ICIMOD

INTERNAL REPORT

Regional Cooperation for FLOOD DISASTER MITIGATION

IN THE HINDU KUSH-HIMALAYAS

Report of the Consultative Meeting on
Developing a Framework for Flood Forecasting in the Hindu Kush-Himalayan Region
15-18 May 2001, Kathmandu, Nepal

Organised by

The International Centre for Integrated Mountain Development (ICIMOD)
and
The World Meteorological Organisation (WMO)

Co-hosted by

The Department of Hydrology and Meteorology, HMG/Nepal

ABOUT THE ICIMOD

The International Centre for Integrated Mountain Development (ICIMOD) is an international organisation devoted to the development of the Hindu Kush-Himalayan region covering all or parts of eight sovereign states, Afganisthan, Bangaladesh, Bhutan, China, India, Myanmar, Nepal and Pakistan . The center is located in Kathmandu, Nepal. The primary objective of the center is to promote the development of an economically and environmentally sound mountain ecosystem and to improve the living standards of mountain populations.

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&
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Foreword

Most of the mighty river basins of the Hindu Kush-Himalayan (HKH) region – the Indus, the Ganges, the Yarlung Tzangbo-Brahmaputra, and the Mekong – start high in the Himalayas at altitudes exceeding 8,000 meters. The rivers then proceed to cross the geographic divide of the high Himalayas and are joined by thousands of tributaries, to discharge water into the aquifers, the agricultural fields, the villages and towns, the factories, and the powerplants that are the engines of our survival and economic growth - joining our countries - and eventually reaching the oceans that we all share.

But when the waters burst from lakes formed by landslides or glacial moraines, or when high quantities of rain falls on saturated grounds, we get floods, which devastate our region. Upstream, bridges and powerplants are wiped out – as they were in the Brahmaputra and Sutlej last year by landslides that created temporary dams and huge lakes in the Tibet Autonomous Region. Downstream, floods exceed the river banks and break river embankments to cause terrible loss of life and livelihoods to those poorest of farmers trying to live in these flood-plain areas.

Too often, the people in the path of these floods have no warning. We know that there are limitations on how much we can control floods in the short run without massive investments – the environmental costs of which can sometimes exceed the benefits. But we also know that we now have the technology and the capacity to provide timely forewarning to everyone downstream – to allow lives to be saved and property losses to be minimised.

We also know that this is necessarily a regional issue and that when the rivers draw us together into common basins, we must come together to link the upstream events with the downstream consequences, and the downstream policies with their upstream consequences. This was the purpose of this consultative meeting - to save lives and productive investments by exploring frameworks for flood forecasting in real time, or at least in time so short that people downstream have the most warning possible of floods coming their way from upstream.

The World Metereology Organisation (WMO) has initiated a World Hydrological Cycle Observation System which is increasingly being used as a framework for such collaboration

– as well as a basis for attracting development investments from bilateral and multilateral sources. WMO is our main co-sponsor and guiding partner in putting together this consultation. We are also inspired by the support for this endeavour by our other co-host the Department of Hydrology and Meteorology of His Majesty's Government of Nepal.

ICIMOD, which has as its member countries all of the HKH countries, has been active in supporting regional efforts to increase scientific and technical collaboration on water issues – from watershed management and micro-water harvesting to regional data sharing through the HKH-FRIEND project supported by UNESCO.

This meeting has started a collective dialogue in which **we are** also benefited by the technical knowledge and support of agencies outside the region. In addition to WMO and UNESCO, we are particularly grateful to the Governments of the United States and Denmark for bringing invaluable expertise, financial support, and enthusiasm to this effort.

The meeting created a unique opportunity for high-level government representatives, directors of national hydrological and meteorological services, and technical experts from the region and international organisations to share information on the extent of flood problems in the region and to discuss organisational and technical approaches to flood forecasting and mitigation of flood-related damages. The participants discussed and agreed on a framework for the development of a *Flood Information System* including state-of-the-art observations, communication technology, modelling, capacity building, and sharing of hydrological and meteorological data and information on the HKH region. The meeting agreed on an initial *Action Plan for Regional Cooperation for Flood Information Exchange* which will be coordinated by ICIMOD in cooperation with regional countries and the WMO.

The cooperative spirit demonstrated by all participants and the valuable contributions provided by the invited technical experts were essential to successfully achieve the objectives of the meeting. The tangible expression of this success is the agreement on activities and milestones to be achieved within the next twelve months.

The present report contains both a record of the outcome of the discussions that took place and the papers presented. The people of the region have learned to seek in the Himalayas both spiritual solace and the means to improve the livelihoods of people living both upstream and downstream. We hope that the optimism displayed at the meeting will be imbued with commitment to follow through in each country and that collective wisdom and practical experience will save lives and improve economies while safeguarding the irreplaceable environment from floods.

Dr. J. Gabriel Campbell

Director General

ICIMOD

Executive Summary

Participants from six countries, namely Bangladesh, Bhutan, China, India, Nepal, and Pakistan came together for a high-level consultative meeting on the development of a framework for flood forecasting in the Hindu Kush-Himalayan (HKH) region. The meeting was organised by the International Centre for Integrated Mountain Development (ICIMOD) and the World Meteorological Organisation (WMO) and was co-hosted by the Department of Hydrology and Meteorology (DHM) of His Majesty's Government of Nepal in Kathmandu from 15-18 May 2001. The meeting was sponsored by the US Department of States -Regional Environment Office for South Asia, the Office of the United States Foreign Disaster Assistance (OFDA), and the Danish International Development Assistance. Recognising the tangible benefits of a regional framework for flood forecasting, representatives from the six participating countries agreed to develop strategies for flood forecasting and a regional flood information system. The consultative meeting served as an important platform for the initial development of these strategies. The participants agreed on an initial Action Plan for Regional Cooperation for Flood Information Exchange in the HKH region to be implemented by 2002.

Rationale for the Meeting

The HKH region is shared by Afghanistan, Bhutan, China, India, Nepal, Myanmar, and Pakistan and is the source of six of the world's largest rivers. The Indus, the Ganges, the Brahmaputra, the Mekong, the Yangtze, and the Yellow River originate in the mountains of the HKH region. These rivers are vital for the socioeconomic development of millions of people in South and Southeast Asia through their potential for irrigation, hydropower generation, fishery, inland navigation and the sustenance of wetlands and their biodiversity. Large snow and ice fields in the Himalayas are important for maintaining the flow margin of these rivers during the dry season. An important characteristic of many of the rivers in the HKH region is that they are shared by several countries before reaching the ocean. In this respect, Bangladesh is included in the HKH region because Bangladesh receives the waters of the Brahmaputra and its tributaries which originate in the Himalayan range.

Devastating floods are an annual phenomenon of the HKH region. While weather-forecasting systems have reached a high level of accuracy and weather data and forecast products are shared on a regional and global basis, there is, at present, no regional mechanism for regular exchange of hydrological data and information. Without a reliable hydrological database and a flood information system which is linked to the weather forecast systems operated by the meteorological services in the region, it is not possible to forecast floods and mitigate their devastating effects. Recurring floods of large magnitude

and frequency are also a big impediment to more rapid development of the HKH countries. An institutionalised exchange of real-time hydrological and meteorological data and information, primarily for flood-forecasting purposes, is therefore a prerequisite for the development of strategies to mitigate the negative effects of floods. Better quality data and state-of-the-art data transmission and dissemination technologies are needed to share information and data on a real-time basis. Although there has been some success in the sharing of historical data, very little has been achieved with regard to sharing real-time data, which is critical for flood forecasting to save lives, property, as well as costly physical infrastructure.

