FEASIBILITY STUDY REPORT

Review and Explore Opportunities for Appropriate TFEWS in Mahakali River Basin

TROSA
TRANS-BOUNDARY RIVERS OF SOUTH ASIA

OXFAM

FEASIBILITY STUDY REPORT

Review and Explore Opportunities for Appropriate TFEWS in Mahakali River Basin

ACRONYMS

AC:	Alternating Current
ADPC:	Asian Disaster Preparedness Centre
CBEWS:	Community Early Warning System
CFF:	Committee on Flood Forecast
CFGORRP:	Community based Flood and Glacial Lake Outburst Flood Risk Reduction Project
CWC:	Central Water Commission
DDMA:	District Disaster Management Authority
DEOC:	District Emergency Operation Centre
DHM:	Department of Hydrology and Meteorology
DL:	Danger Level
DIPECHO:	Disaster Preparedness European Commission for Humanitarian Aid
DLSA:	District Lead Support Agency
DRR:	Disaster Risk Reduction
DWIDM:	Department for Water Induced Disaster Management
ECHO:	European Commission for Humanitarian Aid
ECMWF:	European Centre for Medium Range Weather Forecast
ESWIS:	Electronic Scheduled Waste Information System
FEWS:	Flood Early Warning System
GLOFAS:	Global Flood Awareness System
GON:	Government of Nepal
GOI:	Government of India
GPRS:	General Packet Radio Service
GSM:	Global System for Mobile Communication
HFL:	High Flood Level
IAG:	Inter Agency Group
ICT:	Information and Communication Technology
ICIMOD:	International Centre for Integrated Mountain Development
ISO:	International Organization for Standardization

IMD:	Indian Meteorological Department
JMCWR:	Joint Ministerial Level Commission on Water Resources
JCWR:	Joint Commission on Water Resources
JPO:	Joint Project Office
JSTC:	Joint Standing for Technical Committee
JTF:	Joint Task Force
JCIFM:	Joint Committee on Inundation and Flood Management
KVA:	Kilo-Volt-Ampere
LCD:	Liquid Crystal Display
LWR:	Lutheran World Relief
MEL:	Monitoring Evaluation and Learning
NEOC:	National Emergency Operation Centre
NGO:	Non-Governmental Organization
NHPC:	National Hydro Power Corporation
NRCS:	Nepal Red Cross Society
PPCR:	Pilot Program for Climate Resilience
SMS:	Short Message Service
SOP:	Standing Operating Procedures
TROSA:	Transboundary Rivers of South Asia
TBR:	Transboundary River
TFEWS	Transboundary Flood Early Warning System
UDI:	Uttaranchal Development Institute
UNFCC:	United Nations Framework Convention for Climate Change
UNISDR:	United Nations International Strategy for Disaster Risk Reduction
USB:	Universal Serial Bus
WL:	Water Level
WMO:	World Meteorological Organizations

EXECUTIVE SUMMARY

The effectiveness of early warning system in South Asia requires cross-border collaboration to avert flood damage as the countries in South Asia share major river basins, such as Ganges, Brahmaputra, Meghna and Indus. In order to achieve the aim of Transboundary Rivers of South Asia (TROSA) project, which is to reduce poverty and marginalization of vulnerable river basin communities through increased access to, and control over, riverine water resources on basins of South Asia, PACconducted this study to review, explore opportunities for appropriate trans- boundary early warning system in Mahakali river basin.

The transboundary river Mahakali is a catchment of Ghagra sub basin of the larger Ganga Basin, draining the region through the Tarai plains of Uttar Pradesh. The study areas are the communities across both Nepal and India, upstream and downstream areas of Mahakali river. The districts affected by the floods are Darchula, Baitadi, Dadeldhura, Kanchanpur in Nepal and Pithoragarh, Champawat, Udham Singh Nagar, Lakhimpur Kheri and Sitapur in India.

This report is an outcome of analyzing existing gaps and identify the potential areas for collaboration for an effective TFEWS in Mahakali river basin through field assessments, literature review and stakeholder consultations. Assessments and recommendations for effective TFEWS are done across all four components of early warning-risk knowledge, monitoring and warning system, communication and dissemination and response capacity.PAC Nepal led the field activities across Nepal side while PAC India coordinated the activities across Indian territories. Upstream portion of Mahakali river spanning across Darchula, Baitadi and Dadeldhura was assessed to see suitability of installing hydro-met station for EWS with increased lead time. The suitable site selection for early warning system across the border of India and Nepal was discussed and proposed after conducting the field survey of the river basin of both sides of the border.

Lack of comprehensive risk assessment, manually operated hydro-met services, informal communication across the border, lack of institutional set up and unprioritized early warning in the joint committee for water resources between Nepal and India are some of the challenges of TFEWS in Mahakali basin. Nevertheless, the existing network of hydro-met stations, flood predicting system and the national level response mechanism and the current institutions lay as robust entry points for developing effective EWS in the region.

Risk knowledge can be enhanced through awareness program, updated flood hazard and vulnerability maps. Suggestions for effective monitoring and warning mechanism include installation of real time water and rainfall level, developing forecast model, disseminating the warning at central and local levels, etc. For effective warning and communication, it is suggested to develop location specific warning and alerts incorporating the needs of the vulnerable groups. To enhance the response, it is suggested to identify and build the safe shelters and update the district and local disaster preparedness and response plan. Training, capacity building and appropriate institutional set up between the two governments are pertinent for effective EWS in Mahakali basin.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

1.1 Context of the Study

South Asia is home to shared water resources and ecosystems. The countries of South Asia share some of the world's major river basins – the Ganges–Brahmaputra-Meghna (GBM) and the Indus. The Brahmaputra and the Ganges rivers with their tributaries flow through China, Bhutan, India, Nepal and Bangladesh. Floods in these rivers affect lives and livelihood of millions of people residing along the fertile flood plains.

Successful ecosystem management including the effectiveness of early warning system requires cross-border collaboration. To avert damage caused by flooding, close communication and a coordinated response strategy between upstream and downstream communities are imperative, in order to provide people with a window of opportunity to move with their most vital belongings to higher ground. In addition, there is scope for shared learning across South Asia as the challenges faced across the region are similar, and solutions are readily transferable and replicable. Transboundary water cooperation should facilitate integrated planning for sustainable water resource management. Several categories of cross-border water cooperation have had success in the region, and could be expanded and developed to improve water-resource resilience.

Globally, flood prone nations are facing a major problem in effectively forecasting flooding because they are unable to assimilate data across geopolitical boundaries. Transboundary early warning projects seem to address the problem at a catchment scale across borders in an integrated approach; however, an appropriate institutional set up is a first step for efficient transboundary water projects. The current institutional structures in flood risk management are challenged to cope adequately not only with future uncertainties, such as climate change but the factors and barriers for supporting cross boundary co-operations remain a global issue. Even if the geography is identical, the differences lie in the perception of the problem and how to solve it; in administrative responsibilities and the political will to act (Becker et al. 2007). One of the challenges remains in protecting existing lives and property at risk from flooding whilst ensuring equitable outcomes in terms of risk reduction across borders (Wilby and Keenan, 2012).

1.2 Description of the Project

1.2.1 Transboundary Rivers of South Asia Program

Oxfam is managing a Transboundary Rivers of South Asia (TROSA), a five-year-long project that aims to reduce poverty and marginalization of vulnerable river basin communities through increased access to, and control over, riverine water resources on which their livelihoods depend in Ganges, Brahmaputra and Salween river basins of South Asia. It can only be achieved when decisions over these transboundary resources respect communities' rights and balance the interests of other users including (inter) national interests and those of the private sector.

The expected outcomes of the program are as follows:

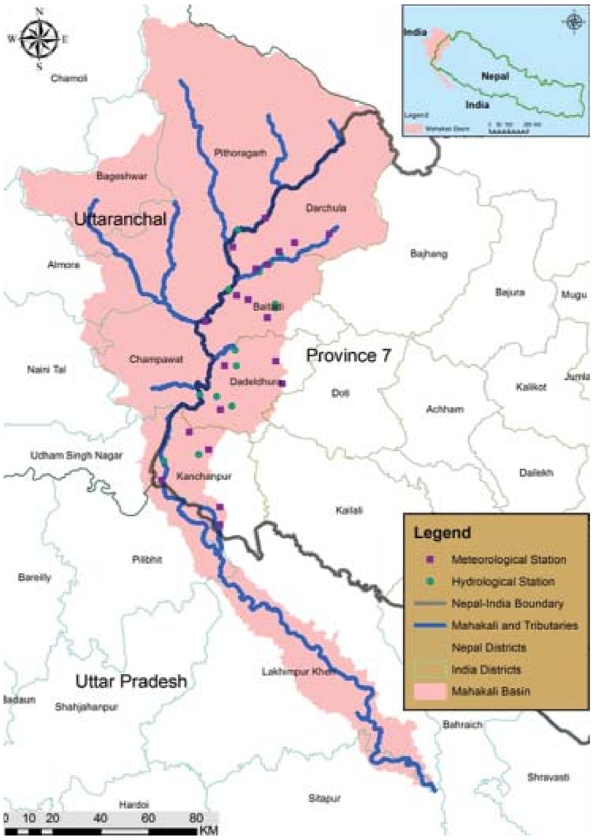
- Government policies & practices at all levels of water resource management are more inclusive of community concerns and meet national & international standards
- Practices of private sector respect community access to water resources actively contributing to reduced conflict
- CSOs increasingly participate in or influence transboundary water governance, women's inclusion and resolution of water conflicts
- River basin communities increasingly influence trans-boundary water governance policies and processes with increased participation & influence of women in transboundary water governance, policy, and processes.

Among them, the project has envisioned Transboundary Flood Early Warning System (TFEWS) as one of the strategic action to reduce vulnerability of riverine communities in the transboundary river basin of Mahakali along the Nepal-India border.

1.2.2 Study Area: Mahakali River Basin

The study areas are both river banks at upstream and downstream areas of the Mahakali River where communities are immediately across the border who need flood information from other side of the border. Figure 1 shows the study area.

Figure 1 Study Area: Mahakali River Basin



Mahakali River Basin: A Snapshot

Catchment Area:15260 sq.km. up to upper Sharda barrage

- India: 9943 sq.km (65%)
- Nepal: 5317 sq.km (35%)

Length of river

- Nepalese side: 223 Km
- Indian side: 323.5Km

Maximum historical flooding

- 15430 m3/sec (Mahakali river in Sarda Barrage, June, 2013)

Major Tributaries:

- India: Dhauli Ganga, Gori Ganga, Ram Ganga, Sarju River, Ladhiya
- Nepal: Chameliya, Surnayagad, Rangun

The river Mahakali (also called as Kali or Sharda), is a Himalayan catchment of Ghagra sub basin of the large Ganga Basin, originating from the Trans Himalayan region of Kalapani (>3600 m) and ultimately draining the region through the Tarai plains of Uttar Pradesh. Numerous rivers and streams join the Mahakali from the higher, middle, lower and outer Himalayas.

Some of the important right (Indian side) tributaries of Mahakali River are Dhauliganga, Goriganga, Ramganga and Sarju. Ramganga joins Sarju much before the latter's confluence with Mahakali/Sharda. Dhauliganga originates in the Tibetan Plateau and traverses largely through Pithoragarh district on the Indian side, before meeting Mahakali/Sharda at Tawaghat. Goriganga too originates in the Tibetan Plateau, slightly west of Dhauliganga and traverses largely through Pithoragarh district. Ramganga originates in areas west of Goriganga and before its confluence with Sharda, it empties itself into Sarju river. Origins of Sarju river are west and south-west of Ramganga and the river traverses through districts of Almora, Bageshwar and partly through Nainital before it meets up with Mahakalil/Sharda. Major tributaries in Nepalese side are Chameliya, Surnayagad and Rangun khola.

1.3 Purpose and Objectives of the Study

The main purpose of the study is to review, explore opportunities for appropriate trans-boundary early warning system in Mahakali river basin.

