South Asia is highly exposed and vulnerable to the impacts of flood events. Every year floods inundate large areas of Nepal, India and Bangladesh. To cope with these trans-border floods, there is a need of regional cooperation and collaboration among the border countries to strengthen country’s flood early warning systems and operate them beyond the borders also.
South Asia is highly exposed and vulnerable to the impacts of flood events. Every year floods inundate large areas of Nepal, India and Bangladesh. To cope with these trans-border floods, there is a need of regional cooperation and collaboration among the border countries to strengthen country’s flood early warning systems and operate them beyond the borders also.

Practices, Challenges and Prospects
Foreword

South Asia is highly exposed and vulnerable to the impacts of flood events. Every year floods inundate large areas of Nepal, India and Bangladesh. These countries are witnessing a surge in natural disasters in recent years mainly triggered by heavy rain and floods. Recurring catastrophes/floods in trans-border river basins of the Ganga and Brahmaputra are causing extensive damages of lives, livelihoods and properties of the communities at risk and have further increased their vulnerability to external shocks, threatening overall achievement of the national socio-economic development targets.

In order to cope with these trans-border floods, there is a need of regional cooperation and collaboration among the border countries to strengthen country's flood early warning systems and operate them beyond the borders also. However, the bilateral river treaties and data sharing agreements currently in place are not sufficient enough to avert and adapt flood catastrophes on a trans-border scale. This initiative/study aims at promoting high level cooperation and collaboration between the South Asian countries for flood early warning communication across borders and explores the ways in which trans-border early warning system could be implemented in context of larger disaster risk management at regional scale. The study has tried to review current practices on flood early warning system across the border of neighboring countries and identify the challenges, potentials and prospects of the system that need to be considered, addressed and harnessed at various levels of coordination and collaboration among the countries while scaling up and scaling out EWS at regional and trans-border levels. Overall, this study provides insights into strengthening and scaling up such pilots for larger resilience building in flood disaster areas across South Asia. This study has been conducted, as a part of Global Flood Resilience Program undertaken by multi-year resilience alliance of Zurich Insurance Group, Practical Action, International Federation of Red Cross and Red Crescent Societies (IFRC), International Institute for Applied Systems Analysis (IIASA) and Wharton Business School’s Risk Management and Decision Processes Center (Wharton).

I would like to acknowledge the authors of this assignment Dr. Mizanur Rahman, Gehendra Bahadur Gurung and Gopal Prasad Ghimire. Similarly, I would like to thank Prof Dr. Narendra Kumar Khanal of Tribhuvan University for the technical review of this document. I would like to thank Practical Action’s Krity Shrestha and Madhab Uprety for their technical assistance in the finalization of report. I thank Archana Gurung and Upendra Shrestha for publication coordination and editorial support.

I hope this document will be helpful to understand the prospects, challenges and opportunities for trans-border early warning system in South Asia and provide evidence for practitioners and policy makers of India, Nepal and Bangladesh and even China to jointly work on across borders to save more lives and properties. I also hope the study can be a crucial source of knowledge in global forum working in trans-border EWS.

Achyut Luitel
Regional Director
Practical Action South Asia Regional Office
Kathmandu, Nepal
About the study

The Sendai Framework for Disaster Risk Reduction (SFDRR) highlights the need for regional and global coordination and collaboration for effective Disaster Risk Reduction (DRR). It recognizes early warning system (EWS) as one of the seven targets for substantial progress to be accessed by, and available to, the people by 2030. The Asian Ministerial Conference on DRR (AMCDRR) 2016 emphasized the need for regional cooperation, collaboration and coordination for coherent implementation of the SFDRR.

In South Asia, EWS has been initiated at both national and community levels. It is also in practice in some of the trans-border communities in this region and is effectively functioning with substantial reduction in loss and damage due to flood disasters. However, on trans-border scale, systematic evaluation of such community-based cross-border flood EWS (FEWS) is lacking. Nonetheless, the lessons from existing initiatives, though in small areas, can help to scale up and scale out disaster risk management at trans-border level. At the same time, it is necessary to understand the institutional and operational challenges and constraints of EWS across borders such that it can be made further effective. Amid this context, this study was conducted to document existing community level trans-border EWS and explore the opportunities for scaling up such EWS practices across borders on a larger scale in order to address the ever increasing flood risk and their impacts across south Asia region.
Executive Summary

South Asia is a disaster hotspot zone with annual episodes of several hazards causing huge loss of lives and properties across the region. Among hazards, flood ranks the highest in terms of human casualties, loss and damage of property, and the number of households affected each year. Despite being an annual phenomenon and common problem for the countries of South Asia, EWS interventions for floods have hardly gone beyond the country’s borders. The Sendai Framework for Disaster Risk Reduction (SFDRR) has identified the need for a substantial increase in the availability of, and access to, multi-hazard EWSs and disaster risk information and assessments to people by 2030 as one of its seven global targets. The Asian Ministerial Conference on DRR (AMCDRR) 2016 has also recognized multi-hazard EWS for DRR as an area where investments, collaborations and global partnerships are needed. The AMCDRR 2018, held in Mongolia, stresses scaling up of EWSs and their translation into early action. Both SFDRR and AMCDRR emphasize global and regional collaborations and partnerships for multi-hazard EWS. However, such collaborations and partnerships are mainly for financial and technical support to each other. It is not very clear how countries collaborate and coordinate with each other for information sharing for effective multi-hazard EWS as hazards cross national boundaries and information, communication and dissemination are essential parts of EWS. The sharing of flood information across borders between countries is often considered as ‘classified’.

This study tries to document the current practices of trans-border EWS across South Asia, primarily between Tibet Autonomous Region (TAR, China)–Nepal, Nepal–India, and India–Bangladesh, together with the challenges and opportunities for promoting trans-border EWS, in context of larger disaster risk reduction initiatives across the region. It is assumed that the output of this study will help to provide a necessary recommendations and basis for decision-makers in south Asia towards effective trans-border EWSs in the region.

The Brahmaputra River (India–Bangladesh), the Karnali River (Nepal–India), and the Poique/Bhotekoshi River in the Koshi Basin (China–Nepal) were taken as cases for field study. Both secondary and primary sources of information were used. Published and unpublished documents and statistics were collected and reviewed. Primary information was collected through field observations, focus group discussions, key informant interviews, consultative meetings with major stakeholders, and workshops at different levels (viz local community, sub-district, district, and national levels). Three sites were purposively selected for field study. A total of ten communities in three river basins were consulted. Local authorities were interviewed regarding the ongoing practices of cross-border flood EWS. Unfortunately, the study team could not visit Tibet because of time and resource constraints.

The policy framework of the government and social contexts of EWS were analysed and areas of technological improvement were explored. Practices, approaches and status on flood risk knowledge, risk monitoring and warning, warning communication and dissemination, and response capability of local communities, key stakeholders and local humanitarian actors at three trans-border sites were assessed. Existing formal and informal practices of flood EWS between the countries and the communities across the political boundaries were studied. Agreements between the countries concerned and their practices, where relevant, accessible and available, were also reviewed. The study has identified the challenges, as well as the improvements, potentials and prospects of existing practices and systems that need to be addressed and harnessed at various levels of coordination and collaboration between the countries for scaling up and scaling out of EWS at regional and trans-border levels.
It was found that each of the three countries, viz Bangladesh, India and Nepal, have been practising flood EWS on different scales employing different approaches and technologies. Some trans-border EWSs are also in practice across these countries. However, the initiatives on trans-border EWSs have been highly driven by humanitarian intent, mostly from community to community who reside across the border as there is a social relationship between the communities. There are agreements between the governments for information sharing on water level and rainfall in the trans-border rivers, but they are yet to get operationalized at a desirable level for improved trans-border EWS.

The study found that there is a need for institutionalizing and strengthening the existing practices of sharing of flood information between the countries for EWS purposes. So far, no trans-border flood risk assessment has been carried out in any of the study areas and the risk information on trans-border floods is poor and lacking. The study team realizes that there is an urgent need for systematic flood monitoring and communication between the countries by utilizing and improving the existing community-based cross-border flood EWS. Governments’ commitment towards sharing of information and effectively disseminating them to the flood prone communities is necessary.
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>AMCDRR</td>
<td>Asian Ministerial Conference on Disaster Risk Reduction</td>
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<tr>
<td>APF</td>
<td>Armed Police Force</td>
</tr>
<tr>
<td>BGB</td>
<td>Border Guard of Bangladesh</td>
</tr>
<tr>
<td>BMTPC</td>
<td>Building Materials and Technology Promotion Council</td>
</tr>
<tr>
<td>BWDB</td>
<td>Bangladesh Water Development Board</td>
</tr>
<tr>
<td>BRCH</td>
<td>Building Resilience to Climate-Related Hazards</td>
</tr>
<tr>
<td>BSF</td>
<td>Border Security Force</td>
</tr>
<tr>
<td>BUET</td>
<td>Bangladesh University of Engineering and Technology</td>
</tr>
<tr>
<td>CBDMC</td>
<td>Community Based Disaster Management Committee</td>
</tr>
<tr>
<td>CCDR</td>
<td>Cabinet Committee on Disaster Response</td>
</tr>
<tr>
<td>CDMA</td>
<td>Code-Division Multiple Access</td>
</tr>
<tr>
<td>CDMC</td>
<td>Community Disaster Management Committee</td>
</tr>
<tr>
<td>CDO</td>
<td>Chief District Officer</td>
</tr>
<tr>
<td>CEGIS</td>
<td>Centre for Environmental Geographical System</td>
</tr>
<tr>
<td>CRA</td>
<td>Community Risk Assessment</td>
</tr>
<tr>
<td>CWC</td>
<td>Central Water Commission</td>
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<tr>
<td>DDM</td>
<td>Department of Disaster Management</td>
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<tr>
<td>DDMA</td>
<td>District Disaster Management Authority</td>
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<tr>
<td>DEM</td>
<td>Digital Elevation Model</td>
</tr>
<tr>
<td>DEOC</td>
<td>District Emergency Operating Centre</td>
</tr>
<tr>
<td>DHM</td>
<td>Department of Hydrology and Meteorology</td>
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<tr>
<td>DMC</td>
<td>Disaster Management Committee</td>
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<tr>
<td>DMIC</td>
<td>Disaster Management Information Centre</td>
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<td>DPRP</td>
<td>Disaster Preparedness and Response Plan</td>
</tr>
<tr>
<td>DRR</td>
<td>Disaster Risk Reduction</td>
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<tr>
<td>DSS</td>
<td>Decision Support System</td>
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<tr>
<td>ECMWF</td>
<td>European Centre for Medium Range Weather Forecast</td>
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<tr>
<td>EFAS</td>
<td>European Flood Awareness System</td>
</tr>
<tr>
<td>ESCAP</td>
<td>Economic and Social Commission for Asia and the Pacific</td>
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<tr>
<td>EWS</td>
<td>Early Warning System</td>
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<tr>
<td>FAP</td>
<td>Flood Action Plan</td>
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<tr>
<td>FEWS</td>
<td>Flood Early Warning System</td>
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<tr>
<td>FFWC</td>
<td>Flood Forecasting and Warning Centre</td>
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<tr>
<td>FGD</td>
<td>Focus Group Discussion</td>
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<tr>
<td>GDP</td>
<td>Gross Domestic Product</td>
</tr>
<tr>
<td>GIS</td>
<td>Geographic Information System</td>
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<tr>
<td>GLOF</td>
<td>Glacial Lake Outburst Flood</td>
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<tr>
<td>GPRS</td>
<td>General Packet Radio Service</td>
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<tr>
<td>HFA</td>
<td>Hyogo Framework for Action</td>
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<tr>
<td>ICIMOD</td>
<td>International Centre for Integrated Mountain Development</td>
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<tr>
<td>ICT</td>
<td>Information and Communication Technology</td>
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<tr>
<td>IMD</td>
<td>Indian Meteorological Department</td>
</tr>
<tr>
<td>IMDMCC</td>
<td>Inter-Ministerial Disaster Management Coordination Committee</td>
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<tr>
<td>INGO</td>
<td>International Non-government Organisation</td>
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<tr>
<td>ISTD</td>
<td>International Subscriber’s Trunk Dialling</td>
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<tr>
<td>IVR</td>
<td>Interactive Voice Response</td>
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<tr>
<td>IVRS</td>
<td>Interactive Voice Response System</td>
</tr>
<tr>
<td>IWFM BUET</td>
<td>Institute of Water and Flood Management/ Bangladesh University of Engineering and Technology</td>
</tr>
</tbody>
</table>
IWM  Institute of Water Modelling
JCIFM  Joint Committee on Inundation and Flood Management
JCWR  Joint Committee on Water Resources
JRC  Joint River Commission
JSTC  Joint Standing Technical Committee
KII  Key Informant Interview
LDMC  Local Disaster Management Committee
LBLOF  Landslides Blocked Lake Outburst Flood
MRC  Mekong River Commission
NDMA  National Disaster Management Authority
NDMC  National Disaster Management Council
NEOC  National Emergency Operation Centre
NESAC  North Eastern Space Application Centre
NGO  Non-Government Organization
NOAA  National Oceanic and Atmospheric Administration
NWP  Numerical Weather Prediction
O&M  Operation and Maintenance
PPP  Public Private Partnership
PGVS  Purbanchal Grameen Vikas Sansthan
QPF  Quantitative Precipitation Forecast
RIMES  Regional Integrated Multi-hazard Early Warning System
SAARC  South Asian Association for Regional Cooperation
SDMA  State Disaster Management Authority
SDMC  SAARC Disaster Management Centre
SFDRR  Sendai Framework for Disaster Risk Reduction
SMS  Short Messaging System
SOD  Standing Orders on Disasters
TV  Television
UDC  Union Digital Centres
UDMC  Union Disaster Management Committee
UNEP  United Nations Environmental Program
UNISDR  United Nations International Strategy for Disaster Reduction
VDC  Village Development Committee
VDMP  Village Disaster Management Plan
VLMCC  Village Land Management and Conservation Committee
WMO  World Meteorological Organization
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1. Introduction

1.1 Context of Flood Disaster

South Asia accounts for more than 21 per cent of the world population (Memon, 2012) and is one of the most densely populated regions on the earth. The region faces frequent and intense natural disasters each year. In recent years, the countries in the region have endured a series of catastrophic disasters, including devastating floods, compounding their pains of poverty and poor performance in various sectors of human development (Memon, 2012). Losses and damage from flood account for 4.75 per cent, 2.58 per cent, 1.36 per cent, 0.98 per cent and 0.84 per cent of national Gross Domestic Product (GDP) of Bangladesh, Afghanistan, Nepal, Pakistan, and India respectively (Luo et al., 2015).