Objectives

The meeting was held to develop a framework for regional cooperation in flood forecasting and flood information sharing, to discuss options for its implementation, and to agree on a strategy, using the concept of the World Hydrological Cycle Observing System (WHYCOS) formulated and implemented by the WMO. Another objective was to prepare an initial action plan for regional cooperation for timely flood information exchange to save lives and property in the HKH region. Identification of capacity building needs for personnel and hydro-meteorological services entrusted with activities related to data acquisition, dissemination, modelling, and flood forecasting in the participating countries was also an integral part of the agenda of the meeting.

Results

Country Case Studies

The case studies presented by participants from Bangladesh, Bhutan, China, India, Nepal, and Pakistan showed great diversity in technological, scientific, and institutional know-how in dealing with floods. The participants recognised the potential for mutual technical assistance and sharing of technical expertise and know-how. Common to all case studies was the need for an enhanced capacity for flood modelling, real-time data acquisition, and improved accuracy in forecasts. Almost all case studies reported insufficient communication with meteorological services to improve input information for flood forecasting, inadequate hydrological networks and data quality, and technological deficiencies in real-time data acquisition and dissemination. Some countries also cited the need to improve the institutional capacity to deal with floods, including the need for trained personnel and institutional structure and organisation. Deficiencies in the dissemination of information to vulnerable communities were also cited as a major area where improvement is necessary. Some countries have made significant progress in the implementation of flood-forecasting systems on a national level and the possibility for technical cooperation between these countries and those that could benefit from improved flood-forecasting systems was highlighted. At the regional level, improved exchange of data was seen as essential for the improvement of flood information, especially in shared river basins.

Technical Concepts for Flood Forecasting

The participants were informed about the concepts, activities, and lessons learned by regional cooperative projects such as the WHYCOS, HKH-FRIEND (Hindu Kush-Himalayan - Flow Regimes from International Experimental and Network Data), and the

Mekong River Commission. Political will, sound technical concepts, and full ownership of the plans, results, and benefits of regional cooperation are essential for successful regional cooperative efforts. The participants agreed that the WHYCOS concept of WMO is a proven and suitable technical concept for the establishment of an operational flood information system. The results of the HKH-FRIEND working groups, especially those on Floods and on Databases, could add value from a scientific point of view. Exchange of information and experiences from organisations involved in river basins, such as the Mekong River Commission, was seen as highly useful in the development and implementation of an HKH regional framework for cooperation.

At the conceptual and technical levels, the participants learned of the activities in relation to the Flood Action Plan in Bangladesh, National Oceanic and Atmospheric Administration (NOAA), and the United States Geological Survey (USGS). It became apparent, that hydro-meteorological networks and related databases (i.e., topographic databases) need to be integrated using modern communication and information exchange protocols. Full use should be made of the capabilities of GIS, weather and climate related information, and satellites for regional observation, forecasting, data transmission, and relay platforms. The Internet was seen as a clear favourite to serve as the platform for regional and global exchange of data and information for flood-forecasting purposes and the dissemination of forecasting products down to the level of national flood-warning centres.

The Framework for Regional Cooperation

A framework for regional cooperation was elaborated during break-out sessions and presentations of and discussion on the results of the subgroups took place in the plenary. The basic components of the framework are summarised below.

a) All countries expressed the need for improvements in flood-forecasting systems, extension and upgrading of hydro-meteorological networks with real-time capacity, data quality, and information collection and dissemination.
b) Capacity building in terms of institutional capacity and professional expertise was recognised as essential for the development and implementation of an operational, multilateral flood information system.
c) In all countries, there is a multitude of cooperating organisations and government agencies. There is a need to coordinate their activities for the establishment of a regional flood information system. Improved consultation and exchange of data and information was recognised as the principal approach to achieve this goal.
d) Effective organisational concepts and mechanisms for the dissemination and use of flood-forecasting products need to be developed to ensure the use of flood-forecasting services at the local, national, and regional levels. This includes the dissemination of information to flood-prone areas in order to ensure effective disaster preparedness.
e) A review of existing flood-forecasting systems based on the country papers and additional information and concepts to improve information collection, data sharing, data transmission, and data screening is needed for the development of an effective flood forecasting information system.
f) In this regard, national procedures for data collection, processing, quality control, archiving, access, modelling, flood forecasting, and dissemination of flood warnings and forecasts need to be improved through joint effort towards regional cooperation.

Strategy for Regional Cooperation in Flood Forecasting

There was a general consensus that the implementation of the framework should be based on a number of key strategic principles and approaches. These are outlined below.

a) The development of the flood information system is a fully voluntary, participatory effort of the countries of the HKH region.
b) The existing national activities related to hydrological networks and flood forecasting should be integrated into the regional system based of prioritisation. Likewise, full use should be made of the ongoing activities undertaken through bilateral agreements.
c) For regional cooperation, the flood information system needs to be built on a proven concept. Therefore, the WHYCOS concept of WMO was chosen as a blueprint to be adapted to the specific needs of the HKH region.
d) Upgrading of hydrological networks, including real-time capacity for data acquisition and dissemination, and a mechanism for the exchange of hydrological data and information is at the core of the anticipated system. As all participating countries (with the exception of Bhutan, at present) are members of the WMO, the WMO resolutions addressing the exchange of meteorological data (12th WMO Congress, Resolution 40) and the exchange of hydrological data (13th WMO Congress, Resolution 25) will form the basis for exchange of data and information in the HKH region.
e) Flood forecasting is primarily a national task and responsibility. Therefore, flood forecasting is confined to national territories but the data and flood-forecasting products are shared on a regional basis.
f) Full integration of weather and climate information related to modelling and forecasting and improvement of observations from satellites, including rapid image processing and interpretation, is required to improve real-time flood forecasting and the accuracy and timeliness of forecasts.
g) Capacity building and technical cooperation at the regional level are an integral part for the development and implementation of the framework.

At the technical level, the following activities were chosen as start-up activities leading to the technical development of the system.

a) Preparation and exchange of an inventory of existing hydrological and meteorological data of the HKH Region.
b) Establishment of a regional centre for data acquisition, processing, and dissemination and assessment of the existing network for flood forecasting (real-time network data). Part of the initial activities of this centre would be the formulation and establishment of protocols for the exchange of data and information to:
    I. identify the focal points for data exchange,
    II. exchange standards (formats, etc) of data and information,
    III. exchange real-time data on water levels, flows, extent of snow cover, precipitation, and flood-prone areas, and
    IV. establish one common website as a regional communication platform for the exchange of data and information.
c) The participants agreed that, based on its capacity, ICIMOD should be designated as the regional centre and also as the focal point for the Regional Hydrological Data Centre within the framework of the HKH–FRIEND project of UNESCO, with active involvement of WMO.

