Establishment and Operation of a Flood Information System in the Hindu Kush Himalayas

"Making information travel faster than floods"

HKH HYCOS USER PHASE

2015 – 2019

Project Document

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Contents

List of Acronyms

ADDG	Abu Dhabi Dialogue Group
APFM	Associated Programme on Flood Management
BMD	Bangladesh Meteorological Department
BWDB	Bangladesh Water Development Board
CMA	China Meteorological Administration
CWC	Central Water Commission (India)
DANIDA	Danish International Development Agency
DCP	Data Collection Platform
DHM	Department of Hydrology and Meteorology (Nepal)
DHMS	Department of Hydromet Services (Bhutan)
DMC	Disaster Management Centre (India)
FFC	Federal Flood Commission (Pakistan)
FFD	Flood Forecasting Division (Pakistan)
FFWC	Flood Forecasting and Warning Centre (Bangladesh)
FMI	Finnish Meteorological Institute
FNEP2	Finnish-Nepalese Project for Improved capability of the Government of Nepal to respond to the increased risks related to the weather-related natural disasters caused by climate change ICI project 2nd phase
GBM	Ganges, Brahmaputra and Meghna river basins
GLOF	Glacial Lake Outburst Flood
GTS	Global Telecommunication System
HKH	Hindu Kush Himalayas
HYCOS	Hydrological Cycle Observing System
ICI	Institutional Co-operation Instrument by the Foreign Affairs Ministry of Finland
IMD	India Meteorological Department
ICIMOD	International Centre for Integrated Mountain Development

NHSs National Hydrological Services

NMSs National Meteorological Services

NHMSs National Hydrological and Meteorological Services

NIDM National Institute for Disaster Management (India)

PMD Pakistan Meteorological Department

PMU Project Management Unit

RGoB Royal Government of Bhutan

RSC Regional Steering Committee

SAARC South Asia Association for Regional Cooperation

SAWI South Asia Water Initiative

SHSB Strengthening Hydro-Meteorological Services for Bhutan ICI project

USAID/OFDA United States Agency for International Development, Office of US Foreign Disaster Assistance

WAPDA Water and Power Development Authority

WIS WMO Information System

WHYCOS World Hydrological Cycle Observing System

WMO World Meteorological Organization

Executive Summary

Floods are a major natural disaster aggravating poverty in the Indus and Ganges-Brahmaputra-Meghna (GBM) basins, which is home to over 600 million people and almost half of the world's poor. The increasing frequency and intensity of transboundary flood events in the Hindu Kush Himalayan (HKH) region, which is likely to continue or worsen due to climate change, reinforces the importance of regional cooperation and capacity development in flood forecasting and early warning systems. Recent floods in Pakistan (2010) and India and Bangladesh (2007) highlight the tremendous impact, including humanitarian and economic losses, of floods on communities across this vulnerable region. The HKH-HYCOS project represents a regional response to these challenges through the establishment of a regional flood forecasting information system in the HKH region based on the World Meteorological Organization's WHYCOS (World Hydrological Cycle Observing System). In the **preparatory phase** from 2001-2005– ICIMOD and the World Meteorological Organization (WMO) led a consultative process with hydrometeorological services and disaster management agencies in the HKH region together with interested donors to establish a WHYCOS-type system. These endeavours culminated in the funding of the HKH-HYCOS project from 2009-2014 by the Government of Finland, representing the **implementation phase**.

The Implementation Phase of the HKH-HYCOS project delivered tangible outputs towards improved regional cooperation on flood risk management including the installation and operation of 30 upgraded hydrometeorological stations in four countries (Bangladesh, Bhutan, Nepal and Pakistan) and the facilitation of real-time data transmission using state-of-the-art technology. Regional and national flood information systems have been developed, and during 2014 the data from these systems will be used to pilot regional flood outlooks. Quality control guidelines have been developed and will be implemented during 2014. A framework for cooperation among partner countries has been established through regular six-monthly meetings of the Regional Steering Committee. Training activities have improved the capacity of partner country agency staff on the installation, operation, and maintenance of hydrometeorological stations, and on the operation of national flood information systems. Studies have been completed on the assessment of early warning systems from a gender perspective. This Phase of the project will come to an end in December 2014.

Based on lessons learned and achievements of the previous phases of HKH-HYCOS and on feedback from partner institutions in the member countries, this document sets out the design for a new phase of work to expand and scale up its operations. **The overall goal of HKH-HYCOS User Phase is to contribute to protect lives, livelihoods, property of vulnerable communities, and infrastructure by enhancing flood risk management capacity in the HKH region**. This fits into the ICIMOD's 2012 strategy and results framework 2013-2017.

Two key outcomes are envisaged:

- (1) Improved end user interface through the improvement of the operation and application of flood information systems and their products by member states and vulnerable communities.

- (2) Improved flood forecasts for flood risk management through building capacities of hydrometeorological services in member countries.

These outcomes will be delivered through five main components and two supporting components:

- Component 1: Institutional mechanisms for an end-to-end flood early warning system at national and local levels (Outcome 1)
- Component 2: Capacity of partner institutions in flood modelling, forecasting, and information exchange (Outcome 2)
- Component 3: Observation network operation and maintenance (Outcome 2)
- Component 4: Flood information system operation and maintenance (Outcome 2)
- Component 5: Regional and international partnerships (Outcome 1)

Supporting Components

- Component 6: Project reporting and monitoring
- Component 7: Communication and Outreach

The total cost of the project is 5,000,000 Euros.

The project will enhance the technical capacities of national hydrometeorological agencies and improve communication between disaster management authorities and the end users of flood information. In partnership with various stakeholders, the project will build the capacity of vulnerable communities and enhance their accessibility, understanding, and acceptance of different flood information products and the associated timely response.

At the end of the project, countries will be able to operate a comprehensive flood information system that provides the most important information for flood risk reduction based on users' needs; flood information will be disseminated at regional, national, and local levels, including to communities at risk, through strengthened institutional mechanisms; and there will be enhanced regional cooperation in flood forecasting and information exchange and real-time data will be available and utilized in transboundary basins.

HKH-HYCOS User Phase will build on successful engagement with agencies in Bangladesh, Bhutan, Nepal, and Pakistan and will seek greater involvement with agencies in China and India, and potentially Afghanistan. In this way, and through the components and activities described in detail in this document, the goal of contributing to protect lives, livelihoods, property, and infrastructure by enhancing flood risk management capacity in the HKH region can be achieved.

1 INTRODUCTION

This document sets out the design for the new phase of a project to establish and operationalize a regional flood information system in the Hindu Kush Himalayas (HKH). Based on the World Meteorological Organization’s WHYCOS (World Hydrological Cycle Observing System), the HKH-HYCOS project is entering a new phase of work building on previous achievements, expanding its network, and scaling up its operations. **The overall goal is to contribute to protect lives, livelihoods, property of vulnerable communities, and infrastructure by enhancing flood risk management capacity in the HKH region**.

This new phase of work termed as the “**User Phase**” builds on efforts by ICIMOD, WMO, and regional partners to establish a regional flood information system since 2001, which culminated in the implementation of the HKH-HYCOS project from 2009-2014 with financial support from the Government of Finland. This project contributes to the ICIMOD strategic Framework 2012 and the medium term action plan set out for 2013-21017. In particular, contributing to ICIMOD’s strategic goals of making significant advances in generation and use of relevant data, knowledge and analysis; and the goal of enhanced regional cooperation related to sustainable mountain development (ICIMOD, 2012). This proposal is based on the discussions of the participating countries with ICIMOD and WMO through several meetings and experiences of the activities in the preparatory and implementation Phases.

This document comprises an introduction, four sections and seven appendices. After this Introduction, Section 2 aims to provide a brief and strategic analysis of the background to the HKH-HYCOS project and the need to mitigate flood risks in the HKH region to support sustainable development in the context of climatic and societal change drivers. Section 3 sets out the project’s goals and objectives as well as the theory of change and impact pathways underlying this project. Section 4 describes the draft work plan and component descriptions. Section 5 describes the implementing and resourcing of the project and its long-term sustainability. Appendix I provide background information on natural vulnerability to flooding and climate change. Appendix II provide socioeconomic indicators of the countries of HKH. Appendix III provide background information on the characteristics of the project river basins. Appendix IV provides information on cooperation and data sharing activities between countries of the HKH region. Appendix V provides a brief note on flood forecasting. Appendix VI provides details on other regional initiatives relevant to the HKH-HYCOS project. Appendix VII provides the logical framework analysis (LFA) for the project.

The International Centre for Integrated Mountain Development, ICIMOD, is an inter-governmental, regional knowledge development and learning centre serving the eight regional member countries of the Hindu Kush Himalayas (HKH); Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal and Pakistan. Further information on the ICIMOD’s strategic framework and organizational setup is available at the website www.icimod.org. In 2013 ICIMOD celebrated its thirtieth year working for the mountains and people of the HKH region.

2 BACKGROUND AND RATIONALE FOR USER PHASE

2.1 Historical background and project partners

The origin of the HKH-HYCOS project, or preparatory phase, began between 2001-2005 with a feasibility and infrastructure testing study with the objective of developing a framework for regional flood cooperation to support disaster prevention and flood management. ICIMOD and WMO in May 2001 organized a high level consultative meeting on Regional Cooperation for Flood Forecasting and Information Exchange. This meeting was supported by the US Department of State (Regional Environment Office for South Asia), the US Agency for International Development, Office for US Foreign Disaster Assistance (USAID/OFDA), and the Danish International Development Agency (DANIDA). Participants from Bhutan, Bangladesh, China, India, Nepal and Pakistan by consensus agreed on the need for sharing of high river flow data and expressed interest in establishing a regional flood information system based on the proven concept of the WHYCOS (see http://www.whycos.org/whycos/ for more details). A project document “Establishment of a Regional Flood Information System in the Hindu Kush Himalayas” was prepared and endorsed by the regional member countries in May 2005.

This full project document was submitted to the Government of Finland, Ministry of Foreign Affairs, which funded the project from Dec 2009 - Dec 2014. Therefore this project is a regional component of the global WHYCOS programme. This implementation phase of the HKH-HYCOS project, current Phase, focussed on capacity building for flood forecasting, establishment of a regional flood information system and methodologies to obtain real-time hydrological observations.

The Regional Steering Committee (RSC) was established as the highest executive body of the HKH-HYCOS project. Its role is to ensure project coherence and to oversee project policy, strategy, and implementation. It decides on any changes to the project document and approves the annual work plans, budgets and reports, and undertakes other executive responsibilities. The committee consists of representatives of the participating countries and their executing agencies, ICIMOD and World Meteorological Organization (WMO), and is serviced by the Project Management Unit (PMU). To ensure the effectiveness of the RSC, the participating countries designate representatives with clear decision-making authority in matters pertaining to the implementation of the project within an agreed policy framework. The RSC meets on a six monthly basis. A list of HKH-HYCOS partners is provided in Table 1.

Table 1 List of partners of HKH HYCOS

Implementing and coordinating agency	ICIMOD
Technical/scientific support agency	World Meteorological Organization (WMO) Finnish Meteorological Institute (FMI)
Partner countries	Bangladesh: Bangladesh Meteorological Department (BMD); Bangladesh Water Development Board (BWDB)
	Bhutan : Department of Hydro-Met Services (DHMS)
	China: China Meteorological Administration (CMA); Bureau of Hydrology (BoH) Observer
	Nepal: Department of Hydrology and Meteorology (DHM)
	India: Central Water Commission (CWC) Observer Indian Meteorological Department (IMD) Observer
	Pakistan: Pakistan Meteorological Department (PMD); Water and Power Development Authority (WAPDA)
Private sector partner	Real Time Solutions (RTS) Pvt Ltd

2.2 Key achievements of HKH-HYCOS to date

The implementation phase of the HYCOS project has strengthened regional cooperation for sharing of hydrometeorological data in the HKH region. The project has established a regional flood information system with access to real-time data from 30 hydrometeorological stations installed in four countries with plans to install another 8 stations before the end of the project period. There is exchange of flood data and information within and among four participating countries through the flood information system. All 6 partners from 4 participating countries have reported positively on their ability to receive real-time data and they are in the process of submitting the second monsoon report elaborating the experience and use of data in the second year of operation.

Several value-adding knowledge products, for example regional flood outlooks, quality control procedures, database management systems are being developed. The Department of Hydromet Services of Bhutan has implemented quality control procedures during the monsoon of 2013 and other partners have agreed to conduct the quality control at national level following similar guidelines. The quality control procedures will be embedded in all NFISs by 2014. The regional flood outlook will be piloted in 2014.

Meteorological data, from the Global Telecommunications System (GTS) network maintained by WMO, of close to 300 stations which includes data from China and India, satellite precipitation estimates, and hydrometeorological data provided by partners from non-HYCOS stations are some examples of value-added data and information being integrated into the regional flood information system. Furthermore, the project is also conducting studies on the evaluation of early warning systems with a gender perspective in Nepal, Bhutan, and Pakistan with plans to initiate studies in Bangladesh.

Framework for Cooperation

- **Strengthened framework for cooperation on sharing of regional flood data and information among partner countries**

An institutionalized cooperation among the countries Bangladesh, Bhutan, China, Nepal, and Pakistan in the field of hydrometeorology has been established. This cooperation has progressed through six-monthly meetings of the RSC and manifested in data sharing activities between these countries.

Regional flood observation network

- **Establishment of a flood observation network in selected basins in partner countries**
  Thirty hydrological and meteorological stations have been set up or improved in four countries: Bangladesh, Bhutan, Nepal and Pakistan (Figure 1). The stations automatically transfer real-time data to the Regional Flood Information System housed at ICIMOD and the National Flood Information System in each partner country. These stations are equipped with state-of-the-art sensors primarily from Vaisala and Ott international manufacturers. Eight more stations are planned for installation during 2014. Field staff from each of the member country has been trained in the installation, operation, and maintenance of the stations.

Flood information system

- **Establishment of regional and national flood information systems to share real-time data and information and increase lead time**
  A database management system has been set up at regional and national levels through the flood information system (FIS). Experts from the countries have been trained in database management. The data is available on a real time basis from www.icimod.org/hycos.

  A working group led by Finnish Meteorological Institute (FMI) developed basic quality control guidelines that have been implemented in Bhutan and will be implemented in other partner countries in 2014. A manual for quality control is available and being used by partners.

  A manual for operation of the FIS has been prepared.

  First information products, e.g., network information, graphics, and statistics, have been developed and available on the website.

  The flood outlook has been piloted in the Ganges and Brahmaputra basins and regional flood outlooks are under development.

Training and public awareness

- **Enhanced technical capacity of partners on communication to end users**
  Public awareness activities have been conducted in some countries. Initial planning towards the effective dissemination of data and information to the end users has started.

  Two regional trainings were held in Nepal focusing on training middle-level managers so that they could further train junior staff during national level trainings. These trainings were held on a training-of-trainers basis on the following themes:
  - Installation, operation, and maintenance of hydrometeorological stations; and
  - Database management and operation of NFIS.

The training on installation, operation, and maintenance of hydrometeorological stations was repeated at a national level in Bhutan, Nepal, and Pakistan where the trainees of the regional training served as trainers. A similar national training will be held in Bangladesh in 2014.

Likewise, database training was repeated in Bhutan and plans are underway to conduct these trainings in other countries.

Three studies on the assessment of early warning systems with a gender perspective have been conducted in Bhutan, Nepal, and Pakistan. An additional study in Bangladesh is due to be completed in 2014.

Each country has different levels of know-how and capacity, and the adoption of the project's products depend on each country's needs and capacity. For example, Bhutan has fully adopted the project's Flood Information System (FIS) and uses it for its national flood risk management. Nepal is also largely adopting the FIS for national use. Bangladesh is integrating the flood risk data delivered by HKH-HYCOS into its own national information system.

In addition, the HKH-HYCOS system includes real-time data from over 70 hydrometeorological stations from the flood-forecasting network of Nepal, kindly provided by the Department of Hydrology and Meteorology, Nepal. Fifteen of the World Meteorological Organization's (WMO) Global Telecommunication System (GTS) stations are in Nepal. Meteorological data from an additional 300 stations in the region from the GTS network which includes meteorological stations from China and India will be displayed as soon as the Department of Hydrology and Meteorology (DHM) upgrades its server.

2.3 Mid-Term Review

From September to December 2012 a mid-term review was carried out covering the topics of effectiveness, impact, efficiency and programme management, sustainability, cross-cutting objectives, aid effectiveness, coordination, complementary and coherence and design. The investigation provided some valuable recommendations and lessons learned for the next phase. e.g.:

- Letters of intent from partner institutions should be obtained before submitting proposals to donors.
- The involvement of national hydro-met institutions as project partners has been a good, strategic choice.
- Steering mechanisms and implementation arrangements warrant a detailed analysis of the project design to support efficient project management also under difficult circumstances.
- Capacity building activities must suit the local context and address local capacity building gaps to be truly relevant and sustainable.

When planning investments on modern hydrometeorological equipment, aspects of operation and maintenance of the equipment and instruments are important criteria that should be considered during instrument selection. Partner responsibilities for operation and maintenance should be clearly outlined in the agreements.

This proposal has been developed considering the lessons learnt from the Implementation Phase of the project and recommendations made by the mid-term review.