Photo 1 Map of South Asia and the study locations
South Asia (Photo 1) consists of varied physiography and varied climates, which is a challenge for flood forecasting and early warning. The monsoon phenomenon is the main source of flood. The southernmost parts of south Asia, including southern part of India, Sri Lanka and southern part of Bangladesh, have two dominant climates (Peel et al., 2007). The tropical wet (or equatorial) dominates the climate in the south of Sri Lanka, south of Bangladesh and the Maldives, with heavy rainfall and potential floods from storm surges with no dry season. The equatorial climate is found in the west coast of India almost as far up as Mumbai. A dry or tropical savannah of semi-arid and desert climate dominates in western India, Pakistan and Afghanistan.

Very heavy rains occur between July and December in southern India, southern Bangladesh and Sri Lanka. Wet air moves into south Asia from the Indian Ocean, rises up as it approaches the Himalayas and pours huge amounts of rain in Bangladesh, north-east and northern India, Bhutan and Nepal, which causes various types of floods such as riverine floods, mostly in plain areas, and flash floods caused by cloud bursts, landslide-blocked lake outburst floods, and glacial lake outburst floods in mountain areas. Towards north, the equatorial and tropical savannah gives way to humid subtropical conditions. Humid subtropical climates are characterized by hot and humid summers and mild to cool winters, and cover northern India, northern Bangladesh, Nepal and Bhutan. Further north, snow hydrology is the dominating factor as the source of rivers and sometimes floods that flow downstream, meeting the Indian Ocean in the Bay of Bengal.

The Indus, the Ganga and the Brahmaputra are three major rivers in south Asia. The Indus originates in Tibet, China, and flows southwards through Pakistan to the Arabian Sea. The Brahmaputra originates in the Chinese side of the Himalayas and, after traversing about 1,800 km through Tibet and India, enters Bangladesh (Photo 1). Called the Jamuna in Bangladesh, it flows for an additional 275 km, up to its junction with the Ganga. The Ganga flows for about 2,000 km through India, enters the western side of Bangladesh and flows south-east for another 250 km to join the Brahmaputra. The Ganga and the Brahmaputra are trans-border rivers and flow into the Bay of Bengal through Bangladesh. Some of the most fertile farmlands in the world lie along these rivers. One-tenth of the world’s population live in the alluvial plains of the Ganga River.

Every year, floods inundate large parts of the Ganga and Brahmaputra plains, crossing the borders of China, Nepal, India and Bangladesh. They cause loss of lives, livelihoods and property, as well as displacing millions of people, threatening achievement of national socio-economic development targets. The trans-border EWS could play a vital role in reducing the loss and damage of lives and property across the region.

This calls for effective cooperation and coordination among the countries concerned, viz Bangladesh, Bhutan, China, India and Nepal, towards flood disaster management, including trans-border EWS across these transborder rivers. However, the bilateral river treaties and data-sharing agreements currently in place are not sufficient for an effective trans-border EWS to avert and adapt to flood catastrophes on a trans-border scale. An effective trans-border flood EWS (FEWS) requires high level of cooperation and collaboration between the countries in the region. It is in this context that this study on the existing trans-border practices of EWS and further potential to manage flood disaster risk was carried out.

1.2 Rationale of the Study

Over the years, the level of human suffering and loss of lives and properties due to floods have been increasing and posing huge socio-economic losses across South Asia (Doocy et al., 2013). Figure 1 clearly illustrates the increased level of flood impact in South Asia. There are relevant scientific researches, as well as bilateral collaborations for systematic data sharing, but coordination and collaboration for flood risk reduction and management at regional level have not happened
hitherto. Considering the fact that population and economic activities are increasing in the region and downstream communities across borders are exposed to increased level of flood risks, if flood information is not shared between one country and another for EWS, there is high likelihood of increase in human suffering and loss of human lives and property due to floods in those trans-border rivers.

![Figure 1](image)

**Figure 1** Population affected by floods in Bangladesh, India and Nepal from 1950 to 2000 (Rasul, 2015)

The Sendai Framework for Disaster Risk Reduction (SFDRR) 2015–2030 outlines the need for regional and global coordination and collaboration for effective DRR. EWS has been recognized as a critical need for DRR at various levels. The Asian Ministerial Conference on DRR (AMCDRR), held in New Delhi, India, in November 2016, has also emphasized the need for promoting cooperation, collaboration and coordination among the countries for an effective multi-hazard EWS. The Delhi Declaration called on the governments and stakeholders to invest more in multi-hazard EWS for effective preparedness through effective and meaningful partnerships. The AMCDRR 2018, held in Mongolia, has called for scaling up of EWSs and their early translation into action.

The countries in south Asia have been practising FEWS in their river systems on various scales. However, many of the rivers of South Asia are trans-border and, despite the immediate need of cross-border sharing of information, the FEWSs have not been operationalized in transboundary context. Whatever information is shared is not utilized for early warning purposes systematically. So, the need for a study on trans-border FEWS was realized to identify opportunities and challenges in relation to their design, development and implementation for the region.

### 1.3 Objectives of the Study

The overall objective of this study is to review and document the current practices on FEWS across the border between the neighbouring countries (China–Nepal, Nepal–India, and India–Bangladesh) and identify the challenges, potentials and prospects of the system that need to be considered, addressed and harnessed at various levels of coordination and collaboration between the countries while scaling up and scaling out EWS at regional and trans-border levels. The output of this study is expected to be helpful for decision-makers in south Asia for effective trans-border EWS in the region, which is essential for better management of flood disaster risks.
The specific objectives of the study are:

- To assess and identify replicable practices of cross-border FEWS taking place in local communities in border areas connected by river flood
- To explore and analyse the social, technological and governance systems across the national boundaries that enable and/or hinder setting up of and sustaining smooth operation of FEWS across the borders, and
- To identify appropriate interventions for effective trans-border FEWS and inspire governments of the respective countries for their implementation

1.4 Report Organization

Chapter 1 of this report provides an introduction to the study and outlines the objectives and scope of work. Chapter 2 describes the methodology and strategies adopted for this study, whereas Chapter 3 is the review of relevant literature. Chapter 4 describes output of the field studies and consultations with policymakers, administrators, experts and local community. Chapter 5 presents the conclusion of the study and suggestions, with identified needs for trans-border FEWS in the region.
2. Methodology

In order to obtain information on the concept of EWS and existing practices of cross-border EWS at different levels, a thorough review of available literatures was undertaken. Followed by the several kinds of consultations meetings like focus group discussions (FGD), key informant interviews (KII), face-face meetings with relevant institutions, and organization, workshops, different issues towards cross-border EWS were critically examined and analysed. Three trans-boundary rivers, viz Karnali, Koshi and Brahmaputra, draining three countries, viz China, Nepal, India and Bangladesh, were identified for detailed study together with field activities. A brief description of the methods adopted is given below.

2.1 Literature Review

Published and unpublished documents on EWS were collected from different sources. Based on the review of literature, the concept of EWS was discussed. Although the review was focused on three selected trans-border rivers in China, Nepal and Bangladesh, EWSs practised in other regions of the world were also reviewed. The main focus of the review work was to examine whether there was recognition of the importance of flood information sharing and communication and any forms of agreements or practices of mutual cooperation and coordination for trans-border flood risk reduction exist between the countries studied. National policies that address the need for trans-border flood information sharing and communication were also reviewed. Another important area of review was in-country FEWS practices in each country and provisions of any cross-border information sharing initiatives. All the elements of EWS—risk assessment and information, monitoring and dissemination, and building response capacity of communities and stakeholders—were taken into consideration during literature review. Overall the literatures related to trans-border issues and existing gaps and challenges towards operationalizing FEWS in transborder context were thoroughly reviewed.

The existing national- and local-level EWSs were reviewed to explore the potentials for transforming them into trans-border EWSs. The traditional approach in data collection and monitoring, data analysis and forecasting, information communication, warning dissemination, lead time of warning message, efficiency of warning system, response implementation, and community participation within the existing EWSs were also taken into consideration while reviewing the literature.

Based on the review of literature, the gaps in social networks for early warnings, and their dissemination together with capacities of border communities to respond to floods were identified. Technologies required for data collection and transmission from country to country, and governance frameworks for communication and response capabilities by national disaster management authorities, local government and communities at the trans-border level were also explored.

2.2 Field Studies

Primary data and information on EWS, both in country and cross-border, were collected at different levels—community, sub-national (district) and national in consultation with different stakeholders, ie experts, policy-makers, administrators, disaster risk managers, and local people, in three countries, viz Nepal, India and Bangladesh, that are drained by three selected trans-boundary rivers. Although all three rivers originate in Tibet in China, it was not possible to carry out field work there within the timeframe of this study because of difficulty in getting permission for field work for foreign scientists. However, attempts were made to collect information from secondary sources.
2.3 Community-level Focused Group Discussion

At least two communities living near the international borders in the upstream and downstream countries in each of the three selected trans-boundary rivers were purposively selected for the field study. The main criterion for site selection was connectivity between the upstream and the downstream of the river across the international border of two adjoining countries. Since the communities of the two sites were exposed to cross-border floods, they were expected to be able to communicate and receive messages across the border.

Out of the two communities selected for the study, efforts were made to ensure that one was from the left bank of the river and the other from the right bank. Accordingly, three communities at Liping, Tatopani and Janbu settlements along the Poiqu/Bhotekoshi River were selected for field data collection, representing the cross-border EWS between China and Nepal (Table 1 and Photo 2). Similarly, the Phanta community in Tikapur in Kailali district and the Sanghars Nagar community in Rajapur in Bardia district in Nepal in the upstream and the Maikapurva and Dallipurva communities in Bahraich district in India in the downstream along the Karnali River were selected for case studies of trans-border EWS between Nepal and India. Likewise, two communities, Dhubri and south Salmara in Assam, India in the upstream and Chilmari in Kurigram and Islampur in Jamalpur in Bangladesh along the Brahmaputra River were selected for the case of India and Bangladesh.

A total of nine FGDs, all semi-structured guided by predefined checklist, were carried out (Table 1). Information on the EWSs in the Nepal side was collected through KIIs, whereas majority of EWS information was based on the secondary sources for the Poiqu River Case Study for the China side in the Koshi Basin. The size of focus groups ranged from 4 to 16 participants.
Table 1: Study Areas

<table>
<thead>
<tr>
<th>Trans-boundary River</th>
<th>Study Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poiqu/Bhotekoshi River, Koshi Basin (China–Nepal)</td>
<td><strong>Upstream: Tibet (China)</strong>&lt;br&gt;No field work was carried out. However, information was collected through consultation with experts and review of literature.</td>
</tr>
<tr>
<td></td>
<td><strong>Downstream: Nepal</strong>&lt;br&gt;Liping in Sindhupalchok district&lt;br&gt;Tatopani in Sindhupalchok district&lt;br&gt;Janbu in Sindhupalchok district</td>
</tr>
<tr>
<td>Karnali River (Nepal–India)</td>
<td><strong>Upstream: Nepal</strong>&lt;br&gt;1. Phanta community, Tikapur in Kailali district&lt;br&gt;2. Sanghars Nagar community, in Bardiya district</td>
</tr>
<tr>
<td></td>
<td><strong>Downstream: India</strong>&lt;br&gt;1. Maikapurva community, in Bahraich district&lt;br&gt;6. Dallipurva community, in Bahraich district</td>
</tr>
<tr>
<td>Brahmputra River (India–Bangladesh)</td>
<td><strong>Upstream: India</strong>&lt;br&gt;1. Dhubri community, in Assam&lt;br&gt;2. South Salmara community, in Assam</td>
</tr>
<tr>
<td></td>
<td><strong>Downstream: Bangladesh</strong>&lt;br&gt;1. Chilmari community, in Kurigram&lt;br&gt;2. Islampur community, in Jamalpur</td>
</tr>
</tbody>
</table>

2.4 Key Informant Interview

Consultations were held with the stakeholders and government authorities across the borders at local, sub-national and national levels. A total of 18 key informants at local, sub-national and national levels were interviewed.