ACTION PLAN

An action plan was prepared on the basis of the recommendations made by the break-out groups and these were discussed in and endorsed by the plenary. The participants agreed on a detailed initial action plan on the basis of the WHYCOS concept with an objective to further develop an HKH-Hydrological Cycle Observing System (HYCOS) project with emphasis on the establishment of a regional flood information system. The action plan entails the following activities and schedule to be completed within June-July 2002.

a. **Preparation of the Meeting Report:** Preparation and circulation of the draft report to all participants for feedback and revision of the report on the basis of comments received from the participants (June - September 2001).
b. **Establishment of a Consultative Panel:** The participating countries are encouraged to nominate members for the panel which will meet to discuss concept papers on regional cooperation for information exchange (June – October 2001).
c. **Formulation of a HKH-HYCOS Concept Paper:** A draft concept paper for regional cooperation for flood information exchange will be developed and circulated to participants for their feedback and endorsement resulting in the production of a project document (November 2001 – June/July 2002).
d. **Exchange of Regional Information:** The participating countries are expected to contribute to the preparation of a web page and establish an open system database as well as a regional hub for exchange of data/information (March 2002).
e. **Preparation of Technical Papers:** Technical papers will be developed by experts selected mainly from the HKH region for presentation at the HKH-HYCOS consultative meeting (May/June 2002).
f. **Second HKH-HYCOS Consultative Meeting:** Asecond HKH-HYCOS consultative meeting will be held to assess the progress and to advise on the operationalisatiion of HKH-HYCOS. ICIMOD and WMO will be responsible for organising the meeting and preparing the meeting documents (June/July 2002).

Conclusions

The meeting created a unique opportunity for high-level government representatives, directors of national hydrological and meteorological services, and technical experts from the region and international organisations to share information on the extent of flood problems in the region and to discuss organisational and technical approaches to flood forecasting and mitigation of flood-related damages. The participants fully recognised the significant benefits that can be derived from multilateral efforts in sharing of data and information to improve timeliness and accuracy of flood-related information. During the three-day meeting, the participants discussed and agreed on a framework for the development of a Flood Information System including state-of-the-art observations, communication technology, modelling, capacity building, and sharing of hydrological and meteorological data and information on the HKH region. The meeting agreed on an initial Action Plan for Regional Cooperation for Flood Information Exchange which will be coordinated by ICIMOD in cooperation with regional countries and the WMO.

List of Abbreviations

ADB	Asian Development Bank
ADPC	Asian Disaster Preparedness Centre
AFWA	Airforce Weather Agency
ALERT	Automated Local Evaluation in Real Time
APT	Automatic Picture Transmission System
BDP	Basin Development Plan
BMD	Bangladesh Meteorological Department
BWDB	Bangladesh Water Development Board
CMA	China Meteorological Administration
CNMC	Cambodia National Mekong Commission
CWC	Central Water Commission
DANIDA	Danish International Development Assistance
DCP	Data Collection Platform
DHI	Danish Hydraulic Institute
DEM	Digital Elevation Model
DHM	Department of Hydrology and Meteorology
DPTC	Disaster Prevention Technical Centre
EROS	Earth Resources Observation Systems
FEWS NET	Famine Early Warning System Network
FFWC	Flood Forecasting and Warning Centre
FMO	Flood Meteorological Offices
FRIEND	Flow Regimes from International Experimental and Network Data
FWC	Flood Warning Centre
GBM	Ganga-Brahmaputra-Meghna
GIS	Geographical Information Systems
GLOF	Glacier Lake Outburst Floods
GOES	Geostationary Operational Environmental Satellite
GPS	Geographical Positioning System
GTS	Global Telecommunication System
HKH	Hindu Kush-Himalayas
HMG/N	His Majesty's Government of Nepal
HYCOS	Hydrological Cycle Observing System
ICIMOD	International Centre for Integrated Mountain Development
IMD	India Meteorological Department
IHP	International Hydrological Programme

JICA	Japan International Cooperation Agency
JRCB	Joint River Commission of Bangladesh
LNMC	Laos National Mekong Commission
MRC	Mekong River Commission
NASA	North American Space Agency
NFFB	National Flood Forecasting Bureau
NGO	Non Government Organisation
NHSs	National Hydrological Services
NMO	National Meteorological Office
NOAA	National Oceanic and Atmospheric Administration
NWS	National Weather Service
NWIS	National Water Information System
NWSRFS	National Weather Service River Forecast System
OFDA	Office of US Foreign Disaster Assistance
OHP	Operational Hydrological Programme
PARDYP	People and Resource Dynamics Project of ICIMOD
PMD	Pakistan Meteorological Department
PMS	Pakistan Meteorological Service
PRC	The Peoples Republic of China
QPM	Quantitative Precipitation Measuring
TAR	Tibetan Autonomous Region
TMDL	Total Maximum Daily Load
TNMC	Thailand National Mekong Commission
TU	Tribhuvan University
UNESCO	United Nations Educational, Scientific and Cultural Organisation
USAID	United States Agency for International Development
USEDF	United States Environmental Diplomacy Fund
USGS	United States Geological Survey
VHF/HF	Very High Frequency/High Frequency
VNMC	Vietnam National Mekong Commission
WAPDA	Water and Power Development Authority
WECS	Water and Energy Commission Secretariat
WB	World Bank
WMO	World Meteorological Organisation
WHYCOS	World Hydrological Cycle Observing System
WUP	Water Utilisation Programme
WWW	World Wide Web

chapter one

Introduction and Background to the Meeting

Preamble

A four-day meeting was held from 15th – 18th May 2001 in Kathmandu to discuss a Framework for Flood Forecasting in the Hindu Kush-Himalayan (HKH) Region. The meeting attracted over 60 high-level government officials and experts from six countries of the HKH region, viz., Bangladesh, Bhutan, China, India, Nepal, and Pakistan and international experts on floods and flood forecasting (the list of participants is given in Annex 3). The meeting was organised jointly by the International Centre for Integrated Mountain Development (ICIMOD) and the World Meteorological Organisation (WMO) and co-hosted by the Department of Hydrology and Meteorology (DHM) of His Majesty's Government of Nepal (HMG/N). The US Department of State (Regional Environment Office for South Asia), USAID/OFDA, and DANIDA sponsored the programme. On the first day of the meeting, the participants were taken on a field trip to the border areas of Nepal and the Tibet Autonomous Region of China to observe the effect of floods on people and property along the Bhote Koshi River. This provided an opportunity for the participants to observe what ICIMOD and other organisations are doing to mitigate disasters caused by floods at the field level. The rest of the three days were devoted to technical presentations by regional participants and other international experts on floods and flood-related issues, discussions on flood forecasting and flood information sharing, and presentation of outcomes.

On the second day of the meeting an inaugural ceremony was held in Kathmandu which was inaugurated by the

Honourable Minister for Science and Technology of HMG/N. The Director General of ICIMOD, officially welcomed the participants, observers, and guests to the meeting. Others, representing the organisers and sponsors, made brief remarks emphasising the importance of the meeting and the need for participants to ensure that concrete steps are taken to develop a workable framework to help prevent the disastrous effects of floods in the HKH region. A summary of the opening speeches and remarks are given in Chapter 2. Soon after the inaugural ceremony, the working sessions commenced and continued until the afternoon of the fourth day. An 'Action Plan for Regional Cooperation for Flood Information Exchange' was endorsed by the participants in the concluding session.