The specific objectives of the study can be detailed out as follows:

- To document existing Transboundary Flood Early Warning Systems in trans-boundary area of Mahakali river basin (Nepal and India)
- To understand the functionality and gaps of existing early warning systems in the Mahakali basin.
- To identify the potential areas of collaboration between the concerned departments and institutions of Governments of Nepal and India for the establishment/strengthening of a trans-boundary flood EWS in the basin/sub-basin
- To seek opportunities for low-cost community-to-community level EWS around sharing of river/flood data and information for disaster preparedness.
- To Identify the potential sites/sub-basins in the basin to establish suitable trans-boundary Flood Early Warning System
- To suggest ways to strengthen and build strong flood early warning systems taking into account the trans-boundary nature of the flood disaster risk in the basin. This should include an analysis of different piloted and proven affordable technology (hardware) and the institutional mechanisms and community-level information sharing systems (software) mechanisms

2

RESEARCH QUESTIONS AND METHODOLOGY

2.1 Research Questions

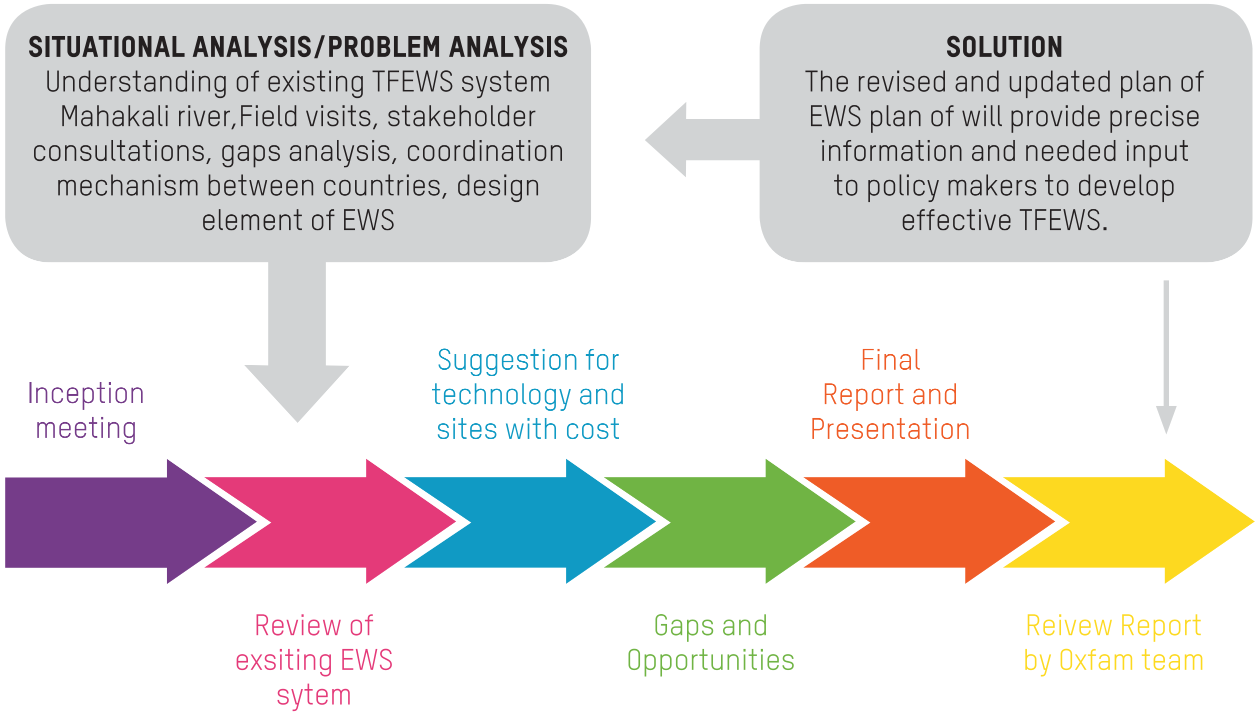
The study comprised the literature review, stakeholder consultations, and field assessments of existing hydro-met stations and site conditions for any new stations in the river basin to review and explore the potentiality of operationalizing early warning system in Mahakali river basin across the Nepal-India border. In order to achieve the intended objectives, the following research questions were developed to guide the study.

- What are the existing practices of Transboundary flood early warning systems in trans-boundary context across South Asia such that the lessons learned from them could be materialized for Mahakali River Basin?
- Are there any existing mechanism of flood risk reduction and management particularly the risk knowledge level, risk monitoring and communication practices, prediction and forecasting warning information, and response capability of the local communities, stakeholders and local humanitarian actors in the Nepal-India border areas of Mahakali Basin?
- Are there any existing Transboundary Flood Early Warning System set up in Mahakali river or its sub-basins? If yes, how can these systems be strengthened and utilized for the benefits of communities across borders? If no, what are the potential sites at basin or sub-basin scale to establish suitable transboundary flood early warning system?
- What are the key gaps or barriers at various levels that need to be addressed while promoting smooth operation of flood early warning system across Mahakali borders?
- What could be the potential areas of institutional collaborations and opportunities for Government of Nepal and India to set up trans-boundary early in Mahakali river basin?
- What would be the practical interventions in terms of technology (hardware), socio-economic, institutional andcommunity level information sharing (software) mechanism for addressing transboundary nature of flood risk in Mahakali Basin?
- What could communities, local authorities, sub-national authorities and national governments could or need to do (take policy and coordination actions) to setting up, strengthen and sustain EWS helping each other to saving lives and properties in the respective areas and across the borders?

2.2 Methodology

The methodology adopted was based upon participatory research, action learning and collaborative strategy development. This entailed review of literature, widespread stakeholder consultations; participatory needs assessments involving communities and other stakeholders.

Figure 2 Methodological Flow Chart for the Study and Deliverables



The overall study involved conducting the literature review, developing the framework of analysis for EWS review, conducting inception meeting, conducting field visits, stakeholder consultation, key informant interviews, community interaction, data collection and analysis. The stepwise detail research design is presented in Figure 2 and discussed in detail below.

2.2.1 Literature Review

Review of existing treaties and agreements among/between the concerned governments and its practices, frameworks and policies regarding flood information sharing between the countries were carried out. The literature review was not only limited within 4 key elements of EWS rather focused on trans-border issues and gaps necessary for setting up community based early warning system (CEWS) including the aspects of institutionalization and sustainability of the system. Nonetheless, the literature review focused on aspects and activities having a clear relationship to the objectives of the study and the related practices, challenges and prospects.

Technologies required for data collection and transmission from country to country, and governance frameworks for communication and response capabilities by national and sub-national disaster management authorities, local government and communities at the trans-border have been explored under this study.

2.2.1.1 History of Flooding in Mahakali Basin

Some of the important causes of floods in Mahakali/Sharda river include heavy rainfall and cloudbursts in the area, together with glacial melting, heavy land erosion, slides and mass movements in saturated fragile geology. Heavily loaded water flow triggers further devastation. More losses have been observed in unprotected areas and low-level settlements. Failure or opening of water body such as dams and barrages adds to the floods and devastation.

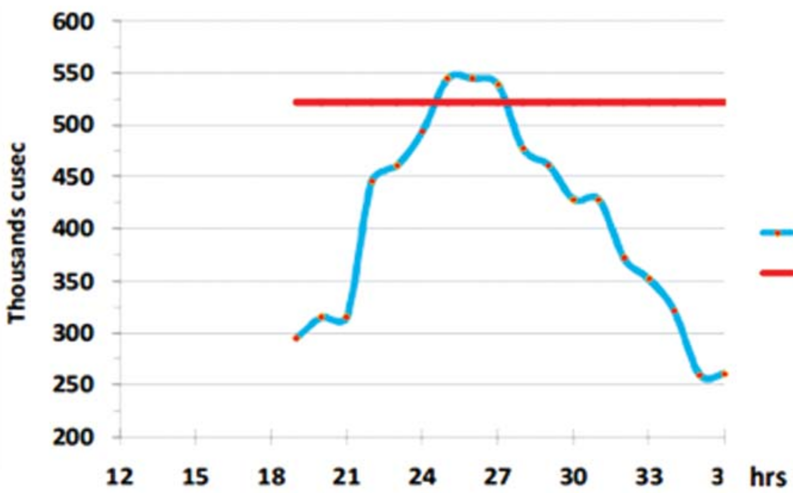
During the floods in 2013, the losses in Darchula including in Main Khalanga (Nepal part of Darchula) add to full destruction of 129 houses and 32 huts and partial destruction of 55 houses. Roads measuring 4km got washed away.

In 2013, Flood Discharge in Mahakali River in Sharda Barrage in17-18 June 2013 (15430 m3/sec) exceeded the historical records (14915 m3/sec in 1934 AD). Mahakali, Mohana, Macheli, Seti and Karnali were flooded due to heavy rainfall between June 17 and June 18 that caused immense socio-economic damage across the region. The East-West highway was eroded in 2/3 places in Kailali and Kanchanpur districts along with damages to irrigation projects, transmission lines, and other public and private infrastructure.

The unprecedented rainfall in Uttarakhand state of India and Far-western region of Nepal in June, 2013 caused widespread devastations across the basin. The discharge in the Mahakali river rose from 139,000 cubic feet per second to 440,716 cubic feet per second on 17 June – higher than 2012 flow value of 398,000 cubic feet per second. The cloud outburst was due to simultaneous activation of monsoon arms from eastern and south-western direction. The rainfall was higher than eight times of normal rainfall in Dehradun and more than double in Pitthoragarh district in India (ICIMOD,2013).

In Nepal, Dipayal station recorded daily rainfall of 80.4 mm in June 16 and 221.8 mm in June 17. Figure 3 shows the corresponding flood hydrograph for the rainfall in the region at Sharadabarrage.

Figure 3 **Flood Hydrograph for Mahakali river basin (June 17-18, noon 2013) (ICIMOD,2013)**



The flooding exceeded all past records as well as 100-year design discharges of Banbasa and Tanakpur Barrages.

The flooding in Indian part of Mahakali basin triggered landslides and flash flood which further devastated the lives and livelihood in Uttarakhand district. Chaurabari lake level rose to overflow as a stream. The river upstream of Kedarnath Temple was flooded along with heavy debris flow sweeping away houses in Kedarnath region. Steep slope of river to Rambara and Gaurikund caused heavy losses in the area with debris deposition. Besides Kedarnath area, other high hill centers affected by the floods and landslides in the region are Uttarkashi, Gaumukh, Chamoli, Shrinagar, Pauri, Rudra prayag, Joshimath, Tehri, Dev prayag, Rishikesh, Haridwar, Dehradun and Yamunanagar(ICIMOD,2013).

The flooding in Nepalese part of the basin was further exacerbated by increased run off due to rapid melting of glaciers and debris loaded water. Also, the local people believed that devastation in Darchula was aggravated due to sudden opening of sluice gates of the Dhauliganga dam constructed in one of the major tributaries of the Mahakali upstream of Darchula headquarter. However, there is no proof that the increased flow was due to opening of sluices (ICIMOD,2013).

Embankment protection work in India was robust and intact after the event while in Nepalese side it was scattered and weak and easily eroded and washed away. The accumulated flow entered Bhujela village downstream of Sarada barrage through the unprotected gap portion between Nepal and adjoining India border. In Bhujela village, settlements and school building were swept away by the flood. The effect was substantial in the ward nos. 11, 12 & 13 of Bhimdutta Municipality. The effect of flooding, inundation and destruction was observed in various areas under Dodhara and Chandani VDCs (ICIMOD,2013).

Figure 4 Key elements of early warning system

2.2.1.2 Mahakali Treaty

Government of Nepal and India entered into treaty in regards to rights, obligations and duties and utilization of water in Mahakali basin in 1996. The treaty does not mention at all the issues related to flooding in the region or the impact of dams, barrages or hydropower projects in the rise of water level that could potentially give rise to flooding in the region. The bilateral Mahakali Commission has set three priorities, as below

1. Management of the Sharda canal, already in existence which diverts water from Mahakali/Sharda river at Tanakpur (Sharda barrage) to the dry and over-abstracted basin of Gomti river to the South in the Indian State of UP.
2. Management of Tanakpur barrage, commissioned in 1993 which is part of the run of the river hydroelectric power scheme, located at Banbassa near the town of Tanakpur.
3. Development of the proposed Pancheswar multi-purpose project, with central structure of which is the proposed dam stemming the Mahakali/Sharda river. The dam when constructed may submerge an area of 121 sq miles. A centrepiece of the Mahakali treaty is the Pancheswar Multipurpose dam, which is proposed at Pancheswar which is downstream from the confluence of Sarju and Mahakali/Sharda. Sarju is one of the right tributaries and is a perennial spring fed river, with clear water flowing from the Himalayas.

Under the article 7 and article 8, each Party has undertaken the obligation of not to obstruct or divert the water of the Mahakali River adversely affecting its natural flow and level except by an agreement. This provision of the obligation is applicable in relation to the tributaries of the Mahakali River also. Dhauliganga is a tributary to the Mahakali River. In June 2013 flood, it was believed that the construction and operation of the Dhauliganga Power Project affected that the natural level and flow of the Mahakali River. Government of India constructed the project without entering into some prior understanding as required by the treaty to ensure that its operation would not affect the natural flow of Mahakali River including adverse effect downstream on either side.

2.2.1.3 Current Practices of Early Warning System

The first community based EWS in Nepal was a Watch and Warn EWS piloted by the NGO Practical Action in 2002 for the East Rapti River in Central Nepal (Smith, Brown et al. 2016, Practical Action 2016). Since then, there has been a gradual institutionalization of Flood Early Warning System (FEWS) with relatively advanced flood monitoring and communication mechanism (Practical Action 2016) with focus on community considering all four aspects of early warning. The United Nations International Strategy for Disaster Reduction (UNISDR) platform for the promotion of Early Warning System has identified four key elements of a complete and effective early warning system. These four components are a) Risk knowledge and scoping, b) Community Based Monitoring and Early Warning c) Dissemination and Communication d) Response Capacity and Resilience (See Figure 4).

The Department of Hydrology and Meteorology (DHM) has been upgrading hydrological and meteorological stations to web-based telemetry system. This has indeed facilitated Flood EWS to get integrated to real time observation network across the nation for efficient and timely flood warning information. In this telemetry system, the real time flood information data is accessed from the server, interpreted based on the flood threshold level and provided warning to the vulnerable people by institutionalizing the communications and response system at local and district level.