Across three study countries, KIIs were conducted with national and international experts and policy level authorities concerning flood risk management at national and transborder level. In Bangladesh, key interviewee include high level officials from Joint River Commission (JRC), officials from the Flood Forecasting and Warning Centre (FFWC), experts from the Institute of Water Modelling (IWM), researchers/scientists from Centre for Environmental Geographical System (CEGIS), and the Institute of Water and Flood Management/Bangladesh University of Engineering and Technology (IWFMBUET). In India, KIIs involved Director of the Purbanchal Grameen Vikas Sanstan (PGVS), district administration, district disaster management authorities of respective districts in India, and NGO workers. For Tibet (China), experts from the International Centre for Integrated Mountain Development (ICIMOD) were interviewed. KIIs in Nepal included respective district administrations in Nepal, Department of Hydrology and Meteorology (DHM), Nepal Red Cross district officials, Building Resilience to Climate-Related Hazards (BRCH) project and ICIMOD. The common techniques used for KIIs were face-to-face interviews, telephone/Skype interviews and email correspondence.

A check-list was developed in line with the four elements of the EWS to guide the discussion with the key informants. A brief presentation explaining the purpose of the study and the consultation meetings was also prepared and shared during the KIIs.
Table 2 Number of methods used for primary data collection

<table>
<thead>
<tr>
<th>Rivers</th>
<th>Poiqu/Bhotekoshi in Koshi Basin</th>
<th>Karnali/Ghagra</th>
<th>Brahmaputra</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Country</td>
<td>China</td>
<td>Nepal</td>
<td>Nepal</td>
<td>India</td>
</tr>
<tr>
<td>FGD</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>KII</td>
<td>x</td>
<td>4</td>
<td>9</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Consultative meetings</td>
<td>x</td>
<td>2</td>
<td>2</td>
<td>x</td>
</tr>
<tr>
<td>Workshop</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

### 2.5 Consultative Meetings and Workshops

A total of four consultative meetings and two workshops were organized. The participants in the consultative meetings were from Red Cross, Armed Police Force and personnel from disaster risk management projects at both local and national levels.

Two workshops were organized with the stakeholders in the Brahmaputra River trans-border basin. One was organized in Jamalpur district, Bangladesh and the other one in Dhubri in Assam, India. In the case of unavailability of relevant stakeholders and a consultation workshop couldn’t be made possible, information were collected via KIIs in those areas.
3. Review of Flood Early Warning System in South Asia

The United Nations International Strategy for Disaster Reduction (UNISDR) defines EWS as “the set of capacities needed to generate a meaningful warning information and disseminate timely and meaningful warning information to enable individuals, communities, and organizations threatened by a hazard to prepare and to act appropriately and in sufficient time to reduce the possibility of harm or loss” (UNISDR, 2009). Similarly, United Nations Environment Programme (UNEP, 2012) defines EWS “the provision of timely and effective information, through identified institutions, that allows individuals exposed to hazard to take action to avoid or reduce their risk and prepare for effective response”. An end-to-end or people-centred EWS is a complete set of components that connects those who need to receive messages from others who compile and track the hazard information of which messages are composed (NOAA, 2010). Therefore, a functional EWS is a chain of information communication systems comprising sensor, detection, decision, and other subsystems to prepare resources and response actions to minimize the adverse impact on people and their property by a hazard.

The Third International Conference on Early Warning (UNISDR, 2006) described four key elements of people-centred effective early warning system as 1) risk knowledge, 2) risk monitoring and warning, 3) risk information dissemination and communication, and 4) response capacity of communities and the authorities to respond to the risk information (Photo 3).

### Photo 3 Elements of Early Warning System (UNISDR, 2006)
3.1 Flood EWS at Global, Regional and National Levels

3.1.1 Global Context

EWS took its systemic development following the Third International Conference on Early Warning System in Bonn in 2006. The Hyogo Framework for Action (HFA) 2009 emphasized cooperation at regional and international levels to assess and monitor regional and trans-boundary hazards, exchange information and provide early warnings through appropriate arrangements, such as, inter alia, those relating to the management of river basins.

The Sendai Framework for Disaster Risk Reduction 2015–2030 (UN, 2015) recognized EWS as one of its seven targets by stating “Substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments to people by 2030”.

3.1.2 South Asia

The Asian Ministerial Conference on Disaster Risk Reduction (AMCDRR) 2016 called for increasing investments in disaster risk reduction, including multi-hazard early warning systems. The AMCDRR 2018, held in Mongolia, called for scaling up EWS and early actions.

A disaster management centre of the South Asian Association for Regional Cooperation (SAARC) exists for overall disaster management at the SAARC level through coordination, collaboration and sharing of knowledge and information. One of the objectives of the centre is “to establish a regional system to develop and implement regional programmes and projects for early warning” (SAARC, 2008). However, in its actions for 2006–2015, the regional or trans-border EWS could not receive priority. The centre is yet to develop its next action plan to align with the Sendai Framework for DRR. SAARC has the policy of not addressing any bilateral issues, however, transborder water governance issues are mostly framed as bilateral debate. Nonetheless, the establishment of the SAARC Disaster Management Centre (SDMC) demonstrates recognition of the need for cross-border collaborations though the SDMC requires more active functioning.

3.1.3 Other Regions

The European Flood Awareness System (EFAS) exists for monitoring, forecasting and sharing flood information across European countries for a common flood alert system (Thielen et al., 2009). The EFAS has four centres namely 1) EFAS Meteorological Data Collection Centre, 2) EFAS Hydrological Data Collection Centre, 3) EFAS Computational Centre, and 4) EFAS Dissemination Centre, all of them coordinating each other for regional level flood forecast and alert. Another good example of trans-boundary flood management is that of the Mekong River, where six countries, namely Cambodia, China, Lao PDR, Myanmar, Thailand, and Vietnam, have engaged to share the hydrological and meteorological data on the river (Chellaney, 2011).

3.1.4 South Asian Countries

The flood forecasting and warning systems in Bangladesh, India and Nepal are discussed below.

3.1.4.1 Flood Forecasting and Warning in Bangladesh

Bangladesh established Flood Forecasting and Warning Centre (FFWC) in 1972 as a permanent entity under the Bangladesh Water Development Board (BWDB). FFWC issues five-day deterministic flood forecasts for fifty-two locations and ten-day probabilistic flood forecast for thirty-eight locations. Satellite altimetry-based flood forecasting technology has also been developed, providing lead times of up to eight days for thirteen locations. Flash flood forecasts, based on rainfall intensity–duration thresholds, are issued for two locations (RIMES, 2015). This forecast product is available at trans-
border gauge stations on the Brahmaputra River (Figure 2). Flood forecast information is made available on the webpage of the FFWC (http://ffwc.gov.bd), also disseminated via SMS and toll-free 24-hour Interactive Voice Response (IVR). So, community are able to access flood information directly without paying any mobile bill.

Discharge forecasts at boundary locations use Mike 11 hydraulic model to generate water-level forecasts at thirty-eight locations downstream of the Brahmaputra, Ganga and Meghna Rivers. The FFWC carries out monitoring, forecasting, dissemination and communication of flood early warning (Rahman et al., 2012). Different NGOs have done risk assessments at community level. But these risk assessments are not systematically linked with the information being disseminated.

The response and preparedness capacity has been framed through standing orders on Disaster (SOD) at the national, district (sub-national) and local government levels, but it is loosely coupled with flood victim community at the grass roots level. The SOD does not encourage flood victim communities to involve in systematic procedure to respond to floods. Communities are not empowered for preparedness and response to flood warnings.

The FFWC generates flood bulletin and flood situation summary on a daily basis during the monsoon (May–October). Such information is uploaded on its website (ffwc.gov.bd) and transmitted to the Department of Disaster Management (DDM), ministries and other stakeholders (like NGOs, donors, district headquarters, etc) through emails and faxes. At the dissemination stage, these messages are further transmitted by the DDM to district and Upazilla DMCs through mobile phone and fax. The information is further disseminated down to union DMC and community level through mobile phone and one-to-one contacts. Ideally, there should be a meeting of union DMC when the warning is issued. The discussions in the community indicated that this national structure worked well up to the Upazilla level, but the dissemination channels down from Upazilla are weak, and the short lag time for information delivery from the Upazilla to community level hinders the community from taking protective measures to the maximum extent. The communities fail to prepare themselves due to insufficient lead time. The FFWC issues five-day deterministic forecast running hydrological and hydrodynamic models on a rolling (day-to-day) basis, but floods are not always detected five days ahead. The most common lead time is three or four days for warning in Bangladesh, but due to weak dissemination channels and the lack of capacity and resources at the Upazilla and community levels, the community gets only a day or two for preparation, and, in some cases, the information arrives with the floodwater.

Besides these, the Bangladesh Water Development Board (BWDB) has flood information centres in all its offices and they providewater-level information to relevant stakeholders as per need. Though agencies like military and the police do monitor flood information from the BWDB website, they are...
only in action during the response period and have no role in warning communication. The DDM has been operating a toll-free Interactive Voice Response System (IVRS) where people can call and listen to national-level flood information.

The national government covers all necessary capital investments and shares the operational and maintenance (O&M) costs for national-level detection, data collection and forecasting activities. At union (local government) level, the contributions of community users, local government and/or NGOs should cover the O&M costs concerning local dissemination and response, as well as the local activities involved in data collection.

A public–private partnership (PPP) with a union-level social business model aims at generating additional cash flows that can cover the O&M costs of the decentralized elements of improved EWS. Together, these two elements create incentives at the national and local levels for an effective and sustainable EWS.

### 3.1.4.2 Flood Forecasting and Warning in India

India's national flood forecasting and warning network of the Central Water Commission (CWC) comprises 176 (28 inflow and 148 water level) flood forecasting sites (Rimes, 2015). The Flood Forecasting and Warning Network has thirteen regional field offices, through which the CWC issues forecasts by email, SMS and website to different agencies, which include civil/engineering agencies of state and central governments, such as irrigation, revenue, railways, public undertakings, dam/barrage authorities, and district magistrates and sub-divisional officers, apart from defence authorities involved in flood mitigation work. The communication channel for flood information is shown in Figure 3.

![Figure 3 Communication structure of flood early warning in India](image)

In the communication channel (Figure 3), the end user is the Panchayat (local government), and the community is not connected. Wireless communication system, which has been installed in about 550 monitoring base stations, is the backbone of the communication system for flood forecasting activities. So far, 445 stations have been modernized with automatic data collection and transmission systems. Work is in progress to increase the total number of telemetered stations to 1,061 at the end of the government's twelfth plan (GoI, 2017).
Out of twenty-four basins as mentioned in Table 3, mathematical models have been developed for Jhelum, Alaknanda, Bhagirathi, Ganga, Brahmaputra, Yamuna, Chambal, Baitarani, Vamsadhara, Subarnarekha, Mahanadi, Tapi, Godavari and Krishna rivers. The Indian Meteorological Department (IMD) generates three-day quantitative precipitation forecast (QPF) for several river basins. A QPF-based flood forecasting system has been developed and is operational for the Jhelum basin. Also, a Glacial Lake Outburst Flood inventory has been prepared.

### Table 3 Index of Flood Forecasting and Warning Network in India (GoI, 2017)

<table>
<thead>
<tr>
<th>Basin Code</th>
<th>Basin Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Indus (Up to border)</td>
</tr>
<tr>
<td>2a</td>
<td>Ganga</td>
</tr>
<tr>
<td>2b</td>
<td>Brahmaputra</td>
</tr>
<tr>
<td>2c</td>
<td>Barak and Others</td>
</tr>
<tr>
<td>3</td>
<td>Godavari</td>
</tr>
<tr>
<td>4</td>
<td>Krishna</td>
</tr>
<tr>
<td>5</td>
<td>Cauvery</td>
</tr>
<tr>
<td>6</td>
<td>Subarnarekha</td>
</tr>
<tr>
<td>7</td>
<td>Brahmani and Baitarni</td>
</tr>
<tr>
<td>8</td>
<td>Mahanadi</td>
</tr>
<tr>
<td>9</td>
<td>Pennar</td>
</tr>
<tr>
<td>10</td>
<td>Mahhi</td>
</tr>
<tr>
<td>11</td>
<td>Sabarmati</td>
</tr>
<tr>
<td>12</td>
<td>Narmada</td>
</tr>
<tr>
<td>13</td>
<td>Tapi</td>
</tr>
<tr>
<td>14</td>
<td>West flowing rivers from Tapi to Tadri</td>
</tr>
<tr>
<td>15</td>
<td>West flowing rivers from Tadri to Kanyakumari</td>
</tr>
<tr>
<td>16</td>
<td>East flowing rivers between Mahanadi and Pennar</td>
</tr>
<tr>
<td>17</td>
<td>East flowing rivers from Pennar and Kanyakumari</td>
</tr>
<tr>
<td>18</td>
<td>West flowing rivers of Kutch and Saurashtra, including Luni</td>
</tr>
<tr>
<td>19</td>
<td>Area of inland drainage in Rajasthan</td>
</tr>
<tr>
<td>20</td>
<td>Minor rivers draining into Bangladesh</td>
</tr>
<tr>
<td>21</td>
<td>Minor rivers draining into Myanmar</td>
</tr>
<tr>
<td>22</td>
<td>Area of north Ladakh not draining in Indus</td>
</tr>
<tr>
<td>23</td>
<td>Drainage Area of Andaman and Nicobar Islands</td>
</tr>
<tr>
<td>24</td>
<td>Drainage Area of Lakshadweep Islands</td>
</tr>
</tbody>
</table>

#### 3.1.4.3 Flood Early Warning in Nepal

Nepal has a telemetry system for real-time data acquisition from forty-four stations in major river basins and seventeen stations in the Bagmati basin (Gautam, 2011). The Department of Hydrology and Meteorology (DHM) of Government of Nepal started modernizing its meteorological and
hydrological observation system in 2008 (RIMES, 2015). Currently, its observation network includes seventy-five rainfall and thirty-two flow gauging stations, with GPRS/CDMA communication system integrated into them for real-time data transmission. This real-time observation network was primarily developed for flood warning in the Terai. The network is sparse in hilly and mountainous areas.