Rationale, Objectives, and Methodology of the Meeting

The mountains of the HKH extend over about 3,500 km from west to east across Afghanistan, Pakistan, China, India, Nepal, Bhutan, and Myanmar and are the largest storehouse of fresh water in the lower latitudes. The mighty rivers of South and Southeast Asia, namely, the Indus, the Ganges, the Brahmaputra, the Mekong, the Yangtze and the Yellow river, originate in these mountains and the Tibetan Plateau. These rivers not only provide sustenance to millions of people in south, southeast, and east Asia but also possess tremendous potential for hydropower generation, which could accelerate the pace of economic development of the countries of these two regions. However, these mighty rivers also cause extensive damage to life and property every year due to devastating floods.

Timely warning of such disasters is therefore crucial not only to save lives and property but also for the development, operation, and management of large water resources' projects. Better quality data and careful planning using the latest flood-forecasting technology, equipment, and communication systems, such as those envisaged in the World Hydrological Cycle Observing System (WHYCOS) of the WMO, are needed to share information and data on a real-time basis. Although there has been some success in the sharing of historical data, very little has been done with regard to sharing real-time data, which is critical for flood warning and forecasting to prevent damages to lives and property.

The need for developing early warning systems and flood forecasting is obvious. Better systems for collecting good quality hydro-meteorological data and their quick transmission based on a thorough understanding and cooperation among the regional countries will help in effective management of the vast water resources and the mitigation of flood disasters. The participants from the region, therefore, appreciated that such a meeting was held to help develop strategies for flood forecasting and flood information exchange in the HKH region.

Main Objectives

The main objectives of the consultative meeting were to develop a framework for regional cooperation in flood forecasting and to devise concrete options for its implementation using the WHYCOS concept formulated by the WMO. The meeting focused on the following:

- achieving consensus among the regional participants on the needs for a regional approach to flood forecasting and flood information sharing,
- developing a technical concept to define the capacity-building needs of the participating countries in hydro-meteorological services, and
- preparing an action plan to implement a technical concept in terms of an operational regional flood-forecasting system.

Methodology

Presentations were made by representatives from the participating countries and international experts on invited policy and technical papers. The participants also discussed in detail, specific topics on flood forecasting and information sharing in break-out sessions. The outcomes of the break-out sessions were presented for further discussions and endorsement at the plenary sessions.

The Report

This report is divided into six chapters preceded by a foreword, an executive summary, and a list of abbreviations and followed by Annexes. Chapter one gives an introduction and background to the consultative meeting. Chapter two covers the Inaugural Session and gives a summary of the speeches. Prior to the inaugural session, a one-day field visit was organised and a brief report on this can be found in Annex 1. Chapter three covers the country case studies and the first part of the technical presentations on flood forecasting systems and highlights the key issues. Chapter four covers the second part of the technical presentations, the issues covered by the break-out groups, a summary of the key issues raised, and the development of an action plan for the establishment of regional flood-forecasting systems. Chapter five primarily includes the presentation of the Action Plan and the Framework for Regional Cooperation in Flood Forecasting and Management. Chapter six covers the key achievements and conclusions. Annex 2 provides the programme agenda of the meeting while Annex 3 gives the list of participants.

chapter two

Day Two: Inaugural Session

Inaugural Session

The inaugural session was held in the morning of Wednesday 16th May 2001. The chief guest was the Honourable Minister for Science and Technology, Mr. Surendra Prasad Chaudhary. Over 90 persons including participants, observers, and guests attended the opening session. A summary of the speeches in the order that they were made is presented below.

Welcome Remarks: Dr. J. Gabriel Campbell, Director General, ICIMOD

Dr. J. Gabriel Campbell welcomed the Honourable Minister for Science and Technology, the distinguished participants from the regional countries, international experts, organisers, and sponsors to the meeting. He noted that the focus of the meeting was to save lives and to encourage productive investments by exploring frameworks for flood forecasting and timely warning for people in downstream areas.

Dr. Campbell stressed that the existing bilateral agreements and regional networks were a good basis for expanding regional collaboration. He mentioned that ICIMOD had been active in supporting regional efforts to increase scientific and technical collaboration on water issues – from watershed management and micro-water harvesting to regional research data sharing through the HKH-FRIEND (Flow Regimes from International Experimental Network Data) project supported by UNESCO. In addition to WMO and UNESCO, he also expressed gratitude to the United States

and Denmark for bringing invaluable expertise, financial support, and enthusiasm to the effort.

Based on consultations already conducted informally, he suggested some tentative areas for follow-up for the participants' consideration. These included the following areas.

1. Mapping and analysis of flood disasters by experts from governments and institutions in the region using state-of-the-art tools and technologies so as to better assess where to invest most efforts to save lives and property
2. Development of compatible technical standards in collaboration with national experts from governments and principal institutions in the region to facilitate the potential for real-time flood forecasting
3. Study of the mechanisms and regulatory frameworks for collecting and sharing hydro-meteorological data through international data-sharing protocols
4. Follow-up meetings to this one to periodically review progress and map out follow-up actions
5. Coordinated national investments, supported by international agencies, to strengthen the capacity needed to turn hopes into reality

Dr. Campbell stated that the people of the region have learned to seek in the Himalayas both spiritual solace and the means to improve the livelihoods of people living both upstream and downstream. He expressed the view that collective wisdom and practical experience could be shared to formulate concrete steps that all the participating countries could take to save lives and improve economies while safeguarding the irreplaceable environment from floods.

Inaugural Speech: The Honourable Minister for Science and Technology, Mr. Surendra Prasad Chaudhary

In his inaugural address the Honourable Minister for Science and Technology, Mr. Surendra Prasad Chaudhary, mentioned that the existence of the HKH countries predominantly depends on their rivers, which have given birth to civilisations in ancient times. The great civilisations in this region flourished along the banks of the great rivers originating form the HKH. Water still dominates the contemporary cultural, economic, as well as the socio-political activities and aspirations of the people of the region. He went on to state that, *"Water can turn out to be a blessing as well as a formidable challenge for the countries of the HKH region. Every year millions of people are rendered homeless and several hundreds lose their lives in disasters caused by floods. Heavy precipitation from June to September, saturated watersheds, steep slopes, and strong river gradients contribute to the magnitude of floods occurring regularly in many countries of this region."* The Honourable Minister appealed to the participants to arrive at a consensus on developing a practically-workable agenda for flood forecasting in the region, in order to enable the participating countries to better manage and mitigate the adverse impact of floods in a spirit of genuine regional cooperation and good will.

The Honourable Minister further added that larger social and economic forces are operating to trigger the expansion of human settlements to river basins and the proliferation of agriculture into flood-affected plains. It will, therefore, be a daunting and unrealistic task to attempt to prohibit the people from living in flood-prone areas or to prevent more people from further migrating into such areas. A more pragmatic and attainable

approach would perhaps be to assist the people living in the river basins to adjust to and cope with flooding instead of attempting to forcibly regulate human settlements in these plains. Maybe the people living in the flood plains should be taught the philosophy *"of living with floods."* Accordingly, he suggested that along with flood forecasting and warning systems, in view of the short lead-time in which floods reach the settlements along the numerous rivers subject to flash floods, we should also place emphasis, where feasible, on *"local preparedness"* and *"social protection"*. This should be done with a view to promote, adapt, and live with flood strategies.