The real-time telemetry system has been integrated with the community-based communication, dissemination and response mechanism. Currently, such community based FEWSs are operational in several river basins across Nepal (Karnali, West Rapti, Babai, East Rapti, Narayani, Bagmati, Kankai and Koshi basins (Smith, Brown et al. 2016). Flood warning information based on pre-determined warning and danger levels are disseminated through DHM website, mobile phones, and siren and are complimented by community-based dissemination and response mechanisms, developed in collaboration with local governments, community-based organizations, and non-government. This information is also transmitted to the District Emergency Operation Center (DEOC), District Disaster Relief Committee (DDRC) and the National Emergency Operation Center (NEOC). Similarly, gauge readers who are responsible for data collection transmit information to relevant stakeholders, communities, local government officials, Red Cross society chapters and local NGOs (Practical Action and Mercy Corps, 2012). Community Based Early Warning Systems in Nepal have protected the lives and livelihoods of people residing in downstream communities (Zurich 2015). However, there are numerous challenges in operationalizing early warning systems as current early warnings are based upon direct observations not forecasts, resulting in short lead times for response, especially for rivers with origins in mountainous catchments.

In Mahakali basin, the Department of Hydrology and Meteorology, Government of Nepal conducted an assessment to identify the potential sites for hydrological station along the upstream of Mahakali River and analyze the status of DHM based stations. This report submitted in November, 2013, post Mahakali flood of 2013 proposed two sites (Dattu and Parigaon) for the establishment of manual station along with telemetric system considering the vulnerabilities and the potential to benefit the downstream communities. The need to establish prioritized hydrological stations and upgrade the existing stations in different stretches of the Mahakali River has been highlighted in the report.

Mercy Corps, Nepal along with the local partner Nepal Red Cross Society piloted and implemented programs on community based early warning system in far-western region funded by ECHO and DIPECHO from 2007 to 2010. The challenges of working in Kanchanpur district in far-western region came from sparsely located hydrological stations and the high number of shorter rivers that give rise to flash floods. Rain and staff gauges were established in the communities of Macheli and Banahara river catchment area covering villages, such as Dayaamarpur,Bayelkundi, Katan, Tilki and Simari Further tasks carried out included training, preparing communities for response and development of communication channels.

In India, the Central Water Commission(CWC) has a total of 226 flood forecasting stations, consisting of 166 level forecasting units in towns and important villages and 60 inflow forecasting stations for dams and reservoirs. Maps are available to show the location of these stations. The colour signifies the basic characteristics of the station. Green colour denotes flood level forecast station basically in important towns and villages, while blue colour is used for inflow forecast station for dams, reservoirs, barrage etc.

The colors will be changing dynamically as per water level with regard to Warning Level (WL), Danger level (DL), and High Flood Level (HFL). Normally dynamic information level is available during flood period from 1stMay to 31stDec every year. Low Flood: Yellow, which means the river level is at or above WL, but below DL. Moderate Flood: Pink, when river water level is at or above DL, but below level which is 0.5m below HFL. High Flood: Orange, when river water level is within 0.5metre of HFL, however below HFL. Unprecedented Flood: Red colour, when river water is at or above HFL. HFL itself is updated on a yearly basis before the start of the flood season. Newly attained HFL during the flood season of a particular year in any station will be updated in the next year, before the start of the flood season.

In E-SWIS portal, on opening a particular station, a window opens showing static information about the station. The latest available dynamic information such as water level and flood forecast issued are also displayed in the window (http://www.india-water.gov.in/eSWIS-MapViewer/)

Figure 5 **Central Water Commission Flood Forecast Map Viewer**

In the State of Uttar Pradesh, flood situation reports are prepared by PGVS and Christian Aid for Ganga basin and shared with all concerned(e.g. August 2017 floods). This includes situation as regards trans-border linkages. They also share the maps of flood affected areas. As for example, in case of Sharda, the reporthas mentioned about the flow of the river at Lakhimpur Khiri in Paliakalan. The reports also provide daily data summary of river water levels for the month, showing rising or falling trends. The geographical areas (including blocks and villages) affected or threatened by floods are given together with reasons. The impact is provided sector-wise e.g. WASH, health, shelter, food security. The report also contains recommendations of the Revenue Officer concerned. Action taken by the State Government in terms of mobilisation of response is also provided. This is a part of Inter Agency Group (IAG) UP Activity and they keep revising the resource mapping on a daily basis. The IAG monitors the situation closely and coordinates with the local network and government departments. It also provides a summary of the immediate needs with regard to various sectors like WASH, Health, Shelter,Food etc.

2.2.1.4 Case studies on Trans-Boundary Early Warning System

Transboundary Flood Resilience Project for Gandak/Narayani and Koshi river basin

Lutheran World Relief (LWR) launched the Transboundary Flood Resilience (TBR) project in 2013 and reached 51,966 community members in 136 villages across India and Nepal by the end of 2016.

Highlights of the TBR Project:

- LWR's TBR project doubled the speed of real-time flood warning information traveling downstream from 48-hours using official national EWS communication channels to only 24 hours using the transboundary community-driven EWS approach piloted in TBR.
- Community based early warning system is strengthened across all four components of early warning.
- Understanding that DRR must be tied into long-term resilience programming in order for development outcomes in these communities to be achieved, the TBR project also promotes access to social insurance schemes and savings mechanisms and includes livelihood components such as agricultural training in flood resistant crops, livelihoods diversification
- LWR and their partners are working closely with the Governments of India and Nepal as well as with the Asian Disaster Preparedness Center (ADPC) to advocate and advise on the national and regional adoption of TBR practices

Community based early warning system for flash flood in Ratu river basin

The CBFEWS in Ratu River was piloted by Nepal's Department of Hydrology and Meteorology (DHM)/Community Based Flood and Glacial Lake Outburst Risk Reduction Project (CFGORRP) and Koshi Basin Initiative, ICIMOD in 2015. While community based early warning system in riverine basin is not new, this was the first time a warning system was installed for flash flood prone river in Nepal. Ratu river had no gauging station. The system not only warned them of the approaching flood during 25 July, 2015 flood but also prepared them for response, saving the lives and livelihood in the region. Ratu river originates from Chure hill and flows through the middle of Dhanusha and Mahottari district in Terai in Nepal and flows towards India.

Highlights of the ICIMOD Intervention:

- The upstream downstream linkages are such that the warning received is shared across the geopolitical boundaries through community linkages between Nepalese and Indian side.
- The Project has incorporated on all four components of early warning-risk knowledge, monitoring and warning mechanism, communication and dissemination mechanism and response capacity.
- The morphological characters of the Ratu River have been changing by the course and expansion of bed width due to the deposition of the heavy sediment loads, bed level rise and channel shift and bank cutting. As a result, it is challenging to predict the hydrological characteristics of the river, especially for flash flood
- Since the river was ungauged, the hydrological gauge station in the river is managed by local community with basic trainings.
- The characteristic of catchment is such that the lead time available for the warning is very small, so the community was prepared to adapt to the existing small lead time with participation, training and awareness.

Community based early warning system in Jiadhal River Catchment, Assam, India

Conventional flood management in the Jiadhal catchment was based mainly on the construction of embankments. When it was realized that the structures such as dykes have underperformed or become counterproductive as a result of poor maintenance, the need of non-structural measures such as flood forecasting, early warning, catchment treatment, and enhancement of adaptive capacity was introduced in the region. In 2013, ICIMOD and Aaranayak installed CBFEWS in the Jiadhal and Singora rivers in Assam.

Highlights:

- The project has incorporated all four aspects of early warning.
- The river frequently changes its course during flash floods, resulting in the breaching of embankments, widespread riverbank erosion, and massive inundation and destruction of houses and farmland.
- Mapping of hazard, vulnerability, and risk was done using a method designed for this study that integrates information about the physical environment derived from analysis of high-resolution Google Earth Pro Images and socioeconomic data derived from field studies using Participatory Rural Appraisal techniques
- The United Nations Framework Convention on Climate Change(UNFCC) Conference of Parties, UNFCC awarded ICIMOD and Aaranayak the Momentum of Change 2014 Lighthouse Activity Award under the ICT Solutions category.

Community based early warning system in Karnali basin

Practical action in collaboration with Department of Hydrology and Meteorology (DHM) and Zurich has set up community based early warning system in Karnali basin in Nepal. The river Karnali flows through the Terai region in Nepal and meets the Ganga river in India.

Highlights of the project:

- The project has incorporated all four aspects of flood early warning.
- The real time status of water level and weather is freely available at http://hydrology.gov.np/
- The Indian communities can access early warning through community to community linkages between Nepalese and Indian side.
- Twenty hydro-meteorological stations within the Karnali river basin have been upgraded to telemetry which enabled DHM to run a forecasting model based on real time data

2.2.1.5 Legislations and Institutions for Transboundary Collaboration between Nepal and India

Sendai Framework for disaster risk reduction 2015-2030: The Sendai Framework for disaster risk reduction highlights the importance to promote transboundary cooperation to enable policy and planning for the implementation of ecosystem-based approaches to build resilience and reduce disaster risk under priority 2-Strengthening disaster risk governance to manage disaster risk.

There arefour high level bilateral committees between Government of Nepal (GON) and the Government of India (GOI) for resolving water resources, inundation and flood management issues in transboundary rivers and rivers flowing from Nepal to India. These are India-Nepal Joint Ministerial Level Commission on Water Resources (JMCWR), Joint Committee on Water Resources (JCWR), Joint Standing Technical Committee (JSTC) and Joint Committee on Inundation and Flood Management (JCIFM).

Joint Committee on Water resources (JCWR):

The India-Nepal Joint Committee on Water Resources (JCWR) was formed inpursuance of the decision taken by the Prime Ministers of Nepal and India duringthe visit of the Prime Minister of Nepal to India from July 31 to August 6, 2000.The first meeting of JCWR was held from October 1 to 3, 2000.

JCWR, amongst other aspects, deliberated on the ongoing scheme formulated in1988 named "Flood Forecasting and Warning System on Rivers Common toIndia and Nepal". Recognising the importance of Flood Forecasting as one ofthe effective non-structural measure to forewarn and manage the flood disasterJCWR agreed to further enhance close co-operation in this field. Towards thisend, it was agreed to form a Committee on Flood Forecasting (CFF) to reviewthe existing flood forecasting system and also to prepare a Comprehensive FloodForecasting Master Plan. This plan was also to include proposals for upgradingthe data transmission system and exchange of hydrological and meteorologicaldata for an integrated flood management. CFF was set up in pursuance to thedecision taken in the first meeting of JCWR.

The first meeting of CFF was held in New Delhi on 26-27 April 2001. A decisionwas taken in this meeting to constitute a Joint Task Force (JTF) for preparing theComprehensive Flood Forecasting Master Plan (CFFMP). The draft CFFMPdeveloped by JTF was discussed and reviewed during the second CFF meetingin Kathmandu during 6 to 8 May 2002 and finalised during the third CFF meetingin New Delhi held from 2 to 5 April 2003.

The second meeting of JCWR held in New Delhi during 7-8 October 2004endorsed the flood forecasting master plan prepared by the Committee on FloodForecasting (CFF). JCWR accepted the recommendations of CFF fordesignating it as the Standing Committee on Flood Forecasting (SCFF) and itwas agreed that the SCFF would work for the implementation of the master plan.

Joint Standing Technical Committee (JSTC):

The third meeting of JCWR held in Kathmandu during 29 September – 1 October2008 decided to have three tier joint mechanism to expedite the decision makingprocess and the implementation of decisions undertaken at the institutionalinteractions. A Joint Standing Technical Committee (JSTC) was constituted torationalize technical committees and sub-committees that were existing betweenIndia and Nepal related to flood management, inundation problems and floodforecasting activities besides projects specific committees on hydropower. TheJSTC will be coordinating all technical committees and sub-committees underJCWR.

The fourth meeting of the JCWR held in New Delhi during 12-13 March 2009decided to form a joint committee on inundation and flood management (JCIFM)to look into all matters related to floods and the works previously entrusted tofour other committees; like SCEC, SCFF, JCFM and HLTC. The first meeting ofJCIFM was held on 30 June to 5 July, 2009 at Kathmandu.

Joint Committee on inundation and flood management (JCIFM):

The Nepalese team of JCIFM is led by the Director General of the Department of Water Induced Disaster Management (DWIDM) and composed of the representatives from Department of Irrigation, Department of Hydrology and Meteorology, Water and Energy Commission Secretariat, Ministry of Finance and Ministry of Foreign Affairs. The Indian team is led by the Member (Planning), Ganga Flood Control Commission and composed of the representatives from the Central Water Commission, Ministry of Water Resources, Water Resources Department of the Government of Bihar, Irrigation Department of the Government of Uttar Pradesh and Embassy of India, Kathmandu, Nepal.

The eleven meetings held between 2009 to 2017 were mostly focused on structural measures of flood risk management, such as embankment and flood protection work in Kamala river, Lalbakeya river and Bagmati rivers. None of the meetings had the agenda on flooding issues in Mahakali/Sharda river. In the second meeting a five-year master plan for flood forecasting and warning was prepared for Nepalese side and handed over to the Indian side for approval. The fourth meeting included brief discussion on telemetry system and acquisition of data from Indian side for early warning system in the Koshi river basin in the Nepalese side. In the fifth meeting, it was proposed that the un-interrupted transmission of real time data from Nepalese to the Indian side would be provided through the website www.hydrology.gov.np. In the seventh meeting, 2013, a list of trans-boundary rivers had been provided to the Indian side based on the study carried out by the Joint Committee for comprehensive strategy for flood management control. Further a list of 16 priority rivers were handed over to the Indian side. In the prepared Flood Forecasting Master Plan, altogether 27 meteorological stations situated in Nepal formed part of Flood Forecasting Network. In the eighth meeting, meteorological stations in Nepal were reduced from 27 to 25 in number. A proposed hydrological station network in Pancheswor in Mahakali was recommended to be removed from the network of 21 selected sites in Nepal and 18 sites in India. The proposed flood forecasting network of 64 stations consists of total 46 sites in Nepal and 18 sites in India. No support on manpower and equipment were required as the upgrading of these forecasting network were already underway through DHM.