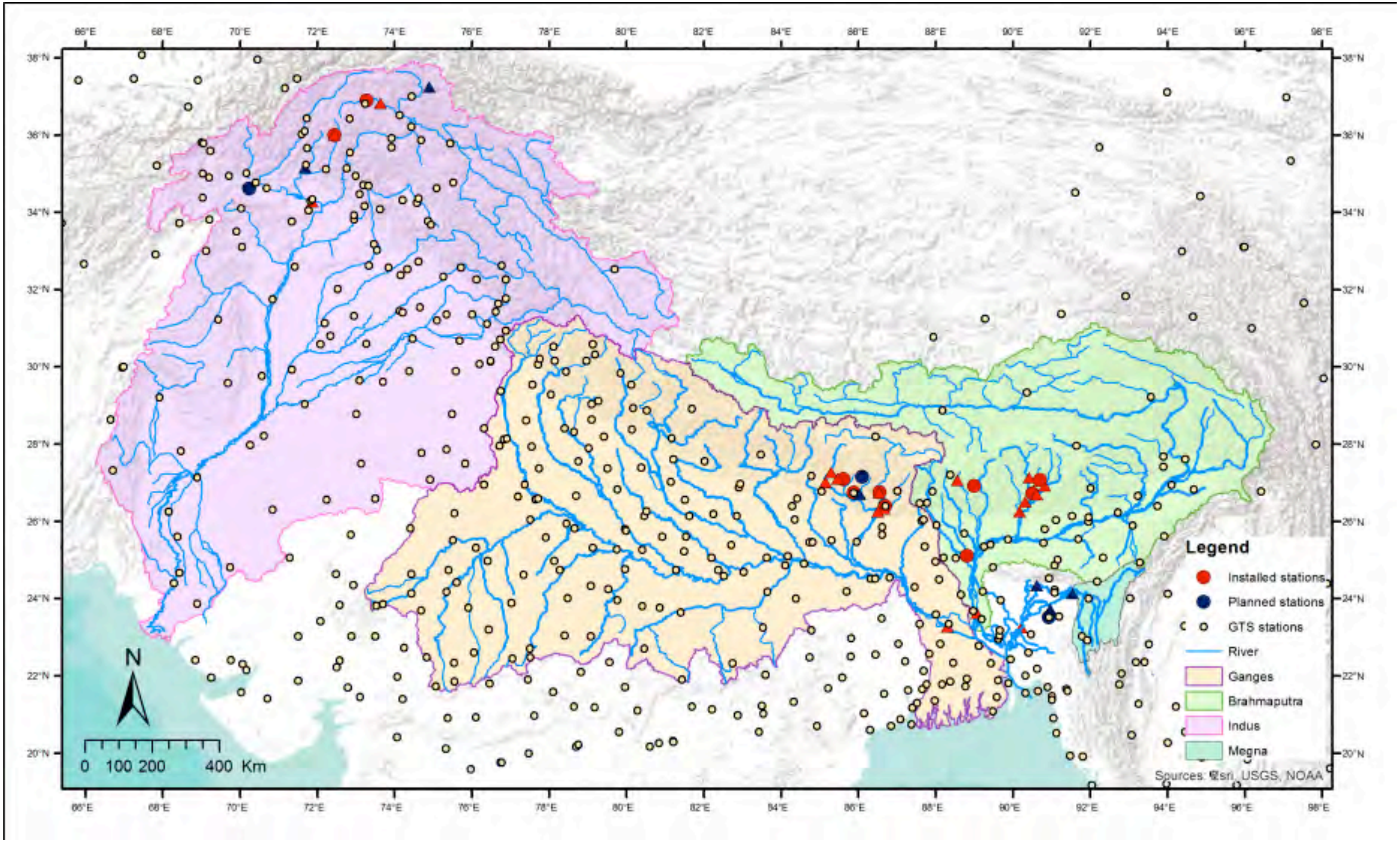

Figure 1 Location of hydrometeorological stations upgraded in implementation phase

2.4 Making the case for a User Phase of HKH-HYCOS

2.4.1 Rationale

The frequency and intensity of transboundary flood events in the region have increased in the past decade, and this pattern is likely to continue or worsen due to climate change. Every year, a large swathe of India – notably the Indo-Gangetic Plain – and a quarter of Bangladesh are inundated with flood waters, which displace millions of people and result in damage estimated at billions of dollars. The 2010 floods in Pakistan killed 2,000 people and left 20 million homeless, with a financial loss of USD 10 billion (FFC, 2010); the 2007 floods in India and Bangladesh killed more than 3,000 people and left millions homeless. These flood events emphasize the need to strengthen national flood forecasting systems, which can be done through the establishment of a regional flood observation system that takes a basin-wide approach.

Kundzewicz (2002) analysed the sustainability of various flood preparedness measures. Non-structural measures, such as flood forecasting and warning, disaster contingency planning, capacity building, improving flood awareness, understanding and preparedness, were rated higher with respect to sustainability than the construction of large physical flood infrastructure and other structural flood preparedness measures.

Improving flood forecasting in the countries of the Hindu Kush Himalayan region requires a comprehensive system with extended spatial coverage beyond national boundaries that can contribute vital real-time data to a regional flood information system that is integrated with national information systems. The sharing of data and information will contribute towards building confidence and mutual trust among countries. By assisting in helping with the exchange of real-time data it will promote awareness and understanding of water resources issues regionally and needs within each country. This will have positive effects on promoting regional cooperation and on broader economic developments by improving river basin management.

Information products such as flood outlooks and early warnings should be developed to enhance the utility of the system both at regional and national level. It is necessary to demonstrate the utility of data that is being observed in real time and the dissemination of information and products to the end-users – the people and communities at-risk. Accurate forecasts should be translated into reliable warnings. There is a need for an end-to-end flood early warning system with seamless linkages between data collection, transmission, utility of data for flood modelling, development of flood information products, decision making, and dissemination of products to the communities at risk (Figure 2). The communities must be able to access, and understand these products in order to take timely action to protect their lives and property and reduce losses.

The current phase of HKH-HYCOS has developed a flood information system with limited spatial coverage and basic operational products. Through a selective network of 30 real-time hydrometeorological observation stations, it has demonstrated the willingness of the regional countries and the technical possibilities of sharing real-time data and information among countries sharing common river basins. While the activities conducted in the implementation phase of the project need to be continued for strengthening of the capacities of hydrometeorological services to provide timely and reliable flood forecasts there is a need to ensure delivery of these forecasts to end users for which appropriate institutional mechanisms need to be in place. The flood forecasts need to be tailored to the needs of the communities to prepare and respond to flood disasters. There is a need for interpretation, translation, re-packaging of forecasts/flood outlook products to increase access, understanding, and acceptance of the forecasts by communities for better preparedness.

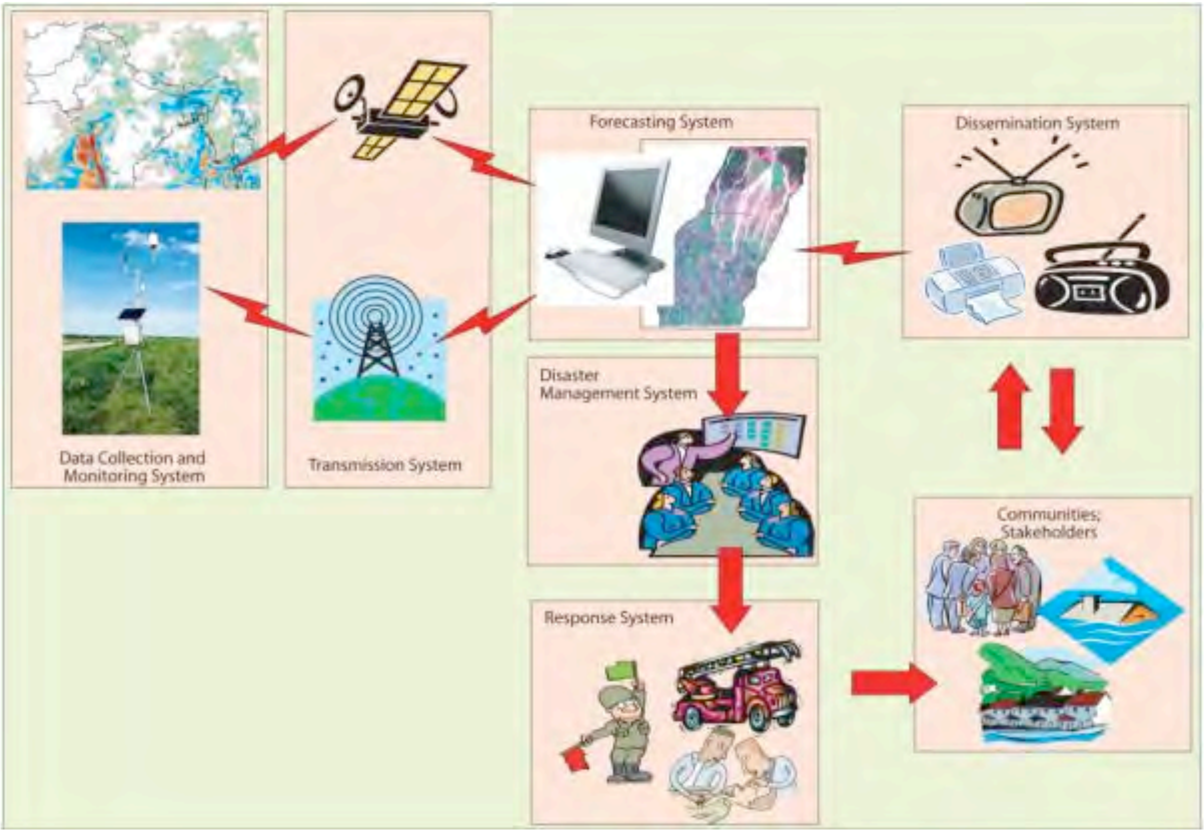

Figure 2 End to end flood early warning system

Building on the current Phase of the project, the new phase of HKH-HYCOS must further strengthen the hydrometeorological capacities of the countries in the region. In addition to regular efforts to promote regional cooperation, partners have voiced, through regular Regional Steering Committee meetings and consultations, the need to further strengthen national hydrometeorological services in terms of building their capacities in planning, operation, and the provision of hydrological information and products at the national level, as well as empowering them with appropriate mechanisms for making flood information available in a timely manner to the end users. A regional mechanism and approach is essential to ensure that countries sharing common rivers develop and adhere to similar data standards so that independent systems can communicate with each other and regional flood products are made available to support flood forecasting in the countries. This can be achieved by providing dedicated funds for national capacity building activities conducted by the countries facilitated by mandated regional and global organizations such as ICIMOD and WMO.

2.4.2 Needs of Partners

Based on discussions of the Regional Steering Committee members from the regular regional steering committee meetings, inputs and priorities expressed by partners through in country consultations, and lessons learned and achievements of the current phase of the HKH-HYCOS project the regional partners have identified the following elements for the next phase:

- Expansion of the hydrometeorological observation network within the regional member countries and upgrading of infrastructure
  - Establishment of a model station in each country
  - Installation of new hydrometeorological stations on transboundary rivers enabling partner countries to access observation-based flood information in a transboundary environment
  - Expansion of the current real-time hydrometeorological observation network
  - Supporting discharge measurements and identification of datum levels at station locations for disaster risk reduction. Discharge measurements are required to develop appropriate rating curves that can help develop the stations that translate into discharges for a given water level. Discharge data and datum levels are required for hydrological modelling, including flood forecasting and the production of regional flood flow outlooks.
  - Robust and user-friendly flood information system
  - Improvement of the quality control system and implementation of sound quality control procedures for validating data received from hydrometeorological stations
  - Operation of regional and national flood information systems in terms of data acquisition and sharing
  - Support for strengthening national flood information systems and making appropriate connections for hydrological modelling
  - Identification of appropriate alert levels, such as warning and danger levels, in hydrological sites at which to automatically alert concerned officials and communities
- Knowledge products and flood information generation
  - Review of all flood modelling tools and technologies available in the regional member countries for flood forecasting
  - Strengthening of flood modelling capabilities for improved flood forecasts at the national level to improve flood warning at the local level
  - Generate flood outlooks at the regional level
  - Incorporation of additional integrated regional and local products into the flood information system
- Strengthening end user interface
  - Linking of early warning and flood information products with national disaster management authorities and related agencies
  - Development of communication strategies and mechanisms for dissemination of the flood information to the end users
  - Processing, packaging, and dissemination of information to the end users for timely action to be taken on the ground

- Strengthening of public awareness and communication to end users with a special focus on disaster risk reduction

- Capacity building, education, and training
  - Execution of continued capacity building programmes, embedded in national services and with a regional perspective
  - Strengthen the capabilities of the national services to provide important information of the country for public awareness and communication to end users with a special focus on disaster risk reduction
  - Improving quality and reliability of monitoring data and hydrological products through training, personnel exchange between the countries to strengthen the comparability, quality of data, and products as well as standardized management and procedures
  - Improving capabilities for data collection, processing, archiving, and provision of data
  - Improving the capabilities for modelling and flow forecasting at national services, including the transfer of know-how to enable the use of other global and regional terrestrial and space-based observational data and models
  - Implementation of e-learning programmes and certification of skilled officers
  - Supporting the exchange of hydrological data and products, other than those included in the HKH-HYCOS, between the national services to develop precise flood information in a transboundary environment
  - Provision of mid-term support to the countries with spare sensors and loggers as well as equipment for the operation of the network
  - Facilitating cross-learning
- Cooperation/coordination with other hydrometeorological projects in the region.

2.4.3 **Beneficiaries and benefits to be derived**

The main beneficiaries of the Project are the vulnerable communities living in the flood prone areas in the region, whose lives and livelihoods are at risk due to extensive flooding. Being among the poorest of the poor they are extremely vulnerable to floods, and timely exchange of data and knowledge products on floods through proper institutional mechanisms at various levels will make it possible to reduce the threats to their lives and livelihoods and infrastructure. The project will thus have a direct and substantial poverty reduction effect particular to those living in flood prone areas.

As an outcome of the current phase of the project there is access to and exchange of real-time data from a network of hydrometeorological stations in the GBM and Indus river basins between and amongst the countries. Decision-makers in flood forecasting centres and National Hydrological and Meteorological Services and organizations that are responsible for flood forecasting, flood disaster prevention and management in each of the participating countries are direct beneficiaries of the project. Further strengthening the capacity will lead to improving their capacity to forecast floods more accurately, issue flood warnings and provide flood advisory services that are critical for flood disaster prevention and management. Other benefits of the project include capacity building and institutional strengthening of and improved institutional linkages within and between hydrometeorological services. Their ability to operate and manage the modern systems for data collection and management, data exchange and information dissemination in both national and regional contexts will be strengthened.

In the next phase the project seeks to strengthen the current institutional mechanisms of early warning system with better linkages between hydrometeorological services and disaster management authorities and public awareness and sensitization of flood management and flood preparedness at various levels will be piloted in communities. The hydrometeorological agencies will continue to benefit with Improving national capabilities for delivering improved flood forecasting services and providing extended forecasting period through the availability of regional flood information products.

The benefits derived by upper riparian countries vary depending upon their capacities. While some upper riparian countries would mostly benefit through improved knowledge, flood forecasting capabilities, improved infrastructure and improved methods and standards of network operations and data management, other countries would benefit by extending humanitarian concern for saving lives and property, generation of knowledge and knowledge products and broadening regional cooperation. Additionally, the incentive for lower riparian countries would be extended warning times of floods. Lower riparian countries will derive additional benefits from environmental conservation activities of the upper riparian countries. The project will provide a forum to assess the contribution of upper riparian countries in reducing flood magnitudes through careful forest management practices, for example. This assessment would lead to identification of activities for protection of watersheds in upper riparian countries.

It should be noted that the population affected by floods in the downstream region is greater than the population that resides within the flood-prone areas of the Himalayan region. Floods due to the intertwined social-economic conditions affect most of the nearly 600 million people living in the GBM and Indus basins. The target population can, in general, be characterized as having limited resilience to recurring flood events.

An important spin-off effect would then also be the availability of regional hydrological data for a whole host of other applications including on water resources assessments. In addition, the benefits of participating in WMO's WHYCOS programme will be an opportunity to cooperate more effectively with other members of the international community, thus ensuring access to, and benefit from, state of the art forecasting, early-warning methods, operation of trans-boundary, integrated hydrological information systems and aspects of flood management.

2.4.4 Expected end-of-project situation

Based on the WHYCOS concept, the project will establish a framework for regional co-operation that will ensure efficient collection and real-time transmission of hydrometeorological data for flood forecasting and warning and the sharing of information for effective flood management within the GBM and Indus river basins. The end-of-project situation is expected to be:

- the countries will be able to operate a comprehensive flood information system that provides the most important information for flood risk reduction based on the needs of the users;
- flood information is disseminated at regional, national, and local levels including communities at risk through strengthened institutional mechanism;
- there is enhanced regional cooperation in flood forecasting and information exchange and real-time data are available and utilized in transboundary basins.

3 USER PHASE – EXPANDING AND OPERATIONALIZING HKH-HYCOS

3.1 Project goal

The overall project goal is to contribute to protect lives, livelihoods, and property of vulnerable communities and infrastructure by enhancing flood risk management capacity in the HKH region.

3.2 Outcomes

Outcome 1. Improved end user interface through the improvement of the operation and application of flood information systems and their products by member states and vulnerable communities

Indicators

- 1.1 Number of community organizations, local government institutions adopting project products in their Disaster Risk Reduction plans in at least 4 Regional Member Countries.
- 1.2 Increased demand of flood information and related products by government line agencies and community organizations in at least 4 Regional Member Countries.
- 1.3 Provincial, district, and local level disaster management authorities utilize flood information products in a timely manner.
- 1.4 Number of Regional Member Countries participating in transboundary cooperation activities.

Outcome 2. Improved flood forecasts for flood risk management through building capacities of hydrometeorological services in member countries

Indicators

- 2.1. National institutions providing quality real-time data and shared at national and regional levels.
- 2.2. Operational forecast models are used by national hydrometeorological services for flood forecasting
- 2.3 Regional flood outlook products used by national agencies (Maps, alerts, water levels, and discharge at various locations along the rivers)

3.3 Expected outputs

Expected outputs are:

- The hydrometeorological network for real-time data collection and transmission is expanded in the regional member countries (Component 3)

- Quality real-time data is available through the flood information system of regional member countries through implementation of enhanced quality control procedures (Component 4)
- Improved capacity of regional member countries to run flood models and provide forecasts (Component 2)
- Regional flood outlook products are developed and made available to national hydrometeorological agencies. (Component 2 and Component 4)
- National Hydrometeorological agencies capacity built to use state-of-the-art technology, real-time quality data and models for flood forecasting (Component 2)
- Flood information products available from national hydrometeorological services to disaster management authorities (Component 1)
- Institutional mechanism for flood information dissemination developed/strengthened (Component 1)
- Public awareness and communication efficient mechanisms are in place to share flood information and outlook products to end users for timely response (Component 1)
- China and India provide knowledge products and information to support flood information systems (Component 5)
- Improved coordination and cooperation with other hydrometeorological projects in the region and implementation of existing and available products, e.g. WMO regional project " South Asia Flash Flood Guidance System" (SAsia- FFG), the World Bank „Pilot Project on Climate Resilience" (PPCR) and other regional and national projects.

3.4 Project components

The expected outcomes will be delivered through five main components and two supporting components.

- Component 1: Institutional mechanism for an end-to-end flood early warning systems (Outcome 1)
- Component 2: Capacity of partner institutions in flood modelling, forecasting, and information exchange (Outcome 2)
- Component 3: Observation network operation and maintenance (Outcome 2)
- Component 4: Flood information system operation and maintenance (Outcome 2)
- Component 5: Regional and international partnerships (Outcome 1)

Supporting Components

- Component 6: Project reporting and monitoring
- Component 7: Communication and outreach

Component 1: Institutional mechanism for an end-to-end flood early warning system

The aim of this component is to develop an end-to-end flood information system and pilot flood early warning system as a means to strengthen institutional mechanisms for flood information delivery to at-risk communities and ensure last-mile connectivity. The communities at risk need to understand the flood information and knowledge products delivered to them and act in a timely manner in order to save lives and property. Activities under this component will focus on understanding the current institutional mechanisms in place for flow of information and the accountability/responsibility structure, documenting best practices of early warning systems in the regional member countries, coordinating with various stakeholders including the disaster management authorities and those representing social and economic interests, and providing training to communities, sensitizing and raising public awareness.