The Honourable Minister also pointed out that, today, when the information technology is unfolding wonders hitherto not witnessed in the history of humankind, the people of the region deserve to get an optimum level of service from the use of such technologies to relieve them from the adversity caused by floods. He expressed the belief that the sharing of information and real-time data, particularly between and amongst co-riparian nations, is essential in the protection of lives and property from the devastation of floods. In this connection, he mentioned that His Majesty's Government of Nepal was in the process of finalising Nepal's National Water Resource Strategy, which focuses on joint regional cooperation in flood management, information sharing, and forecasting and warning systems as important components. The prime objective of the strategy is to harness and develop Nepal's water resources in a sustainable and equitable manner for the benefits of its people as well as its neighbours.

He expressed confidence that the consultative meeting would arrive at consensus on developing a practically-workable agenda for flood forecasting for the region. In conclusion, he thanked the organisers and sponsors for their support and welcomed the regional participants and international experts.

Remarks: Mr. Adarsha P. Pokhrel, Director General, DHM, HMG/ Nepal

Mr. Adarsha P. Pokhrel began his remarks with a quote from the old scriptures which describes the fundamental science behind the hydrological cycle as: *"Adityad Jayate Bristi"* or 'the sun is the creator of precipitation'. The scripture also states *"Aapoh Nara"*, meaning 'water is life'. He argued that these statements teach people the importance of water in sustaining life and hence the need to ensure effective management in times of water scarcity and overabundance. He pointed out that the overwhelming nature of seasonal rainfall and run-off in the HKH region and its impact, both positive and negative, on millions of people who inhabit this region constitute the primacy of water. Every monsoon, torrents of water flow unpredicted across national frontiers, often with devastating fury bringing in their wake immense damage to life and property. Yet, if harnessed judiciously, prosperity through water resource development is the cherished dream of many in the region. He pointed out that mitigation and management of floods, together with water resource development for realisable multiple benefits and consequently the creation of wealth to alleviate poverty in the region, is an aspiration that all share. He stated that the consultative meeting aims to support the technical management of 'too much' water in the region.

Mr. Pokhrel recounted the recent history of flood disasters in Nepal and other neighbouring countries. In Nepal, he stated that in a relatively quiet year –1999– water-induced disaster claimed the lives of 209 people. The loss was estimated to be NRs 365 million (USD 4.8 million approx.). The 1993 flood, one of the worst seen recently in Nepal, claimed 1,336 lives with an estimated property loss of NRs 4,904 million (USD 64.5 million approx.). He stated furthermore, that every year due to floods Bihar, Uttar Pradesh, Assam, and other Indian states experience heavy losses of lives and property. In China and Bangladesh floods are regular events claiming heavy losses of lives and property. The incidence of these recurrent floods every monsoon across the region warrants timely warning of hydro-meteorological disasters to save lives and property, and also the development, operation, and management of water resource related projects. He also opined that for the consultative meeting to be of any support to reduce this heavy loss, it is important that all should make a joint effort to ensure effective flood management.

Mr. Pokhrel pointed out that the acquisition and dissemination of hydrological information was essential not only for flood mitigation but also to judiciously harness the weather resources abundantly available in the region. This, however, requires substantive investment as testified by a recent initiative undertaken in India. A hydrology project was set up in 1996 to collect hydrological information covering 8 southern states of India with a loan from the World Bank of US$162 million and credit from the government of the Netherlands of US$ 17 million.

Mr. Pokhrel concluded by saying that he was convinced that the meeting will be successful in achieving consensus on a regional approach to the problem. This, he said, would be achieved by defining the capacity building needs of the participating countries in hydro-meteorological services and by preparing a workable action plan for an operational regional flood-forecasting system. He suggested that periodic follow-up meetings should be held, as these would be essential in ensuring that the action plans agreed to are practically implemented.

Remarks: Dr. Wolfgang Grabs, Chief, Water Resources' Division, WMO

Dr. Wolfgang Grabs expressed pleasure in seeing the interest shown by the participating governments by sending high-level officials to the meeting. He noted that this demonstrated a growing awareness of the need for regional collaborative efforts aimed at improving flood information systems and the management of floods. He said that improved forecasting and risk management would be an incentive to draw the much-needed investments, especially in low-lying areas. Dr Grabs stated that the development of well-defined and demand-driven projects was the key for attracting donor assistance for the implementation of these projects. He emphasised that significant progress had been made by the hydrological services of the world to cooperate in the exchange of know-how and technologies. He also noted that the development of joint products for forecasting and other hydrological applications and the exchange of data provide a basis for forecasting and water resources' management.

In order to demonstrate the political will and technical capacity for cooperation, Dr. Grabs mentioned that within the framework of the WHYCOS project of WMO, six out of 14 regional HYCOS projects were in various phases of advanced planning or

implementation with the participation of 78 countries. The World Bank, the European Union, and bilateral donors such as France provided funding for these projects.

Dr. Grabs stated that the meeting provided a unique platform for deliberations and mutual information sharing about the current state of flood issues and forecasting in the HKH region. Furthermore, the meeting will provide a foundation for an assessment of needs and opportunities for cooperation and the development of an action plan for the establishment of a framework for a regional flood-forecasting system. In conclusion, he also stressed that the meeting provided an excellent opportunity to make or refresh personal contacts between eminent persons in the areas of flood management, cooperation in river basins, and the donor agencies.

Remarks: Ms. Deborah Seligsohn, First Secretary, The US Embassy - Kathmandu (Regional Environment Office for South Asia)

Ms. Deborah Seligsohn expressed her happiness to see that almost all countries in the region were represented by high-level participants. She also welcomed the representation of international experts and hoped that their representation would help enrich the discussions of the meeting. Ms. Seligsohn stressed that floods can have tremendous impacts on people and economies causing adverse damages to lives and property. No matter how high the design of infrastructure, floods could still be higher. Ms. Seligsohn suggested that safety paradigms were needed to mitigate the destructive effect of floods. She also stated that floods would not follow national borders or policies and hoped that participants would endeavour to reach an agreement that will help deal with flood-related problems in the region. She further stressed a need to build a bridge between society and science.

Remarks: Dr. Guna Paudyal, DANIDA/DHI Water and Environment, Bangladesh

Dr. Guna Paudyal stated that the low-income economies of this region were gravely handicapped by recurrent natural disasters such as floods and cyclones. Increasing use of the flood plains and increased economic activities in flood-prone areas have resulted in extensive damages to life and property in all the countries. The South Asian society as a whole lives under the risk of floods for at least 4 months a year. He warned that the structural flood control measures alone cannot completely overcome the devastating floods that occur every year. No matter how high a design flood is, there is a possibility of even higher floods that will cause losses. He suggested therefore, that there is an urgent need to make societies in the HKH region more disaster conscious and be better prepared to deal with floods. Since a flood protection system guaranteeing absolute safety is an illusion, a shift in paradigm is needed; it is necessary to live with the awareness of the possibility of floods.