The National Emergency Operations Centre (NEOC) which is under Ministry of Home Affairs (MoHA) has been in operation since early 2011 to strengthen communication among national and district centres across the country. The District Emergency Operation Centres (DEOCs) are also operating to further strengthen communication and facilitate dissemination of information for early warnings and emergency response to various sectors and communities.

As such, there is no standard operating system, but the emergency centres communicate to each other on the phone. The centres also communicate to the Armed Police, Nepal Police and the nearest army camp for rescue and relief operations. The communications also filter down to communities, but they are not ensured by a government-recognized communication framework. So, what to communicate and whom to communicate depends on the knowledge and practice from district-level down to the communities.

The existing DHM flood warning system shares general weather forecasts and disseminates flood gauge height through its website (hydrology.gov.np) and mobile SMS alert systems to communities and stakeholders. aMass SMS system is in operation to provide flood alerts to individual mobile numbers that are within the risk zone once the flood level reaches the pre-identified warning and danger level.

Real-time data measurement and collection uses automatic sensors, Internet and text messages that use the mobile communications network. Flood information display boards have also been installed at the NEOC and some of the DEOCs in the Terai.

Photo 4 Communication structure of early warning in Nepal
There is a mechanism for real-time flood information to reach the community. However, the time is very short for the communities, ranging from minutes for five or six hours only.

3.1.5 Bilateral Efforts

Nepal and India have constituted three levels of joint committees for management of trans-border rivers: 1) Joint Committee on Water Resources (JCWR), 2) Joint Committee on Inundation and Flood Management (JCIFM) and 3) Joint Standing Technical Committee (JSTC). The JCWR focuses more on policy level, JCIFM more on flood management, whereas the JSTC provides technical support to the JCWR and JCIFM. The JCIFM has been regularly holding meetings on flood management in the cross-border rivers that flow from Nepal to India since 2009. Flood forecasting and flood information sharing have now become regular agenda of the meetings, which are usually held twice a year. After a series of discussion, the JCIFM and JSTC are now preparing technical plans for modernizing flood forecasting in those rivers that flow from Nepal to India (minutes of meeting JSTC held on May 26, 2016).

However, Nepalese government (DHM) have been sharing real-time hydro-meteorological information to Indian government (CWC) on daily basis during monsoon (1 June–31 October) (minutes of JCIFM meeting, December 6–10, 2015). Furthermore, the real-time flood and meteorological information on Nepal rivers is also displayed on the DHM website, which can be used by the Indian government as information for early warnings to flood that will ultimately come to India and the rainfall that will result in runoff and floods (minutes of meeting of JCIFM, April 16–21, 2017). So, practice exists for flood information sharing between the governments of Nepal and India at national level.

Similarly, Indo-Bangla Joint River Commission (JRC) also exists. The major responsibilities of the commission are trans-border flood management, including advance flood warning, flood forecasting and cyclone warning (JCRB Website). Besides JRC, there are committees specific to certain responsibilities, and one of them is Indo-Bangladesh Experts on Flood Forecasting and Warning. The Experts have been meeting on flood forecasting and warning issues (JCRB Website). The Indian Meteorological Department (IMD) posts forecast information on its website, which can be used by the Bangladesh authorities to strengthen their warning information that is to be delivered.

Under the existing bilateral memorandums of understanding, China provides to India hydrological information on the Brahmaputra and Sutlej rivers during the flood season of May 15–October 15 every year. The Bangladesh Flood Forecasting and Warning Centre also receives river discharge data from China for the Brahmaputra River.

There is no trans-border river agreement between Nepal and China. Likewise, there is no practice of sharing flood information between the governments of Nepal and China.

3.2 Conclusion of the Review

Each of the countries has a national-level flood warning system that has been developed at different levels using diverse technologies. The countries display hydrological and meteorological information on real-time basis on their official websites, which is open and accessible to all. Such information can be used by other countries concerned for early warning purpose. However, the data is displayed in different forms, depending on the capacity, feasibility, technology availability and convenience of the country concerned. There is no uniformity in the data display system. The river data from Tibet, however, could not be browsed openly on the Internet. The FEWS in Tibet has yet to be explored and studied.

No systematic data-sharing mechanism exists between any two countries in south Asia (Tibet–Nepal, Nepal–India and India–Bangladesh) from the EWS point of view. However, such information-sharing practices exist elsewhere like the European Flood Awareness System (EFAS) and Mekong River Commission (MRC).
There is an immediate need of developing a flood and meteorological data-sharing mechanism between two countries or more in South Asia. This will enhance flood early warning across the borders, saving lives and properties of the downstream countries. There is also a need for agreeing on minimum levels of information and their standards to share across the border so that the interpretation of information among the countries is consistent and smooth and can be disseminated with less significant adjustments. The expert groups from the countries need to identify the hydrological and meteorological stations along the trans-border rivers, update them with similar technologies, and share the information through a common platform, possibly through the SAARC DMC website.
4. Results from Field Studies

4.1 Introduction

Field studies were carried out focusing on the four elements of an effective EWS. These elements are:

- Risk assessment and risk knowledge
- Risk monitoring and warning
- Risk communication and dissemination, and
- Response capability

These four elements indicate the need for involvement of diverse stakeholders in EWS, including individuals, communities, local government, national government, people from different sectors, academia, ground-level practitioners, etc. Some form of cross-border FEWS exists in the study areas on different scales. These are discussed below.

4.2 Poiqu/Bhotekoshi River in Koshi Basin (China–Nepal Trans-border)

The river originates in Tibet. This higher mountainous region have been experiencing outbursts of glacial lakes and flash floods associated with localized intense rainfall. Heavy rainfall can take place in the windward side of the mountains within Nepal in the border areas. But most of the glacier lake outburst floods (GLOF) originate in Tibet.

4.2.1 Early Warning Practices in Tibet, China

Flash floods associated with heavy precipitation events and GLOFs and landslide dam outburst floods have been experienced from time to time in the headwater of the Poiqu/Bhotekoshi River in Tibet Autonomous Region (TAR), China. Three meteorological stations, viz. Quxiang (3,350 m), Nyalam (3,750 m) and Zhangmu (2,200 m), are located in this watershed. No information is available about the existence of hydrological station along this river. Similarly, no information about the early warning practices in this area is available. As mentioned earlier, it was not possible to carry out field studies in the headwater in TAR. So, the discussion on early warning practices in the Poiqu/Bhotekoshi River between China and Nepal is based only on the information collected during the field studies in Nepal and is discussed below.

4.2.2 Early Warning Practices in Nepal

Historically, there have been floods in the Bhotekoshi River (known as the Poiqu River in Tibet), causing loss and damage of life and property in both public and private sectors in Nepal. The flood in the Bhotekoshi River carries high significance for Nepal as the road along the river is the main trade link between Nepal and China. Two devastating GLOFs that originated in China—one in 1981 and the other in 2016—resulted in substantial loss and damage of property and infrastructure in Nepal. The outburst flood from Zangzambu (Ci-Ren-Ma-Co) glacial lake swept away five people, forty-one houses, two highway bridges, and many water mills. About 27 km of roads were severely damaged. The total loss was estimated about USD 4 million. Trade and traffic flow was blocked for thirty-six days and transport services between Barhabise and Kodari were disrupted for three years (Khanal and Acharya, 2008; Khanal et al., 2013, 2014, 2015, 2015a). Similar sorts of damage with estimated loss between USD 66.35 and 77.34 million occurred due to outburst flood of the Gongbatongshacuo Lake in 2016 (CDG-TU, 2017). The flood on June 5, 2016 destroyed roads; since then, the trade between the two countries has been halted, even during the time of this field study. It has been causing significant impact on the national economy of Nepal.
After the GLOF of 1981, the Bhotekoshi Hydropower Project installed an EWS with five sensors and automatic sirens at four locations within its project area near the Nepal-China Friendship Bridge. People living in those areas were trained by the project, and signboards about the siren system were placed. The system collapsed in the wake of the 2015 Gorkha Earthquake. There is no any functional EWS system between Tibet and Nepal. Whenever the river level rises, people from Nepal who happen to be in Tibet at the time of the flood provide information to their friends and acquaintances in Nepal over phone. In the Tibet side, the settlements near the border are not highly exposed to floods. The Zhangmu settlement, which is nearest to the border, is located far from the main river channel. Occasionally and informally, the border security force of Tibet communicates to the border security force of Nepal. However, this is not a systematic and reliable activity and does not fall under the mandatory responsibilities of the security forces. Although Nepal is the main victim of the floods in this river, there is no effective EWS in the country. After the flood in 2016, the government of Nepal installed a river monitoring station at the Friendship Bridge, mainly for monitoring the river level. If the device detects a high flow, the telemetric system it sends signals to the Nepalese authorities. The system also blares the siren whenever the river rises dangerously high. However, it is yet to be tested and doesn’t function as a complete early warning system.

Quite a few scientific studies on GLOFs, the losses and damage they cause, and their potential risks have been carried out on the Pique/Bhotekoshi/Sunkoshi River, and their results have been published in national and international journals and books (Khanal and Acharya, 2008; Khanal et al., 2013, 2014, 2015, 2015a). However, the communities and stakeholders concerned are not aware of the risks of floods at different levels of river discharge or water level at the monitoring station. No disaster risk management committee exists in riverine communities.

Risk Knowledge:

The Liping and Tatopani villages are located in the lower part of high and steep mountain slopes. Rocks fall from these hills, and landslides, along with floods, cause severe disasters during monsoon. The local communities there know that there are many glacial lakes within and outside Nepal. The most dangerous glacial lakes are located in the China side. Local communities are aware that they are at risk due to the steep topography and lack of accessible alternative safe locations during flood events. People are aware that floods originate in China, but they have no idea about the magnitude of flood and their subsequent causes.

Monitoring and Forecasting:

As mentioned earlier, a flood monitoring and warning system was developed by the Upper Bhotekoshi Hydropower project. The river discharge monitoring station was located near the Friendship Bridge, but the GLOF of 2016 swept it away. After the June 2016 flood, the DHM installed a flood sensor at the Friendship Bridge. The local communities do not have easy access to the information transmitted by it as it is at an initial stage. People are aware of the siren installed at the Friendship Bridge, but they do not know how it functions or whether it works or not. The station is 1 km upstream from Liping, 4 km from Tatopani, and 25 km from Bahrabise. With more than 200 households, Liping and Tatopani areas have very short lead time even if a warning is generated by the flood monitoring and warning device installed in the Nepal side. The lead time can be increased substantially if a monitoring and warning station is installed upstream in the China side.

The threshold or danger level and potential damage of floods in the downstream are not known. Since these are flash floods, monitoring and warning about them are equally challenging. The monitoring technique for floods in the plain areas cannot be applied to the floods in the hills or mountains. Therefore, there should be appropriate technologies for monitoring floods in the hills and mountains. Since the major source of devastating flood events experienced in this area is glacial lakes, it is necessary to monitor glacial lakes and determine the potential risks from GLOFs.
Communication and Dissemination:

There is no formal communication and dissemination channel of flood information from the government to the community in Sindhupalchowk district in Nepal or from the Chinese government to the Nepalese government. Usually, the security force stationed in the upstream area in China informally shares flood information with Nepal’s Border Armed Police Force whenever there is a flood. The armed police in Nepal have Chinese mobile SIM cards through which they communicate during disasters. In the 2016 flood, information was conveyed by the Chinese security forces stationed in the upstream area to the chief of the Nepal Armed Police Force in Tatopani, who relayed the information to the local communities, but the available lead time was very short. Usually, there is regular communication between the area chiefs of the armed forces of Nepal and China regarding border security issues. However, no systematic flood warning communication between the communities living in both sides of the border exists. Usually, Nepalese citizens visit nearby market towns in China for trade and business or as labourers or live there as spouses of Chinese citizens. So, when they detect a flood event in China, they communicate about it to their relatives in Nepal.