The hydrological stations at Banbasa and Paliakalan in Sharda river in India and Dadeldhura meteorological station in Nepal are included under the Flood Forecasting System for Mahakali river. Nepalese side has regularly shared the data of Dadeldhura station during monsoon season to the Indian side. But Nepalese side has not received data of Banbasa and Paliakalan stations from Indian side.

2.2.2 Field Visit

Field trips to Nepal-India territory across Mahakali basin was conducted from 16-27February, 2018 to understand upstream-downstream linkages, assess existing disaster governance structure across border communities and critically examine the context for transboundary collaboration on flood early warning system in the region. PAC Nepal led the field activities across Nepal side while PAC India coordinated the activities across India territories. Upstream portion of Mahakali river spanning across Darchula, Baitadi and Dadeldhura was assessed to see suitability of installing hydro-met station for EWS with increased lead time. Existing hydrological and meteorological stations operated by DHM were visited to assess their conditions and check for their operability for EWS. The hydro-met stations visited during the field program are Attariya, Dadeldhura, Patan, Gothalapani, Nayalbadi, Gokuleshwor, Dattu, Darchula, Kainpani, Jogbudha and Mahendranagar. The suitable site selection for early warning system across the border of India and Nepal was discussed and proposed after conducting the field survey of the river basin of both sides of the border. Details are provided in Section 3 and 4.

For Nepal part, the flood plain region of Kanchanpur district particularly the Pipariya and Bujhela of Bhimdatta Municipality were visited to carry out necessary consultations with the communities and local government representatives.

Across the border, Banbasa,Tanakpur, Jauljibi, Pithoragarh and Dharchula of Uttarakhand and Kheri and Pilibhit of Uttar Pradesh were visited. Field visit included consultations with district key stakeholders for DRR.A five days visit was conducted by PAC India DRR and Climate Change team from 23-27 February, 2018 to understand the issues of Trans- boundary early communication on Mahakali/ Sharda river. Team has visited several places to gain the knowledge and understanding of early warning issues across India and Nepal. Some of the key observations points are as following:

- The water resources development plans, which create large economic benefits - in contrast affecting the eco-systems. However, the river flow in the dry season remains low due to interplay between developments of hydropower and irrigation. Flooding during monsoon season has become a growing problem in the basin, mostly due to watershed deterioration. Clear statements of national water-related policies and strategies are lacking therefore.
- There is a lack of technical and management framework between two countries on overall water resources development and early warning communications. Though there are several rivers-based treaties between two countries but that doesn't provide the enough arguments for to establish the communications between and among the states.
- Different departments and institutions set for different objectives are continued to play their role in silos. There is a lack of coordination between departments of irrigation, central water commission at national and state level, Indian meteorological services and several other hydropower companies operating in the state of Uttarakhand.
- The state and district disaster management authority don't work directly on the issue of trans-boundary early communications. They mostly deal with training and capacity building issues and development of state, district and village disaster management plan.
- The unregulated urban development in the hills especially in Dharchula district that encompasses both India and Nepal also creates hindrance to the flow of water. The severe damages causes to the Nepal side of habitation in Darchula district can be attributed to unregulated urban development.

2.2.3 Consultation Meetings and KIIs

Primary data have been collected through stakeholder's consultation process. Interactions have been conducted with NGOs, communities, Red Cross, responsible Government actors in India and Nepal and humanitarian organizationsworking on flood EWS and preparedness systems in the basin. Standard Process of community based discussion has been adopted in forms of key informant's interviews and one to one interviews. The semi-structured interviews were conducted with government officials and members from national and international NGO community. Key Informant's Interviews based on structured guiding questions are effective ways of consultations to collect primary baseline information.

In Darchula, consultation meetings were conducted with Sankalpa (a local NGO), District Emergency Operation Center, and District Administration Office. In Baitadi, consultation meetings were conducted with Dasharath Chand Nagarpalika, District Administration Office, Nepal Red Cross Baitadi Chapter, and Communities of Jhulaghat. In Dadeldhura, consultation meetings were conducted with Rural Women Development and Unity Center (RUWDUC), District Administration Office, District Emergency Operation Center, Nepal Red Cross Society (District and Jogbuda Subchapter), and DHM Field Office. In Kanchanpur, consultation meetings were conducted with NNSWA, DEOC, DWIDM, Mercy Corps, NRCS, and local government officials of Bujhela.

In India, consultation meetings were conducted with Uttaranchal Development Institute (UDI), District Disaster Management Authority (DDMA)Pithoragarh,District Disaster Management Authority Champawat,National Hydro Power Corporation (NHPC) at Dhauliganga Power Station, CWC Gauge Station at Jauljibi, and NHPC at Tapovan near Dharchula.

2.2.4 Framework for Analysis of the existing gaps and opportunities

The following points are looked at while analyzing gaps and opportunities:

- Risk knowledge
- Monitoring and warning services
- Dissemination and communication
- Response capability
- Training and capacity building
- Disaster risk governance and sustainability

2.2.5 Criteria for Site Selection forTFEWSin Mahakali Basin

The following criteria are considered for the selection of sites for early warning system.

i. Physical Criteria: Should have representativeness, accessibility, manageability, suitability, and presence of geographical and hydro-meteorological connectivity between upstream and downstream of the Mahakali River
ii. Facilities: Should have data transmission and backup facilities, history of monitoring and detection system, data analysis tool to detect the floods, knowledge based stakeholder's involvement
iii. Potentials of the Basin/Sub-basin: Frequent flooding communities, potential for scaling and enhancing trans-border flood EWS, some existing practice of flood information communication between the local or national authorities and the local communities, communication potential, DRR potential, potential for bench-mark basin, potentiality for the filling gaps
iv. Vulnerabilities: Should have vulnerability to floods/landslide/debris/sediment hazard, and climate
v. Beneficiaries: Downstream beneficiaries close to the border, potential for trans-border EWS pilot testing, and technology transfer

3

MAIN FINDINGS

3.1 Risk Knowledge

The areas exposed to floods in Mahakali River and its tributaries in Nepal and India are presented in Table 1 below.

Table 1 **Flood affected areas along the Mahakali River and its tributaries**

District	Flood affected areas
Darchula	Ward no. 1, 4-9 of Mahakali Nagarpalika including Khalanga Bazaar, Dattu, Joljibi area, ward no. 6 and 7 of Malikarjun, ward no. 3 of Lekam, ward no. 3 of Duhu, Lali area and ward no. 5 of Byas Gaupalika
Baitadi	Serra, Jewali, Jada Bagar, Tir Khadeni, Simtadi Bhekkar, Balara, Gokuleshwor and Shivnath Gaupalika
Dadeldhura	The Alital, ward no. 4, 5, 6, 7 and 12 of Parshuram Nagarpalika, Sirsa, ward no. 1 of Bhageshwor Gaupalika
Kanchanpur	ward no. 9-13 of Bhimdatta Nagarpalika including Bhujela, Odali, Badaipur and Pipariya, ward no. 1, 4, 6, 9 and 10 of Mahakali Nagarpalika including Dodhara Chadni and Kutia Kavar
Pithoragarh	Dharchula, Nigalpani, Kalika, Balwakot, Jhulaghat, Jauljibi
Champawat	Tanakpur, Banbasa
Udham Singh Nagar	13 villages of Puranpur Block of Pilibhit district
Lakhimpur Kheri	22 Villages of Nihasan Block of Lakhimpur Kheri district
Sitapur	26 villages of Behta Block of Sitapur district

Most of the people in the flood affected areas are poor and their livelihood is based on subsistence farming. The socio-economic condition of the communities residing along the flood plain is increasing their vulnerability. The communities have the following basic infrastructures and capacities which are useful for effective early warning system.

Power supply: Some of the flood affected areas are connected with power supply from central grid. But the power supply is irregular and hence warning equipment based on electric power may not be viable. Hand operated sirens and megaphones are recommended for the dissemination of warning information at the communities.

Radio ownership: FM radio ownership is good and the local FM station could play a major role in disseminating information widely.

Telephone connectivity: Most of the flood affected areas have good connection with mobile phone networks (NTC, Ncell in Nepal).

Infrastructures: Most of the flood affected areas have schools and health posts and are connected with roads.

Technical capability of the community: Most of the communities have very low technical capability for operation and maintenance of monitoring, communication and dissemination equipment. They are not familiar with existing monitoring, communication and dissemination system.

Linkage with government agencies (DHM, DEOC) is not satisfactory in all districts. There should be linkage with district level emergency service bodies and the existing disaster response mechanism.

3.2 Monitoring and Warning

The hydrological stations in the Mahakali River and its tributaries in Nepal are given in Table 2 below.

Table 2 **Existing hydrological stations in Mahakali River and its tributaries in Nepal**

SN	Station No.	River	Station Name	Lat	Lon	Elevation (m)
1	105	Mahakali	Dattu	29.8	80.42	678
2	115	Naugraha Gad	Harsing Bagar	29.70194	80.60722	784
3	120	Chameliya	Nayalbadi	29.6747	80.5627	680
4	125	Jamari Gad	Panjewanya	29.63833	80.51389	580
5	169	Chandrai Gad	Barayal	29.50333	80.58556	1330
6	169.8	Surnaya Gad	Gujar Gaon	29.51667	80.58333	1275
7	175	Kakrighat	Bhageshori	29.34167	80.4125	650
8	176	Rupali Gad	Rupal	29.28333	80.41667	1267
9	177	Sirsa Gad	Sirsh	29.16667	80.33333	598
10	178	Mahakali	Parigaon	29.17	80.26	310
11	178.1	Rangun Khola	Kainpani	29.13111	80.39889	388

Dattu and Parigaon stations are equipped with real time telemetry system to measure water level in the Mahakali river in Nepal part.The meteorological stations in Mahakali basin are given in Table 3 below.

Table 3 **Existing meteorological stations in Mahakali basin in Nepal**

SN	Index	Station Name	Lat	Lon	Elevation (m)	Type
1	0101	Kakerpakha	29.65	80.5	842	Precipitation
2	0102	Gothalapani	29.55	80.41667	1635	Precipitation
3	0103	Patan	29.4663	80.5504	1300	Climatology
4	0104	Dadeldhura	29.3014	80.5877	1872	Synoptic
5	0105	Lalpur	29.03333	80.21667	176	Agrometeorology
6	0106	Belauri Santipur	28.68333	80.35	159	Precipitation
7	0107	Darchula	29.8427	80.5389	880	Climatology
8	0108	Satbanjh	29.53333	80.46667	2370	Precipitation
9	0109	Lumpthi	29.78333	80.81667	1676	Precipitation
10	0110	Dhaulatiya	29.75	80.66667	1524	Precipitation
11	0111	Dharmpaniya	29.73333	80.4	1402	Precipitation
12	0113	Gokuleshwor	29.66667	80.55	756	Precipitation
13	0114	Binayak	29.45	80.28333	762	Precipitation
14	0116	Rupal	29.28333	80.36667	1430	Precipitation
15	0117	Saunkharka	29.21667	80.61667	2073	Precipitation
16	0118	Jogbudha	29.11667	80.35	418	Precipitation
17	0119	Hanuman Nagar	28.96667	80.3	225	Precipitation
18	0121	Dodhara	28.85	80.1	188	Precipitation
19	0124	Jhalari	28.75	80.35	213	Precipitation
20	0233	Gaira	29.16667	80.59999	1885	Precipitation

The hydrological stations present in the Indian side operated by Central Water Commission (CWC) are given in Table 4.

Table 4 **Existing hydrological stations in Mahakali basin in India**

SN	Name	River	Lat	Long	Elevation (m)
1	Tawaghat	Mahakali	29.9786	80.5724	1310
2	Jauljibi	Goriganga	29.9575	80.6006	1135
3	Ghat	Sarju	29.7519	80.376	614
4	Pancheswor	Mahakali	29.5239	80.1	505
5	Banbasa	Sharda	29.4448	80.2432	443
6	Paliakalan	Sharda	28.9963	80.1084	221

Apart from the hydrological stations of the CWC, the gauge stations have been set up by the State Irrigation Department Uttarakhand as well as NHPC for their uses.

Water level gauges are also present at the following locations. In many places, during floods, water level is noted every fifteen minutes, manually.

- Dhauliganga– by CWC
- Dharchula – by the Irrigation Department of the State as well as by CWC
- Jauljibi, where the Goriganga joins the Mahakali/Sharda river, established both by the Irrigation Department as well as by the CWC
- Rameshwar Ghat across Sarju river, after its confluence with Ramganga
- NHPC also measures discharge of water at their plant at Dhauliganga

The meteorological stations present in the Indian side are presented in Table 5.