Dr. Paudyal concluded his remarks by pointing out that among the non-structural means of flood alleviation the most effective ones are:

- flood hazard mapping,
- flood insurance, and an
- effective flood mitigation system comprising of flood forecasting and warning, dissemination, evacuation, relief, and post-flood recovery.

He further added that being able to forecast floods well in time with acceptable accuracy and in a way that is easily understood by those who will be affected as well as those involved in relief operations is the key to a successful forecasting and warning system.

Remarks: Prof. Suresh R. Chalise, ICIMOD

Prof. Suresh Chalise provided a background as to why there is a need for a high-level regional consultation to develop a framework for flood forecasting in the HKH region. He mentioned the increasing frequency of extreme weather events by citing the flood disasters in the region in recent years. During the 2nd Steering Committee Meeting in April 2000 of the HKH-FRIEND, which is one of the eight groups of the FRIEND project of UNESCO under its International Hydrological Programme, regional experts, members of the HKH-FRIEND Steering Committee, and representatives from supporting organisations had discussed the idea of holding a high-level regional consultation on flood forecasting. He was pleased to inform the participants that the idea of holding a high-level consultative meeting received wide support and encouraging response from collaborating partners including the DHM, HMG/N, WMO, and the US State Department Environmental Hub Office for South Asia, USOFDA, and DHI/DANIDA. He also pointed out that the major rivers of the HKH originate in the Tibetan Autonomous Region of China and pass through the HKH mountains and reach the ocean only after passing through at least two or three countries of the region. Hence cooperation in the sharing and exchange of hydro-met data, particularly real-time data, is of utmost importance for flood forecasting in the downstream regions. Experience, he stated, has shown that engineering solutions alone cannot prevent devastation caused by flood disasters, whereas dependable flood forecasting and warning systems could help considerably in reducing the damages to life and livelihoods of the people. Examples of initiatives on flood forecasting systems are available at national, sub-regional, regional, and global scales (e.g., WHYCOS of WMO). Furthermore, we now have access to new data tools and techniques such as remote sensing, satellite data and information, the Internet, and the use of GIS and GPS.

Professor Chalise concluded by requesting the participants to consider the planned activities suggested earlier by Dr. Campbell for future work of sharing information on floods and flood forecasting in the region.

Vote of Thanks: Dr. Binayak Bhadra, Director of Programmes, ICIMOD

Dr. Bhadra started by thanking the sponsors and participants for making the meeting possible. He opined that the meeting was about how to make the people of the HKH region less vulnerable. He stressed that as far as floods are concerned, the problems are not just in relation to upstream or downstream countries as it affects all the countries. He believed that the meeting was an opportunity to begin action that would help mitigate floods in the region. He further argued that, *"We have the possibility to carry on forward, provided that we are able to come up with a successful framework for greater regional cooperation in developing the water resources of the region."* The mountains of the world have contributed a lot to humanity. The future in terms of clean energy, conservation of bio-diversity, and in being able to mitigate disasters and also the possibility of getting over these hurdles, does provide the governments in the region with the incentive to cooperate and collaborate, he stated. Dr. Bhadra concluded by stating that regional collaboration will very much depend on the test case of being able to collaborate and develop a framework for the future.

chapter three

Day Two: Status and Need for Regional Cooperation in Flood Forecasting

Presentations of Country Case Studies and Technical Papers

The working session of the consultative meeting began in the late morning of 16th May with presentations of case studies by representatives from the participating countries. This was followed by technical presentations by international experts. The presentations outlined flood-related issues and emphasised the need for information sharing and effective flood forecasting in the HKH region. They also highlighted the need for international cooperation to mitigate the devastating effect of floods in the region.

Session 1: Country Case Studies

Chairperson: A.Y.B.I. Siddiqui, Secretary, Ministry of Water Resources, Government of Bangladesh

A summary of the case studies presented by representatives from the participating countries is given below.

Bangladesh

Flood Forecasting Activities in Bangladesh and the Recent Floods in the Southwest Region -Mr. A.N.H. Akhtar Hossain, Director, Processing and Flood Forecasting, BWDB

Mr. Akhtar Hossain stated that the history of floods in Bangladesh is long. However, the flood in 1998 which flooded 70% of the country is one of the recent floods that is remembered for its wide devastating effect on the country. Infrastructures were severely damaged, industries

closed down, crops destroyed, about a 1,000 people killed, and a large number of people were rendered homeless. Thus, flood forecasting in Bangladesh is essential for the country's economic stability and improved living conditions of its people.

Mr. Hossain then pointed out that the sources of floods in Bangladesh were mainly extensive rainfall, tidal blockage, drainage congestion in urban areas, and the spill from the Brahmaputra (50%), the Ganga (40%), and the Meghna (10%). The causes of these floods, he stated, were low topography, extensive run-off from upstream, river siltation, swelling of the seas during the monsoon, and tectonic anomalies in the ocean. Thus, it will be difficult to foresee floods unless there is an extensive number of flood-forecasting stations in the country.

In conclusion, Mr. Hossain listed the progress made in recent years. He noted that an extensive effort has been made to forecast floods in Bangladesh. In 1972, a Flood Forecasting and Warning Centre (FFWC) was established and 10 real-time flood-monitoring stations were made operational. Furthermore, gauge-to-gauge correlation and the Muskinghum-Cunje flood routing model were put in place. From 1995 to 1999, the Mike 11 Super Model with GIS was incorporated and 30 real-time flood-forecasting points were established. Currently, 50 rainfall monitoring points and 60 water-level measuring points have been established to forecast potential floods. In order to be effective, the warning is being disseminated to the media for broadcast to concerned organisations that are prepared to provide relief and to the vulnerable communities.

Bhutan

Flood Impact on Investment and Life - A Presentation of the Report on Dutekhla and Pasakha (Barsachhu) Floods in Phuentsholing - Mr. Dorji Namgay, Executive Engineer, Head of the Hydrology Unit, Department of Power

Mr. Dorji Namgay argued that as Bhutan's foothills are close to the Indian plains, the floods in the rivers depend, in respect to their magnitude and duration, almost wholly on the intensity, aerial distribution, and duration of the precipitation over the catchment area. If the catchment receives copious rainfall, the situation in the river becomes critical, resulting in high discharge and correspondingly high water level. Therefore, the low-lying areas along the river courses get flooded quite quickly. If structures are installed in the flood plains they are damaged or washed away causing significant economic losses and sometimes losses of precious human lives.

For a country like Bhutan with limited financial resources it is imperative to protect existing social and economic infrastructure, properties, people, animals, etc. Thus, flood forecasting is essential for Bhutan. However, there are several drawbacks in and constraints to data collection. Firstly, there is no hydro-meteorological station in the difficult areas and therefore the data required for analysis does not exist. Secondly, there is a lack of institutional capacity in the subject matter and of facilities/funds to procure recent topographical maps and satellite images. All work so far has been carried out using old topographical maps, which were produced in the 1960s and 1970s by the Survey of India. Thirdly, there is an absence of experts and the studies are extremely time-consuming.