Component 2: Capacity of partner institutions in flood modelling, forecasting, and information exchange

During consultation with the partner countries the development of expertise in hydrologic and hydraulic modelling and flood forecasting was highlighted as a key requirement by the hydrometeorological agencies. Developing flood outlook products that are of national and regional interest requires trained human resources within the national hydrometeorological services. This can be achieved through capacity building activities particularly relating to flood modelling and outlook development skills. Activities under this component will focus on implementing various trainings in flood modelling and the development of outlook products and the utilization of the real-time data from the hydrometeorological stations.

Component 3: Observation network, operation, and maintenance

In the implementation phase of the HYCOS project, a limited number of hydrometeorlogical stations were installed to demonstrate the willingness of regional member countries to share real-time data and utilize state-of-the-art technologies for data collection and transmission. This limited number of stations needs to be further expanded to be able to provide real-time data for flood forecasting.

The activities in this component will build on current phase and will include procurement and delivery of equipment to the partner countries. The partner countries will be responsible for the civil works, installation, operation, and maintenance.

In addition, discharge measurements to establish rating curves at the hydrological stations will be carried out so that the data collected can be used for flood forecast modelling and early warning. Furthermore, efforts will be made to work with hydrometeorological agencies, local government bodies, and NGOs to establish different alert levels for providing warning services through the institutional mechanism.

Component 4: Flood information system operation and maintenance

A flood information system at the national and regional level will be set up and upgraded as part of the activities of this component. For the flood information system to be robust and useful, it is essential to ensure interoperability of different systems to provide real time data for flood forecasting. For this purpose, the project will make efforts to provide interoperability within and across the countries.

The database developed in the current phase will be improved and upgraded to house high quality real time data and information. Quality control procedures will be implemented by all regional partners in their national flood information system and will operationalize the system on a 24/7 basis. In order to add value to the flood information system, data from various sources, including space based information, will be integrated for use in flood modelling and developing flood outlook products.

Component 5: Regional and international partnerships

There are a number of institutions and agencies at the national and regional level that have synergies with the HYCOS project. Activities of this component will include building synergy with other programmes and projects and avoiding the duplication of efforts in order to strengthen the capacities of hydrometeorological agencies to deliver products and services to protect lives and livelihoods.

As an activity under this component, concerted efforts will be made to bring in India and China on board. While it is desirable to bring them fully on board, which will be a long-term effort, during the project period India and China are expected to join as knowledge partners sharing know-how and data products for improved flood forecasting in the region and participating in capacity building activities of the project.

The project will also attempt to scale out by expanding its geographic focus to include Afghanistan.

Component 6: Project reporting and monitoring (Supporting Component)

This supporting component is designed to maintain the effective coordination and integration of all component outputs to deliver high quality science with clear development impact. ICIMOD will lead this through the activities of a Project Management Unit (PMU). Further details on the PMU and other project management issues are described in Section 5. Activities under this component include day-to-day management and coordination, the organization of workshops and other meetings, project reporting, and overall project monitoring.

Component 7: Communication and outreach (Supporting Component)

Communication is a key element for the achievement of HKH-HYCOS programme goals. Knowledge and communication tools will be used to foster the development of best practice procedures for supporting end-to-end flood risk reductions; to give voice to relevant beneficiaries; to mobilize people for participation and action; to convey information for learning and training; to promote regional cooperation; and to support efficient intracomponent collaboration and effective component outputs. Key aims of this component will include:

- To share and deliver knowledge in audience-appropriate forms
- To raise awareness of HKH-HYCOS results and demonstrate programme outputs
- To support intracomponent collaboration and effective component outputs with quality communication tools, locally, regionally, and globally
- To communicate evidence-based knowledge and policy options that will enhance decision making and to ensure the coproduction of knowledge with communities and across national boundaries.

Particular attention will be given to identifying and engaging with key target audiences in an appropriate manner (Table 2).

Table 2 Knowledge sharing strategy and means

Audience	**Knowledge sharing strategy and means**
Scientific community	- Primarily through publication in peer-reviewed journals or books - Participation and presentations in conferences
Policy makers	- Policy briefs, face-to-face meetings, policy conferences, checklists, side events in regional and international processes - Multimedia products (video, slideshows)
Local communities, organizations, and stakeholders	- Intermediaries (extension workers, practitioners, NGOs) - Posters, cartoon booklets, multimedia and video products, radio and TV programmes, street theatre - Formal and informal local networks
(Inter)national institutions	- Strategic and operational partnership - Contact database creation
Mass media	- Press releases, news stories, articles, web-based stories, multimedia products - Well-established network and partnership with local, national, and regional journalists and media houses - Use of social media (Twitter, Facebook, YouTube)

3.5 Gender Integration

Gender equality is one of ICIMOD's strategic functions and trying to integrate the issue across all its programmes and initiatives by ensuring the points of view of everyone in the society, regardless of gender, caste, or ethnicity (ICIMOD 2012). The findings of country studies on flood early warning systems indicated that gender integration is in very early stages, with a limited understanding of vulnerability and capabilities of the population at risk. Women are more at risk because of social constraints and traditional roles where they are confined–such as agriculture – which is more at risk to floods. The level of awareness on the importance of gender concern in EWS has been raised, but there are little practical insights on how and why gender consideration is relevant to flood EWS.

All participating countries are quite good in disseminating formal warning messages across national, provincial, and local scales; however, the vulnerable communities are not being well-served by the current formal flood EWS. There are multiple organizations involved in disaster risk reduction within the country, but their roles, inter-relationships, coordination and accountability mechanisms are not very clear as most of the activities and responsibilities are overlapping and fragmented. This suggests for an urgent need to improve current practice through collective efforts among key stakeholders that enable them to negotiate and agree on joint plans for people-centered flood EWS. Such a platform demands the strong involvement of local actors, such as district and municipal government representatives, NGO field staff, and community representatives in developing guidance on resource mobilization for its effectiveness and sustainability. To be effective, early warnings must have a sound scientific basis along with a strong focus on serving the people exposed to flood risk.

Current approach on DRR focuses mainly on the response capacity, and communication and dissemination, with weak linkages to systematic risk assessment and monitoring mechanisms. The people-centered flood EWS need to be promoted strategically at the national and community levels integrating gender with strong commitments of key stakeholders at all levels.

Specific recommendations for integrating gender into early warning systems include:

- Sensitization on people-centered flood EWS is needed for key stakeholders at national, provincial and local levels. A regional workshop to share learnings from country studies could be a key activity.
- Capacity building of key stakeholders, including government staff, and community volunteers on gender sensitive early warning systems.
- Develop context-specific communication strategies focusing on dissemination channels and information products that are gender-sensitive and inclusive.
- Conduct an in-depth study on existing institutional mechanisms to see gender differences and impacts on disaster risk reduction

Considering these lessons, the next phase of HYCOS will pilot gender integration in ten selected risk prone communities to enable an effective end-to-end flood information system and have in place a gender responsive flood early warning system.

3.6 Project activities

Based on the stated necessities of the partners the following activities are planned:

3.6.1 Component 1: Institutional mechanism for an end-to-end flood early warning system at national and local levels

3.6.1.1 Review of the current institutional mechanisms for flood information dissemination and regional cooperation mechanism

Current national institutional mechanisms in place for flow of information from flood observation, processing, and dissemination to key stakeholders and strategies to achieve last-mile solutions will be reviewed and analysed in the regional member countries. The review will also include better understanding the accountability/responsibility structure for flow of information between and within institutions. The review shall analyze the gender differences existing in the institutions within the country and also between and among the countries. More importantly, new stakeholders from the private sector will be identified to play a role in national institutional mechanisms and recommendations will be made for formalizing a regional mechanism.

3.6.1.2 Understanding current effectiveness of flood forecasting at community level

For an end to end flood early warning system there is a need to understand the effectiveness of flood forecasting at community level to see whether the information is reaching out to them in a manner that is understandable and actionable. This will be done through field work and local level consultation with village communities.

3.6.1.3 Document best practices of end-to-end flood risk reduction

Best practice procedures of early warning systems for supporting end-to-end flood risk reduction, e.g. support of warning products using both regional (HKH-HYCOS) and national flood information and forecasts will be documented.

3.6.1.4 Organize national multi-stakeholder consultation

Integrated flood management is influenced by economy, ecology and sociology. The project will therefore also address the social aspects presented by stakeholders. There will be a national stakeholder consultation in each partner country to create linkages between national hydrometeorological services with disaster management authorities as well as other players in disaster risk reduction. The multi-stakeholder consultation will establish links between various actors and improve communication to better understand the end users needs.

3.6.1.5 Organize regional consultation of hydrometeorological and disaster management authorities

The regional consultation will expand cooperation of hydrometeorological agencies with disaster management authorities in the countries and improve communication through the sharing of experiences and know-how in the field.

3.6.1.6 Institutionalize gender mainstreaming in early warning systems (EWS)

The recommendations based on a study of EWS with a gender perspective in regional countries conducted in the current phase will be implemented to make EWS gender sensitive. Experiences from other regions indicate that early warning systems are more effective if individuals and groups understand the benefits of such systems. The activity will include public awareness campaigns, trainings and understanding the needs of the communities. The activity will focus on building capacity of women and men to access understand and respond to flood forecasts.

3.6.2 Component 2: Capacities of regional member countries in flood modelling

3.6.2.1 Review of current flood modelling tools and methods

There are many hydrological models in use by partner countries to generate runoff from catchments. Stocktaking of the various existing hydrologic and hydraulic models that are being operated by the member countries for generating runoff and flood forecasting purposes will be conducted.

3.6.2.2 Develop training materials in flood forecasting tools and modelling

Training material and training courses will be developed by ICIMOD together with the academic institutions and provided to the RMC hydrometeorological services and universities. As much as possible e-learning programmes will be developed.

3.6.2.3 Hold regional training in flood modelling for the transfer of know-how to further develop modelling capacity in the countries

Support the countries through trainings to use real-time data for flood forecasting and developing flood outlooks, watches, and warnings that are relevant to local impact and vulnerable constituencies at the sub-basin, sub-catchment, and watershed level.

Certification courses will be conducted for skilled officers of national services.

3.6.2.4 Hold regional level training on the integration of weather forecasts into flood modelling

Integration of regional weather forecast information such as WRF and GFS from global and regional institutions into flood models to improve flood forecasts.

3.6.2.5 Flood modelling at a basin level by partners

Based on a review of the models and performance identification, the appropriate model for rainfall runoff and flood forecasting purposes (across all member countries) will be identified and selected.

Provision of the model to partners in regional member countries

Partners will conduct flood modelling in selected basins. Partners will set up, calibrate, and validate the model for selected pilot catchments at a national level.

Support will be provided in post-processing, information service packaging, and information dissemination to the users.

3.6.2.6 Develop and implement a flood outlook model for the Indus, Ganges, and Brahmaputra basins

The model used in the current phase for the development of flood outlook products will be further explored and up-scaled to develop and implement a forecast model for the Indus, Ganges and Brahmaputra basins at ICIMOD to provide regional flood outlooks.

Detailed analysis of snow contributions will be incorporated into the model for more accurate, finer resolution forecasts.

3.6.2.7 Study exchange programme between countries

Study exchange programmes between the countries will be coordinated to strengthen the comparability and quality of products and to learn from each other's experiences.

3.6.2.8 National-level trainings and workshops

In addition to regional-level trainings, national-level trainings will be held based on the needs identified by the partners. A training needs assessment by the national partners will be undertaken. Based on this assessment there will be a total of four national level trainings in each country.

3.6.3 Component 3: Observation network operation and maintenance

3.6.3.1 Expansion of hydrological network at the national level

Building on the experience of the implementation phase and the current network of hydrological stations in each of the regional member countries, new sites will be identified based on a set of agreed criteria. At these stations, instrumentation including sensors and data collection platforms (DCPs) will be procured in accordance with ICIMOD's procurement rules and regulations. ICIMOD will tender documents with the technical specifications in consultation with the regional partner countries.

New instrumentation will fill up monitoring and observational gaps for flood data acquisition, with the idea to provide maximum benefits for flood forecasting services at the national and regional level.

The civil works, installation, operation, and maintenance will be the responsibility of the partners.

The project encourages the inclusion of existing national hydrological stations in the framework of the HKH-HYCOS project on a voluntary basis.

3.6.3.2 Expansion of meteorological networks at the national level

As with the hydrological stations, national meteorological networks will be expanded based on experiences from Implementation Phase.

Civil works, installation, operation, and maintenance will be the responsibility of the partners.

Additional weather parameters that influence hydrological cycles, especially in the Indus basin, such as solar radiation, soil moisture, soil temperature, and snow depth will be considered for generating more precise forecasts.

The project encourages the inclusion of existing national hydrological stations in the framework of the HKH-HYCOS project on a voluntary basis.

3.6.3.3 Operation and maintenance of the existing network

Hydrometeorological stations will be operated and maintained by the partner countries. Identified staff of partner countries will be trained in operation and maintenance and will have the responsibility to carry-out regular operation and maintenance and necessary improvements for the smooth operation of the stations.

The regional partner countries will include the stations in their national network and allocate sufficient funds for operation and maintenance.

Spare parts of sensors and loggers are essential for the operation and maintenance of the stations and will be provided by the project to the partner countries.

3.6.3.4 Planning and implementation of discharge measurements at hydrological stations

At existing and planned water level stations, discharge will be measured enabling the partner countries to access observation-based flood information in a transboundary environment. The determination of the quality of the discharge measurement and the stage-discharge relation curve is crucial and must be carried-out carefully, especially as they will be used for flood forecasting models.

Depending on the type of river in each partner country, discharge measurement methods will be selected, for example the use of cable car, ADCP or current meters. Based on the type of discharge measurement selected, appropriate will be procured.

The establishment of model stations in each partner country to carry out the measurement in a standard manner will be supported.

3.6.4 Component 4: Flood information system operation and maintenance

3.6.4.1 Acquisition of real-time data in regional and national database.

3.6.4.2 Sharing of data from other real-time stations from partner countries to support flood forecasting

The exchange of hydrological data and products from all national stations, including those not upgraded by the HKH-HYCOS, will be promoted between the national hydrometeorological service providers to develop more precise flood information in the transboundary environment.

3.6.4.3 Further development of the website and HKH-HYCOS data management system

The regional and national website will be updated.

3.6.4.4 Operation of the flood information system and flood outlook

3.6.4.5 Implementation of quality control guidelines

The quality control guidelines developed during the current phase will be implemented by the national services involved. Based on the performance of implementation of Quality control guidelines the thresholds will be adjusted by regional partners to ensure quality data transmission.

3.6.4.6 Use of space-based products in the flood information system

Various space-based products, for example satellite-based rainfall estimates, etc., will be accessed and utilized for flood modelling.

Transfer of know-how regarding the use of global and regional terrestrial and space-based observational data will be facilitated through training and model development with regional partners.

3.6.5 Component 5: Regional and international partnerships

3.6.5.1 Hold an inception meeting

Hold an inception meeting to launch the project, to define clear roles and responsibilities of all the partners, and to prepare a detailed workplan for the first year implementation of the programme. The workplan will include the activities and tasks along with the schedules and resources available.

3.6.5.2 Organize Regional Steering Committee meetings

Members of the Regional Steering Committee (RSC) will meet twice a year to evaluate the project progress and ensure the smooth operation and implementation of the project and recommend necessary mid-term changes. RSC meetings will be organized by the Project Management Unit (PMU) and hosted by each participating regional member country on a rotational basis with an additional day for field visits.

3.6.5.3 Build synergy with other ongoing initiatives in the region

Build networks and contact other organizations operating observation systems in each of the partner countries for sharing in the regional flood information system.

Exchange of information will be secured and coordination and cooperation activities will be carried out by sharing knowledge and information to build synergy with the HYCOS project.

3.6.5.4 Build regional and international partnership

Contribute to global programmes such as the Global Framework for Climate Services (GFCS) and improve climate services at the national and local levels. Explore the implementation of existing and accessible products, e.g. flash flood guidance system.

Contribute regional analyses to important global and regional studies on the effects of climate variability on hydrometeorological observations.

3.5.5.3 Expand geographic focus

Upon request from RMC partners, the project will try to establish partnerships with government and non-governmental agencies in Afghanistan with the objective of improving the capacity of agencies responsible for developing flood products. Owing to political instability, it may be difficult to consider operational partnership at this time.

3.5.5.4 Engagement with India and China

Building on the high level meetings held with authorities in India in 2013 for example the meeting of the Director General of ICIMOD with the secretary of water resources of India, the presentation by the Director of Programme Operations at the Planning Commission of India and several other meetings ICIMOD will continue its efforts to bring India on board the HKH HYCOS initiative. ICIMOD is also engaged in high level policy dialogue for example in the Himalayan Circle to engage India and China and seek their involvement in the project.

Supporting Components:

3.6.6 Component 6: Project reporting and monitoring

3.6.6.1 Reporting

The reporting of the project progress will be done on an annual basis in close coordination with ICIMOD and in line with the donor requirements. The progress report shall provide the status of project implementation along with the budgetary status.

3.6.6.2 Monitoring and Evaluation

Monitoring and evaluation as per ICIMOD's day-to-day coordination and management of project activities.

3.6.7 Component 7: Communication and Outreach

3.6.7.1 Development of a communication strategy and strengthening of communication mechanisms, making sure to incorporate gender-concerns and gender-specific skills, knowledge, and experiences during the process of strategy development

3.6.7.2 Use of innovative methods for packaging information targeting the needs of end users; preparing warning products that are simple and gender-sensitive. The activity will include translation of technical advisories and flood bulletins into information that is understood by local people.

Transfer of know-how to the countries will be facilitated to educate and create far greater awareness among impact communities/sectors/entities and national flood risk and disaster management partners in terms of preparedness and response systems.

3.6.7.3 Monthly conference calls among the coordinators from the participating organizations and face-to-face meetings at least once per year (in conjunction with the overall joint programme meeting)

3.6.7.4 Creation of an intranet for internal document sharing and creation of an internal calendar for event and meeting planning

Support to the design and development of post-processing information packages and ways to disseminate these knowledge products to relevant audiences will be provided.