Table 5 **Existing meteorological stations in Mahakali basin in India**

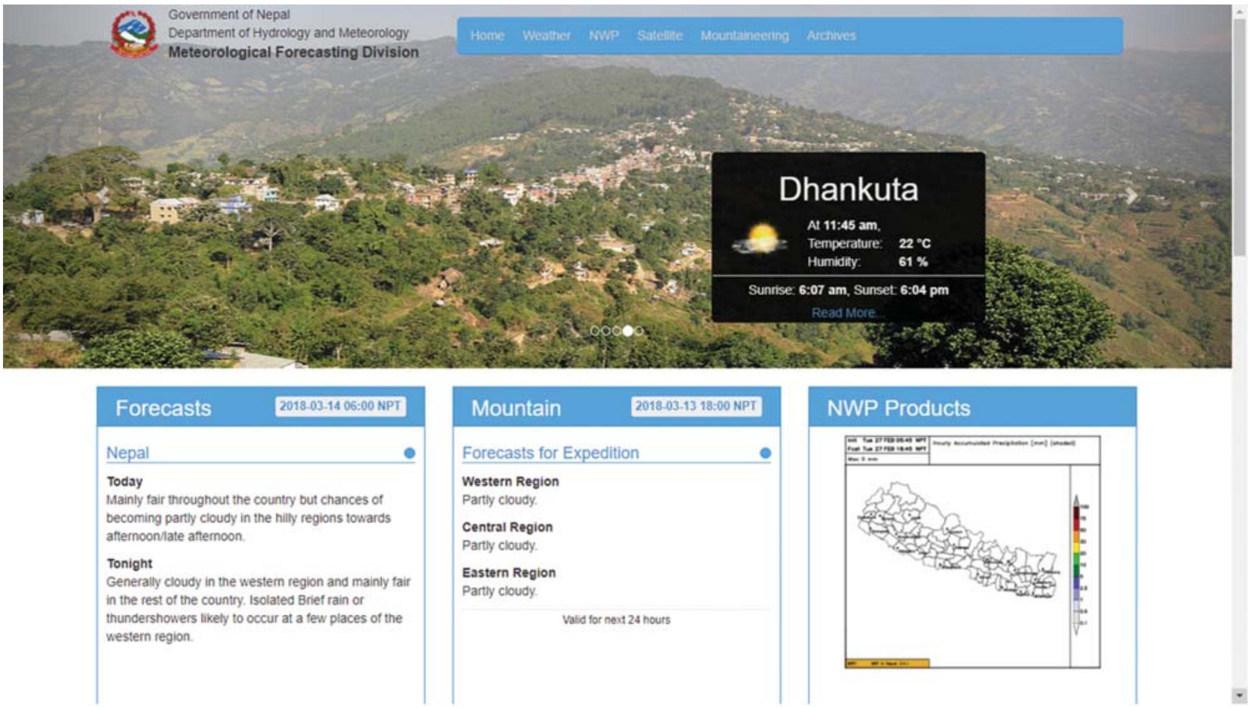
SN	Name	River Basin	Lat	Long	Elevation (m)
1	Purnagiri	Sharda	29.1370	80.1764	353
2	Pancheswor	Sharda	29.4461	80.2345	447
3	Banbasa	Sharda	28.9887	80.0763	228
4	Paliakalan	Sharda	28.4351	80.5726	162

A meteorological station exists at Pancheswar since 1982 on the Indian side. The Joint Project Office (JPO) also set up weather stations at Pancheswar, Rupaligad and Purnagiri sites for recording daily temperature, rainfall, wind speed and direction and sunshine. CWC rain gauge stations are available at Banbasa, Pancheswar, Paliakalan and Shardanagar. India Meteorological Department (IMD) has set up weather/rain gauge stations in each of the districts of Uttarakhand.IMD has proposal to set up automatic weather stations – at least in two blocks in each of the district of Uttarakhand.

Apart from IMD, several other organisations are known to have set up/ established weather stations/automatic weather stations etc. These include universities, State Irrigation Department, State Forest Department, Watershed Development Directorate, State Agriculture Department, National Hydropower Corporation etc. Apart from these, private players too are believed to have established weather stations/ automatic weather stations. Precise details will still need to be collected from the organizations concerned. Automatic weather stations are available in Pithoragarh, Munshiari. Proposal to set up nearly 11 automatic weather stations, many along the course of River Sharda is under active consideration. Establishment of Doppler weather radar in the region also is under consideration.

No real time data sharing mechanisms seem to exist between India and Nepal. The communication system in sharing information within India and across Nepal is very poor. There is not much cooperation between NHPC, CWC and other actors such as the State Irrigation Department in sharing river flow data. Each organisation has its own tasks and mandate and collect data accordingly.
The Meteorological Forecasting Division of DHM issues nationwide weather forecast for 24 hour and numerical weather prediction for 72 hours. These forecasts are available at the website:
http://mfd.gov.np/, http://mfd.gov.np/nwp/

Figure 6 DHM website to disseminate weather forecast

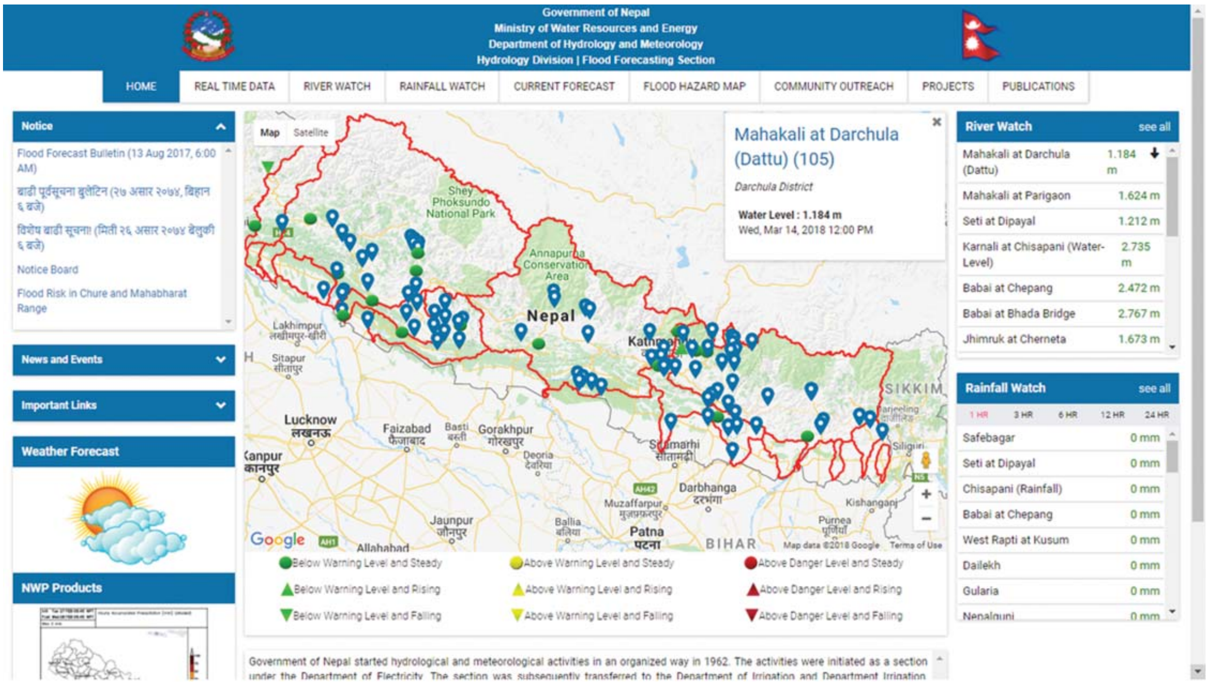


The flood warning and danger levels are set for Dattu and Parigaon stations in Mahakali River. Real-time water level information of Dattu and Parigaon stations and flood bulletins are posted at the website: http://hydrology.gov.np.

Table 6 Warning and danger levels for Dattu and Parigaon stations

Station Name	Mahakali at Dattu	Mahakali at Parigaon
Latitude 29° 47′51″	29° 10′ 20″	
Longitude	80°25′17″	80°15′38″
Warning level	5.80 m	5.80 m
Danger level	6.50 m	7.00 m

Figure 7 **Web-based flood information system of DHM**



The Global Flood Awareness System (GloFAS), jointly developed by the European Commission and the European Centre for Medium-Range Weather Forecasts (ECMWF), has included Dattu and Parigaon as reporting points where flood forecasts are available two weeks in advance (http://globalfloods.jrc.ec.europa.eu/glofas-forecasting/).

Figure 8 **GloFAS reporting points in Nepal**

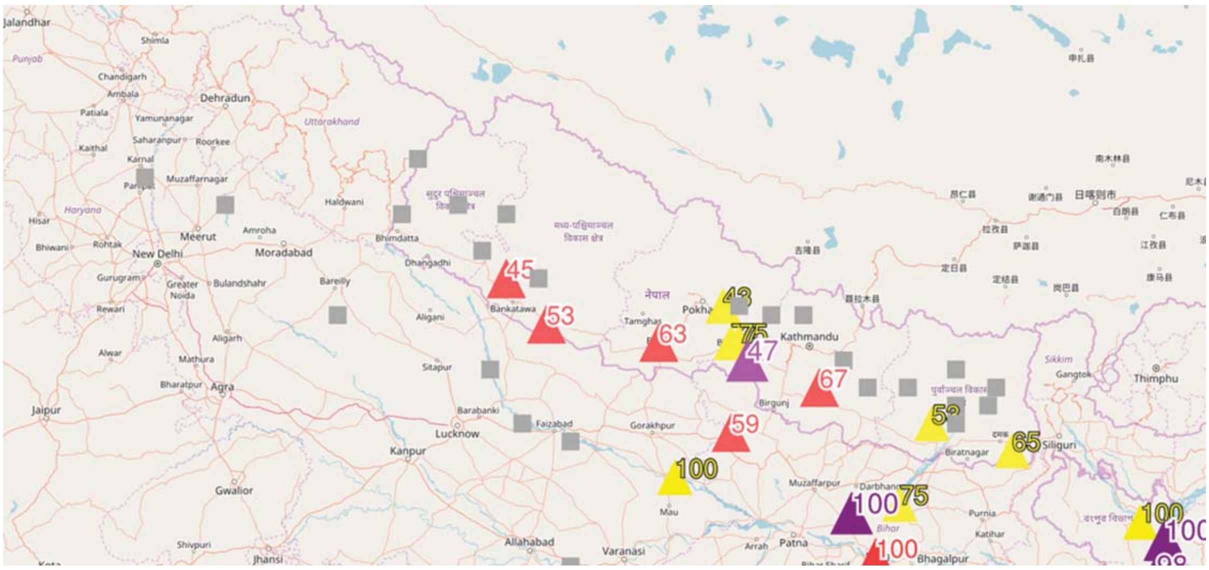


Figure 9 **GloFAS forecast for Dattu station in Mahakali on 1 August 2017**

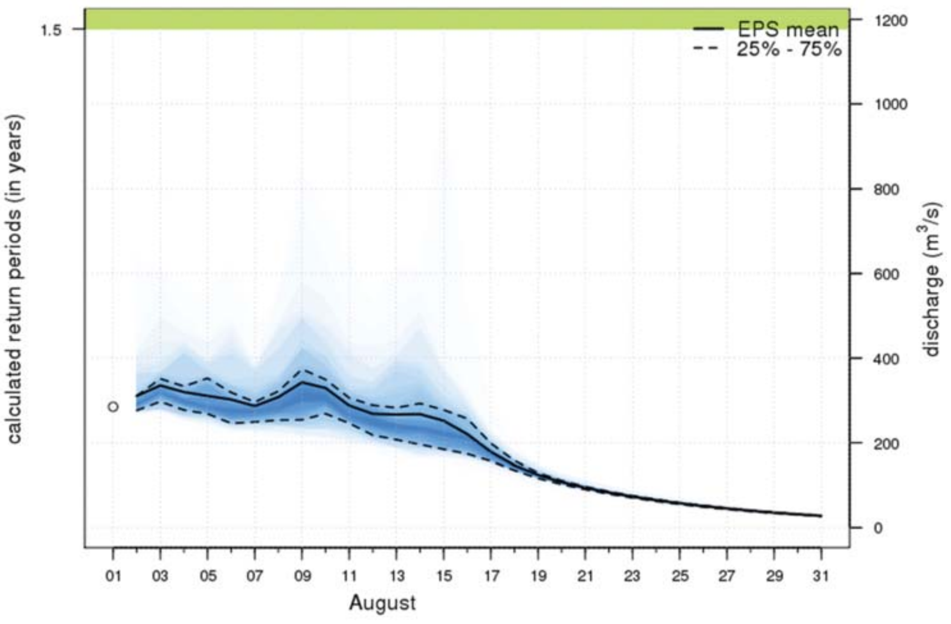


Figure 10 **CWC website to disseminate flood forecast**

The Central Water Commission (CWC) provides flood forecast information in the form of maps, list and flood category through its website (http://www.india-water.gov.in/ffs/flood-forecasted-bulletins/). In E-SWIS portal (http://www.india-water.gov.in/eSWIS-MapViewer/), on opening a particular station, a window opens showing static information about the station. The latest available dynamic information such as water level and flood forecast issued are also displayed in the window. DDMA Pithoragarh works very closely with the Irrigation Department of the State not only in monitoring of the river flows, but also in generating warning messages

3.3 Communication and Dissemination

The DHM is regularly posting the flood warning bulletin on the website during the monsoon season. The forecasting stations at Dattu and Parigaon collaborate with the local communities, media and district disaster relief committees to share flood level data and warning information.

