu Watershed was carried out through three different approaches: a geomorphic approach using a geographical information system (GIS) and remote sensing (RS), measurement of rainfall-runoff processes using the Hydrological Engineering Corporation's River System Analysis (HEC-RAS) model, and social flood hazard mapping based on local experiences. The main sources of information were maps, aerial photographs, selected imagery, household survey and group discussions, field

observations, and published and unpublished documents. GIS-based softwares, such as ArcView, the Integrated Land and Water Information System (ILWIS), and the Hydrological Engineering Corporation's River System Analysis [U.S.Army Corps] (HEC-RAS and HEC-GeoRas) were used for data processing and analysis.

Flood risk and vulnerability maps prepared for the Ratu Watershed show that nearly 18% of the area is in the high-risk category. Inundation-hazard maps show that a large part of the area in the south, near the Nepal-India border, is subject to extensive inundation even by floods in the two-year return category. A comparison of hazard maps prepared based on the three different approaches shows that GIS and RS are useful for mapping the flood hazard, risk, and vulnerability of a large area at watershed level.

Flooding, cutting of river banks, and shifting channels, are the most frequently occurring water-induced disasters in the lowland area of the Ratu Watershed. On average, nearly 8% of the total annual household income is lost as a result of floods. Nearly 61% of the households in the watershed are exposed to flood hazards, among them, 21% of the households are situated in high-hazard areas.

The risk of flooding and its associated processes, such as a rise in the river bed, cutting of river banks, and shifting channels, in the Ratu Watershed is great. Moreover, the risk of inundation has increased over recent years because of added infrastructure such as roads and bridges. This is the case not only in Nepal but also in the nearby border area in India.

Responses to flood hazards are confined to rescue and relief during flooding and some mitigation measures such as construction of dams, spurs, retaining walls, plantation, and drainage management. These activities are insufficient, on the one hand, and, on the other, there are no activities or programmes on flood preparedness. People in the locality realise the importance of incorporating components of watershed conservation and drainage management through proper land-use guidelines, income-generating activities, community-based early warning systems, and awareness creation in plans for watershed conservation. They also realise the need for a local institutional network to design and implement such activities.

An attempt was made to develop a community-based early warning system and identify safe evacuation routes and areas safe for shelter in order to improve the local capacity to respond and manage flood hazards during the second phase of the project. In this context, people were trained to read and record precipitation and discharge in upstream areas; and discussions took place on the use of maps of safe evacuation routes and shelters in downstream areas. The benefits of these efforts have yet to be realised through organising and networking to establish an early warning system and by creating awareness.

This publication is a summary of a detailed study on flood-risk and vulnerability mapping of the Ratu Khola using GIS methods. It is divided into four chapters. Chapter One describes the biophysical and socioeconomic characteristics of Nepal, discusses the types, frequency, and magnitude of losses from different types of natural disaster and their spatial concentration with special reference to flood disasters, and assesses the vulnerability to flood hazards in the country. Chapter Two describes flood-hazard and risk mapping in the Ratu Watershed. This chapter provides details of the project area and the methodology for and results of hazard, risk, and vulnerability mapping. Chapter Three gives an account of the assessment carried out on response and resilience in the context of hazard, risk, and vulnerability in the Ratu Watershed. Chapter Four covers the main findings, conclusions, and recommendations.

Acronyms and Abbreviations

AV-RAS	Arc View Extension for River Analysis System
DPI	dots per inch
DTM	digital terrain model
DWIDP	Department of Water Induced Disaster Prevention
FCC	false colour composite
HEC-RAS	Hydrological Engineering Corporation, River System Analysis, US Army Corps
IHP	International Hydrological Programme
ILWIS	Integrated Land and Water Information System
LRMP	Land Resources Mapping Project
JICA	Japan International Cooperation Agency
MBT	Main Boundary Thrust
MCT	Main Central Thrust
RGB	red green blue
RMS	root mean square
TM	thematic mapper
TIN	triangular irregular network
UNDRO	United Nation's Disaster Relief Organization
WECS	Water and Energy Commission Secretariat
WMO	World Meteorological Organization
3D	three-dimensional

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