3.7 The Theory of Change, Anticipated Outcomes and Impact Pathways

The theory of change, including anticipated outcomes and impact pathways, for ‘Establishment and Operation of a Flood Information Systems in HKH’ was developed in a participatory way among the core national, regional, and international stakeholders during the 7th Regional Steering Committee Meeting held in Islamabad, Pakistan from 10-12 December 2013. During this meeting, stakeholders reflected on their experiences from the current phase of the HYCOS project. The participants discussed country-specific and transboundary issues as well as regional institutional, human, scientific and technical areas that require greater coordinated efforts of RMCs in order to enhance flood risk management capacity in the HKH region. Based on these deliberations, the project identified critical areas where further intervention is required. The expected outcomes are related to both the institutional and technical capacity development of stakeholders, particularly improvements in the information flow mechanism related to flood disasters at multiple nodes among stakeholders involved at various levels. The outcomes are also related to improvements in technical aspects such as the accuracy and timeliness of flood forecasts for flood risk reduction (Figure 3).

Flood risk management is a complex process that involves both structural and non-structural measures. Effective non-structural measures include flood forecasting and early warning. These require access to real-time, flood-related data, flood forecast models, capacity in flood forecast modeling and flood-related information generation, including specific flood outlook products and effective dissemination techniques. Flood risk management from a regional perspective involves the sharing of transboundary flood-related information within a diverse political landscape, which makes this process even more complex and necessitates a thorough monitoring and evaluation mechanism to reach the desired impact. Our approach to impact is based on the identification and understanding of the fundamental human, institutional, and technical capacities and requirements needed to enable effective flood risk management in the HKH region, which are equally important at the national and regional level. From this understanding, appropriate pathways can be identified to reach the desired impact.

We understand that changes in the knowledge, attitudes, skills, behaviours, and practices of stakeholders – including immediate, intermediate, and end users of flood-related information – are critical. Therefore, by increasing our understanding of the conditions leading to flood-related vulnerabilities, with particular focus on strengthening information sharing and dissemination mechanisms within communities, RMCs and across national borders, and enhancing institutional and technical capacities in flood forecasting, we aim to improve flood risk reduction and support the protection of the lives, livelihoods, and property of vulnerable communities and infrastructure in the HKH region. The overall project goal is to contribute to protect lives, livelihoods, and property of vulnerable communities and infrastructure by enhancing flood risk management capacity in the HKH region. The goal has been further defined through two anticipated outcomes:

1. Improved end-user interface through improvements in the operation and application of flood information systems and products by RMCs and by vulnerable communities.
2. Improved flood forecasts for flood risk management through institutional and technical capacity building of hydrometeorological services in RMCs.

To achieve this impact, ICIMOD will continue to play an influencing role in the region and to facilitate the process of dialogue and coordination with and among RMC governments, including India and China, to strengthen regional and international partnerships; strengthen institutional mechanisms for flood risk management; build national capacities for flood modeling and forecasting; strengthen, operationalize, and expand observation networks; and expand and operationalize flood information systems within RMCs and across the region. To achieve the anticipated results at different levels of the objective hierarchy, the project will further identify and strengthen effective pathways to impact. Towards this end, ICIMOD has already brought together representatives from four regional member countries in a comprehensive process of dialogue and sensitization on the underpinning of regional and national flood information systems, with plans to include China and India in the future. Throughout the implementation of the project, other impact strategies and processes to further define the functions, roles, and responsibilities of hydrometeorological and disaster management agencies within RMCs and across the region will be refined and strengthened.

To improve the end-user interface, the project contribution to impact will be enhanced through the strengthening of institutional mechanisms for information generation, information access, and timely dissemination to immediate and intermediate users and operational actors. At the end-user level, the project contribution to impact will be enhanced through building the capacity of vulnerable communities and enhancing their accessibility, understanding, acceptance of different flood information products and the associated timely response. At the same time, the project contribution to impact will also be enhanced through the timely communication of flood products to end users and by building the capacity of disaster management agencies to respond in a timely manner to flood disasters and to expeditiously reach out to vulnerable communities.

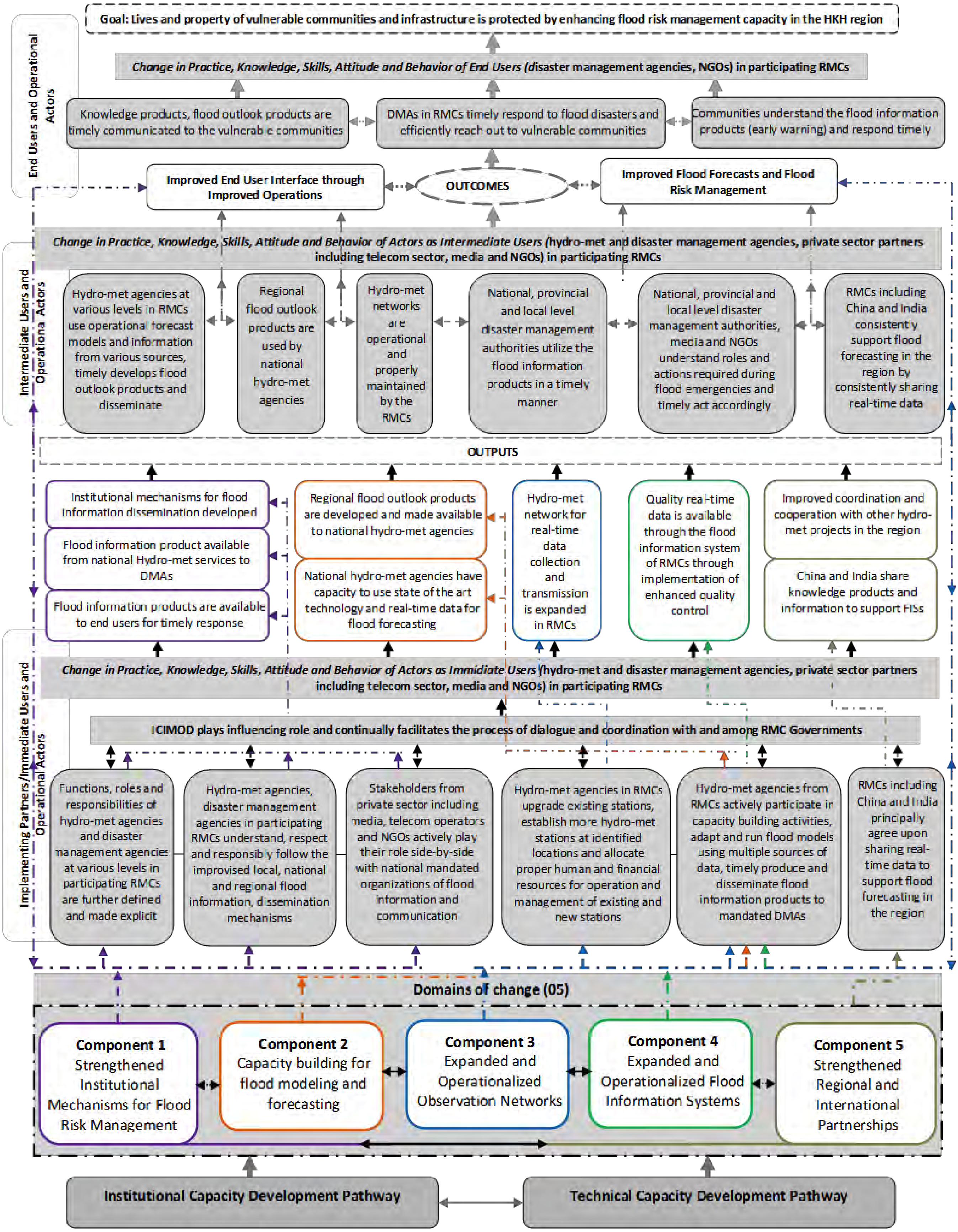

Figure 3 The Impact pathways diagram

4 DRAFT WORK PLAN AND BUDGET

4.1 Draft Workplan

The proposed work programme comprises seven components – two components focusing on institutional capacity development, three in technical capacity development and two supporting components on project management and communication and outreach (See Figure 4).

Components 1 and 5 are designed to support the development of the institutional mechanisms of partner organizations for flood risk management and to develop regional and international partnerships with other relevant organizations and initiatives. Components 3 and 4 support the technical capacity development of partners through improving the observational network and the flood information system. Component 2 uses the information generated by Components 3 and 4, together with other relevant datasets, to support partners' capacity in flood modelling and forecasting. Components 2, 3 and 4 will also have two-way feedbacks to each other – for example modelling activities (Component 2) will also help inform gaps in the observation network (Component 3) and the flood information system (Component 4). Component 6 and 7 are supporting components. Component 6 includes project reporting, monitoring and evaluation and audits. Component 7 supports the project through its communication strategy and outreach activities.

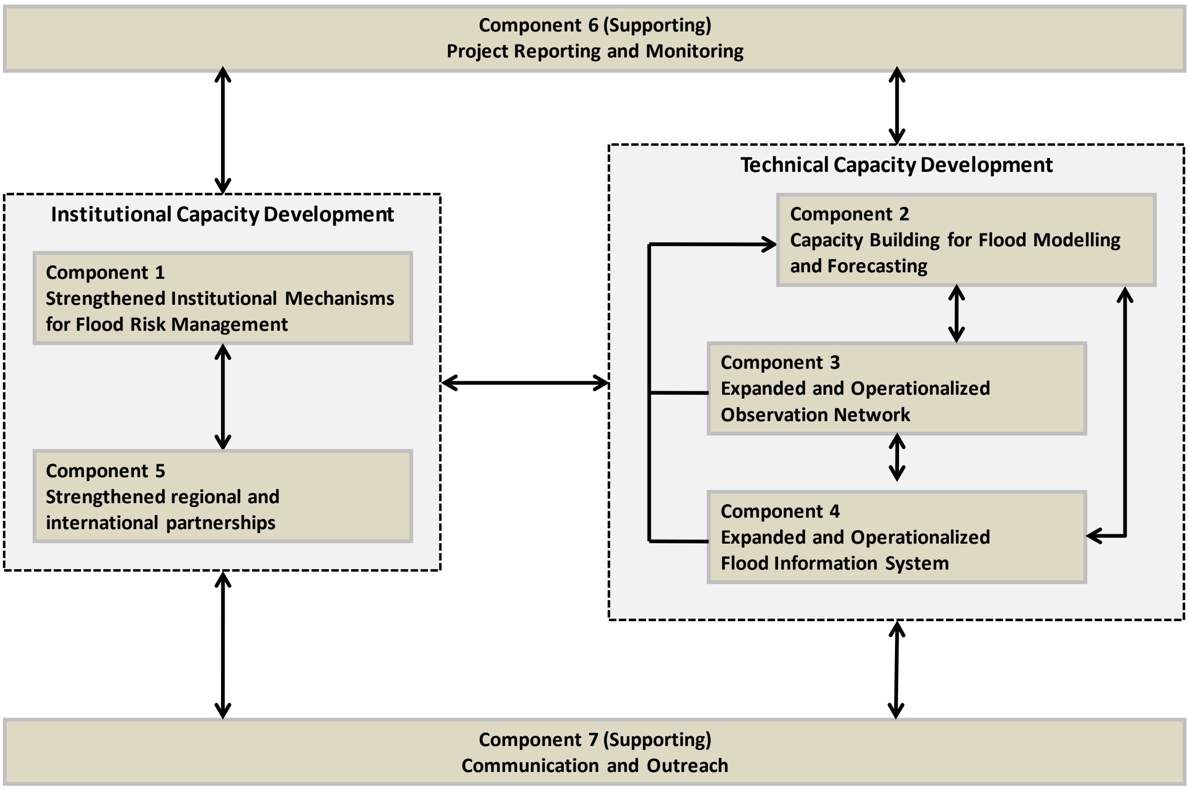

Figure 4 HKH-HYCOS components and their inter-linkages.

A detailed work programme will be developed during the Inception Workshop at the beginning of the project. Table 3 provides an outline for the draft work plan.

Table 3 Implementation plan

Work Plan	**Years/Quarters**																			
Components / Activities	2015				2016				2017				2018				2019			
	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th
1. Strengthened Institutional Mechanisms																				
1.1 Review national institutional mechanisms	■	■	■																	
1.2 Document best practice early warning systems		■	■	■																
1.3 National multi-stakeholder consultations					■								■							
1.4 Regional hydromet/DRM authority consultation						■								■						
1.5 Gender mainstreaming in early warning systems									■	■	■	■	■	■	■	■				
2. Capacity Building for Flood Modelling and Forecasting																				
2.1 Review current flood modelling tools and methods	■	■	■																	
2.2 Develop training materials and courses			■	■	■	■														
2.3 Hold regional trainings on flood modelling for national services						■														
2.4 Regional trainings on integration of weather forecasts						■														
2.5 Flood modelling in selected basins by partners						■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
2.6 Develop large-scale forecast model for IGB basin	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
2.7 Study exchange programmes						■				■				■						
2.8 National level needs-based trainings and workshops						■				■				■				■		
3. Expanded and Operationalized Observation Network																				
3.1 Procurement and delivery of equipment			■	■	■	■														
3.2 Expansion of hydrological network at national level (Civil works, installation etc)					■	■	■	■	■	■										
3.3 Expansion of meteorological network at national level (Civil works, installation etc)					■	■	■	■	■	■										
3.4 Operation and maintenance of existing networks	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
3.5 Discharge measurements at hydrological stations for rating curves							■	■	■	■	■	■	■	■	■	■	■	■	■	
4. Expanded and Operationalized Flood Information System																				
4.1 Acquisition of real-time data from current and proposed stations	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
4.2 Data-sharing from stations not upgraded by HYCOS between national services	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
4.3 Develop, upgrade and update the HYCOS website and data management system	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
4.4 Development and operationalization of flood outlook	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
4.5 Implement quality control guidelines	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
4.6 Training and application of space-based products										■										
5. Strengthened Regional and International Partnerships																				
5.1 Build synergies with other regional intitiatives	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
5.2 Build regional and international partnerships	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
5.3 Explore partnership opportunities with Afghanistan authorities	■	■	■	■																
5.4 Expand engagement with Indian and Chinese authorities	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
6. Project Management																				
6.1 Staff recruitment	■	■																		
6.2 Inception Workshop		■																		
6.3 Regional Steering Committee (RSC) meetings		■		■		■		■		■		■		■		■		■		■
6.4 Reporting				■				■				■				■				■
6.5 Monitoring and Evaluation	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
7. Communication and Outreach																				
7.1 Develop cummincation strategy	■	■																		
7.2 Develop innovative methods for packaging project products			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
7.3 Establish regular communication with partner coordinators	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
7.4 Develop intranet for document sharing and meeting planning		■	■	■		■		■		■		■		■		■		■		

4.2 Budget

The total budget of the five year project is 5,000,000/- Euros.

Table 4 provides the breakdown of budget according to the seven components. Table 5 provides a detailed budget by line item.

Table 4 Summary of Budget by Components

S No	Component / Activity	Year-1	Year-2	Year-3	Year-4	Year-5	Total	%
1. Institutional mechanism for an end to end flood information system at national and local		€ 166,613	€ 116,431	€ 157,875	€ 156,398	€ 104,545	€ 701,862	**14**
2. Capacities of regional member countries in modeling		€ 244,737	€ 285,409	€ 170,707	€ 89,178	€ 137,394	€ 927,425	**19**
3. Observation network, operation and maintenance		€ 74,435	€ 848,827	€ 198,026	€ 59,995	€ 35,856	€ 1,217,138	**24**
4. Flood information system, operation and maintenance		€ 172,285	€ 92,605	€ 203,982	€ 103,157	€ 139,958	€ 711,988	**14**
5. Regional and international partnerships		€ 169,865	€ 194,455	€ 161,680	€ 149,696	€ 152,106	€ 827,802	**17**
6. Project reporting and monitoring		€ 31,269	€ 32,934	€ 34,552	€ 36,192	€ 134,129	€ 269,076	**5**
7. Communication and Outreach		€ 60,017	€ 65,883	€ 64,496	€ 80,702	€ 73,613	€ 344,710	**7**
	Total	€ 919,221	€ 1,636,543	€ 991,319	€ 675,318	€ 777,599	€ 5,000,000	
	%	18	33	20	14	16		100

14% of the budget is allocated for component 1 which studies, field investigations, trainings and awareness campaigns at all levels for end to end system. Component 2 covers 19% of the total budget to build capacities of the partner organizations in flood modeling and forecasting through national and regional trainings and learning visits.

Component 3 is on upscaling hydrometeorological networks is the largest component with a budget of 24%. All the hydrometeorological instruments are procured, installed, operated and maintained under this component. Component 4 accounts for 14% which deals with development, operation and maintenance of a flood information system. It covers the costs of purchasing/developing software and hardware for flood data management and modelling.

Component 5 covers partnership development and accounts for 17% of the budget. This component covers the cost of RSC meetings, obtaining synergies with other national and regional ongoing efforts. The project will also try to expand the geographical focus of the project to cover Afghanistan.

Component 6 covers 5% of the budget primarily for review, reporting, monitoring and evaluation of the project Component 7 covers 7% of the budget. The major element of this component is innovative packaging and dissemination of flood information for various types of data users.

Table 5 Summary budget by line item

S No	Line Item	Year-1	Year-2	Year-3	Year-4	Year-5	Total	%
1	Staff Cost	€ 240,809	€ 236,050	€ 226,196	€ 216,718	€ 322,206	€ 1,241,979	25
2	Consultancy	€ 150,500	€ 90,500	€ 30,518	€ 31,500	€ 111,500	€ 414,518	8
3	Travel	€ 40,000	€ 36,000	€ 37,000	€ 24,000	€ 24,000	€ 161,000	3
4	Equipment	€ 30,000	€ 34,000	€ -	€ 10,000	€ -	€ 74,000	1
5	Workshop	€ 45,000	€ 122,000	€ 40,000	€ 30,000	€ 20,000	€ 257,000	5
6	IT Communication	€ 150,000	€ 40,000	€ 30,000	€ 20,000	€ 10,000	€ 250,000	5
7	Material Supply	€ 7,350	€ 7,600	€ 7,358	€ 6,000	€ 6,000	€ 34,308	1
8	Partner Fund	€ 122,000	€ 835,000	€ 476,209	€ 238,977	€ 172,047	€ 1,844,233	37
	Total Direct Costs	***€ 785,659***	***€ 1,401,150***	***€ 847,281***	***€ 577,195***	***€ 665,753***	***€ 4,277,037***	
9	Overhead 14%	€ 133,562	€ 235,393	€ 144,038	€ 98,123	€ 111,846	€ 722,962	14
	Total	***€ 919,221***	***€ 1,636,543***	***€ 991,319***	***€ 675,318***	***€ 777,599***	***€ 5,000,000***	
	%	€ 18	€ 33	€ 20	€ 14	€ 16		100

Partner fund represents the portion of funds that are either directly managed by the partner or funds expended by ICIMOD but for the direct benefit of the partners. It includes the cost of hydrometeorological instruments, costs of its operation and maintenance, costs of hosting the RSC meetings and regional and national level trainings and sensitization and awareness workshops. The cost appears highest in Year 2 because most of the instruments are planned to be procured in this year.