A general network of major stakeholders for communication and dissemination of risk information is available for Darchula. The information flow channel needs to be revised and made specific. There is no communication and dissemination channel designed for Baitadi.

The District Emergency Operation Centers of Dadeldhura and Kanchanpur are receiving bulletin issued by DHM. The real time water level data from Dattu and Parigaon stations are displayed at DEOCs of both districts on electronic boards. There are communication and dissemination channels developed for Dadeldhura and Kanchanpur which need to be updated.

Recently, Mercy Corps has developed a mobile app diary (EWS Kanchanpur) to provide EWS related information available at android phones. This is a good initiative which could be replicated by other districts.

Figure 11 Mobile application for Kanchanpur EWS (Mercy Corps, 2013)

Dhauliganga dam at Chirkila which is built across Dhauliganga river (right tributary of Sharda) which originates in the Himalayas and flows through Indian territory for almost a hundred kilometres before it empties itself into Sharda. This is a rock fill dam with an elevation of 1351 metres above mean sea level. The length of the dam is 298 metres and height is 56 metres. Length of the reservoir is 1.2 kms Gross storage is 3.08 MCM and live storage is 2.51 MCM. The dam generates about 280 MW of electricity, in four turbines of 70MW each.

The dam has two spillways. The spill ways are generally kept closed during the lean season and during the monsoon season, the spill ways are opened at least two times to let out the extra water. At the time of letting out the water, sirens are usually sounded and jeeps are sent to a distance of about 5km (upto confluence of Sharda). The information about the release of water is also conveyed to the power station down below, which in turn is relayed to all others concerned downstream.

According to the standard operating procedures followed by the dam, the minimum height of water required for the operation of the power generating turbines is 1326 metres. The moment the water storage level exceeds 1338 metres, the sluice gates are opened and extra water is let out, with due warnings to all concerned.

There has been some concern about the opening of the sluice gate of this dam being responsible for the washing away of part of the market in Tawaghat and damage to Nepal side of Darchula during the unprecedented rainfall in June 2013.

3.4 Response Capability

District disaster preparedness and response plans are prepared by all four districts. These plans are yet to be updated in the context of newly elected local governments and their responsibilities.

In Darchula, Mahendra Higher Secondary School, Army Camp, Basanta Valley Public School and Chhanna Tinkari Girls School are used as a temporary shelter during disasters in the past. No evacuation routes are designated. No drills are conducted for preparedness and response. Red Cross has stockpiling facilities at Darchula district. Cluster system needs to be made active at Darchula.

There are four ambulances and one fire engine with Dasharath Chand Nagarpalika of Baitadi. There are several storage facilities with Red Cross. District Emergency Operation Center (DEOC) isn't yet set up at Baitadi. District Lead Support Agency (DLSA) is also not assigned.

In Dadeldhura, Red Cross has 26 sub-branch offices covering almost all Gaupalikas with facilities for stockpiling of relief and rescue materials. Community volunteers and task groups are also formed in some communities. The shelters are not sufficient and not friendly to children, women, elderly and disabled people. Sirens are also available at few communities.

In Kanchanpur, standard operating procedures (SOPs) for forecast based flood preparedness are also prepared. But a training and capacity building program is required to make the SOP fully operational. DEOC, NEEDS and Red Cross have stockpiling facilities. The communities at Bhujela have siren, life jackets and hand microphones. There is a need of safe shelters.

DDMA Pithoragarh uses the SSB (Sashastra Seema Bal, a para military force) extensively for disaster warning, especially for those communities living in the low lying areas along River Mahakali/Sharda. This is because SSB is posted extensively in these areas which constitute the international border between Nepal and India. Often there is constructive collaboration between the DDMA, SSB and the Army for disaster response. DDMA also shares weather warnings with the Army located in the higher reaches. DDMA Pithoragarh and other organizations also have access to digital satellite phones for sharing disaster information and for disaster response purposes. DDMA would support joint exercises involving all stakeholders (including the army, SSB and others) both on the Indian and Nepal side for sharing disaster related information and alerts. DDMA Pithoragarh also operates control room (managed round the clock). The DDMA Pithoragarh seems very well organised with all information and data.

3.5 Trainings and Capacity Building

The awareness level of the communities on the causes and effects of flood risks is poor. They are not familiar with the water level and rainfall monitoring system. The communities lack the capacity to extract and interpret warning information and take appropriate action. Information management officers at DEOC lack the capacity to interpret and customize weather forecast and flood bulletins published by DHM. The communities lack the skills to operate and maintain the equipment for monitoring, communication and dissemination, and search and rescue.

3.6 Disaster Risk Governanceand Sustainability

Transboundary level: The JCIFM is a guiding and supervisory mechanism to enhance transboundary collaboration in flood early warning system in transboundary Rivers between India and Nepal. However, there is no institutional mechanism established between two countries to exchange the flood data and information through user friendly platform. The Mahakali treaty between India and Nepal of 1996 has no provision for flood risk management.

Federal level: In Nepal, the DHM is responsible for operation and maintenance of monitoring stations, weather and flood forecasting, and communication and dissemination of flood risk information to different users and stakeholders. The NEOC is responsible for further communication and dissemination of risk information, emergency preparedness and response. In India, the CWC, IMD as well as NHPC are responsible for operation and maintenance of hydrological and meteorological stations.

Provincial level: In Nepal, the provincial structures are still in development stage. In India, State Irrigation Departments of Uttarakhand and Uttar Pradesh also operate and maintain hydrological and meteorological stations.

District level: In Nepal, the DDMC, DEOC is responsible for further communication and dissemination of risk information, emergency preparedness and response. In India, DDMA is responsible for further communication and dissemination of risk information, emergency preparedness and response.

Local level: The local government and community based organizations are responsible for further communication and dissemination of risk information, emergency preparedness and immediate response.

Clear statements of national water-related policies and strategies on flood risk reduction and early warning system are lacking.

There is lack of coordination between departments of irrigation, central water commission at national and state level, Indian meteorological services and several other hydro power companies operating in the state of Uttarakhand.

The state and district disaster management authority don't work directly on the issue of trans-boundary early warning communications. They mostly deal with training and capacity building issues and development of state, district and village disaster management plans.

The unregulated urban developments in the hills especially in Dharchula in India and Khalanga in Nepal also create hindrance to the flow of water. The severe damages caused to the Nepal side of habitation in Darchula district can be attributed to unregulated urban development.

4

CHALLENGES AND OPPORTUNITIES FOR TRANSBOUNDARY COLLABORATION

4.1.1 Current challenges for Nepal-India in Transboundary Early Warning System

Risk assessment: Basin wide flood risk assessment is lacking. A comprehensive assessment of flood hazard, vulnerability and capacity is required to set up effective TFEWSand for informed decision making and development planning.

Monitoring and observation system: Most of the hydrological and meteorological stations in Mahakali basin are manually operated. Real time river level and rainfall data are required for operational early warning system.

Communication and dissemination system: The current early warning communications between the two countries are informal; existing mostly between the communities. Such communications lack accountability, reliability and timeliness. Some flood data is managed by India in Tanakpur and Banbasa. No real time data sharing mechanisms seem to exist between India and Nepal. The communication systems are very poor in sharing of information within the country in India and across Nepal. Real time mechanism is therefore required for sharing information about the flow/discharge in the main river Mahakali/Sharda, but also in its tributaries – both left and right. Such data should be accessible to all the stakeholders. Flood forecasting information should be shared and awareness programme to be developed and disseminated.

Lack of appropriate institutional set up: There is a lack of cross-border institutionalized early warning system that encompasses all four components of early warning.

Un-prioritized early warning: Joint committees that exist between Nepal and India deal with water management issues such as hydropower and irrigation; however, early warning is not a priority in the cross-border water management issues.

Differences in social, technological and policy level governance between the two countries: Such differences bring forth differing opinion on early warning governance and management in two countries. Even though both the countries have well established system for early warning within the borders, extending the collaboration at transboundary level requires revisiting of plans and policies.

Thus, the central level and provincial level governments in the two countries should address such differences.

Bilateral relationship: The community level, regional and national level early warning relationship between Nepal and India exists based on the assumption that there is smooth relationship between the two countries. If any disturbance occurs in the bilateral relationship, the early warning relationship between the two countries will be affected. In 1996, both the government entered into the treaty concerning integrated catchment development in regards to the water management and utilization in Mahakali River. However, no policies exist regarding the early warning and flood management.

4.1.2 Opportunities for Transboundary Collaboration in EWS

Monitoring and observation system: There is a good network of hydrological and meteorological stations in both sides of Mahakali basin. This provides an opportunity to upgrade these stations with telemetry system and to use real time data in EWS.

Prediction system: The CWC, IMD and DHM produce weather and flood forecast information and issue bulletin during monsoon season which could be further customized and utilized for operational EWS in Mahakali River. GloFAS forecast is also available for two stations in Mahakali River.

Communication and dissemination system: Although, the current early warning communication system between the two countries is informal; existing mostly between the communities, this provides an opportunity to upgrade it into the formal transboundary communication and dissemination system. This also encourages the governments in both countries to promote bilateral cooperation in flood information sharing.

Response mechanism: There are community based disaster management committees formed at local level which could be trained for forecast based preparedness and response. Red Cross has a very good presence in most of the vulnerable communities with stockpile of basic relief and rescue materials.

Institutional set up: The joint committees that exist between Nepal and India could be utilized to promote transboundary collaboration in EWS. The community based disaster management committees could be strengthened to take care of EWS at local level.

5 RECOMMENDATION

5.1 Risk Knowledge

The following activities are recommended to enhance risk knowledge:

1. Organize awareness raising programs on cause and effects of flood risks and application of EWS in Mahakali (Radio and TV program, mass media, workshops, seminars, posters, calendars, leaflets, wall paintings, field visits, song competitions, street theatre, schools art and essay competitions etc.)
2. Prepare/update flood hazard maps
3. Assess/update warning and danger levels for all flood monitoring stations
4. Assess exposure of the people and properties to flood hazards
5. Assess vulnerabilities and prepare vulnerability maps
6. Assess resources and capacity
7. Assess flood risk faced by the communities
8. Identify and evaluate activities that reduce flood risks
9. Integrate flood risk assessment into local development plans

5.2 Monitoring and Warning

The following activities are recommended to enhance monitoring and warning system:

1. Establish/upgrade real time water level and rainfall monitoring networks
2. Process and analyze real time water level and rainfall data and make available in standard formats
3. Generate warning bulletin
4. Develop flood forecast model to understand and predict the flood hazards
5. Develop web based DSS for early warning system
6. Develop mobile app for EWS
7. Set up operation center at central, district and local level

The Table 7 presents the hydrological stations proposed for flood early warning system in Mahakali River in Nepal part.

Table 7 **Proposed hydrological stations in Nepal**

SN	Station No.	River	Station Name	Lat	Lon	Elevation (m)	Remarks
1	103	Mahakali	Tigram	29.9329	80.5797	1048	new
2	105	Mahakali	Dattu	29.7975	80.4215	678	existing
3	120	Chameliya	Nayalbadi	29.6747	80.5627	680	existing
4	178	Mahakali	Parigaon	29.1723	80.2606	310	existing
5	178.05	Rangun Khola	Kalakot	29.1277	80.4663	524	new
6	178.1	Rangun Khola	Kainpani	29.1311	80.3989	388	existing

Mahakali at Tigram and Rangun Khola at Kalakot are two new stations proposed for EWS. The station in Chameliya at Nayalbadi is being upgraded by World Bank funded Pilot Program for Climate Resilience (PPCR) project of DHM. The details of the proposed river monitoring sites are presented in Annex 1.

Table 8 presents the hydrological stations proposed for flood early warning system in Mahakali River in Indian part.

Table 8 **Proposed hydrological stations in India**

SN	Station Name	River	Lat	Long	Elevation (m)	Remarks
1	Chirkila	Dhauliganga	29.9786	80.5724	1310	existing
2	Tawaghat	Mahakali	29.9575	80.6006	1135	existing
3	Jauljibi	Goriganga	29.7519	80.376	614	existing
4	Ghat	Sarju	29.5239	80.1	505	existing
5	Pancheswor	Mahakali	29.4448	80.2432	443	existing
6	Banbasa	Sharda	28.9963	80.1084	221	existing
7	Paliakalan	Sharda	28.3856	80.552	158	existing

Table 9 presents the meteorological stations proposed for flood early warning system in Mahakali River in Nepal part.

Table 9 **Proposed meteorological stations in Nepal**

SN	Index	Station Name	Lat	Lon	Elevation (m)	Type	Remarks
1	0102	Gothalapani	29.55	80.41667	1635	Precipitation	existing
2	0103	Patan	29.4663	80.5504	1300	Climatology	existing
3	0104	Dadeldhura	29.3014	80.5877	1872	Synoptic	existing
4	0105	Lalpur	29.03333	80.21667	176	Agro-meteorology	existing
5	0107	Darchula	29.8427	80.5389	880	Climatology	existing
6	0113	Gokuleshwor	29.66667	80.55	756	Precipitation	existing
7	0118	Jogbudha	29.11667	80.35	418	Precipitation	existing
8	0121	Dodhara	28.85	80.1	188	Precipitation	existing
9	0233	Gaira	29.16667	80.59999	1885	Precipitation	existing

The precipitation stations at Gaira, Siradi and Simalbanda stations are important for EWS in Rangun Khola. Precipitation stations at Siradi and Simalbanda are operated and maintained by NGOs to support their community based projects on climate change and disaster risk reduction. These stations are not integrated in DHM network. These stations need to be upgraded with telemetry system and integrated with national network for flood forecasting.