There is no proper communication channel for dissemination and communication of information about floods from the central government to the community. There is DEOC in the Sindhupalchowk district headquarters, but it has no mechanism to access the flood information generated by the DHM. In other districts that are properly connected with DHM information, the DEOCs have flood information display boards for relevant rivers. Such display boards should also be installed in the DEOC of Sindhupalchowk to display information on floods in the Bhotekoshi River, which can be monitored by the DEOC authorities in the district headquarters. Whenever the flood in the Bhotekoshi River crosses the danger mark, then they can communicate this information to Nepal’s border forces and communities.

Similarly, there is a lack of linkages between the communities and the DEOC for communication of flood information. At the community level, there is no village or community disaster management committee or task forces. No communication and disseminations mechanism exists. In case flood information is generated either by the monitoring device installed at Friendship Bridge or the DHM, there are no any telephone tree and equipment such as hand siren, hand mike, etc., at the community level such that the information is further disseminated to endusers. However, there are some youth clubs who engage in communication, dissemination and humanitarian assistance during disasters. Their activities can be capitalized on and linked with disaster management programmes.

The Border Armed Police Force has been requested to read the flood monitoring device installed at the Friendship Bridge, but they are not clear to whom they should communicate, whether up to to district and centre or down to local governments and communities.

Response Capabilities:

Currently, there is no CDMC at the community level. In the past, VDCs worked as village disaster management committees. The VDCs prepared village disaster management plans (VDMPs), which identified flood as a priority hazard, followed by landslides. The plan also recognized the need for FEWS. The disaster management plan made the community aware of their main hazards to some extent. However, VDCs had no any task forces to compliment the implementation of these disaster management plans, The institutional provisioning for disaster management at field level is lacking across these border communities. The communities also have no communication and dissemination equipment or physical infrastructure that is needed for responding to flood information. No safe and open spaces and evacuation routes and centres where they can assemble during disasters have been identified. They have no proper orientation and training in EWS with mock drills. So, at the community level there is a gap in terms of capacity to respond to warning information if they receive it.

At the district and stakeholders levels, the Armed Police Force (APF) have limited materials for rescue and relief operations. Furthermore, the APF have limited understanding of EWS, apparently because their main roles and responsibilities are to address the border security needs.
The local people have no rescue or relief materials and gears. Trained organizations for sharing, communicating, and undertaking rescue and relief operations are also lacking at the grass roots level.

There are strong cultural ties between the peoples living near the border. The people living near border areas are allowed to cross the border without visa. So, communications at personal level across the border exist. However, there are no settlements near rivers in the China side, who could have monitored the flood and communicate to the communities in Nepal. In Sanugumza, Nyalam and Chhakysyang in Tibet people live close to rivers. But, on the one hand, these settlements are far inside China and, on the other, the socio-cultural ties with the people in downstream Nepal are not so strong.

4.2.3 Development of China–Nepal Trans-border EWS

Though a trans-border flood risk assessment has been carried out, updated information covering all four elements of EWS is lacking. Moreover, the research results and findings are not properly disseminated to the local people and institutions. Since the river has a high gradient, the risk assessment should not only look at the volume and level of river but also assess the force of the river, which can destabilize the slopes of the banks and cause severe erosion of banks and landslides in the hills and mountains.

It is necessary to establish adequate river and precipitation monitoring stations at strategic locations in the upper watershed of the Poique/Bhotekoshi River in China. Similarly, timely monitoring of glacial lakes using remote sensing technologies, as well as field survey, is necessary. The information obtained from the monitoring stations need to be communicated to the Nepalese authorities when the water level exceeds the warning and danger mark. There should be also a provision for regular communication between border authorities during the normal flood level such that Nepal authorities can have access to the flood information as and when required and requested.

It is also necessary to develop a communication channel and system between Chinese and Nepalese authorities regarding who communicates to whom and what means of communication (telephone, SMS, Internet, etc) can be used. There should be a common language that is understandable so that both parties can easily and confidently communicate flood information among each other.

In the Nepal side, the following are the actions points that require immediate attention:

- Formation of community and municipality-level disaster management committees, including community volunteers, and strengthening their capacity to identify and understand flood risks, communicate and disseminate risks, develop response plans and apply them in practice.
- Awareness raising of the community to understand the EWS and respond to flood information.
- Develop specific communication channels and systems in each community and municipality for flood warning.
- Empower the communities and local authorities as guided by the national policy and legislative framework for DRR
- Build the communities’ capacity through various trainings and workshops to assess flood risks monitor the threshold river stage and transform this scientific information as per their local and societal relevance to get better prepared for the disaster.
- Since no community lives near rivers in the upstream country, China, there is no such possibility of setting up community to community linkages for trans-border early warning information. Communication of early warning information across borders should take place through national and local government authorities. A mutual agreement between the two governments is needed to materialize such communication for flood warning.
- Scientific collaboration will be required for risk assessment, monitoring of floods and dissemination of flood warning information between China and Nepal.
4.3 Karnali River [Nepal–India Trans-border]

4.3.1 Early Warning Practices in Nepal

An end-to-end (E2E) FEWS exists in the Karnali River within Nepal. Following are some of the information on E2E in the Karnali River.

There are twenty hydro-meteorological stations with the telemetry system within the Karnali River basin to run forecast-based FEWS. The system generates flood information from a) real-time flood monitoring, b) five-hour flood forecast using probabilistic model, and c) flood forecast products using Quantitative Precipitation Forecast (QPF). Calibrated flood forecasting model has been validated for three-day lead time based on the Weather Research and Forecasting (WRF) model’s rainfall forecast and Early Warning Decision Support System (DSS).

Regarding trans-border EWS, the DHM has posted all real-time monitoring data on the website with warning sirens effective for the communities inside Nepal. The DHM communicates any flood information daily to the CWC offices in Patna and Lucknow in India.

The E2E EWS in the Karnali Basin involves District Emergency Operation Centres (DEOC) at district level, Local Disaster Management Committees (LDMC) at local government level, community disaster management committees (CDMC) at community and village levels, and early warning task forces at community levels. The committees and task forces have been trained in EWS. There is flood information communication in practice between the communities in Nepal and India during flood season. The DHM provides real-time flood information to the CWC under the governance framework of the Joint Flood Information Commission, which was solely established for reservoir and barrage operation (structural) purpose but now also used for EWS across borders.

Risk Knowledge:

The communities in upstream of the Karnali River in Nepal have good risk knowledge. They know their assets, number and types of houses, population, number of animals, etc which are exposed to different scale of flood as per the flood level monitored at the gauging station upstream. They are aware of their capacities to respond to floods, including knowledge of floods, available human resources (task forces, committees), social capital, existing physical infrastructure access to emergency shelter, road network and service facilities etc.

Monitoring and Forecasting:

There are several river gauges along the Karnali River that are used to monitor and forecast flood. The one at Chisapani is the major flood forecasting station for Karnali one, which is used for to monitor flood level that can have likely impact across the downstream flood plains. Monitoring is through radar-based technology, which transmits information of the flood level to the server through the telemetry system, which is then disseminated widely through the website and SMS. There is also presence of a DHM staff at the gauging station to ensure that the machine is functioning properly. Table 4 shows the threshold levels of flood at the Chisapani Gauge Station in the Karnali River in Nepal.

Table 4 Different threshold levels of flood at Chisapani Gauge Station, Karnali River, Nepal

<table>
<thead>
<tr>
<th>Flood Level at Chisapani</th>
<th>Meaning</th>
<th>Local Indication</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 m water level</td>
<td>Be careful</td>
<td>Blue</td>
</tr>
<tr>
<td>10 m water level</td>
<td>Get ready</td>
<td>Yellow</td>
</tr>
<tr>
<td>10.8 m water level</td>
<td>Leave home and go to safer place</td>
<td>Red</td>
</tr>
</tbody>
</table>
These critical levels of flood were calibrated using computer models, which are basically applicable for the bank characteristics inside Nepal. The cross-border implications of these levels haven’t been assessed and thus are unavailable.

The communities in Nepal below this station are aware of the implications of these different levels of flood at the Chisapani Gauge Station. They are also aware of necessary actions to be taken by them at local level at different levels of the flood. The system is equipped with an alert alarm system, which gets activated when the water level reaches the yellow and red marks. The communities are also aware of the travel time of flood from the Chisapani Station and available lead time for each location.

**Communication and Dissemination:**

The communities receive flood information through different channels. The gauge reader in Chisapani personally communicates the information to key persons in the community. The communities can also communicate to the gauge reader if they anticipate flood based on their observation of the rainfall. The communities also receive flood information from the area police office in Rajapur Municipality when flood reaches the warning and danger mark. They also receive alerts and warning information through SMS.

Once the flood information reaches key persons in the community, the task force members and CDMC further disseminate it to the households and individuals through loudspeakers, hand siren, home visits, etc as quickly as possible. The upstream community also disseminates information to the downstream communities within Nepal (cascade process of communication).
Community-to-community communication is very strong, quick, effective and regular in this well established EWS. Awareness activities implemented in the community from time to time have increased their capacity to respond to FEWS. The communication and dissemination of information is basically through mobile phone. However, recharging of mobile phone batteries is not that easy during rainfall and flood event. Electricity disruption is common and solar light is also not adequate for charging batteries.

**Response Capacity:**

There are CDMCs functional across border communities of Nepal. Under the CDMC, different task forces (e.g., Early Warning, Rescue and Relief, First Aid, Temporary Shelter Management, Women Volunteer, etc) are functioning with clear roles and responsibilities.

Several flood shelters have been built for flood prone communities of Nepal. Communities also use nearby bridges, houses and embankment as temporary flood shelters. Government support is needed to improve roads, bridges and communication system for quick rescue and access to such facilities. Communities maintain materials for logistic support such as life jackets, ropes, boat, stretcher, headlight, helmet, etc in emergency shelters. They maintain a complete inventory of contact persons and other resources for emergency. Task force members (male and female) are usually skilful in swimming that they learned locally.

Regarding sustainability of the community-based EWS, the community members have received various training regarding diversification of their livelihoods and sources of income through which they are creating fund to cater their needs during emergencies. The task force members of the EWS can share their learnings via knowledge nodes, expert interactions, knowledge camps, and so on. This has demonstrated local confidence across technological and social aspects of early warning system and increased collaboration and coordination with government institutions to sustain this community-based EWS. So far, the EWS in the Karnali River has been strengthened with support from national nongovernmental organizations (NGOs) and international nongovernmental organizations (INGOs). As these support from I/NGOs are short-term and project specific, the government should urgently integrate the EWS to government DRR and development programmes and continue to operate and manage the system beyond NGO/INGO support.

According to Chief District Officer (CDO), Bardiya district, there is regular communication between the CDOs of Nepal and District Magistrates (DM) of India regarding concurrent issues. Communication also takes place on floods during the flood season. A more formal communication channel might be needed for flood information communication between the two countries at the local government level.

The DEOC in Bardiya in Nepal is the focal point to communicate information about flood situations if there is a query from DM of India about the situation in the Karnali River. Although there is no such specific focus on flood information sharing between local governments of Nepal and India, a general agreement and understanding is there to have a regular communication across the borders if that relates to the the security of people and their assets across the border. From the Nepal side, flood information is provided specifically to the staff at the Bahraich Barrage manage the barrage whenever there is an impending high flow situation. However, lack of any formal understanding of flood warning communication between the two countries at national level, the communication of flood information haven't been a part of job responsibilities of the local government. Mostly the transborder communication is being done in ad-hoc basis. The CDO of Nepal has however, realized the importance of collaboration between the neighbouring districts of Nepal and India for transmitting flood information through community radio and mentioned that they are planning to include such provision and mechanism in the district-level Disaster Preparedness and Response Plan (DPRP).

Indian security staff provide necessary coordination and support for any requested actions (e.g., crime control, border security, illegal logging, wildlife crime control, etc). There is also informal sharing between sectoral offices and departments of the countries (e.g., District Forest Office of Nepal to
Divisional Forest Office of India, chief wardens of national parks of Nepal to chiefs of conservation area in India, etc) at local level. So, such relationships for trans-border information sharing and collaboration can also be harnessed for FEWS between the two countries. Border security is a sensitive issue while early flood warning is a humanitarian issue, which, if shared, can save lives and property.

There are barrages in India close to the Nepal–India border, which are used for regulating irrigation water in India. During floods, the backwater effect from barrages inundates the upstream of the reservoir towards Nepal. Such backwater effect sometimes becomes a severe problem as it inundates land in both Nepal and India, creating problems for communities living in both sides of the river in the upstream of the barrage.

### 4.3.2 Early Warning Practices in India

**Risk Knowledge:**

In 1983 and 2014, major flood events occurred downstream of the Karnali River in India. The flood in 1983 caused one human casualty, loss of 38 cattle, loss of crops and damage to household goods. Whereas the 2014 flood was almost the same or even larger in magnitude and was more devastating compared to that of 1983, the one in 2014 didn’t cause any human casualty. The communities, however, lost agricultural crops, livestock, household goods and even some houses.

The communities in India showed that they do have good knowledge of multi-hazard risks such as fire, flood, threat from wildlife, draught, diseases and pests, cold and heat wave, etc. Communities are well organized. They are also aware of their exposure to flood and their capacity to respond. The area is at risk of wildlife like snakes, crocodiles, etc during floods. However, systematic risk assessment of floods of different levels and discharge at gauge stations for downstream communities is sorely lacking.