Mr. Namgay recommended that the catchment areas should be declared protected areas. In addition, he said that the construction of new roads should be restricted and, if necessary, strict environmental criterion should be applied. Furthermore, he emphasised the importance of installing hydro-meteorological stations and doing a detailed profile survey of the riverbed. He also stressed that there is a need for a detailed geological study and mapping of the landslides.

China (1)

Recent Flood Events and Proposal for an Early Flood Warning System in the Chinese Himalayas - Prof. Dr. Qin Dahe, Chief Administrator, China Meteorological Administration, and the Cold and Arid Regions Environmental and Engineering Research Institute

Dr. Qin Dahe began his presentation by pointing out that China has an extensive mass of glaciers, especially around the Tibetan Plateau. However, the current sizes and mass of the glaciers are not known because systematic inventories of the glaciers in the Chinese Himalayas have not been prepared for the past 20 years.

Dr. Qin argued that rapid global warming of the past decades has exerted remarkable changes on the glacial terminal positions and areas and the ice volumes. For example, the Rongbuk Glacier has retreated 170-270 metres during the last 30 years. These extensive environmental changes have a large influence on surface runoff, agriculture, vegetation, industry, as well as the daily life of the people in the downstream regions. Thus, the question that arises is how will the glaciers vary in the next decades and what implications will that have on floods in the Himalayas?

Furthermore, Dr. Qin pointed out that there is a need for a data collection system to be set up and hence for installing a real-time data collection and transmission system. The observation stations should include the hydrological and meteorological stations in the intercepting catchment. The acquired data can be transmitted to the National Hydrological Services (NHSs) and regional centres through a regional telecommunication system. The transmission should be conducted via satellites or the Internet. He also stressed the significance of a digital elevation model (DEM) of the intercepting catchment, which could be borrowed from the HYDRO1k developed at the US Geological Survey (USGS), EROS data Centre. Furthermore, he emphasised the importance of establishing regional data-receiving centres.

Dr. Qin also presented the methods for flood forecasting. Firstly, he mentioned the hydrologic models that are used in making hydrologic forecast and advisories, using GIS to collate the aerial data from different sources and present them in a form suitable for the model. Secondly, he mentioned the acquisition of medium resolution satellite images as an option. Thirdly, he put forward the development of a methodology by using Remote Sensing (RS) and GIS techniques for an inventory of glaciers and glacial lakes, GLOF monitoring, and early warning systems.

Dr. Qin further pointed out that a number of investigations were carried out including aerial photography of glaciers and glacial lakes over the middle section of the Himalayas. He also emphasised the importance of studies on climatic changes in ice cores for comparison with the instrumental records.

China (2)

The Important Role of Hydrological Data in Flood Forecasting in the Tibet Region - Mr. Gong Tongliang, Director, Tibet Hydrology and Water Resources Bureau, Tibet Autonomous Region

Mr. Gong Tongliang's presentation covered the following three topics:
(1) Yigong landslide and flood forecasting,
(2) Hydrological station network in Tibet, and
(3) International cooperation in the field of flood forecasting.

In his presentation, Mr. Gong showed the areas that have been devastated by floods and landslides as well as the damages caused to lives and property in the areas. He also showed how successful work is being carried out through the hydrological station in Tibet. He emphasised the need for international cooperation in the field of flood forecasting, especially in the HKH region.

India (1)

Flood Forecasting in India – Meteorological Aspects - Dr. R. R. Kelkar, Director General, India Meteorological Department (IMD)

Dr. Kelkar pointed out that it is a combination of factors that causes flooding. These include the meteorological, hydrological, and anthropogenic factors among which only the last is the result of human interference and thus controlled by human actions. But how do we prepare ourselves when we cannot control the events, he asked? Dr. Kelkar argued that there is a need, first of all, for flood hazard reduction through control measures such as construction of dams and embankments, afforestation campaigns, building stronger and more elevated structures that can withstand floods, and prohibiting housing construction in flood-prone areas. Furthermore, Dr. Kelkar also pointed out the need for disaster response in terms of preparation of emergency shelters and creation of public awareness.

However, forecasting floods is also essential in order to enable the vulnerable population to take evacuation measures and save whatever can be saved. The techniques used for flood forecasting vary from hydrological process models to mathematical hydraulic models. But, to be able to forecast floods, he emphasised that data, that is hydrological, meteorological, topographic, geological, demographic, etc., is absolutely essential. The data is being collected in India through, among others, cyclone and storm detection radar networks, satellite observation, and a large number of monitoring and observation stations covering the whole country. The Central Water Commission (CWC) is the nodal agency for flood forecasting and warnings. They get the data from over 150 flood-forecasting stations and IMD through 10 Flood Meteorological Offices (FMO). The warnings are addressed to specific users and state governments who in turn warn other agencies and the public.

India (2)

State-of-Art Flood Forecasting – Advancement and Issues - Mr. S. B. Srivastava, Chief Engineer, CWC, and Mr. R. Yadav, Assistant Commissioner, Ministry of Water Resources

Mr. Srivastava opened his presentation with the remark that the CWC of India has set up a network of 157 flood-forecasting stations in the country, among which 132 are for water stage forecast and 25 for inflow forecast for major basins. The FMOs of the IMD provide information on general meteorological situation, such as rainfall amount, heavy rainfall warning, and the range of quantitative precipitation forecasts in various river basins to the respective flood-forecasting centres of CWC. The data is simultaneously transmitted to the circle headquarters that supervise forecasting works for overall scrutiny, analysis, compilation, and monitoring.

He further explained that the transmission of real-time data from the hydro-meteorological sites to the Flood Forecasting Sub-division/Division office is carried out over a dedicated communication network comprising of VHF/HF wireless sets. A master station from each sub-basin is connected to the central network at CWC Headquarters in New Delhi.

The forecast tools are either in the form of graphical relations or mathematical equations. The variables that affect the stage or the discharge at each forecasting site are identified and graphical or mathematical relations are established between the stage and discharge at the base and the forecast sites. Mr. Srivastava mentioned that the following are some of the important variables:

- stage and discharge of the base station,
- stage and discharge of previous periods of the forecasting station,
- change in stage and discharge of the base station,
- travel time between base station and forecast station at various stages, and
- the rainfall (amount, intensity, and duration) in the intercepting catchment.

Mr. Srivastava stated that the CWC is the pioneer organisation for the establishment of flood forecasting activities in India. The flood-forecasting system in India is set up by CWC and covers almost all major and medium river systems using simple models requiring moderate skill at the field level. This system, he suggested, has been very cost effective and the input data requirement and equipment are simple and easy to operate. The communication network adopted is totally dedicated to the system resulting in near real-time data transmission to the central-processing centres. Of the total number of forecasts that are issued, 96% are found to be within an acceptable range.

To keep pace with improving technologies, Mr Srivastava suggested that the data transmission system is being progressively modernised. Efforts are being made to adopt the latest technology in equipment and methodology for forecast formulation based on a comprehensive model. The performance of a number of models and their suitability have been examined for specific river reaches. However, mathematical models with moderate data requirement are being introduced as far as possible.

Mr. Srivastava concluded by noting that the requirement for extension of flood-forecasting services to more areas with the existing manpower has been one of the major deciding criteria in planning future extension of a flood-forecasting network. A number of pilot schemes have been taken up to adopt the above techniques with a view to extend them to other basins on the basis of their performance. Area-specific studies for improving flood-forecast techniques are also carried out.