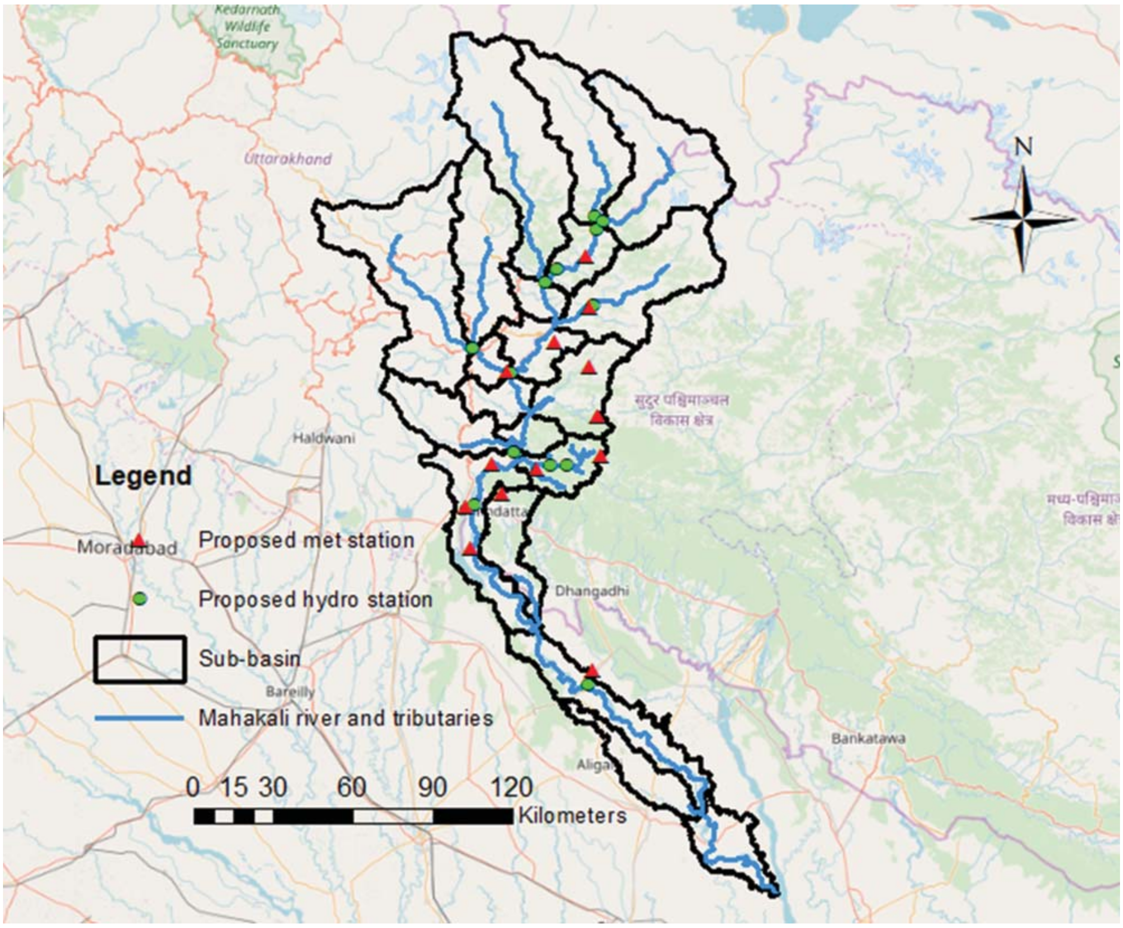
Dadeldhura, Darchula and Gaira stations are being upgraded by World Bank funded Pilot Program for Climate Resilience (PPCR) project of DHM. The details of the proposed weather monitoring sites are presented in Annex 2. Table 10 presents the meteorological stations proposed for flood early warning system in Mahakali River in Indian part.

Table 10 **Proposed meteorological stations in India**

SN	Station Name	River Basin	Lat	Long	Elevation (m)	Remarks
1	Purnagiri	Mahakali	29.1370	80.1764	353	existing
2	Pancheswor	Mahakali	29.4461	80.2345	447	existing
3	Banbasa	Sharda	28.9887	80.0763	228	existing
4	Paliakalan	Sharda	28.4351	80.5726	162	existing

Figure 12 below shows proposed hydrological and meteorological stations network for EWS in Mahakali basin.

Figure 12 **Proposed hydrological and meteorological stations**



5.3 Communication and Dissemination

Real time mechanism is required for sharing information about the stage/discharge in the main river Mahakali/Sharda, but also in its tributaries – both left and right. Such data should be accessible to all the stakeholders. The Department of Hydrology and Meteorology (DHM) is sharing water level and rainfall data of Nepalese portion of Mahakali basin to CWC Patna and Lucknow during monsoon season regularly. Although, Banbasa and Paliakalan stations are included in Nepal-India Flood Forecasting Scheme, DHM has not received water level and rainfall data from these stations in Indian portion of Mahakali basin. Hence, this issue should be resolved through the bilateral mechanism between India and Nepal such as JCIFM, JSTC and JCWR.

The communication and dissemination flow charts for Darchula, Dadeldhura and Kanchanpur need to be revised in the context of newly elected local government and new organizational set up envisioned by DRRM Act, 2017. The communication and dissemination flow chart should be prepared for Baitadi district. Such flow charts should also be prepared for all local government units. The District Disaster Management Committee, local disaster management committees, local media, the Red Cross, local police, military units and others need to be brought into a network with the flood monitoring and forecasting station of DHM.

There is a need to form provincial level disaster management committees and emergency operation centers as envisioned by the Disaster Risk Reduction and Management Act, 2017.

Informal civil society organizations and NGOs could play a vital role in connecting vulnerable communities of India and Nepal for effective TFEWS in Mahakali River.

Sirens and hand microphones need to be provided to the vulnerable communities to disseminate the risk information at the local level. A task group with volunteers needs to be formed at each community to further disseminate the risk information to the most vulnerable groups such as children, women, elderly and disabled people.

The following activities are recommended to enhance communication and dissemination system:

1. Customize communication/dissemination system to the requirements and suitability of the local communities (e.g. radio or television, phone or sms, sirens, megaphone, shouting, messenger runner)
2. Prepare warning alerts and messages (booklets, leaflets, pamphlets, electronic messages etc.) to targeted communities
3. Develop location specific warning alerts and messages
4. Develop different warning alerts for different threats
5. Conduct awareness campaign and simulation exercises on how to respond to flood hazards after early warning message is received
6. Developwater level and rainfall data sharing mechanism for Mahakali basin between India and Nepal through JCIFM

5.4 Response Capability

Response mechanism should be formed at the community level by forming different task groups and volunteers.The district disaster preparedness and response plans should be updated in the context of newly elected local governments and their responsibilities. These plans should also include forecast based flood preparedness procedures. Local preparedness and response plans also need to be formulated.

The following activities are recommended to strengthen response capability.

1. Formulate/update district and local disaster preparedness and response plan
2. Undertake regular tests and drills to verify the effectiveness of the early warning dissemination process and response
3. Identify and establish temporary shelters
4. Establish storage houses and stockpile relief and rescue materials
5. Establish emergency response mechanism at the community level based on cluster approach
6. Develop multi-cluster/sector initial rapid assessment system for loss and damage

Safeguarding people's lives, livestock, seeds, household necessities and farm equipment is the prime response of the community after receiving a flood warning. Prompt response is necessary in moving goods and people to higher grounds, shelters or safe areas. The following commodities or materials need to be stockpiled at the vulnerable communities for immediate response: Life jackets, Boats, Ropes, Shovels, Vehicles, Ambulances, Torch lights, Bags, Tents, Utensils, Hygiene kit, First aid kit, Dry foods, Water purifying tablets etc.

5.5 Training and Capacity Building

Four levels of training and capacity building programs on EWS are identified:

Module I (gauge readers, part-time observers)
Characteristics of precipitation in project basins; recording/non-recording raingauges, non-recording water level gauges (vertical and inclined staff gauges);recording gauges (float type, pneumatic type, radar type); fillings of datain formats; flow measurement, routine inspection; cross section measurements;maintenance of telemetric system

Module II (community response team, community task forces, local government representatives, NGOs, Red Cross)
Causes and effects of flood risk; flood monitoring; access and interpretation of weather and flood bulletin; local communication and dissemination; preparedness and emergency response; initial rapid assessment of loss and damage; post event evaluation

Module III (DEOC, cluster members, district level NGOs and development partners)
Causes and effects of flood risk; flood monitoring; access and interpretation of weather and flood bulletin; interpretation of forecast uncertainties; customization of forecast for the region; communication and dissemination; preparedness and emergency response; initial rapid assessment of loss and damage; post event evaluation

Module IV (technicians and officers for weather and flood forecasting)
Telemetry system; database management; weather forecasting; customization of weather forecast for flood forecast; flood forecasting by stage to stage correlation; rainfall-runoff modeling; hydraulic modeling; data assimilation; error correction; preparation and dissemination of bulletins

The training program should include table-top simulation exercises, functional mock drills and field visits to upstream monitoring stations to make the participants familiar with the monitoring system of flood hazard.

5.6 Disaster Risk Governance and Sustainability

The following activities are recommended to strengthen disaster risk governance and sustainability.

1. Assist to establish Provincial and Local Disaster Management Committees envisioned in Disaster Risk Reduction and Management Act, 2017
2. Establish definite linkage among different institutions working on flood risk management
3. Develop Standard Operating Procedure (SOP) to define the processes, and roles and responsibilities of all organizations generating and issuing warnings
4. Ensure inclusive access, representation and meaningful participation of children, women, elderly, people with disability and marginal communities in EWS
5. Promote use of modern Information and communication techniques in EWS
6. Develop data and information sharing mechanism among different organizations and stakeholders
7. Influence policy to develop transboundary flood data and information sharing mechanism between India and Nepal through JCIFM
8. Establish local data depository system
9. Develop Monitoring, evaluation and learning (MEL) plan
10. Analyze economic benefits of flood early warning system
11. Integrate flood early warning system into national/local development planning and projects
12. Establish a network of organizations working on community based early warning system
13. Formulate necessary rules and regulations required for the effective EWS
14. Establish a process to review and update flood risk data each year, and include information on any new or emerging vulnerabilities
15. Influence policy to include provision of flood risk management in the Mahakali treaty between India and Nepal

6

PLAN OF ACTION TO ESTABLISH TFEWS IN MAHAKALI BASIN

Table 11 presents the plan of action for establishing TFEWSin Mahakali basin.

Table 11 Plan of action for establishing TFEWSin Mahakali

1.	Risk Knowledge	
	Activities	**Time Frame**
1.1.	Awareness raising program on cause and effects of flood risks and application of EWS in Mahakali (Radio and TV program, mass media, workshops, seminars, posters, calendars, leaflets, wall paintings, field visits, song competitions, street theatre, schools art and essay competitions etc.)	By 1st year
1.2.	Preparation and upgrading of flood hazard maps	By 1st year
1.3.	Assessment of degree of exposure of the people and properties to flood hazards	By 1st year
1.4.	Assessment of vulnerabilities for flood hazards, Preparation of and updating vulnerability maps	By 1st year
1.5.	Assessment of resources and capacity	By 1st year
1.6.	Assessment of flood risk faced by the communities	By 1st year
1.7.	Identification and evaluation of activities that reduceflood risks	By 1st year
1.8.	Education and training on TFEWS	By 2nd year
1.9.	Establishment of Training Centers and development of training materials for TFEWS	By 2nd year
1.10.	Integration of flood risk assessment into local development plans	By 3rd year

2.	Monitoring, Prediction and Warning	
	Activities	**Time Frame**
2.1.	Identification of required number and locations for hydrological and meteorological networks	By 1st year
2.2.	Establishing/upgrading of water level and rainfall monitoring networks	By 1st year
2.3.	Real time river water level and rainfall data processing and making available in standard formats	By 1st year
2.4.	Obtaining and reviewing data on vulnerabilities associated with floods	By 1st year
2.5.	Data analysis, prediction and warning generation started, issuing warning products	By 2nd year
2.6.	Promotion of indigenous knowledge on early warning to flood disaster	By 2nd year
2.7.	Research work on flood forecast model development and use to understand and predict the flood hazards	By 3rd year
2.8.	Training and capacity building on flood forecasting and warning	By 3rd year
2.9.	Development of web based DSS for early warning system	By 3rd year
2.10.	Development of mobile app for TFEWS	By 3rd year
2.11.	Integration into national and regional networks	By 4th year