**Monitoring and Forecasting:**

The community reported that they used the real-time flood information relayed by the Chisapani Station, maintained by the DHM. Local people know the danger levels of flood at Chisapani, but there is no cross-border assessment of risks of different flood levels at Chisapani to the communities in India. The community is also aware of the flood travel time, which is 8 to 10 hours from Chisapani in Nepal to their settlements in India.

A display board for real-time flood information of Chisapani Nepal has been installed in the Tehsil office of Nanpara, which provides real-time flood information regularly. Whenever they observe warning and dangerous level of flood in Chisapani, Nepal, they prepare themselves for the response; warning information is issued by Pradhan to citizens at the warning level and household members are asked to leave home and go to safer places when the river level reaches the danger level.

**Communication and Dissemination:**

The CWC maintains flood monitoring stations across India and provides observed information to district level and then to central level. The warning information is then relayed downwards to district level, but information is not effectively communicated to communities. The information is also posted on the website, to which communities have no easy access and is difficult to understand for them. There is a big communication gap in respect of flood information between district-level stakeholders and communities. Under such circumstances, information reaches the communities late. Though a flood forecasting system is maintained by the CWC, but the community have limited access to the information. The community suggested that the gauge readers should directly communicate real-time flood information to downstream communities.
There are community-based disaster management committees (CBDMC) and task forces which were trained by certain projects in the past. The members of these committees and task forces are aware of their roles and responsibilities in relation to the EWS.

The means of early warning dissemination to communities are the mobile phone, hand mike, hand siren, and physical communication by task force members. Priority in communicating information is given to women, children and people with disabilities. The focal person receives phone calls from Nepal. He/she has to inform the Pradhan (head of Panchayat) before disseminating the flood information to the communities. As soon as the Pradhan approves the information, then early warning task force members disseminate the information to the communities. The community reported that sometimes the mobile network didn’t work and sometimes the batteries of the mobile phones couldn’t be charged due to lack of a power backup system; so, communication becomes challenging in case of poor network. Therefore, getting of approval from Pradhan to disseminate information at household level should also be done via phone. Sometimes the government provides alert messages to Pradhan.

**Response Capacity:**

The community reported that there is no designated raised platform that can function as flood shelter or evacuation centre and there is only one search and rescue boat, which is not sufficient. All households are exposed to flood and schools are also not safe for emergency shelter as they are not designed to cater to this additional service.

Emergency support (e.g. food, water, boat, vehicle, ambulance, first aid, compensation, etc.) is provided by Tehsil office, the sub-district office, during flash floods. Furthermore, coordination and collaboration among local communities are very good. People from one community help other communities. The local people said, in most of the cases, they were aware of the skills and materials they needed to respond to floods once they had received information. The community shared that the government and voluntary organizations only come after the flood and often do not know the local needs. There is a lack of a one-window system during the distribution of relief materials after floods.

The interviews with the Tehsil officer, Sub-division Magistrate and PGVS official working in Nanpara, Bahraich and Lucknow respectively highlighted some key issues relating to flood risk communication and response operations, which are listed below:

- There is no safe house to stay during floods in the area. All the houses where FGDs were conducted had experienced inundation during floods.
- There are sanitary problems during floods, with no toilet at household and community levels, no raised hand water pumps at safe level in the village during floods.
- Phone calls from India to Nepal are expensive and are not affordable for poor communities in villages, and sometimes the network does not work.
- Very few people have smart phones, which could have enabled them to browse websites for flood forecasts and weather information, which is also equally expensive for them.
- Often, the text messages of flood warning cannot be read by all; voice messages could be more appropriate to the communities.
- The number of flood information display boards is not sufficient and within access of all people in the village.
- Lack of funds at community level for sustainable running of EWS is also a constraint.
- Though the present practice (community-level EWS and trans-border community-to-community EWS) is well recognized by the government, it is not supported through funding.
- There is a functional network led by Civil Society Organizations (CSOs) for exchanging flood data and information from the upstream country (Nepal) across the border. However, this informal mechanism needs government backstopping for sustainability and continuation.
- Capacity-building programmes for community task forces should be continued for updating their skills to cope with the changing technology adopted in the EWS.
Furthermore, during the consultations with the stakeholders, it emerged that the authorities get prepared for delivering relief and response services once they receive flood information from the authorized government departments of India. The practice of urgently relaying the information to the communities so they can take measures for staying safe and move to safer places, protect their assets and property before the flood reaches their area is sorely lacking. There is need for capacity building of the district-level government authorities in respect of how the EWS works and how they can play effective roles in saving lives and property of communities.

4.3.3 Development of Nepal India Trans-border EWS

The responses on the development of cross-border EWS, its scope for improvement, and challenges faced during the FGDs, KIIIs and consultations with the key stakeholders are discussed here. The findings show that there is an effective FEWS in the Karnali River in the Nepal side. Efforts have been initiated to communicate real-time flood information from communities in Nepal to communities in India living across the border and along the river (Photo 6). This community-to-community cross-border practice has been found effective. However, because of lack of government support, the practice is not sustaining. The means of communication across the border is international telephone calls, which are very expensive for poor communities. There are informal and ad hoc communications on real-time flood information between the local governments of the two countries. However, there is no institutionalized mechanism and formal bilateral agreement to communicate real-time and forecasted flood information between communities and local governments at local level.

As mentioned above, a joint commission on rivers and water resources between Nepal and India exists to discuss issues related to water resources and to find solutions. An agreement between Nepal and India exists to communicate flood information at national level. The DHM of Nepal shares such information with the CWC and Department of Irrigation (DoI) of India. This sharing takes place on daily basis, and the frequency is increased during the monsoon. However, use of such information in India is primarily for irrigation and infrastructure management and very little for flood risk management at the community level.

Until now, there has been no such cross-border flood risk assessment across Nepal and India.
A clear communication channel between the authorities of the two countries should be established at local level. They should be authorized to develop and strengthen a mechanism for communication of real-time flood information between them. The linkage established between the communities should be strengthened and sustained with support from the governments. Institutional mechanisms of the communities living in the border areas and between the communities across the border should be developed and their capacity should be enhanced to communicate flood information and to respond to it. The Nepalese and Indian governments should recognize the existing cross-border communication between the communities and support and facilitate the communities by subsidizing the cost of international telephone calls related to flood information from one country to another.

4.4 Brahmaputra River [India–Bangladesh Trans-border]

4.4.1 Early Warning Practices in India

The two sites visited for field study along the Brahmaputra River in India were Dhubri and South Salmara (Table 1). The results from the field study in this area are discussed below.

Risk Knowledge:

The major flood events in the Brahmaputra occurred in 1968, 1988 and 1998, and the biggest one in 2016, which affected about 350,000 people, among which children were affected the most. The 2016 flood was one of the biggest, which severely affected about 80 per cent of the area. Excessive rainfall in Meghalaya causes flash floods and magnifies the flood level, adding to the water level in the Brahmaputra River. It was reported that the sudden release of water from the Kurishu dam in Bhutan is another cause of flood in this area. Besides, three rivers originating in Bhutan regularly contribute to flash floods in this area. The sedimentation in the bed of the Brahmaputra aggravates the duration of floods and erodes banks. The floods damaged crops, livestock, infrastructure such as road, school buildings, fisheries, etc.

The practice of community/household-level vulnerability mapping and its updating and educating local population was missing. Most of the information and knowledge about the risk and vulnerability are limited to district officials. Interviews with the district programme officer and district disaster management authorities show that the district office carries out vulnerability assessment, formulates disaster management plans and prioritizes DRR activities based on the results of vulnerability analyses. However, such activities are still not practised at community level. The community reported that structural measures such as embankment could reduce the suffering by as much as 50 per cent.

The district-level workshop participants unanimously said that excessive rainfall in the upstream catchments of the Brahmaputra and release of water from hydropower plants are the main sources of flood. Majority of the participants agreed that a national early warning system exists, but they are not properly aware of its existence. The elements that are most at the risk of flooding are crops, livestock, children, roads, household assets, health, etc, as perceived by the participants. It is reported that livestock is at the highest risk of flooding in this locality.

Monitoring and Forecasting:

During discussions, it was found that the community largely depends on informal communication channels. Specific information about the level of water arriving in the village from Upper Assam doesn’t reach them. The CWC maintains the staff gauges and provides information on flood water levels. However, the community is not aware of the existing flood monitoring stations in the region.

Although the CWC does provide flood water information, it doesn’t provide information on lead time available for the settlements downstream of the river gauge. Communities are also not capable of interpreting the flood levels (ie what the normal level is, what the danger level is, what the warning level is and so on). They need flood information as early as possible so that they can prepare and take necessary steps to take shelter at safe places along with their belongings.
The estimated lead time for flood water to reach Dhubri is approximately forty-eight hours as water starts receding from Upper Assam, Dibrugarh District. This assumption about the lead time, used by the local people, is based on the local knowledge and past experience. It came to light that the information from district administration or disaster management unit rarely reaches the grass roots level.

It was learnt that the North Eastern Space Application Centre (NESAC) developed a flood early warning system in 2011 and Dhubri is one of the districts that receive information about floods at regular interval. However, overall, the existing EWS is not very effective in the state of Assam where communities are connected to the system, engage in flood information communication and dissemination, and response activities.

Very few participants of the district-level workshop at Dhubri had knowledge of the danger level of floods, and only a few were aware of the existence of the flood monitoring gauge at Dhubri or its location maintained by the government of Assam. Majority (about 90%) of the respondents reported that they receive early warning twenty-four hours ahead of a flood, while none of the participants said the warning they received at the community level is not trustworthy. Although the flood information is received twenty-four hours ahead, all of them stated that this lead time is not sufficient for preparation and responding. They demanded a forecast with longer lead time. None of the participants had an idea of how the cross-border flood is monitored, but all of them agreed on the need for establishing trans-border flood monitoring and communication.

Communication and Dissemination:

The communities in this area receive real-time flood information from Panchayat and ward members who receive it from district administration or disaster management unit. The Panchayat uses telephone, and local people use drums and whistle for information dissemination.

Flood early warning is also received through television news bulletins, radio news bulletins, Gram Panchayat, etc. The weather status information from IMD sometimes reaches the communities, but the information is not well disseminated among the communities, despite existence of some good practices. During the 2016 flood, Deputy Commissioner personally sent flood warning SMS to the Pradhans of the Panchayats and the Pradhans disseminated it to their ward members. Overall, information coming from the television was found to be most popular choice. Some people prefer radio because can be operated with batteries and even during power outage. Pradhans and ward members of Panchayats coordinate with the district authorities to get information and sometimes make phone calls to key persons in the community who are in their contact to inform the households within their territory. Panchayats also sometimes use public mikes during emergency to inform the community to move to safer places. Besides, those who come to know about flood information through television or radio share it with their neighbouring households who do not have television or radio sets. So, there is some level of flood warning practice inside India along the Brahmaputra River, but it needs to be institutionalized and systematized. The following technology and media are suggested as useful for communication and dissemination of flood information:

- More specific announcement/warning on television channels and radios
- Flash chart/display screen in market and other prominent places
- Installation of television sets in Panchayat offices
- Announcement through loudspeakers

The flood information in India usually does not cross the border between India and Bangladesh to inform the communities in Bangladesh living on the other side of the border and downstream of rivers, to help protect their lives and property. Majority of the community in Bangladesh do not have direct or indirect access to flood information from India. They suggested that the Border Security Force (BSF) of India and the Border Guard of Bangladesh (BGB) have good communication facilities through wireless, which could be used for exchanging flood information across the border.
Most of the participants of the district-level workshop believed that there are complexities in obtaining information on upstream floods across the border. About half of them were of the opinion that these issues should be resolved at the state level, while the other half believed that, besides state-level cooperation, free communication system should be established between flood-affected communities from each side of the border and their social relationship can break the barriers to information exchange. They suggested involving border security forces for communication building on the established bilateral communication system at the border level. Some of them suggested installing flood warning signals at top of the BSF tower or public domain apps or website to disseminate flood information.

The respondents shared that the main medium of dissemination is print and electronic media, followed by government administration. The stakeholders provide voluntary services to distribute relief materials during flood disasters. No local focal points have been identified for dissemination and communication of early flood warning. Currently, no NGO is working on FEWS in this study area.

At district level, the interpretation of flood information is satisfactory, but understanding the information is a big challenge at the sub-district level. The responders preferred radio and mobile SMS through authorized channels as a means of communication for flood early warning, followed by loudspeaker in temples and mosques. It shows that radio and mobile SMS or voice broadcasting are the most preferred mediums because they do not require continuous power connection, so, are not much affected by power cuts, which can go as long as two to three days. The respondents preferred local wireless networks and solar-based alerts for information communication about floods.

District Program Officer and District Disaster Management Authority (DDMA) informed that the district provides information to the circle offices and Panchayats. Early warning messages are generated by the National Disaster Management Authority (NDMA), which is then provided to the Assam State Disaster Management Authority (ASDMA), which further relays the message to district- and village-level authorities or elected members. The key means of communication are maps, SMS and alerts on television and radio. According to them, trans-border sharing and communication with Bangladesh is very difficult. Formal sharing is not in practice. If it is centrally agreed, sharing between the two countries at local level would be possible. Local communities might talk to the communities in Bangladesh, but a formal linkage between them does not exist.