<u>In-kind contributions from member countries in project support:</u>

There is in-kind contribution from the regional country partners in support of the project. The in-kind contributions include:

- Staff support for 5 year
- Office running costs including communication, reporting, support staff
- Support for field visits

It is estimated that the cost is about 100,000 Euros per year to a total of 500,000 Euros for five years.

5 PROJECT IMPLEMENTATION AND RESOURCING

5.1 Organization and management

5.1.1 General outline

The organization and management of the project is based on the concept that the participating countries have full ownership of the project and will execute the project through their dedicated national organizations and agencies. WMO and ICIMOD are jointly facilitating the planning and region-wide implementation of the project within their specific mandates in the project, which are described in detail in the following paragraphs. In its facilitating role, ICIMOD will be responsible for the coordination of the regional implementation of the project. WMO as the custodian of WHYCOS will be responsible for the technical support of the project. The supreme executive role will be vested with the Regional Steering Committee (RSC), in which the participating countries and their executing agencies and the facilitating agencies will be adequately represented.

5.1.2 Facilitating, implementing and executing partners in the project

The project will be facilitated with technical support provided by ICIMOD in an implementing and coordinating role and the WMO in a supporting and advisory role.

The project will be executed by the relevant national organizations of the participating countries listed below:

Bangladesh: Bangladesh Water Development Board and the Bangladesh Meteorological Department

Bhutan: Department of Hydromet Services, Ministry of Economic Affairs

Nepal: Department of Hydrology and Meteorology and the Department of Water Induced Disaster Prevention

Pakistan: Pakistan Meteorological Department, Water and Power Development Authority and the Federal Flood Commission

ICIMOD and WMO will strive to achieve a higher-level participation of China and India in the project. Relevant national organizations in these countries are:

China: China Meteorological Administration and the Bureau of Hydrology

India: Central Water Commission and the India Meteorological Department

In addition, countries may decide to add other national organizations with a defined role in the execution of the project.

The project will also try to expand partnership with Afghanistan to up-scale HYCOS activities.

5.1.3 Management and reporting structure

A project Regional Steering Committee (RSC) will be established to oversee policy issues and the strategy and implementation of the project. ICIMOD will be the Implementing and Coordinating Agency. The PMU will be established at ICIMOD and headed by a Project Coordinator/Manager. The project will be monitored and evaluated based on ICIMOD's results based monitoring and evaluation system. Staff of the PMU will include a project coordinator, assistant project coordinator, data processing expert, sociologist/hydrologist and a technical assistant. Provision is also made for short-term services of international consultants on hydrometeorology, flood forecasting, and database management. The staff of the PMU should preferably be drawn from within the region, with due attention given to competence and experience of the candidates in the selection process. The selection of the staff of the PMU will be made by ICIMOD. Project management will be guided by an annual project plan, against which reporting will be made to the PMU semi-annually.

ICIMOD is centrally located in the HKH region and each of the countries is officially represented on its Board of Governors. ICIMOD draws on professional expertise from the participating countries and has substantial experience in water resources and hazard management, some of which is in transboundary settings. ICIMOD is well qualified to undertake the role of Implementing and Coordinating Agency. The ICIMOD Secretariat will be the host for the PMU. Details of ICIMOD's activities can be viewed at http://www.icimod.org.

WMO shall be the Technical/Scientific Support Agency. WMO, as the custodian of WHYCOS, has been collaborating with National Hydrological and Meteorological Services and donor organizations in the planning and implementing of more than 15 demand-driven regional HYCOS projects involving more than 100 countries in various regions of the world. WMO will facilitate data and information exchange and provide technical support and guidance so as to ensure that HKH-HYCOS is consistent with other HYCOS projects and meets the global objectives of WHYCOS. The full scope of WMO's overall activities can be viewed at http://www.wmo.ch. Specific information on the WHYCOS programme of WMO can be viewed at www.whycos.org.

5.1.4 Responsibilities of project implementers

Regional Steering Committee (RSC)

As in the current phase the RSC will be the highest executive body of the project. Its role will be to ensure project coherence and to oversee project policy, strategy, and implementation. It will decide on any changes to the project document and approve the annual work plans, budgets, and reports and undertake other responsibilities. The RSC will consist of representatives of the participating countries and their executing agencies, the facilitating organizations ICIMOD and WMO, and will be serviced by the PMU. To ensure the effectiveness of the RSC, the participating countries will designate representatives with clear decision-making authority in matters pertaining to the implementation of the project within an agreed policy framework. These representatives which may be the same focal person as in the current phase are expected to attend all meetings and be able to devote the time needed for the work of the RSC. As an important part of its activities, the RSC will prepare detailed proposals, in particular with regard to the expansion of services provided by the project on advanced regional early warning products, the expansion of the hydrometeorological network contributing to the regional flood information system capacity building, the sustainability on national regional levels of the project activities and further phases of the project.

Responsibilities of the Regional Steering Committee are:

• Determine project policies and strategies

• Mediate different interests among participating countries and executing agencies • Approve the project implementation plan and the project implementation manual

• Approve annual work plans, budgets, and reports

• Approve changes to the project document

• Evaluate project progress and impacts

• Provide a communication channel with regional bodies and other national, regional and global organizations as required

• Seek synergy with on-going and planned projects that are related to the project proposed in this document

• Seek concurrence with higher national authorities as required

• Facilitate the development of follow-up phases of the current project phase on the basis of progress made in the funded project phase and emerging needs

• Facilitate the development of complementary project proposals in line with national and regional interest of countries

• Facilitate the development of a contingency plan for post-project operation and maintenance of the technical project outputs and for post-project coordination

5.1.5 Participating countries

The participating countries through their dedicated national agencies and organizations have the primary responsibility for the execution of the project. To assure project success and to help ensure post-project sustainability, it will be essential to have the agreement of the participating countries to act on these responsibilities. This will be in the form of a Memorandum of Understanding (MOU) between ICIMOD and the participating countries. The partner countries should commit themselves to provide the real-time data generated under the project to the PMU. The likelihood of project success will be increased if funds can be provided to the NMS and NHS of the participating country to cover their project-related costs. The Facilitating Agencies will assist participating countries and, in particular, their national agencies in determining their budgetary requirements to meet their obligations and fulfil their responsibilities in the project.

Responsibilities of the participating countries/national organizations are

• Provide support to missions by staff from the Facilitating Agencies, PMU, and project consultants

- Provide appropriately qualified staff to participate in project activities, as required
- Manage any impediments to successful project execution (e.g., land access)
- Carry out installation and other work required to establish the projects components, with the assistance of the PMU
- Perform ongoing, routine activities related to the operation and maintenance of project installations and the operation of the national components of the regional flood information system
- Disseminate data and information to users and to the PMU
- Provide information about the project to national authorities, the public, and other regional and global organizations with an interest in project activities and results
- Ensure integration of all project-related activities and installation of stations etc in the national flood forecasting system and providing an end-to-end mechanism with national agencies responsible for disaster risk reduction.

5.1.6 Implementing and Coordinating Agency - ICIMOD

ICIMOD, as the Implementing and Coordinating Agency is responsible for the day-to-day implementation and coordination of project activities, which includes the management of external project funds, tender and procurement processes, and technical assistance in the establishment of components of the project (such as Data Collection Platforms) within the scope of the project. It will be responsible for the implementation, management, and administrative/financial control of the project, as well as the other tasks that are summarized in Table 8. ICIMOD will establish the PMU as a sub-unit of its organization. The PMU will carry out the project activities within the scope of its responsibility under the responsibility and control of ICIMOD to which it will report regularly.

Responsibilities of ICIMOD are:

- Obtain and administer project funding and its allocation to project partners
- Prepare a draft detailed project implementation plan
- Set up the PMU
- Manage the tender process for the provision of services and procurement of equipment under the individual sub-projects; all procurement will be made in accordance with ICIMOD procurement guidelines
- Manage procurement of materials and equipment
- Provide the RSC with a six-monthly progress report
- Provide administrative assistance to the project

5.1.7 Project Management Unit (PMU)

The PMU represents the dedicated organizational unit of the Implementing and Coordinating Agency. It will act as a focal point to coordinate the project activities executed in and by the participating countries, foster regional cooperation in sharing basin-wide flood data and information, and provide a forum for exchange of expertise. A key function and responsibility of the PMU is to ensure the reception and re-distribution of all data and information compiled in real-time and through other means from contributions of participating countries and their dedicated services and to develop and widely distribute regional flood Information products that have been generated from national information and additional sources from collaborating institutions providing regional Information products such as Medium Range Weather Forecasting, Flash Flood Guidance and Precipitation Prediction Products.

Summary responsibilities of the Project Management Unit are:

- Act as a focal point to implement and coordinate the project activities executed in and by the participating countries
- Prepare a project implementation manual as a "living document" and a post-project contingency plan
- Monitor receipt of observed data and forward data to NHSs and NMSs that do not have direct access to satellite data
- Manage a regional database and associated functions (data dissemination, etc.).
- Provide all services (training, ongoing assistance and advice, etc.) which are not provided under other arrangements
- Foster regional technical and scientific cooperation in the field of flood monitoring and management
- Provide a forum for exchange of expertise and knowledge

5.1.8 Technical/Scientific Support Agencies

World Meteorological Organization (WMO)

WMO, as the Technical/Scientific Support Agency, will facilitate and provide technical support for the implementation of the project. WMO as the custodian of the WHYCOS will provide critical technical service to guide the PMU on the implementation of the project, ensuring that the project takes maximum benefits from lessons learned in implementing other HYCOS projects and ensuring its linkage with ongoing or planned HYCOS components and with the global WHYCOS programme. As such, WMO shall be a member of the RSC and provide assistance throughout the duration of the project.

Summary responsibilities of WMO are:

- Provide overall guidance in the planning and implementation of the project to ensure its coherence with the guiding principles of global WHYCOS projects
- Assist in seeking project funding

• Provide for technical guidance in project planning and implementation

• Support ICIMOD by advising on technical standards and methods of observation

• Advise on the preparation and evaluation of tenders for equipment and services

• Support the National Meteorological and Hydrological Services of the participating countries with technical support in agreement with the PMU

• Provide the link with the meteorological and hydrological community to facilitate the establishment of telecommunication facilities including, if relevant, the exchange of data through the WMO Information System (WIS) and other means of telecommunication

• Interaction with the project, through regular missions and participation in the RSC meetings and other meetings as necessary.

Finnish Meteorological Institute (FMI)

The Finnish Meteorological Institute (FMI) will provide technical assistance and support to the project with its experience and excellence in providing weather and climate observations and services. FMI has a strong experience and a proven record of successfully implementing bilateral hydrometeorological and environmental projects in different locations around the world, including Nepal and Bhutan. FMI will bring in the state of the art knowledge and techniques in quality control and database management and in providing trainings and building capacity of regional member countries to operate a 24/7 operational hydrometeorological end-to-end system. FMI will helm in customizing products and tailor making it to meet end-users needs.

The FMI has ongoing projects in the Hindu-Kush area, namely the FNEP2 project in Nepal and SHSB project in Bhutan. Both of these projects are ICI-projects funded by the Ministry of Foreign Affairs in Finland. The activities in these projects will be carefully coordinated with the HYCOS-project to utilize synergies and avoid overlaps.

5.2 Project implementation

The project will be implemented in close collaboration with the national counterpart agencies of the four countries sharing the Indus and the GBM river basins through the PMU that will function with support from ICIMOD. It will facilitate dialogue with India and China to bring them as project partners to share flood information and products to the regional flood information system. It will procure and provide field equipment for the collection and transmission of data, office equipment for data reception and for database development and management, and training of staff of the NHSs and NMSs in modern hydrological practices. It will also secure and provide the services of international experts to assist with the implementation of specific project activities. The project will commence with the recruitment of the Project Manager/Coordinator.

A Project Implementation manual will be produced at the outset of project implementation, which will establish, among other things, the methods and procedures for procurement of equipment and services and the detailed work plan.

Individual MoUs will be prepared and signed between ICIMOD and the hydrometeorological services of each participating country with regard to the conduct of civil works necessary for the establishment and/or upgrading of hydrometeorological stations. The MoUs will contain an agreement regulating the responsibility and cost sharing for operation and maintenance of the stations. As relevant, such agreements should also cover other equipment provided with project funding. A contingency plan for post-project operation and maintenance of the technical project outputs including the operation of the regional flood information system and for post-project coordination will also be prepared by the PMU.

5.3 Project monitoring, reporting and evaluation

The project will be monitored and evaluated based on ICIMOD's results based monitoring and evaluation system. The impact pathway and theory of change will further be concretised in an inception workshop with partners. The refined impact pathway will be used to prepare a detailed monitoring and evaluation (M&E) plan, which will help the project management and partners to fix responsibilities for M&E activities throughout the project duration. In order to operationalize the M&E plan the project will also develop a comprehensive baseline of each indicator at the results level specifically to track down the impact of the project at the end user level. Annual review and planning meeting will be organised with regional partners together with the regional steering committee with the aim to review the impact pathway and determine the efficiency and effectiveness of the programme in achieving its results targets and also adjust plans to incorporate lessons learnt during the implementation.

Six-monthly reports will be prepared by ICIMOD for transmittal to the RSC. All reports will cover technical, financial, and administrative matters, using the performance indicators agreed upon. This reporting should also include particular reference to exceptions (i.e., failures to achieve planned results), changing circumstances that present threats or risks to the project, and measures taken or proposed in response. The reports should be suitable for distribution to partners and key stakeholders, and therefore should be of more than simply administrative interest. Project progress and achievements will be evaluated by the RSC based on monitoring and evaluation documentation during RSC meetings.

Reporting procedures will be established with donors in accordance with their preferences.

An independent evaluation will be carried out at the end of the implementation of the project.

A project implementation plan, which will specify milestones and verifiable indicators of achievements, will be set up.

5.4 Key assumptions

The project design is based on the same assumptions from Phase I and II relating directly to the project purpose, including:

- The WMO Information System Service (WIS) including its Global Telecommunication System will be accessible to the project and ICIMOD as well as the national partners will be kept abreast of developments in the implementation of WIS and WMO Integrated Global Observation system (WIGOS);
- The Facilitating Agencies will be able to maintain awareness of events and changing circumstances that have an impact on the project;

- The Facilitating Agencies will be able to establish and maintain effective working relations with the participating national governments, the NHSs and NMSs, and other stakeholders;
- It will be possible to arrange payment of NHSs and NMSs for disbursements and services that they provide under the project;
- Participating national governments and their departments/ministries will agree to their NHSs and NMSs taking responsibility for the routine project activities;
- The regional flood observation network can be technically operated and protected against vandalism and other damage;
- Financing of operation and maintenance of the observation network as well as future replacement investments is secured;
- The operation and maintenance and financing of the regional flood information system is secured;
- NHS and NMS staff that is trained by the project will be retained by their Service, or it will be possible to train replacements in time for them to take responsibility for project tasks;
- Donor support and matching funds from country support will be ensured; and
- Some of the international organizations/institutions will maintain a long-term interest in the project.

Additional critical assumptions for achieving the overall project objective include:

- The NHSs and NMSs will be able to utilize the flood information system as a part of their operational service, and disseminate the information further to the risk reduction agencies in a timely fashion.
- Governments and other actors at the national level make use of the flood information system and are efficient in disseminating warnings without delays through multiple media to the people at risk.
- People at risk are aware and able to take immediate measures to protect themselves and their property against flood incidents.

5.5 Risks

Based on experiences gained during the preparatory and implementation phase, technical and financial risks are generally ranked as low to medium importance and should be manageable. The key issues involving risks and expected mitigation strategies are listed below:

Risk 1: Lack of cooperation between the various NHSs and NMSs in the HKH Region and the PMU in the project design and implementation

Mitigation Strategy: The participating governments and the national agencies concerned have demonstrated during the preparatory and implementation phase their ability to work cooperatively in sharing information for regional flood management. In addition, ICIMOD provides the regional mechanism and focus for the project. Any issues with respect to cooperation would be managed through ICIMOD and the open and participatory approach that has been developed should continue. Provisions will be made for compensating for possible incomplete availability of hydrometeorological data due to the malfunction of stations, inability to share data for political reasons, etc. This can be, for instance, the use of satellite-based altimetry for control of water levels in rivers or the use of modelling based on historical data. The risk of the break-down of communication from the stations to the centre can be reduced through redundant transmission systems.

The project can be planned and operated under the assumption that India and China would not participate fully.

Risk 2: NHS and NMS staff may be overburdened and have limited time to participate in the project execution due to other commitments.

Mitigation Strategy: The project directly involves high-level officials of the Departments of Hydrology and of Meteorology of each participating country, who are aware of staff commitments and other ongoing and potential projects. Synergies between on-going and planned projects (such as the South Asia Flash Flood Guidance Project (SAsia-FFG) are considered from the onset of the project. Flood management is considered a high priority because of its political dimension.

Risk 3: Field equipment installed by the project may be damaged or destroyed due to vandalism, theft, or natural disasters such as floods and thus impact the project activities.

Mitigation Strategy: The project will work with the NHSs and NMSs and the PMU to ensure adequate protection of equipment and that adequate spares and replacement instruments are available. As appropriate and according the needs determined, and after the risk of vandalism is assessed, full-time observers can be hired and located at or nearby the stations, who would also act as guards and security for the stations. All the participating countries routinely operate long-term hydrometeorological networks and have ample national and local experience to prevent significant occurrences of vandalism. The conditions of these stations can be assessed as a part of the project, and the reasons for their successful provision of long-term data series can be highlighted and serve as input to the location of additional stations in the region.

The application of redundant measurement techniques at the most important stations can reduce the loss of data.

Risk 4: Failure to implement project activities due to security problems.

Mitigation Strategy: Security problems exist in isolated areas of the project region. However, the areas of high risk are known and will be excluded in the project design. There is an almost negligible risk that the project could be suspended due to the deterioration of security throughout all project areas in the four participating countries.

5.6 Sustainability

Experience from many developing countries and other HYCOS projects of a similar nature; show that long term sustainability remains a challenge. A good example is the ongoing maintenance of the Mekong-HYCOS project that is the sister project of the HKH-HYCOS project. Fundamentally, projects are more likely to be maintained if they meet clearly defined needs and policy-based objectives which the government is fully aware and the benefits of post-project expenditure clearly exceed the costs as well as the benefits of other possible expenditures. The benefits to be derived from this project with regard to the protection of life, livelihoods, public property and poverty alleviation are abundantly clear from both the socioeconomic and political perspectives. This needs to be expressed-amongst others – in the allocation of budgets in support of continued operations of the project. The project will strive to ensure that additional costs as a result of post-project activities are adequately funded by national governments.