3.	Communication and Dissemination	
	Activities	**Time Frame**
3.1.	Communication/dissemination mechanism customized to the requirements and suitability of the local communities (e.g. radio or television, phone or sms, sirens, megaphone, shouting, messenger runner) about flood hazard and risk information	By 2nd year
3.2.	Preparation of warning alerts and messages (booklets, leaflets, pamphlets, electronic messages etc.) to targeted communities	By 2nd year
3.3.	Development of location specific warning alerts and messages to ensure warnings	By 2nd year
3.4.	Development of different warning alerts for different threats	By 2nd year
3.5.	Development of district level and community level communication and dissemination mechanism	By 2nd year
3.6.	Development of Nepal-India transboundary communication and dissemination mechanism	By 2nd year
3.7.	Conduction of awareness campaign and mock drills on how to respond to flood hazards after early warning message is received	By 2nd year
3.8.	Evaluation of the communication mechanism	By 3rd year
3.9.	Communication mechanism upgraded	By 3rd year
3.10.	Evaluation on how people understood the disseminated messages	By 3rd year
3.11.	Documentation of information on flood hazards, vulnerabilities, risk, and method of reduction of impacts of flood disasters	By 4th year

4.	Response Capability	
	Activities	**Time Frame**
4.1.	Formulation/updating of disaster preparedness and response plan with forecast based flood preparedness procedures	By 2nd year
4.2.	Undertaking of regular tests and drills to verify the effectiveness of the early warning dissemination process and response	By 2nd year
4.3.	Identification and establishment of temporary shelters	By 2nd year
4.4.	Establishment of storage houses and stockpiling of relief and rescue materials	By 2nd year
4.5.	Establishment of emergency response mechanism at the community level	By 2nd year
4.6.	Develop multi-cluster/sector initial rapid assessment system for loss and damage	By 3rd year

5.	Sustainability and Disaster Risk Governance	
	Activities	**Time Frame**
5.1.	Provincial and local Disaster Management Committees envisioned in Disaster Risk Reduction and Management Act, 2017 established	By 1st year
5.2.	Definite linkage among different institutions established	By 2nd year
5.3.	Standardized process, and roles and responsibilities of all organizations generating and issuing warnings established, Standard Operating Procedure (SOP) developed	By 2nd year
5.4.	Inclusive representation in EWS ensured	By 2nd year
5.5.	Use of modern Information and communication techniques in EWS promoted	By 2nd year
5.6.	Development of data and information sharing mechanism among different organizations and stakeholders	By 2nd year
5.7.	Development of transboundary flood data and information sharing mechanism between India and Nepal through JCIFM	By 3rd year
5.8.	Establishment of local data depository system	By 3rd year
5.9.	Development of Monitoring, evaluation and learning (MEL) plan	By 3rd year
5.10.	Analysis of economic benefits of flood early warning	By 4th year
5.11.	Integration of flood early warning system into national/ localdevelopment planning and projects	By 4th year
5.12.	Establish a network of organizations working on community based early warning system	By 5th year
5.13.	Necessary policy and rules and regulations required for the effective EWS formulated	By 5th year
5.14.	Process to review and update flood risk data each year, and include information on any new or emerging vulnerabilities established	By 5th year

REFERENCES

Becker, G., Aerts, J.C.J.H. and Huitema, D., 2007. Transboundary flood management in the Rhine basin: challenges for improved cooperation. Water Science and Technology, 56(4), pp.125-135.

ICIMOD, 2013, ICIMOD Seminar- Kathmandu- Dec3-4, 2013, Case Study Presented by: Prakash Paudel

Mercy Corps, 2013, The role of early warning in Nepal.

PRACTICAL ACTION, 2016. Flood Early Warning System in Practice-Experiences of Nepal. Kathmandu, Nepal: Practical Action.

SMITH, P.J., BROWN, S. and DUGAR, S., 2016. Community Based Early Warning Systems for flood risk mitigation in Nepal. Natural Hazards and Earth System Sciences

Sendai Framework for disaster risk reduction, 2015-2030

JCIFM bilateral meetings, 2009-2017. http://dwidm.gov.np/bilateral-minutes/

JCWR bilateral meetings, 2000-2013. http://www.wecs.gov.np/bilateral-minutes.php

JSTC bilateral meetings, 2008-2010. http://www.wecs.gov.np/bilateral-minutes.php

Wilby, R.L. and Keenan, R., 2012. Adapting to flood risk under climate change. Progress in Physical Geography, 36(3), pp.348-37

ANNEX I

List of Proposed Hydrological Stations in Nepal

Station No: 103 (proposed)
Name of the River: Mahakali
Location: Tigram

GPS Reading
Latitude: 29.9329
Longitude: 80.5797
Elevation (m): 1048

Type of instruments (proposed): Bubbler Level Sensor, Staff Gauges (8 m), Tipping Bucket Rain Gauge

Accessibility: Good Access from India, Need to drive about 20 Km North from Dharchula Bazaar, Cross the Suspension Bridge at Tigram and Site is located at 200 m downstream from bridge

Power supply: National Grid (Indian Supply also there), Good sunlight (6-8 hr)
Communication: NTC, Sky
Signal strength: Good but fluctuating
Present condition of equipment: None
Competency of observer: None

Site condition: Very solid rock base, along the main river course, Small village 20 min walk upward

Maintenance and upgradation required:
New station, fencing is required for rain gauge and data logger

Station No.: 105
Name of the River: Mahakali
Location: Dattu

GPS Reading
Latitude: 29.79583
Longitude: 80.421267
Elevation (m): 673

Type of instruments: Bubbler Level Sensor, Staff Gauges

Accessibility: About 100 m from Darchula highway

Power supply: National Grid, Good sunlight
Communication: NTC, CDMA
Signal strength: Good
Present condition of equipment: Good operational condition, staff gauges need to be repaired
Competency of observer: Good

Site condition: Very solid rock base, along the main river course

Maintenance and upgradation required:
Staff gauges need to be repaired

Station No.: 120
Name of the River: Chameliya
Location: Nayalbadi

GPS Reading
Latitude: 29.67805
Longitude: 80.56215
Elevation (m):756

Type of instruments: Bubbler Sensor (not working) by Kailash Project, Staff Gauge, Cable way, Sediment Sampler

Accessibility: About 1.5 Km from Gokuleshwor on the way to Chameliya HEP

Power supply: National Grid, Good sunlight
Communication: NTC, Ncell
Signal strength: Good
Present condition of equipment: Telemetric system is not working, bubbler sensor requires replacement
Competency of observer: Good

Site condition: Solid rock base, along the main river course

Maintenance and upgradation required:
Telemetric system requires maintainence

Station No.: 178
Name of the River: Mahakali
Location: Parigaon

GPS Reading
Latitude: 29.1495555
Longitude: 80.27244
Elevation (m): 310

Type of instruments: Bubbler Sensor, Staff Gauge (8 m)

Accessibility: Road from Daiji to Jogbudha or Budar to Jogbudha

Power supply: National Grid, Good sunlight
Communication: NTC, Ncell
Signal strength: Good
Present condition of equipment: Telemetric system is working
Competency of observer: Good

Site condition: On footsteps, along the main river course

Maintenance and upgradation required:
None

Station No.: 178.05 (proposed)
Name of the River: Rangun Khola
Location: Kalakot

GPS Reading
Latitude: 29.1277
Longitude: 80.4663
Elevation (m): 524

Type of instruments (proposed): Radar Sensor, Staff Gauge (6 m)

Accessibility: Road from Budar to Jogbudha

Power supply: National Grid, Good sunlight
Communication: NTC, Ncell
Signal strength: Good
Present condition of equipment: None
Competency of observer: None

Site condition: On hard rock, along the main river course

Maintenance and upgradation required:
New station to be constructed with staff gauges and radar level sensor

Station No.: 178.1
Name of the River: Rangun Khola
Location: Kainpani

GPS Reading
Latitude: 29.1311
Longitude: 80.3989
Elevation (m): 388

Type of instruments: Radar Sensor (proposed), Staff Gauges

Accessibility: Road from Daiji to Jogbudha or Budar to Jogbudha

Power supply: National Grid, Good sunlight
Communication: NTC, Ncell
Signal strength: Good
Present condition of equipment: Staff gauges and cable way need repair, Telemetric system proposed
Competency of observer: Good

Site condition: On hard rock, along the main river course

Maintenance and upgradation required:
Cable way and staff gauges need repair, upgrdation required with telemetry

ANNEX II

List of Proposed Meteorological Stations in Nepal

Station No.: 0102
Name of the Basin: Mahakali
Location: Gothalapani

GPS Reading
Latitude: 29.5574
Longitude: 80.4132
Elevation (m): 1350

Type of instruments: Ordinary Rain Gauge and Wet/Dry/Maximum/Minimum Temp

Accessibility: 1 Km from Jhulaghat road

Power supply: National Grid, Good sunlight
Communication: NTC, Ncell
Signal strength: Very Good
Present condition of equipment: Good Operational Condition but requires upgrade to Telemetric
Competency of observer: Good

Site condition: good

Maintenance and upgradation required:
requires upgrading to telemetry

Station No.: 0103
Name of the Basin: Mahakali
Location: Patan

GPS Reading
Latitude: 29.4661
Longitude: 80.5506
Elevation (m): 1294

Type of instruments: Ordinary Rain Gauge, Tipping Bucket (Weighing type), Wind Speed, dry/wet/ maxima/minima temp, data logger

Accessibility: Patan airport, East of Buspark and West of Airport, 500 m from main highway

Power supply: National Grid, Good sunlight
Communication: NTC, Ncell
Signal strength: Very Good
Present condition of equipment: Telemetry not working
Competency of observer: Good

Site condition: Near Airport on a flat terrain, spacious and well protected

Maintenance and upgradation required:
requires maintenance of telemetry

Station No.: 0104
Name of the Basin: Mahakali
Location: Dadeldhura

GPS Reading
Latitude: 29.3014
Longitude: 80.5877
Elevation (m): 1872

Type of instruments: Ordinary Rain Gauge, Tipping Bucket (Weighing type), Wind Speed, dry/wet/maxima/minima temp, data logger

Accessibility: Dadeldhura district headquarter

Power supply: National Grid, Good sunlight
Communication: NTC, Ncell
Signal strength: Very Good
Present condition of equipment: Telemetry not working
Competency of observer: Good

Site condition: Near Syaubari on a flat terrain, spacious and well protected

Maintenance and upgradation required:
requires maintenance of telemetry

Station No.: 0105
Name of the Basin: Mahakali
Location: Lalpur

GPS Reading
Latitude: 29.0333
Longitude: 80.21667
Elevation (m): 176

Type of instruments: Ordinary Rain Gauge, dry/wet/maxima/minima temp

Accessibility: On East-West highway from Daiji to Mahendranagar

Power supply: National Grid, Good sunlight
Communication: NTC, Ncell
Signal strength: Very Good
Present condition of equipment: good, need to upgrade with telemetry
Competency of observer: Good

Site condition: On a flat terrain, spacious and well protected

Maintenance and upgradation required:
requires upgrading with telemetry

Station No.: 0107
Name of the Basin: Mahakali
Location: Khalanga, Darchula

GPS Reading
Latitude: 29.842817
Longitude: 80.539
Elevation (m): 882

Type of instruments: Ordinary Rain Gauge, Tipping Bucket (Kailash Project), Dry/Wet/Maximum/Minimum Temperature, data logger

Accessibility: Darchula Bazaar Near DEOC, District Police Office Compound

Power supply: National Grid, Good sunlight
Communication: NTC, Ncell
Signal strength: Very Good
Present condition of equipment: Telemetry not working
Competency of observer: Good

Site condition: Site is in urban setting

Maintenance and upgradation required:
No such infrastructural interventions required, Automatic station requires maintenance.

Station No.: 0113
Name of the Basin: Chameliya
Location: Gokuleshwor, Nayalbadi

GPS Reading
Latitude: 29.67805
Longitude: 80.56215
Elevation (m): 756

Type of instruments: Ordinary Rain Gauge,Dry/Wet/Maximum/Minimum Temperature

Accessibility: 1 KM upslope from Access road to Chameliya HEP, 1.5 KM from Gokuleshwor Bazaar

Power supply: National Grid, Good sunlight
Communication: NTC, Ncell
Signal strength: Very Good
Present condition of equipment: Good Condition but needs upgrade to telemetric
Competency of observer: Good

Site condition: On a good flat terrain but access is via trail way upward from road head

Maintenance and upgradation required:
No such infrastructural interventions required, Upgrade to Telemetry required.

Station No.: 0118
Name of the Basin: Rangun
Location: Jogbudha

GPS Reading
Latitude: 29.11667
Longitude: 80.35
Elevation (m): 418

Type of instruments: Ordinary Rain Gauge

Accessibility: 200 mfromJogbudha - Daiji road

Power supply: National Grid, Good sunlight
Communication: NTC, Ncell
Signal strength: Very Good
Present condition of equipment: Good Condition but needs upgrade to telemetric
Competency of observer: Good

Site condition: On a good flat terrain

Maintenance and upgradation required:
maintenance of fencing is required, Upgrade to Telemetry required.

OXFAM
Country Office Nepal
Jawalakhel, Ward no. 20, Lalitpur
G. P. O. Box: 2500, Kathmandu, Nepal
Tel: +977-1-5542881 | Fax: 977-1-5523197
Website: www.nepal.oxfam.org
www.facebook.com/OxfamInNepal
www.twitter.com/OxfamInNepal

For further information contact
Rajan Subedi, Team Leader, rasubedi@oxfam.org.uk and
Samira Shakya, Project Coordinator, sshakya@oxfam.org.uk

Sweden Sverige