Response Capabilities:

Local people lack specific knowledge of, or training in, flood risk and flood preparedness. Specific knowledge of EWS includes the capacity of the community to correlate different flood heights or discharges with different levels of impact at different locations, information on gauge stations and the lead time from gauge stations to different points along the river downstream, measures to respond to and disseminate information to communities, individuals and others. Currently, their action plans are based on their own experience. Therefore, response capacity of community is not adequate. In most of the cases, they moved to raised platforms, embankments, etc once they know a flood is coming. The communities have not received any kind of training in EWS. India’s BSF often helps with rescue and relocation during floods. The district disaster management plan of the Dhubri District specifies the role and responsibilities of each of the government departments to respond to during disasters. It also specifies the key search and rescue resources available to the district.

The community has sufficient number of boats, mostly country-made hand-boats; however, roads and other infrastructure are not adequate. In 2017, the Panchayat prepared a plan to build special boats to manage flood preparedness activities. There is a strong bond and cooperation between the communities. No any NGOs/CBOs are working in the area. The government provides relief and rescue services, though often they are not up to expectation. For example, the government has constructed one platform for emergency shelter, whereas there are twenty-two communities who need such evacuation centres in the Dhubri District.

The government provides support from the central- or state-level funds. There is no community-level fund. Households and the entire community depend on government support, which is minimal.
and limited. It was informed that the compensation promised by the government in the wake of the August 2016 floods has still not been provided and, even after eight months, the verification process is ongoing. However, the seven families who lost their family members in the 2016 flood received compensation of INRs 500,000 each within seven working days.

During the district workshop, the participants said that, usually, local people take preparedness measures after they see flood waters and not immediately after receiving the warning. There are no flood shelters or open spaces in the flood-prone areas, especially in rural areas. During floods, victims are allowed to take shelter in school buildings where sanitation and other facilities are limited. Most of the participants reported that the local infrastructures for flood victims were either inadequate or non-existent.

There is village land management and conservation committee (VLMCC) in each village, which is responsible for planning, implementing and monitoring of village-level DRR activities. In case of loss of life, compensation is provided within seven days. However, in case of loss of agricultural crops, livestock, assets and physical property, losses are assessed by the district, state and central governments, which may take time.

The DDMA implements DRR activities based on the Disaster Management Manual issued by the state government. All district-level government agencies and authorities have been assigned specific responsibilities for rescue and relief work. So, collaboration is intact. Planning is also done in close coordination with all line agencies or Panchayat or district elected government members and government authorities. DDMA provides training and orientation to each member of the Panchayat and sometimes to vulnerable communities based on their level of vulnerability.

4.4.2 Early Warning Practices in Bangladesh

Two sites visited for field studies along the Brahmaputra River in Bangladesh were Chilmari in Kurigaon and Islampur in Jamalpur (Table1). The results of the field studies are presented and discussed below.

Risk Knowledge:

The study area experiences riverine and flash floods almost every year. The floods of 2014 and 2016 had significant impacts on people and their livelihood. Almost all the unions of the Upazilla were flooded. The main causes of floods are heavy rains upstream, in Assam in India and, in a few cases, landslide dam outburst floods originating in China. The local rainfall has practically no effect on flooding. In addition, the siltation on the river bed aggravates floods. Sometimes, flash floods occur and cause acute damage to crops, road networks, livestock and livelihood of people. The people living outside the embankment and in unprotected areas are most risk. The community is aware of the danger level at the monitoring station just upstream in Chilmari in Bangladesh. However, most of them cannot signify the threshold values due to either not being able to understand the SI unit (centimetres) or failing to relate upstream threshold with their local context. There is no collaborative relation between two communities upstream (Assam in India) and downstream (in Bangladesh). So, the community downstream does not know the implications of danger level of floods in the Indo-Bangla border. They could not provide any information about any kind of flood extent map at the Upazilla level prepared by the national authorities.

The respondent at the community level was not sure if any community risk assessment was carried. However, it was found that risk and resource map has been produced in some unions. These maps provide an overview and rough sketch of risk scenarios (ie high risk, low risk, etc). The community agreed that such initiative would help them better understand the risk and identify the underlying risk factors. They do not have any idea about the source of early warning information.

The participants of district stakeholders’ workshop revealed that excessive rainfall in the upstream catchments of the Brahmaputra is the main cause of floods in their area. Livestock faces the highest risk of floods in this area. About 70 per cent of area of the district is affected by floods every year. Only 25 per cent of the participants had an idea about the danger level of water at nearby or upstream gauge.
Interviews with officials of several government and non-government organizations involved in flood management practices in Bangladesh revealed that:

- Agricultural crops, physical infrastructures (house, roads, embankments, etc) and human and livestock populations are the most affected elements in Bangladesh.
- Risk assessments have been conducted by DDM and other NGOs, but there is no linkage of these assessments with the community-level FEWS.
- DDM has recently completed a multi-hazard risk and vulnerability assessment, whose findings could be linked with early flood warnings.

The BWDB has also conducted risk assessments through projects like flood action plan (FAP). The danger levels were fixed for different locations through this project, which are currently being used for early flood warning in Bangladesh. However, these danger levels require regular updating, which, however, is not being done currently. Information needs to be properly communicated to the communities and stakeholders in the area.

**Monitoring and Warning:**

A staff gauge is maintained by the BWDB at the Chilmari point to measure the river stage. A local person is assigned to collect and record data from this point. However, the communities do not understand the reading of the gauge. So, they monitor the rise and fall of nearby water level by using traditional techniques. They erect a bamboo stick in the river bank or put a mark on the fences, measure the rise or fall with their fingers every day, and monitor the rate of change of water level. They also use local bridges to monitor the water level. Currently, no official or community-level mechanism is in place for sharing flood information from trans-boundary communities upstream. However, people reported that they have relatives on the other side of the border and, though international calls are expensive, they communicate on the phone to acquire information on flood situations upstream of the Brahmaputra.

Communities are willing to pay the cost associated with flood monitoring. They do not collect or receive information from the upstream communities. Though there is no community-based EWS in this area, they receive information from print and electronic media like television, newspaper, etc, with an average lead time of three or four days at regional level.

Although 41.6 per cent of the participants of the district stakeholder workshop were aware of the flood monitoring gauge maintained by the BDWDB and its location, very few of them knew about the danger level of the river upstream. Similarly, 33 per cent of the respondents reported that they receive early warning ahead of a flood, while 1 per cent said that the warning they receive at the community level is not reliable.

The stakeholders had no idea of how the cross-border flood is monitored, but all of them agreed to pay for establishing a trans-border flood monitoring system. Most of the participants believed that there are complexities in obtaining upstream flood information across the border. About half of them suggested that these issues should be resolved at the state level, while the other half believes, besides state cooperation, free communication system should be established between flood-affected communities from each side of the border and that social relationships can help overcome the barriers of information exchange. About 90 per cent of the participants reported that they receive flood early warning two to three days ahead of flood, and all of them stated that this lead time is not sufficient enough for preparation. They demanded a forecast-based warning with lead time of seven to as long as thirty days.

Interview with officials of different government and non-government organizations involved in flood management practices in Bangladesh revealed that:

- BWDB has hydrological monitoring stations near the border for major rivers. There exist arrangements for receiving flood data from India (since 1972), Nepal (since 2002) and China (since 2006). Currently, India provides flood information through its website; yet, some hydrological data are restricted for sharing.
• Real-time data sharing is not yet established for any of the river basins. Negotiation with all neighbouring countries for basin-level EWS is one way to get data in time.
• The current lead time of flood forecast is up to five days. This lead time is sufficient for emergency response but not for agricultural planning.
• Data sharing from upstream catchment and strengthening technical capacity of the FFWC is required and does not require outsourcing.
• At present, there is no arrangement for community level to provide flood map. It may not be authentic because of non-availability of high resolution DEM.

**Communication and Dissemination:**

The participants reported that the prime source of warning information in their locality is television channels operated by the government and private sectors. Again, they reported that the early warning information that they get from television news doesn’t contain localized forecast and impact information. They also informed that they do not receive any early flood warning formally. The Union Disaster Management Committee (UDMC) is well functioning in their areas, and it meets every three months and calls emergency interim meetings in case of disasters. The union DMC also sets up an emergency operation centre during floods to monitor and coordinate activities. The union is also developing disaster response volunteers at ward level, who could act as good disseminators of flood information. The national security forces (police, BDR and Bangladesh Army) come forward mainly for rescue and emergency measures in times of disasters. There is no telephone tree (channels) being developed with telephone numbers, though there is a toll-free IVRS to enquire and get information on flood levels and flood forecasts from the national-level FFWC. However, the community was not aware of the IVRS. The national structure for warning communication lacks capacity and resources to reach out to the communities effectively. Again, there is no specified communication equipment that is systematically used for warning communication.

The community was of the opinion that, to ensure widespread dissemination of warning information, the community focal points or members of disaster management committees can make arrangements for loudspeakers in crowded places like village market in the locality. They also emphasized direct dissemination of forecast to the community from national and sub-national levels. They believed that direct communication would reduce the lag time in reaching information to them.

Currently, there is no communication mechanism with the upstream community in India. But those who are engaged in the transportation sector, like lorry drivers between Bangladesh and India, can be good means of exchanging trans-boundary flood information. The BGB can also maintain emergency communication with their counterparts on the other side of the border to exchange flood information.

During the district stakeholder workshop, it was reported that the main mediums of flood information dissemination are print and electronic media, and the source is BWDB and district administration. Currently, no NGO is working with early flood warning. It is also understood that no local focal point has been identified for communication and dissemination of early flood warning.

The respondents receiving early warning messages reported that, at the district level, the interpretation of messages is fine but it is a challenge at the union level. It reveals that mobile SMS or voice broadcasting is the most preferred medium. One respondent shared that local cable television network as the preferred dissemination channel.

Interview with professionals from different government and non-government organizations involved in flood management practices in Bangladesh revealed that:

• There is wireless network to exchange water level data between Bangladesh and India. Relevant BWDB telecom operators collect data from the Indian site and transmit this data to local the BWDB offices as well as the FFWC.
• The FFWC disseminates forecast information at national level through email and website. It piloted community-level dissemination with the help of NGOs. At present, there is no operational mechanism to disseminate early flood warning at the community level.
• Early warnings are made available for different levels of disaster management committee through the Internet or e-mails, depending on the scale of disaster
• Community radio and mobile voice and SMS appeared more suitable options for community-level dissemination.
• Community people near the border area could communicate early flood warning information among themselves, which could improve EWS at community level. Upstream community can transmit flood information to downstream communities by using mobile phone.

Response Capabilities:

As the flood level rises, communities shift their belongings to higher ground. Since communities hardly get formal warnings, in most of the cases they relay warning only when they see flood water arriving in their locality. There is no designated flood shelter in the union, but they use the premises of government schools as temporary shelter during crises. It is also reported that, with support from the government, they are furnishing open spaces in higher ground, called ‘Mujib-Killa’, to keep valuable assets, including livestock. In addition, the community pointed out that river erosion is another great problem, which reduces their response capability to flooding and makes the situation far more complex and difficult.

The people have limited understanding of the flood information being communicated and disseminated by the FFWC. Most of them cannot signify the threshold values due to either not understanding the SI unit (centimetres) or failing to relate river stage threshold with their local context, i.e. what the different levels of flood at gauge station imply, what are the types of different impacts and to what extent their lives and properties will be affected.

The communities receive some relief materials like dried food and medicines during floods, but planning for rehabilitation after a flood is either non-existent or inadequate. They also receive micro credits, but there is hardly any relief activity or rehabilitation support.

The community flood preparedness is based on their experience, and they have never received any training in early warning or flood preparedness. Principally, the UDMC has the responsibility of collaborating with communities for taking these types of actions.

During the discussions in the district stakeholder workshop, it was reported that, in 75 per cent of the cases, the community takes preparedness measures after seeing the flood water and not immediately after the warning received from the authorities. They also mentioned that they did not ever get any training in what they should do once they receive warning or how they should respond. The local infrastructures for the communities to respond to flood information are mostly either inadequate or non-existent.

Interview with officials of different government and non-government organizations involved in flood management practices in Bangladesh revealed that:

• Bangladesh has sound disaster management guidelines, Standing Orders on Disaster (SOD). Besides SOD, it has a disaster management policy and plan. It is necessary to implement all of those policies and frameworks to improve the response capabilities through active participation of the community.
• The SODs were prepared with the objective of making the persons concerned understand their duties and responsibilities regarding disaster management at all levels. All Bangladesh ministries, divisions/departments and agencies are required to formulate their own action plans in respect of their responsibilities under the standing orders for efficient implementation. The National Disaster Management Council (NDMC), Inter-Ministerial Disaster Management Coordination Committee (IMDMCC) and Cabinet Committee on Disaster Response (CCDR) will ensure coordination of disaster-related activities at the national level. Coordination at district, Upazilla and union levels will be done by the respective district, Upazilla and UDMC.
• There is a very good framework for cyclone preparedness; however, there are gaps in response capabilities in case of flood disasters.
There are no institutional arrangements for building capacity of the communities to enable them to interpret and apply early warnings for better flood management.