A key thrust of the project is to maximize participation and technical capacity in the participating national meteorological and hydrological services and to support national and regional organizations so that they are willing and able to continue the project activities after the project's external funding is terminated. The likelihood of post-project sustainability varies considerably among the countries of the region. The project is conceived and designed to maximize the likelihood of sustainability in all participating countries, but it cannot realistically be guaranteed. Some countries will be able to stand alone; others will require further external assistance. In either case, the regional bodies will have a crucial role to play.

At the end of the project the regional flood information system will be integrated into database of ICIMOD that is currently under development as part of the regional programme "Mountain Environment Regional Information System (MENRIS)". The MENRIS programme encompasses long-term monitoring, database development, and uptake of knowledge for the region. The system will integrate meteorological, hydrological data, space based information, socioeconomic data as well as many other products for use by partners at local, national, regional and global levels. There will be continuity to the availability and access to regional flood outlook products and information for improving flood forecasts with the RFIS internalised within ICIMOD with considerations for operating a regional help desk within ICIMOD. Besides regional flood outlooks and information system, ICIMOD as per its mandate will continue to play a role promoting regional cooperation while bringing all regional member countries in a common platform to continue the dialogues and enhance cooperation between and amongst countries.

Similarly at the national level the partners will include the hydrometeorological stations in their national network and allocate sufficient funds for operation and maintenance to ensure sustainability of the system. To ensure project success and post-project sustainability, a Memorandum of Understanding for a commitment to act on countries' responsibilities is essential prior the commencement of the project implementation between the core project partners, which are ICIMOD, WMO, and the participating countries. It is also important that the technologies selected builds on the current phase and the existing capacities of the hydrometeorological agencies and are appropriate to the HKH region, including to the acquired skills of NHS and NMS staff during the design life of the equipment. The Regional Steering Committee has a key role in ensuring that these and other sustainability issues are being addressed. ICIMOD will also promote the national ownerships of the hydrometeorological stations and data management systems to ensure sustainability.

ICIMOD celebrated its thirtieth anniversary in December 2013. Since its establishment in 1983 by the eight member countries of the Hindu Kush Himalayan region with support from UNESCO and the Governments of Germany and Switzerland, ICIMOD's importance as a regional hub and knowledge provider and broker in the HKH region has continuously increased. This can be seen from a gradually increasing annual budget, expanded project portfolio, increased interest and demand for ICIMOD's services, and the Centre's contributions to the development of the HKH region. It is highly unlikely that ICIMOD after 30 years of operation should run into the risk of closing down its business. Should any threats mount towards the organization, they could, in the worst case scenario, possibly lead to a redefinition of the Centre's mandate, function, ownership, or implementing role in the region, but it is regarded as a minimal risk that ICIMOD would terminate its function completely. Hence, threats to the sustainability of ICIMOD as a regional centre on the long-term sustainability of the project are regarded as negligible.

APPENDIX I – Natural vulnerability to flooding and climate change

The HKH region is a vast complex of high mountains, intermountain valleys, and plateaus shared by Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan. It is the source of ten of the world's largest rivers: the Indus, Ganges, Brahmaputra, Mekong, Yangtze, Yellow River, Irrawaddy, Salween, Amu Darya and Tarim and produces one of the world's largest renewable supplies of freshwater. These rivers are vital for the survival and wellbeing of more than one billion people, most of whom live in the surrounding plains. The main focus of the HKH-HYCOS project is the Ganges-Brahmaputra-Meghna (GBM) and Indus basins (Figure 1). Further details on the characteristics of these river basins are presented in Appendix I.

The extreme relief of the Hindu Kush Himalayas, which rise from low-lying plains more than 8,000 metres over a horizontal distance of a few tens of kilometres, imparts special characteristics to the region's river systems. The enormous energy potential and numerous storage sites for the control of flow variability are important factors for flood control, hydroelectricity, large-scale irrigation, and navigation. By virtue of their length and enormous volume, the rivers emerging from the Hindu Kush Himalayas extend their influence to an extremely large geographical area far beyond the mountains.

The pattern of runoff from the Hindu Kush Himalayas, as well as its timing and intensity, is governed by the quantity and distribution of precipitation, its form (rain or snow), and seasonality. The heaviest rainfall of the summer monsoon occurs in the eastern Himalayas and produces the strongest impact on such rivers as the Mekong, Brahmaputra, and Ganges. In contrast, towards the northwest, the predominance of high-altitude winter snowfall increases, thus the flow of the Indus is dependent mainly on snowmelt and the ablation of some of the world's largest glaciers outside of the Polar Regions.

The spatial variation is significant throughout the Hindu Kush Himalayan region, and the temporal variation imposes immense difficulty for year-round water utilization in the densely populated plains. Thus, water scarcity continuously afflicts some areas while elsewhere croplands are flooded and settlements are inundated on a regular basis.

During the three decades from 1976–2005, the reported number of natural disasters in South Asia was 943. Out of these, 332 were caused by floods, accounting for 35% of the natural disasters. This is higher than the global value of 30%, showing that, in South Asia, floods are the most prominent hazard followed by windstorms, including cyclones. The distribution of natural disasters in South Asia is presented in Figure 2. In the context of climate change these hazards are likely to increase in magnitude and frequency (Eriksson et al., 2009; Goswami et al., 2006). End-of-the-century modelling of the Brahmaputra River predicts a sharp increase in average and extreme downstream discharges, especially during the monsoon, with a significant threat of flooding in the densely populated floodplain (Immerzeel, 2008).

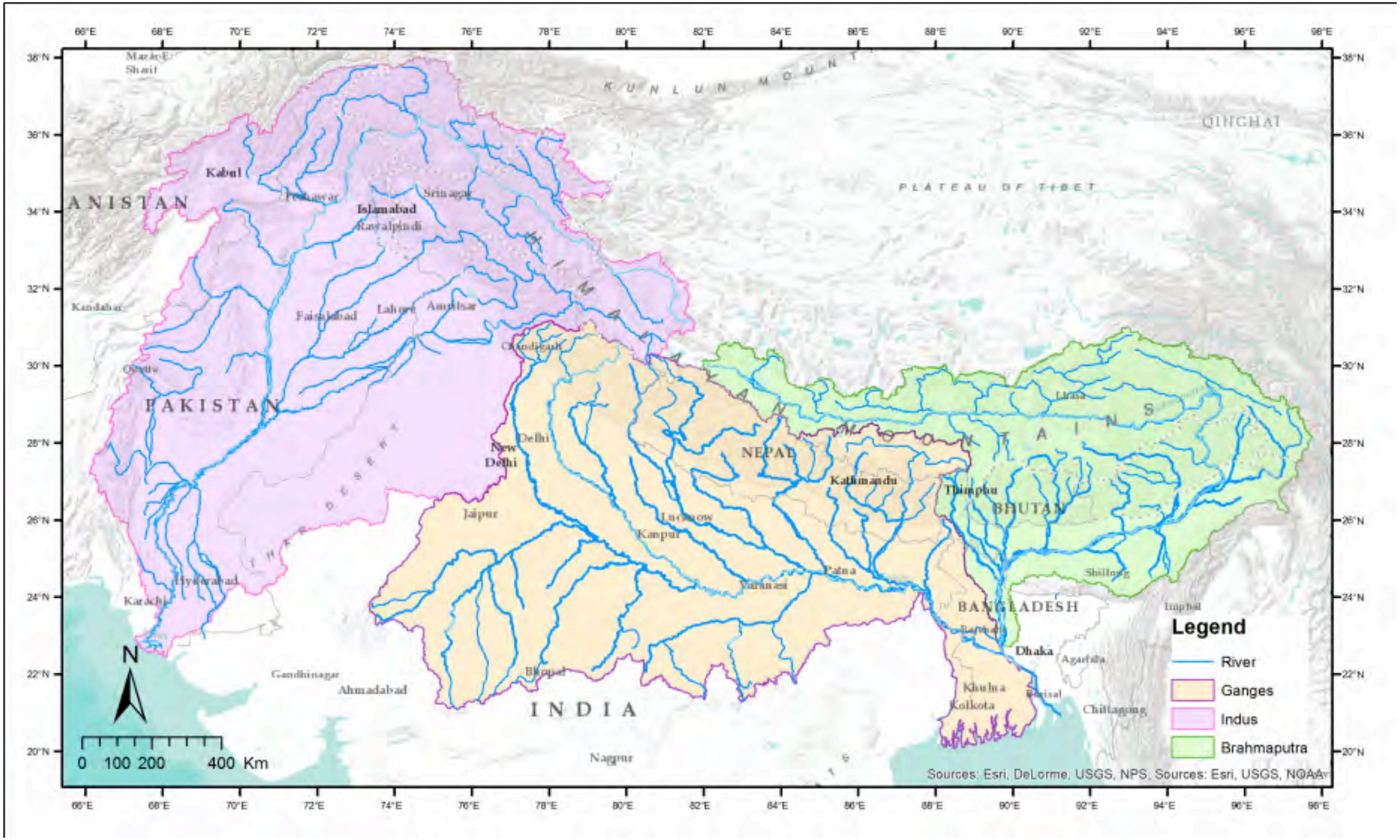

Figure 5 River basins of the Hindu Kush Himalayan region included in the HKH HYCOS project

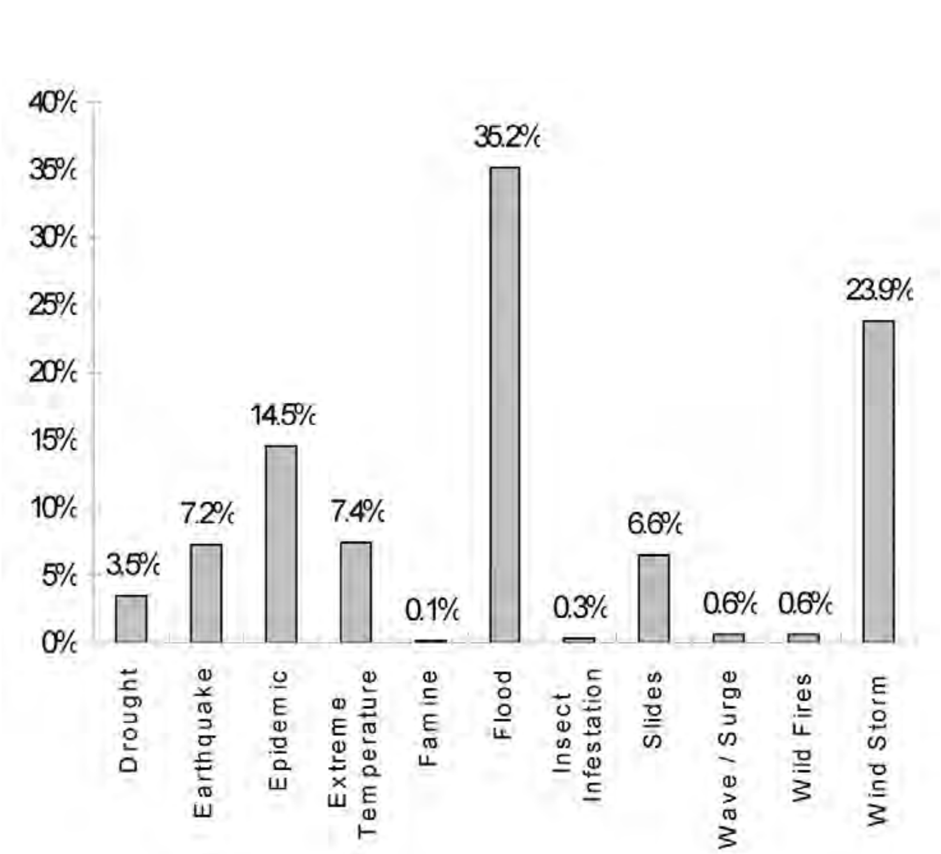

Figure 6 Distribution of natural disasters in South Asia (1976-2005)
Source: Singh Shrestha, 2008

APPENDIX II - Socio-Economic indicators

It is estimated that about 10 per cent of the world's population lives in the GBM region, which represents only 1.2 per cent of the world's land mass. The region is also characterized by endemic poverty and is the home of about 40 per cent of the developing world's poor (with a daily calorie intake of less than 2,200-2,400 Kcal). Even though there has been a decline in the poverty ratio in recent years, the absolute number of poor people has increased due to population growth. The performance of the region with respect to such social indicators as economic growth, education, and health has been disappointing in comparison to other regions of the world. A summary of socioeconomic indicators for Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan is provided in Table 6 below. This socioeconomic context compounds the impacts of flooding in the region, where flood events propagated from upstream can have devastating consequences to vulnerable communities with limited capacity in the densely populated plains downstream.

Table 6 Socioeconomic indicators of the region

Indicator	Afghanistan	Bangladesh	Bhutan	China	India	Myanmar	Nepal	Pakistan
Population (millions) 2007	27.0	158	0.66	1328	1169	48	28	163
Annual growth rate (%) 2007	4.1	1.7	1.5	0.6	1.5	0.9	2.0	1.8
Infant mortality rate (live birth/1000) 2006	165	52	63	19	57	10	46	78
Under – 5 mortality rate (live birth/1000) 2006	257	69	70	23	76	12	59	97
Maternal mortality rate (live birth/100,000)	14 (03)	20 (06)	56 (03)	98 (05)	47 (06)	98 (05)	19 (06)	31 (05)
Access to safe water (% population) 2006	22	80	81	89	89	80	89	90
Access to sanitation (% population) 2006	30	36	52	68	28	82	27	58
Adult literacy rate (% of people 15+) 2007	n/a	53.5	55.6	93.3	66	91.9	56.5	54.9
Female (as % of labour force) 2006	38.6	57.8	49.4	84.1 (07)	38.9	82.3	64.1	36.1
Per capita energy consumption (kg of oil equivalent) 2006	n/a	129	n/a	910	329	268	337	407
Per capita electricity consumption (Kwh) 2005	6	58	69	215	91	30	27	194
Population below national poverty line (%) below US$ 1.25/day 2005	n/a	49.6	26.2 (03)	15.9 (05)	41.6	n/a	55.1 (03)	22.6 (04)
Per capita GDP (US$) 2007	302	455	1356	1602	792	457	287	749

Source: UN ESCAP, 2008 Statistical Yearbook for Asia and the Pacific, *http://www.unescap.org/stat/data/syb2008/index.asp*

APPENDIX III - FEATURES OF THE RIVER BASINS

Geography

The Ganges Brahmaputra Meghna (GBM) river system covers an area of 1.72 million sq. km stretching across five countries: Bangladesh, Bhutan, China, India and Nepal. While Bangladesh and India share all three rivers, China shares with them only the Brahmaputra and the Ganges and Bhutan and Nepal share only the Brahmaputra and Ganges respectively. The population of the region, which has been growing at the rate of about two per cent per year, was estimated at 558 million in 1999.

The river system of the GBM terminates as a delta bounded by the Padma-Meghna in the east and the Hugli in the west, covering much of West Bengal and the floodplain area of Bangladesh where some 210 million people live. Two of Asia's major cities, Dhaka (population over 12 million) and Calcutta (population about 12 million), are situated within the delta. India shares in the population and the area of the GBM region are 76 and 63 per cent respectively, while the corresponding shares for Bangladesh are 21 and 7 per cent respectively. Nepal, with almost its entire territory within the Ganges basin, shares 8 per cent of the GBM area and 3 per cent of the population. All rivers from Bhutan flow into Brahmaputra and make up 6.71 % of the basin area. Table 7 provides a full breakdown of the drainage area, the arable area and the population in the GBM region as shared by the five countries:

Table 7: Area and population as shared by the countries of the GBM

Country/Basin Parameters	Nepal	India	Bangladesh	Bhutan	Tibet (China)	GBM Total
Ganges						
Drainage area 1000 sq km	147	861	46		33	1,080
Arable-area M.ha	2.6	60.2	3.0		-	65.8
Population million	22	370	34		1	427
Brahmaputra						
Drainage area 1000 sq km		195	47	38.5	293	573.5
Arable-area M.ha		5.5	3.6	0.003	-	9.3
Population million		31	47	0.668	2	82
Meghna						
Drainage area 1000 sq km		49	36			85
Arable-area M.ha		1.5	2.5			4.0
Population million		7	42			49
Ganges-Brahmaputra-Meghna						
Drainage area 1000 sq km	147	1,105	129	38.5	326	1,738.5
Arable-area M.ha	2.6	67.2	9.1	0.003	-	79.1

Population million	22	408	123	0.668	3	558

Climate of the HKH Region

The HKH region is characterized by a variety of climatic conditions from tropical to alpine. At macro-scale there is a dominance of monsoon rainfall pattern with maximum precipitation in the summer. The Himalayas are a major barrier for the natural flow of the southwest monsoon (5000 m a.s.l.). Hence, the monsoon takes an entirely different course and the dominance of monsoon is not uniform throughout the region. The rainfall increases from the Indus basin in the west to the east up to Brahmaputra and then decreases in the Meghna basin. Mean annual precipitation ranges from 300 mm in the Ladakh area in the west to 1400 mm in Kathmandu and 4000 mm in Pasighat in the Brahmaputra basin. Similarly, the duration of the rainy season increases from the west (two months) to the east (eight months). As a consequence, the duration: of high flow season increases from west to the east. At meso-scale, the rainfall is highly influence by local orography. Precipitation in general increases from lowland valleys to higher mountain slopes. The windward slope gets more precipitation than the leeward. High intensities of rainfall are the characteristics of microclimate and occur more frequently in lowland areas than in the higher altitude. Such high intensity rainfall causes flash floods. However, such precipitation is highly localized. The lower and upper tropospheric atmospheric circulation results in four distinct rainfall seasons namely pre-monsoon (March-May), summer monsoon (June-Sept), post monsoon (October- November) and winter (Dec-Feb). Pre and post monsoon rain is associated with thermal convection combined with orographical uplift and seasonal shift of the large circulation to the south. Winter rain is influenced by westerly disturbances and decreases from the west to the east. In general 60-90 percent of the annual total precipitation occurs during summer monsoon in the central and eastern part of the region. As a consequence, remarkable variations between high flow and low flow are observed particularly in the Ganges and Brahmaputra rivers.

The onset and withdrawal of monsoon is associated with the northward and southward movement of the equatorial trough or monsoon trough. During the period of very active monsoon, the Westerlies occasionally move south to the Tibetan plateau and easterly jet stream often shifts northwards. During the monsoon period a large bow-pressure cell exists over Southwest Asia, intensified by the location of the Himalayas and Hindu Kush mountains, which trap warm air within the Indian Ocean basin. This low-pressure cell along with the Earth's Coriolis force cause intense winds to blow from the southwest. The south-westerly winds from the Indian Ocean are warm and laden with moisture. As the air rises upon reaching the landmass, it cools off whereby its moisture holding capacity is reduced which results in very heavy rainfall. In the higher altitude, both accumulation and ablation of snow take place in the summer in the Ganges and Brahmaputra basin.

Hydrology

The summer monsoon is the major supplier of water to the Himalayan mountain system. Over 80% of the GBM region annual rainfall is concentrated in three to four monsoon months, with much of the precipitation occurring in about 45 rainy days and more particularly in very heavy spells. Although no precise quantification of the total volume has yet been possible, preliminary estimates have been made of the annual runoff of the major rivers.

Table 8: Annual runoff of the major Himalayan rivers

River System	Average Annual Runoff (BCM)
Meghna	141.9
Yarlungtsangpo	130.5
Brahmaputra	606.8
Ganges	371.1
Indus	143.6

The estimated average annual runoff in these rivers is in excess of 1,400 billion cubic metres (BCM).

A major hydrological problem in the Himalayan region is that of erosion and sedimentation. The Himalayan rivers are active and more dynamic in nature than in other parts of the world in view of the steep slopes and the geologically young Himalayan mountain system. It is estimated that between 0.5 and 1.8 billion tons of sediment are deposited annually in the Bay of Bengal. Not all sediment travel to the Bay of Bengal or to the Arabian Sea, part of it is deposited in the reservoirs and on the floodplains. This results in a gradual depletion of the storage capacity of reservoirs and their economic performance and severely reduces the flow capacity and navigability of river channels and further aggravates the flood problem.

The assessment, development and sound management of the water resources of the Himalayan region call for a thorough understanding of its hydrology. The development of an extensive and regionally accessible database of climate and hydrological parameters should be a major objective of all the countries that share the water resources. However, although repeated alarms have been sounded the continuing lack of adequate data remains a major problem. The relative inaccessibility of the mountain areas and their extreme complexity are possible reasons why no systematic regional observation networks have been established.

A major constraint in the improvement of flood forecasting on national levels is the generally inadequate access to real time hydrometeorological data. At the regional level, the establishment of flood advisory services is constrained by the lack of internationally shared real-time data and information. Some exchange of data has occurred through bilateral agreements between Nepal- India, Nepal-Bangladesh and Bangladesh-India on a real-time basis.

A brief description of each of the major rivers in the GBM system is presented below:

The Indus Basin

The river system of the Indus valley consists of five main rivers namely Indus river, Jhelum river, Chenab river, Ravi river and Sutlej river. Most of the Indus Basin lies in India and Pakistan and 13% of its total catchment is in Tibet and Afghanistan. A brief description of the physiographic features of each of the rivers is provided below.

a. Indus River

River Indus is one of the longest rivers of the world. It originates near lake Mansarowar on the north side of the Himalayas range in the mountain of Kailash Parbat in Tibet at an elevation of 5,500 m. The river length above Tarbela is about 1500 km and catchment area of 466,200 sq. km. There are five right bank tributaries (Singhi, Shyok, Shiger, Gilgit, and Astore rivers) and three left bank tributaries (Tansher, Dras, and Siran rivers). Most of the catchment above Tarbela is mountainous with some of the highest peaks in the world after Mount Everest. Most of the snow melt contribution comes from the area between 3,000 to 5,200 m in elevation. The river enters the plains a few km below Attock. It has very flat slope and wide bed with large formation of deltas in the province of Sindh.

b. Jhelum River

Jhelum River originates in the Kashmir valley about 54 km east of Anant Nag. It flows in a north westerly direction through Srinagar on to Wular Lake. For a short distance of 32 km from the lake to Baramula it moves along a somewhat southerly track and then turns westwards up to Muzaffarabad. The river then takes a sharp turn southwards and continues in that direction up to Mangla. From Mangla to Jhelum City it moves southwards and then turns westwards up to Khushab, beyond which it moves south up to its confluence with Chenab at Trimmu. Total length of the river is 820 km with a catchment area of 63,455 sq. km. Emerging out of its mountainous source it has a steep slope of 43 m/km up to Anant Nag, after which it enters into area sloping at about 2 m/km up to Wular Lake. The catchment between Wular Lake and Baramula is flat with little or no slope. This feature of the area is extremely significant in the context of flood forecasting. River slope is about 7m/km up to Muzaffarabad, increasing to 11 m/km up to Kohala and reducing to 2 m/km to Mangla. The river enters into planes after Mangla with a slope less than 0.4 m/km on the average until it joins Chenab at Trimrnu. River Jhelum has two major tributaries, the Neelum and Kunhar rivers, between Muzaffarabad and Kohala. Further downstream, two more tributaries, the Poonch and Kanshi rivers join it upstream Mangla. Between Mangla and Jhelum three smaler tributaries namely Suketar nallah, Bahdar Kas and Jabbakas enter the river along the left bank while another two nullahs, the Kahan and Bunha join near Jhelum city and Rasooi Barrage respectively along the right bank.

c. Chenab River

Chenab river is one of the largest river of Indus basin exceeded only by the river indus. It has a total length of 1,240 km and a catchment area of 67,600 sq. km. Upper most catchment of the river is snow covered and forms the North Eastern part of Himachal Pradesh. The river originates at the confluence of the Bhaga and Chandra which flow along the two sides of the Baralacha pass at an elevation of 4,900 m and converge at Tandi in Jammu and Kashmir State. From Tandi to Akhnur the river traverses the high mountains which are a part of Himachal and Pir Panjal ranges. The river enters Pakistan a little above

Marala. From the highly elevated source region down to the plains below Akhnur the river under goes sharp variation in its slope. Above Tandi its slope is about 25 m/km, which is reduced to about 5 m/km between Tandi - Akhnur reach, and then down about to 0.4 m/km towards Trimmu. It has twelve tributaries out of which six (Chandra, Bhaga, Bhut Nallah, Maru, Munawwar Tawi and Jammu Tawi) are across the border, while the remaining six (Doara, Dowara, Halsi, Bhimber, Palku and Budhi) join the river between downstream of Marala and Khanki from the right and left respectively. Another four tributaries enter the river above Salal Dam.

d. Ravi River

River Ravi originates from the lesser Himalayas range in India. Total length of the river is about 890km. The upper catchment is bounded to the north by the Pir Panjal range and to the South by Dauladhar range. It has a steep slope of about 3 m/km up to Madhopur which is reduced to above 1 m/km towards Jassar beyond which the river flows through flat plains with slopes averaging only 0.19 m/km (one foot/mile). River Ravi has a catchment of about 40,000 sq. km. It has five major tributaries namely: the Ujh, Bein, Basantar, Deg and Hudiara Nallah. The river runs almost along the Indo-Pakistan border from a point 25 km downstream of Madhopur over a distance of 95 km up to a point 32 km upstream Shahdara. It joins Chenab River below Sidhnai Barrage.

e. Sutlej River

Sutlej River originates in the vicinity of Lake Mansarowar near the source of Indus, Ganges and Brahmaputra rivers. It has a length of about 1,550 km and a total catchment area of 1,22,000 sq. km. More than 70% of the river length, as well as the catchment area, lie above Ferozepur barrage in India. Its uppermost catchment is hilly comprising mountain ranges as Kailas, Panjal and Siwalik. The highest mountain range is the Himalayas range which is almost in the middle of the catchment above Ferozepur. Sutlej River has eight major tributaries. All the tributaries, except Rohinallah join the Sutlej River in India. Bias River is the largest tributary and is 450 km long with a total catchment area of 15,800 sq. km all of which lies in the Indian states of Himachal Pradesh and Punjab. A number of control structures in the form of barrages and dams exist across the border in India.

The Brahmaputra Basin

The Brahmaputra is a major international river covering a drainage area of 580,000 sq. km, 50.5% of which lies in China, 336% in India, 8.1% in Bangladesh and 7.8% in Bhutan. The average annual discharge is about 19,200 cumecs which is nearly twice that of the Ganges. It originates from Tibet and the main stem of it is known as Tsangpo in Tibet, Siang or Dehang in the upstream area in India, and Brahmaputra in the rest of India and Bangladesh. The approximate total length of the river is 2,840 km and it empties into the Bay of Bengal through a joint channel with the Ganges River. The first part flows parallel to the Himalayas from west to east for a length of about 1,130 km. It then turns sharply towards south and enters the state of Arunachal Pradesh of India for about 480 km. Then it turns towards west and flows through Arunachal Pradesh, Assam and Meghalaya states for another about 650 km and then enters Bangladesh. Within Bangladesh, the channel varies considerably in width ranging from less than 2 km to more than 12 km. At the border, the river curves to the south and continues on this course for a length of about 240 km to its confluence with the

Ganges. The basin represents a unique hydro-climatological and geo-biophysical setting characterized by a dominant monsoon rainfall regime, a relatively fragile geologic base, highly active seismicity and an immensely rich biodiversity. The hydrologic regime of the Brahmaputra responds to the seasonal rhythm of the monsoon and freeze-thaw cycle of Himalayan snow in the backdrop of a unique geo-environmental framework.

The Ganges Basin

The Ganges Basin covers an area of 1,080,000 sq. km. The Ganges and Brahmaputra Rivers combined have formed one of the largest deltas in the world, comprising approximately 105,640 sq. km. The Bengal Basin, into which this delta has protruded, is bordered on the west and northwest by lower Jurassic volcanoes and on the east by Eocene sandstones and limestones. The southern boundary is the Bay of Bengal. The Ganges River originates near the Tibet/India border, and then flows southeast across India to combine with the Brahmaputra in the country of Bangladesh. The river has its source in the Himalayas, at Gurumukhi in the southern Himalayas on the Indian side of the Tibetan border. It is 2,510 km long and flows through China, India, Nepal and Bangladesh. The Ganges river basin is one of the most fertile and densely populated in the world and covers an area of 1,000,000 sq km. The river flows through 29 cities with population over 100,000, 23 cities with population between 50,000 and 100,000, and about 48 towns.

The main Ganges River is the flow combination of the two rivers, namely, the Alakananda and the Bhagirathi, which meet at Deva Prayag in Garwal district of Uttaranchal State (earlier Northern Uttar Pradesh) of India within the mountain range of the Himalayas. During its middle course on easterly direction, a number of big and small tributaries have joined on the northern side (left bank) from the Himalayan sub-basin, namely, Rama-ganga, Gomati, Ghagra, Gandak and Kosi, all of which have their origins within the mountain range of the Himalayas in Nepal. Therefore, the contribution of flow of these tributaries is from Nepal within the Himalayan range and also from the Indian soil on the Southern side of the Himalayan foothills. There is another tributary, Mahayana which joins the river in Bangladesh. On the Southern side (right bank), the tributaries are Yamuna, which has joined the Ganges at Allahabad, and other major & minor tributaries are, Kehtons, Sone, Kiul and Punpun, which have origins from peninsular sub-basin. The average annual run-off of the Ganges below Allahabad is about 150,000million cubic metre with the ratio of contribution between the Ganges and the Yamuna as 2: 3.

The river enters Bangladesh after about 50 km below Farakka and its tributaries the Mahananda, Punarbhaba, Atrai (Boral) and Karatoya joins It. The river fully runs into Bangladesh after about another 110 km or so with Rajsahi district on left side and Kustia district on its right. The river joins the Brahmaputra after another 110 km.

In Bangladesh, the basin area amounts to 46,141 sq. km comprising of full and partial area of 161 Thanas (local sub-district administrative units). Most of this area is located in the southwest region of the country. On the north of the area is the Ganges-Padma River, to the west is India and to the east is lower Meghna. To the south of the basin is the Bay of Bengal.

The Meghna Basin

The Surma-Meghna river system flows on the east of the Brahmaputra River through Bangladesh. Out of the two main branches, the Surma River rises as the Barak, on the

Southern slopes of the Nagaland-Manipur watershed in India. The Barak divides into two branches within the Cachar district of Assam in India. The Northern branch is called Surma, which flows through eastern side of Bangladesh by the side of Sylhet town and flows southwards. The southern branch of the Barak is called the Kushiara, which flows through India and then enters Bangladesh. At first the Northern branch joins the Meghna near Kuliarchar and then the southern branch also joins the Meghna river near Ajmiriganj. The lower Meghna is one of the largest rivers in the world, as it is the mouth of the three great rivers- the Ganges-Padma, the Brahmaputra and the Meghna. The total length of the river may be about 930 km. The river is predominantly a meandering channel, but in several reaches, especially where small tributaries contribute sediment, braiding is evident with sand islands, bifurcating the river into two or more channels. The average annual discharge is of the order of 3,510 cumecs, about one-third that of the Ganges.

APPENDIX IV – NATIONAL AND REGIONAL POLICIES AND ACTIVITIES IN THE SECTOR

It is widely recognized that floods in the HKH region cannot be totally controlled and that efforts should therefore be directed towards reducing flood vulnerability and mitigating flood impact through improved flood management. At the level of an international river basin effective flood management calls for meaningful co-operation of the riparian countries. In the HKH region there has been some success in sharing historical hydrological data and bilateral agreements between countries have proven useful in flood forecasting. However, in the regional context, achievements with regard to the sharing of real-time data and information on a regional scale, so critical for flood management, have been limited.

A number of bilateral agreements on water have been forged in the region. Some of these are summarized below.

The Indus Basin Treaty

This Treaty was signed in September 1960 by India and Pakistan. It took nine years to negotiate and resolved a major conflict regarding sharing of common rivers. The Treaty provides a unique solution in that it allocated three rivers, Ravi, Beas, and Sutlej, to India and the three other rivers, Indus, Jhelum, and Chenab, to Pakistan. Each country has unrestricted use of the waters of the rivers allocated to it, with certain exceptions specified in the Treaty. The Treaty has worked well since it was put in practice.

The Ganges Treaty

The Treaty was signed in December 1996 between India and Bangladesh for the sharing of the Ganges waters at Farakka by ten day periods from 1 January to 31 May every year. Although the Treaty is about sharing the lean season flow of the Ganges, it has enunciated a broader cooperation framework to move forward with Treaties/Agreements for sharing the waters of other common rivers and for shaping other mutually beneficial cooperation arrangements. Apart from some initial problems during the first year of implementation, the Treaty has worked well.

The Mahakali Treaty

This treaty was signed in 1996 by India and Nepal concerning the integrated development of the Mahakali Basin. This landmark treaty deals with development of the Mahakali River which is a border river between India and Nepal, between Uttarakhandl and Western Nepal. It regulates the use of the water resources of the Mahakali River at the Sharda barrage and the Tanakpur barrage and proposes the construction of a multipurpose storage dam on the Mahakali River.

The Kosi Treaty

This treaty was signed in April 1954 by India and Nepal. The treaty is mainly for the purpose of flood control, irrigation and generation of hydroelectric power. The treaty was amended in December 1966 clarifying the undertakings by India and withdrawal of water by Nepal. The India- Nepal Agreement on the Kosi Barrage Project also provided for investigations of storage dams on the Kosi or its tributaries. This project is envisaged with two dam sites at Barahkshetra and Kurule respectively.

The Gandak Treaty

This treaty was signed by India and Nepal in December 1959. The main aim of the treaty was in the common interest of Nepal and India for Irrigation and Power. It was to construct a barrage, canal, head regulators and other appurtenant works for purpose of irrigation and development of power for Nepal and India.

Data sharing agreement between China and India

The Chinese and Indian governments reached an agreement on Information exchange for the Yarlungzambo /Brahmaputra River in April 2002. According to the agreement, China is providing near real time hydrological information from three hydrological stations located in the mainstream of the Yarlungzambo /Brahmaputra River, namely Nugesha, Yangcun, and Nuxia, in the flood season from June 1st to October 15th each year.

During the May 2013 visit of H.E. Mr. Li Keqiang, Premier of the State Council of China to India, bilateral relations and international and regional issues of common concern were discussed. It was agreed that the two countries would continue to co-operate in exchanging flood season hydrological data on the Yarlungzambo River. There was an agreement on the provision of hydrological data twice a day from three hydrological stations including Nugesha, Yangcun and Nuxia, lying on the mainstream of Yarlung Tsangpo (Brahmaputra) river during the flood season from 1 June to 15 October. A separate Memorandum of Understanding was signed between the Ministry of Water Resources and China's National Development and Reform Commission for cooperation in "ensuring water-efficient irrigation." The pact aims at enhancing bilateral cooperation in water-efficient technology with focus on agriculture. Mr. Li and Prime Minister Manmohan Singh also announced their willingness to expand cooperation on trans-boundary rivers.

Flood forecasting and warning schemes between India and Nepal

A joint scheme under the name Flood Forecasting and Warning System on Rivers Common to India and Nepal is in operation between India and Nepal. An action plan was agreed between His Majesty's Government of Nepal and Government of India (GOI) in December 1993 under which the logistic problems for commissioning of sites under flood forecasting and warning systems were studied.

The Joint Committee on Water Resources between India and Nepal, which is a meeting between the Water Resources Secretaries of the two countries, met in October 2000 and set up the bilateral Committee on Flood Forecasting which was charged with the task of drawing up the Comprehensive Flood Forecasting Master Plan (CFFMP) for India and Nepal. In total 23 meteorological and 19 hydro-metric stations have been set up in Nepal and 18 hydrometeorological stations in India to facilitate an efficient flood forecasting and warning system for the India-Nepal border region. Around 5 more meteorological stations are to be set up in Nepal. The requisite equipment for these sites has been supplied by GOI and data is being supplied by Nepal on real time basis. In addition to the equipment, GOI has also provided training to Nepalese technicians on various occasions. The Committee on Flood

Forecasting meets regularly to discuss the activities. In Sept 2013 Nepal India Joint Technical Standing Committee meeting was held and discussed issues relating to water resources, electricity, flood forecasting and flood control.

Data sharing arrangement between Bhutan and India

There is an India and Bhutan Joint Expert Team, a bilateral team constituted in 1979 for the monitoring and overseeing of the Flood Warning Program within Department of Hydromet Services under the Govt of India funded 'Comprehensive Scheme for establishment of Hydrometeorological observation and Flood Forecasting Network on rivers common to India and Bhutan'. A Joint Expert Team consists of officials from the Government of India and Royal Government of Bhutan and meets on a regular basis to review the progress and other requirements of the scheme.

Bhutan is collecting and transmitting rainfall and water level data from selected sites of the tributaries of the Brahmaputra originating in Bhutan, like the Puthimari, Pagladiya, Manas, and Sunkoshi. At present, data are continuously transmitted to Cooch Bihar and Jalpaiguri in West Bengal and further data are transmitted to Barpeta/Nalbari and Guwahati in Assam using civil wireless from 28 flood monitoring stations in Bhutan. The flood warning stations are monitored for 24 hrs during the monsoon season and data are transmitted using wireless sets on hourly basis to stations in India.