Early flood warning and preparedness are not well linked in Bangladesh. The DDM needs to play a more active role to link these two components for enhancing community response.

4.4.3 Development of India–Bangladesh Trans-border EWS

There is need for flood risk assessment across the border. A trans-border flood risk assessment is required and the upstream and downstream communities and the authorities should be made aware of such flood risk.

A bilateral agreement between India and Bangladesh exists for sharing hydrological data. Bangladesh receives real-time water level and forecasted data on the Brahmaputra River at Dhubri, India from the CWC website, as well as by wireless communication, which can be used for trans-border early warning in Bangladesh. At the community level, some informal communication takes place because of cultural and social ties between the communities across the border. People in the upstream country send message to their relatives downstream whenever they observe the flood. Such relationships can be capitalized for building trans-border EWS. Furthermore, the existing informal communication mechanism between the local-level authorities can be enhanced. There is no formal community-to-community communication of flood information. A communication channel between upstream and downstream communities and authorities should be developed. The downstream communities should be made aware of river monitoring stations upstream where they can enquire about the level of flood.

Establishment of a direct community-to-community communication channel integrating the DMC is also necessary. As there are more than 130 million mobile phone users, mobile services appear to be the most effective dissemination channel. To be more specific, the existing government IVR system can be enhanced and new services like voice broadcasting, push-pull SMS service, etc can be introduced.

It is also necessary to establish and enhance the relationship between communities in upstream-downstream trans-border countries with engagement of their national mechanism for sharing of flood information.

Development of a communication channel for early warning information from authorities to communities is necessary for effective trans-border EWS. Both communities and authorities, especially in downstream areas, lack capacity to understand the flood information and the capacity to respond if information is received. It should be enhanced. It is also necessary to establish linkages between the communities and the government information communication and dissemination system that exists in Bangladesh.

The capacity of the communities and that of the authorities also needs to be enhanced through infrastructures like construction of evacuation centres, adequate provision of rescue gears, understanding the existing system of government, preparedness for disaster response, etc.

Development of community volunteers on either side of the border for exchange of information on floods is needed. Similarly, the establishment of a web-based communication system that allows video calling between upstream and downstream communities can help in providing evidence of floods. The initial cost needs to be covered by the government, which can be sustained through the Union Digital Centres.

There exists some formal communication between Bangladesh and India, which should be considered as an opportunity for building trans-border FEWS. Usually, any communication between the two countries is through the national level. However, disaster early warning being an issue of safety and security of people and their property at local level, it should be considered as an essential communication that should take place between the local governments.

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1 Union Digital Centres are an initiative of the Government of Bangladesh for ensuring ICT-based service delivery at the grass roots level. It is operated by an entrepreneur who sustains the centre through some commercial service delivery (e.g. mobile banking). More than 4,000 digital centres have been established in the past five years.
5. Conclusion and Suggestions

5.1 Conclusion

In order to explore opportunities, constraints and challenges in relation to enhancing trans-border FEWS in south Asia and increasing the access to EWS for communities, field interactions were held in ten border communities in Nepal, India and Bangladesh. Stakeholder consultations, workshops and KIIIs were conducted with local government units and national decision-making bodies in selected border districts. The study used the EWS framework defined by the Third International Conference on Early Warning (EWC III 2006), which consisted of four elements of an ideal EWS. These elements are 1) risk assessment and risk knowledge, 2) risk monitoring and warning, 3) risk information communication and dissemination, and 4) capability of communities and stakeholders for responding to risk-related information.

There exist some understanding and agreement between the governments concerned over exchanging of flood information. Regular and intermittent meetings are held between the governments of the countries concerned on cross-border flood and water management for mutual benefit. However, these meetings usually take place at national level. Their decisions and agreements are communicated down to the local government for implementation. There is very limited regular and systematic exchange of flood information in times of need, especially during the flood season.

Although warning systems exist within each country, the warning system of one country has no linkage with that of another country, even though both country share same water resource and the river flood. The country's national hydrological and meteorological departments generate flood warning information for national use and pass on such information to district-level government organizations. The flow of information from district level to village and community level is not strongly linked. Up to district level, it is civil servants (bureaucrats) who manage and handle information, whereas at village and community levels, it is basically the elected people. Thus, the information communication between district- and village-level committees and authorities has weak linkage.

When the flood is going to be severe, the DHM also posts information at public sites, like on the Internet. The local people, especially the poor, however, do not have easy access to such information. Even if they have access, they do not fully understand the risk as the information being circulated is not in easily understandable form. They do not understand when the flood will arrive at their place, how high or severe the flood will be, what assets and property will be affected and to what extent, etc. In some cases, information is communicated in the metric system, which communities do not understand, and it is difficult to explain the implications of the flood to them.

Often, by the time the community receive information, it is too late to prepare and to respond to minimize losses and damage from floods. So, the lead-time should be increased either by relaying information from the gauge station in the upstream country well in advance or by forecasting the hazard in advance.

No training is conducted in FEWS at community and village level, except at the Karnali trans-border site. So, communities do not fully understand the implications of flood information being communicated to them. Furthermore, they do not know what response measures to take on flood information. Similarly, there are no evacuation shelters specifically for flood victims for emergencies. So, they usually take shelter in public buildings like schools or roads, etc, whose purpose is not to address victims’ needs in times of emergency. Furthermore, space is insufficient for the evacuated people and facilities like toilets also do not meet the need.

It is also found that information is communicated informally only when the river is flooded and only for the sake of goodwill and humanitarian point of view, as in the case of the Poique/Bhotekoshi River in
the Koshi Basin. No understanding or agreement regarding flood information sharing exists between Nepal and Tibet (China). The repeated events of flood in the river affect the population and the national economy of Nepal.

5.2 Suggestions

5.2.1 Risk assessment and risk knowledge

The most important aspect of an effective EWS is understanding the risk of a flood at different points along its course rather than being confined within a certain geographic locations. Currently, the flood monitored in the upstream country has no information on risks for the downstream country. Unless the risk is assessed for the downstream country with the help of flood information in the upstream country, a trans-border FEWS will not materialize. The knowledge of information on risks should be shared beyond the geographical boundaries of countries. So, there is a need for trans-border flood risk assessment, which needs coordination and collaboration between countries in different sectors and at different levels.

5.2.2 Monitoring of flood

Based on the transborder flood risk assessment, river monitoring, irrespective of country’s territory, need to be extended across upstream and downstream locations. A more holistic approach is necessary to understand the impacts and extents of flooding at different river levels and discharges. It is because a flood which can be disastrous for the upstream country may not be the same for the downstream country because of changes in landscape or interventions due to physical developments in the downstream country. Such information should be identified at the time of trans-border risk assessment.

5.2.3 Communication and dissemination of flood information

Currently, the formal practice of communicating flood information from the upstream country to the downstream country is very rare. Communication between upstream and downstream countries is considered as international communication, which, therefore, has to take place through the central governments. Furthermore, there is very limited understanding and agreement between the countries for communication of flood information from the upstream country to the downstream country. So, there is need for specific agreements for flood information communication between countries, especially during the flood season. Furthermore, such communication should take place between the local governments of the countries. Therefore, local governments should be authorized for such communication. The communication at the local level should take place on a two-way basis.

There is a practice of relevant government organizations putting up hydrological and meteorological information on their websites. However, such information is in different forms, and their implications are often not clear for the downstream countries. Hence, there is need for agreeing on some basic information that each government displays on the website, from which the downstream government can draw inference and implications. Likewise, the downstream country should maximally utilize the information being shared by the upstream country through public sources like websites.

There is also community-to-community communication of flood information between Nepal and India, between India and Bangladesh, and between Tibet and Nepal. Such communication takes place because of the social, economic and cultural bonds between the communities across the borders. The community-to-community communication of flood information takes place through international telephone calls, which are very expensive for the poor people living in vulnerable locations. Therefore, the governments should subsidize such calls for humanitarian purposes. There are various other means of communication between the communities across the borders, which the governments
should facilitate and promote for reducing the cost of communication for humanitarian purposes. The governments concerned should build trans-border EWSs based on the existing practices between the communities living across the political boundaries.

5.2.4 Communication within individual countries

Within individual countries, the national system disseminates information using a wide range of communication channels such as television, radio, Internet, SMS or print materials, assuming that the communities concerned or targeted groups understand it, that information reaches all communities, households and individuals who need it, and that they have access to information. However, information does not reach the target beneficiaries, the most vulnerable communities, and reaches only up to district-level authorities. Information rarely trickles down to communities and individuals below district level. So, linkages should be developed and strengthened between district-level authorities and communities. There should be community-targeted dissemination mechanism or practice, ensuring information reaches the ones who need it. Furthermore, information should be in the language which target beneficiaries understand and should be within their reach or access.

In most cases, the last point beneficiaries or communities receive flood information from the mass media like radio and television, and not necessarily the audiences are the targeted beneficiaries. So, the district authorities who are responsible for disaster management at local level should be given the responsibility to ensure that timely information reaches the communities who are exposed to flood risk.

The information dissemination mechanisms within communities also need to be strengthened. There are community disaster management committees and task force members at community level where there are donor-supported projects. Such institutions rarely exist where there is no external support. Where such committees or task forces do not exist, such institutional mechanisms should be established as essential part of disaster management, communication and dissemination of FEWS within the government’s permanent disaster management mechanism.

5.2.5 Capacity building of communities and stakeholders

In EWS, a number of stakeholders and communities engage with each other with different roles and responsibilities. The hydrological and meteorological organizations generate flood information, both real-time and forecasted, and prepare information for dissemination. Various communication channels disseminate the information once they receive it. Similarly, the disaster management authorities and organizations relay and disseminate the information to communities to ensure that it reaches the individuals who need it. Once the information reaches the communities, the community-based disaster management committees and task forces ensure that the most vulnerable households and individuals also receive information. The disaster management authorities and community-based organizations ensure that households and individuals respond to the flood information properly and in time for saving their lives and property. Preparedness plays a significant role in saving lives and property, which calls for actions at both district and community levels or even at household level. Hence, communities and stakeholders need to develop their capacity to perform their roles and responsibilities the best. Capacity needs to be built at all levels for proper understanding, communication and dissemination of information, as well as for preparing and responding to information effectively and properly. In trans-border EWSs, the need for capacity building is further emphasized by the fact that communities and stakeholders have to respond to the information received from across the border.

Capacity building also requires adequate and appropriate infrastructure such as evacuation centres, evacuation routes, and evacuation and rescue gears. Communities also need livelihood support to enhance their resilience. The poorest that live in the most exposed areas with weak housing structures are the most affected by floods. Such communities should be supported with focused targets by governments for building houses and livelihoods to strengthen their capacity.
5.2.6 Development of regional-level EWS

A common multi-hazard EWS is needed at regional level. At regional level, SAARC Disaster Management Centre (SDMC) exists. Nepal, India and Bangladesh are SAARC member countries. Many of the major rivers in south Asia originate in Tibet, China, and, in many cases, the floods generated in the headwater in China have disaster risk in all three downstream countries. China is not a member of SAARC. So, the SDMC should consider obtaining information from China in attempts at reducing the flood disaster risk in the region.

It is suggested that the SDMC function as the regional centre for collection of information from relevant and designated technical institutions and communicate such information to relevant and responsible government organizations for further dissemination down to local level so that they can respond to the information properly and in time.

Different technical institutions such as hydrological, meteorological, geological, etc need to be designated for regional-level information generation for different hazards and to provide information to the regional disaster management centre and relevant government centres at national level. The national centres will further disseminate the information down to the local level, with focus on the particular areas where the particular hazard is going to be the severest. This will link the regional specific hazard warning centres to the SDMC or any other centre, then to subsequent warning centres at national and local levels.

The SDMC should also be responsible for conducting research and training programmes. The capacity of the disaster management actors also need to be enhanced for regional- and national-level disaster management. FEWS should be one of the focuses of the regional research and training programmes.
References


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About the Zurich Flood Resilience Alliance

An increase in severe flooding around the world has focused greater attention on finding practical ways to address flood risk management. In response, Zurich Insurance Group launched a global flood resilience programme in 2013. The programme aims to advance knowledge, develop robust expertise and design strategies that can be implemented to help communities in developed and developing countries strengthen their resilience to flood risk. To achieve these objectives, Zurich has entered into a multi-year alliance with the International Federation of Red Cross and Red Crescent Societies, the International Institute for Applied Systems Analysis (IIASA), the Wharton Business School’s Risk Management and Decision Processes Center (Wharton) and the international development non-governmental organization Practical Action. The alliance builds on the complementary strengths of these institutions. It brings an interdisciplinary approach to flood research, community-based programmes and risk expertise with the aim of creating a comprehensive framework that will help to promote community flood resilience. It seeks to improve the public dialogue around flood resilience, while measuring the success of our efforts and demonstrating the benefits of pre-event risk reduction, as opposed to post-event disaster relief.

Contact Madhab Uprety for information
Madhab.Uprety@practicalaction.org.np

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