Data sharing arrangement between Bangladesh and India

There is also a joint India-Bangladesh agreement under which India is transmitting actual and forecasted river-level data to Bangladesh from five stations: Farakka on the Ganges, Goalpara and Dhubri on the Brahmaputra, Domohani on the Teesta, and Silchar on the Barak. In addition rainfall data from Goalpara, Dhubri, Tura, Cooch-Behar, Siliguri, Jalpaiguri, and Agartala are also transmitted from India to Bangladesh.

Data sharing arrangement between Pakistan and India

As part of the Indus Treaty, river flow data from Chenab, Ravi and Sutlej at Akhnoor, Madhopur, Harike and Ferozepur respectively are shared between India and Pakistan during the flood season through the courtesy of Pakistan Commissioner for Indus Water and its counterpart in India.

Data sharing arrangement between Bangladesh and Nepal

There is a data sharing arrangement between Nepal and Bangladesh since 1989. Data from two stations; Devghat at Narayani and Chatara at Koshi is shared on a daily basis during the flood season from June through October.

APPENDIX V - FLOOD FORECASTING IN THE HKH REGION

An integrated flood management (IFM) approach, which includes structural and non-structural measures, is being increasingly adopted taking into consideration both the benefits and adverse impacts of floods (WMO, 2009). Structural measures such as building dams, dykes, embankments, retention basins, and channel modifications reduce flood risks. Embankments and other structural measures have played a significant role in flood mitigation; however, as demonstrated by the 2008 Koshi floods in Nepal and India, embankment breaches can also result in heavy losses and widespread sedimentation. An effective flood protection system is a mix of structural and non-structural measures (Kundzewicz, 2002). This is also embodied in the Integrated Flood Management concept of the Associated Programme on Flood Management (APFM) conducted by WMO and the Global water Partnership (GWP), see: APFM Technical Document No. 1 2009, 3rd Edition, WMO No. 1047 (downloadable from: apfm.info).

An important approach to non-structural flood management is the provision of end-to-end flood forecasting and warning services. Flood forecasting and early warnings are among the most efficient and economical methods to provide people with sufficient early warning for them to temporarily leave at-risk areas and seek safety. In the transboundary river basins of the HKH region this approach offers great potential for regional cooperation. The flood forecasting and warning systems need to be integrated with the overall disaster management activities, both nationally and internationally. Riparian states need to agree on the free exchange of relevant hydrological data among them on a real-time basis. In this connection, the value of technology for the real- time transmission of data on high intensity rainfall and associated river stage should be recognized; and for that purpose the installation of an adequate observation network throughout the region is essential. Satellite rainfall estimates now available from various global meteorological satellites add value to the ground observation networks.

The flood forecasting capabilities of the national hydrometeorological agencies in the region vary. India and China have good capabilities in flood forecasting and use of advanced technologies followed by Pakistan and Bangladesh. While, in Bhutan and Nepal flood forecasting is still in its infancy. The extent of cooperation between riparian states in the HKH region, through treaties and data sharing arrangements is presented in Appendix II. It is one of the aims of the HKH-HYCOS project to enhance this transboundary cooperation. Other relevant regional initiatives being implemented by ICIMOD or other institutions are presented in Appendix III.

APPENDIX VI – RELEVANT REGIONAL INITIATIVES

The HKH region has a history where relatively few regional initiatives for cooperation and management of water resources and hazards such as regional floods and flash floods have been realized. In the past, most transboundary collaboration on water management has been of bilateral nature. However, in the light of climate change impact on the water resources in the region, and with several major river basins being shared by three or more countries, the requirement for regional cooperation is gradually growing stronger. This can be seen within the South Asian Association for Regional Cooperation (SAARC), which recently has formed a Disaster Management Centre (SDMC), hosted by the National Institute for Disaster Management (NIDM) within the Ministry of Home Affairs in India. The centre will contribute to increase the regional approach in disaster risk reduction, and ICIMOD is having a close dialogue with NIDM through the implementation of the KOSHI programme to which the HKH HYCOS contributes.

Other signs of increased interest for regional cooperation on water resources in the HKH region are for instance the so called "Abu Dhabi Dialogue" an informal high level dialogue on water resources management in the region, facilitated by the World Bank. Since 2007, ICIMOD have supported the Abu Dhabi Dialogue Group (ADDG) as a knowledge provider, and in 2008 ICIMOD organized the first Abu Dhabi Knowledge Forum on behalf of the ADDG where around 50 key knowledge institutions in the region were brought together to discuss opportunities for regional collaboration on water resources. The World Bank has made financial resources available under the heading South Asia Water Initiative (SAWI) small grants programme (SGP) which is being administered by ICIMOD to support short term regional projects on water resources management of the kind that were proposed during the 2008 Knowledge Forum. The objectives of SGP are to (i) to facilitate the quest to increase knowledge about water resources systems and their uses within the realm of the Greater Himalayas, particularly under stress from climate change and other drivers of change, including those arising from population and economic growth (ii) to facilitate collaboration among knowledge institutions from different countries sharing the rivers of the Greater Himalayas and (iii) to support them to work together in a collaborative manner. The SGP is expected to initiate new knowledge generation, expand current national research activities to extend across boundaries, and disseminate knowledge within the region.

ICIMOD is in continuous dialogue with both NIDM and the World Bank in matters related to regional water resources management and disaster risk reduction. In addition, ICIMOD as one of the few regional intergovernmental organisations in the region, is implementing a series of regional projects targeting flood management, Integrated Water Resources Management, water availability scenario development etc. The next phase HKH HYCOS project would continue to be a part of this family and form a crucial component within ICIMODs Regional River Basin Programme.

ICIMOD is implementing a regional programme "The Himalayan Climate Change Adaptation Programme (HICAP)" which is a collaborative and policy-relevant applied research programme, contributing to enhanced resilience of communities to climate change. HICAP will generate knowledge of climate change impacts on natural resources, ecosystem services, and the communities depending on them, contributing to policy and practice for enhanced adaptation. As part of this programme ICIMOD is working with its partners to pilot community based early warning systems in Assam, India. The experiences and knowledge gained from this initiative is going to link and synergize with the next Phase proposal of HYCOS which provides better linkages of hydrometeorlogical agencies with the end users and seeks to strengthen an end-to end flood information system.

ICIMOD is also currently coordinating a project on HIMALA Climate impacts on snow, glaciers and hydrology of the HKH region, with the purpose to explore the technical and institutional opportunities to utilize satellite based technology for estimation of precipitation and water availability. With this technique developed and fine tuned it will become an important complementary tool in the region, which is suffering from a very scarce network of hydrometeorological stations. This current project is an off-spring of the first phase of the regional flood information system, and has ensured continuity among the national institutes to continue the dialogue for regional cooperation until present.

ICIMOD in partnership with NASA and USAID has established SERVIR-Himalaya in 2010. SERVIR is a regional visualization and monitoring system that integrates earth observation information, such as satellite imagery and forecast models, together with insitu data and other knowledge for improved and timely decision making. The SERVIR-Himalaya provides the opportunity to strengthen ICIMOD's capacity as a regional resource centre for geospatial information and earth observation applications for the HKH region for better resource management. This initiative seeks to work with its national partners to analyze, validate and disseminate information to the various users and could have synergy with the next phase of HYCOS in applying space based products for flood modeling.

Apart from ensuring complimentarity with other regional initiatives, it is also important to link the proposed regional communication initative with national level early warning systems. While the proposed project intends to improve and secure data and information of precipitation and discharge across national boundaries in the region, it is the responsibility of each country to ensure that this information is incorporated into the national level early warning systems for floods. To this end, the project will make considerable efforts to facilitate a seamless interface between the regional and the national dimensions. For this purpose ICIMOD can look back on close collaborations, stretching over a decade or more, with several of the key national institutes such as the Pakistan flood forecasting division and the Department of Hydrology and Meteorology in Nepal. In collaboration with the latter, the "Finnish-Nepalese project" for increased capacity of hydrometeorological services in Nepal is now in its second phase. The goal of the project is to improve Nepalese meteorological expertise and preparedness for natural disasters, which climate change, is expected to increase in the future. The project is expected to contribute to the seamless interaction between the Nepal national, and the regional levels. It is expected that the Finninsh-Nepal cooperation project with the DHM will provide valuable tools and products that could directly be used to improve flood forecasting at national levels as well as being valuable for the generation of regional flood outlooks in the context of the proposed project.

Another project with significant linkage to the HKH-HYCOS project is the South Asia Flash Flood Guidance System (SAsia-FFGS) project that is currently implemented by WMO and the Hydrologic Research Centre (HRC) with USAID funding in Bangladesh, Bhutan, Nepal and Pakistan (where the Pakistan Meteorological Department) has the function of the regional center). ICIMOD is supporting this project through its role as a regional knowldege hub.

Nepal is amongst the nine recipient of the Pilot Programme for Climate Resilience (PPCR) fund. The PPCR is a program of the Climate Investment Funds' Strategic Climate Fund (SCF), and is designed to pilot and demonstrate ways to integrate climate risk and resilience into developing countries' core development planning and actions. As one part of the PPCR is Building resilience to climate related hazards with a total funding of 31 million. The project has four components: i) Institutional strengthening, capacity building and implementation support of DHM; ii) Modernization of observation networks and forecasting; iii) Enhancement of the service delivery system of DHM; iv) Creation of an agriculture management information system (AMIS).

Table 9: List of projects related to flood risk reduction in the regional member countries

S.No	Projects	Country	US$	Description
1	Pilot Programme for Climate Resilience (World Bank) 2013-2018	Nepal (DHM and MOA)	32,000,000	PPCR has four components (i) Institutional strengthening (ii) Modernizing hydrometeorological network (iii) Improving service delivery Agricultural Information system
2	Community Based Flood and Glacial Lake Outburst Risk Reduction Project (UNDP GEF) 2013-2018	UNDP, DHM, DWIDP	7,000,000	To manage the growing risks of Glacial Lake Outburst Floods (GLOF) in the high mountains and flooding in the Tarai and Churia Range of southern Nepal through a strong emphasis on community engagement, empowerment and social inclusion.
3	South Asia Flash Flood Guidance System Project (SAsia-FFGS) (WMO/HRC/NOAA/USAID) 2013 - 2015	Bangladesh, Bhutan, Nepal, Pakistan and Afghanistan (affiliated)	1,100,000	Establishment of an operational Flash Flood Guidance System as part of the WMO Flood Forecasting Initiative. Focus is on small rivers prone to flash floods. Project is under implementation.
4	Addressing the risk of climate-induced disasters through enhanced national and local capacity for effective actions: - Enhanced national capacity for managing climate risks	Bhutan (DHMS) – UNDP-GEF/NAPA	4,410,000	Enhanced quality, availability and transfer of real-time climate data in all districts through expansion of Hydro-Met network and Flood Forecasting and Warning Systems.
5	"Strengthening Hydro-Meteorological Services for	Bhutan(DHMS)-	598,000	Capacity building and institutional strengthening in DHMS for better

	Bhutan" (SHSB)	FMI		Forecasting, Technically sound maintenance and operation, good Data Management with quality control systems and improved Public Service Delivery
6	Development of an Integrated GLOF Early Warning System (IGEWS) with Operational Capacity Enhancement for Climate Change Adaptation in Mangde Chhu and Chamkhar Chhu River Basins in Kingdom of Bhutan	Bhutan (DHMS)-JICA	Technical Cooperation	Setting up a GLOF Early Warning System in the Mangdechhu and Chamkharchhu basin along with national level Flood forecasting and warning coordination.
7	Modernization of Hydrologic monitoring and Expansion of Hydro-geological monitoring network including supply, testing, installation, commissioning and training for installation, handling and operation of equipment ,complete in all respect.	Bangladesh (BWDB)	)0000	Modernizing Hydro-met Network 29 nos. Auto Data Accusation System of surface water level and 9 nos. Rainfall stations and 1 nos. Auto weather station in the coastal area. lydro-geological Information system. 19 nos. of ground water level and salinity concentration measuring stations. Each station consist of 3-5 piezometer in different permeable aquifer in the coastal area. mprovement of Flood Forecasting and warning system.
8	Flood Forecasting Telemetric network **(Ongoing)**	Pakistan (WAPDA)	**installed cos** **5 million** (considerin g US $ rates in 1996 and 2006)	Phase-I, 25 Nos Flood forecasting Telemetric Stations were installed in 1996 and to strengthen this Network, 20 Nos remote stations were installed in 2006 in phase-II under Flood Protection Sector Project. This network of 45 Nos remote stations spread in Khyber pakhtunkhaw (KPK), and Punjab. This network provides quasi real time data of water level and catchment rainfall to issue early warning

9	Glacier monitoring Research Centre Wapda **(Ongoing)**	Pakistan (WAPDA)	**installed cost million** US $ rate in 1996)	Network consists of 20 Nos Data collection platforms installed in northern areas of Pakistan which provides weather data to generate 10 daily and seasonal forecasts for Tarbela, Mangla and Kabul.
10	Expansion of Flood Forecasting Telemetry Network in Upper Indus Basin (UIB) **(Planned)**	Pakistan (WAPDA)	**Prooposed cost** **million** US $ 95)	For better flood forecasting and issue early warning in the Upper Indus River, WAPDA has developed a plan to integrate/add up 18 Nos Flood Telemetric Data Sites at Un-Gauged location of Upper Indus Basin for; (i) Strengthening of Existing Flood Telemetric Network (iv) Capacity Building (v) Improving service delivery (vi) Improving National Flood Information System ration – 1 year (inclusive of O&M)
11	Installation of 14 nos Hydro-meterological station in Hill Torrents areas for flash floods **(Planned)**	Pakistan (WAPDA)	**Proposed cost** **298 million** US $ 95)	To monitor Hill torrents (Flash floods) of DG Khan & Rajanpur districts of Punjab and Barkhan District of Balochistan along with Mangla catchment Duration – 1 year (inclusive of O&M)

APPENDIX VII – HKH-HYCOS USER PHASE – LOGICAL FRAMEWORK

Outcomes	Indicators	Means of Verification	Assumption
Goal: To contribute to protect lives, livelihoods, property and infrastructure by enhancing flood risk management capacity in the HKH region	National statistics and external evaluations show enhanced flood risk management capacity in partner countries of the HKH region	National statistics; External evaluation reports; impact studies	Regional Member Country governments remain committed to their Disaster Risk Reduction agenda and support relevant agencies' role
Outcome 1. Improved end user interface through the improvement of the operation and application of flood information systems and their products by member states and vulnerable communities	Number of community organisations, local government institutions adopting project products in their Disaster Risk Reduction plans in at least 4 Regional Member Countries	External evaluation reports; Impact Studies; Partner Reports	
	Increased demand of flood information and related products by government line agencies and community organizations in at least 4 Regional Member Countries	Number of downloads of HKH-HYCOS flood outlook products by national hydro-met agencies; external evaluation reports and impact studies; Partners progress report	Donor support and matching funds from partner countries secured
	Provincial, district and local level disaster management authorities in at least 4 Regional Member Countries utilize the flood information products in a timely manner	External evaluation reports; impact studies; Partner progress reports	
	Number of Regional Member Countries participating in transboundary cooperation activities	External evaluation; Project reports related to transboundary cooperation	Active engagement with partner facilitating agencies and WMO Information System Service.
Outcome 2. Improved flood forecasts for flood risk management in transboundary basins	National institutions providing quality real time data shared at national as well as at regional level	National statistics; Partner Reports; External evaluation	

	Operational forecast models are used by national hydrometeorological services for flood forecasting	External evaluation reports; Impact studies	
	Regional flood outlook products used by national hydrometeorological agencies (Maps, alerts, water levels and discharge at various locations along the rivers)	External evaluation reports; Impact studies.	

Output	Indicators	Means of Verification	Assumption
Component 1: Institutional Mechanisms for Flood Risk Management (Producing Outputs for Outcome 1)			
Outputs:			
1.1. Institutional mechanism for flood information dissemination is developed/strengthened	National Institutional flood information and dissemination mechanisms in at least 4 countries is reviewed and a functional flood early warning systems put in place in each country	Alert logs from partner institutions, partner reports; External evaluation reports	Cooperation from partner agencies and governments to allow review of institutional mechanisms
1.2. Flood information products available from national hydrometeorological services to disaster management authorities	Number of flood information products made available by National Hydrometeorological Agencies to Disaster Management Agencies in each partner country		
1.3. Flood information and outlook products are available to end users for timely responses	Number of flood outlook products made available to communities in partner countries by Disaster Management Agencies, media and telecom organizations and NGOs	Media coverage and report on public awareness and communication	

Output	Indicators	Means of Verification	Assumption
Component 2: Capacity Building for Flood Modelling and Forecasting (Producing outputs for Outcome 2)			
2.1. National hydrometeorological agencies have capacity to use state-of-the-art technology, real-time quality data and models for flood forecasting	Number of trained and certified human resources in partner agencies by countries to operationalize forecast models Number of trainings and workshops on using state-of-the-art technology, real-time quality data and models for flood forecasting	Training/workshop reports; Partner reports; External evaluation and impact studies	Relevant staff available for training in floods modelling and forecasting that can influence change in the partner agencies
2.2. Regional flood outlook products are developed and made available to national hydrometeorological agencies	Number of regional flood outlook products made available to national hydro-met agencies across Regional Member Countries	Report on project flood outlook products; Logbook on Flood information systems	
Component 3: Observation Network operation and maintenance (Producing outputs for Outcome 2)			
3.1. The hydrometeorological network for real-time data collection and transmission is expanded in the regional member countries	Number of additional hydro-meteorological stations in place, operational and delivering real-time data by the end of project in each partner country Number of existing stations upgraded, operational and delivering real-time data in each partner country	Partner reports; National statistics and external evaluation	Staff and resources in place to fund equipment and training, including on-going operational and maintenance costs Field equipment is kept functional in isolated areas of HKH region.

Component 4: Flood Information System operation and maintenance (Producing outputs for Outcome 2)			
4.1. Quality real-time data is available through the flood information system of regional member countries through implementation of enhanced quality control procedures	National HYCOS websites and data management systems upgraded, updated and operated under quality control procedures Number of regional flood outlook products available on website	Quality Control logs on national HYCOS websites; External evaluations Downloads of HKH-HYCOS flood outlooks by national hydrometerlogical agencies	Partners are able to maintain and operate the flood information system
Component 5: Regional and International Partnerships (Producing Outputs for Outcome 1)			
5.1. China and India provide knowledge products and information to support flood information systems	Number of knowledge products or information provided by Chinese and Indian partner agencies.	Report on project flood products used by HKH-HYCOS partners; External evaluation	Indian and Chinese partner agencies share knowledge products and information; Other regional and international projects, programmes and initiatives take interest and engage in knowledge sharing
5.2. Improved collaboration and cooperation with other hydrometeorological projects in the region and implementation of existing available products, e.g. flash flood guidance system, PPCR and other regional and national products	Number of additional external flood related products used by HKH-HYCOS partners. Number of new partnerships developed		

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