India (3)

Flood Forecasting in the Brahmaputra River, India: A Case Study - Prof. Dr. Dulal C. Goswami, Head, Department of Environmental Science, Gauhati University

Prof. Dulal Goswami stated that the Brahmaputra basin in India represents an acutely flood-prone region characterised by awesome hazards of flood and erosion that create an annual mayhem of devastation bringing untold miseries to the people and causing colossal loss and damages to public property and infrastructure. In recent years, flood hazards have increased significantly.

He pointed out that there is an immense possibility for regional cooperation in the area of water resources' management, especially with regard to flood management, including flood forecasting and warning as an important non-structural measure. He suggested that the development of infrastructure, exchange of technology and manpower, and sharing of water resources' data are some of the possible areas for regional cooperation. Prof. Goswami further suggested that a framework of action for developing a regional flood forecasting and warning network for the Brahmaputra basin needs to be formulated jointly by the concerned nations with support from major international scientific and financial institutions. He further stated that capacity building for water resources' data collection, transmission, and processing should receive more focused attention. As suggested in the Draft National Water Policy (1998) of India, special efforts should be made to develop and continuously upgrade technological capability to collect, process, and disseminate reliable data within the desired timeframe.

Prof. Goswami noted that the Brahmaputra represents one of the least developed major international river basins. It spreads over several South Asian countries viz., Bangladesh, Bhutan, China, and India draining almost the entire eastern Himalayas. The basin is marked by gross under-utilisation of its vast water resource potential and by the recurrent natural disasters of extremely large magnitude causing widespread devastation. The existing hydrological and hydro-meteorological networks in the region are grossly inadequate, especially in the mountainous areas. Moreover, Prof. Goswami opined that, technologies presently used in data collection, transmission, and processing lack the required levels of technical sophistication, operational efficiency, and institutional support. In consideration of the above facts, he suggested that urgent steps be taken to improve the situation. Towards this he suggested the following measures.

- Strengthen technical and institutional capabilities of hydrological and hydro-meteorological services in the Brahmaputra basin through upgradation of data acquisition, transmission, processing, and archival systems and deployment of adequate trained manpower and financial resources.
- Establish a regional network of hydrological and hydro-meteorological observatories that provide timely information of consistent quality transmitted in real time to national and regional databases via the Global Telecommunication System and using modern information technologies such as the Internet.
- Initiate discussions among the participating countries in the basin for evolving mutually-acceptable agreement for cooperation regarding exchange of water related data, transfer of technology, etc.

- Mobilise adequate international technologies and financial support towards upgrading the existing national observatories and establishment of the proposed basin-wide regional network.

Pakistan (1)

Flood-forecasting System in Vogue in Pakistan with a Case Study on the 1992 Flood in the Jhelum River (Indus River Basin) - Mr. Muhammed Munir Sheikh, Chief Meteorologist, Flood Forecasting Division, Pakistan Meteorological Department (PMD)

Floods have caused tremendous damages to life and property in Pakistan. Prominent among them are the floods of 1928, 1973, 1988, and 1992. The occurrence of these floods has reconfirmed the need for a better flood-forecasting system. Since the 1992 floods, the flood-forecasting system has gone through many improvements and is relatively comprehensive but efforts are still underway to make it self-contained. Mr. Sheikh gave a brief introduction to the Indus Basin River system and highlighted the various cases of floods in Pakistan. He also explained the institutional set-up and the flood-management process in Pakistan. The FFD of the Pakistan Meteorological Department is the government agency responsible at the national level for the issuance of flood forecasts and warnings. The existing facilities for flood-forecasting system were briefly summarised. The Pakistan Meteorological Department has a network of around 72 meteorological stations within the country and also a network of Quantitative Precipitation Weather Radars. It is equipped with an automatic picture transmission system for receiving cloud pictures from the NOAA satellites as well as high frequency (HF) radio communication system. Various flood frequency models have been used and developed. The FFD forecasts three types of forecasts, viz., Qualitative, Quantitative, and Significant Flood Forecasts.

Over the years, the flood-forecasting system of Pakistan has shown tremendous improvement but is not perfect and still has some limitations. An evaluation of flood forecasts issued after 1990 was around 90%. Mr. Sheikh also highlighted the various elements for future development and emphasised the need for regional cooperation in flood forecasting in the HKH region. He said that an HKH-HYCOS needs to be developed and the hydrological and the meteorological data should be made easily accessible on Internet on a real time basis.

He stressed the need for exchange of research work through ICIMOD or directly among participating countries. He further stated that the long-term human resource needs should be developed and knowledge and expertise should be exchanged through academic courses, seminars, and workshops.

He then presented a case study on the 1992 flood in Jhelum River and highlighted the role of the Mangla Dam in flood disaster mitigation.

Pakistan (2)

Floods and Flood Forecasting in the Indus Basin – A Case Study from Pakistan - Dr. Muhammed Akram Kahlown, Chairperson, Pakistan Council of Research in Water Resources

Dr. Kahlown's presentation dealt with the serious flood events that had devastated Pakistan over the years. He emphasised the importance of an eventual regional action against

floods. At present, dissemination of flood warnings is the responsibility of the National Flood Forecasting Bureau (NFFB) of the PMD and the Flood Warning Centre (FWC). As surveillance, a telemetric system has been established and is being maintained by the Water and Power Development Authority (WAPDA). Initially more than 40 stations were established but the number was later reduced to 24. He stated, however, that the system is not fully operational at present. A weather satellite based cloud picture receiving equipment, commonly known as the Automatic Picture Transmission System (APT) and Quantitative Precipitation Measuring (QPM) radar, has been established by the PMD. The APT obtains cloud pictures for the detection of flood producing weather conditions. Dr. Kahlown explained that the information is gathered from India and various radars. Meteorological maps and charts based upon the data of meteorological observatories in Pakistan as well as data from India and other countries of the region are also acquired for flood forecasting. Four computerised flood-forecasting models are used in Pakistan. Two are rainfall/runoff models and the other two are routing models.

Dr. Kahlown pointed out that the NFFB had taken the responsibility for dissemination of information gathered. The information is being disseminated to a considerably large number of recipients who are directly or indirectly concerned with flood mitigation. In addition, the FWC is also undertaking dissemination work. During the flood season, the press is briefed regularly to ensure that correct and authentic flood weather information is passed on to the public.

Dr. Kahlown said that through the efforts made to forecast floods, a number of lessons have been learned in flood forecasting. He noted that the factors that affect the efficiency of the early warning systems are as follows:

- incorrect gauge and discharge data,
- lack of understanding of the limitations of flood forecasting,
- limitations of reservoir operational mechanisms,
- limitation in dissemination/forecasting mechanisms,
- non/delayed dissemination of flood forecasts and warning by the Flood Warning Centre, and
- lack of trust on the forecasts/warnings.

Dr. Kahlown made the following recommendations:

- Strengthen regional cooperation for exchange of real-time climatological and hydrological data
- Enable easy access to hydro-climatological data through electronic networking, websites, etc
- Give more consideration to hill torrent areas
- Carry out research studies to take full advantage of the new radar and satellite data to improve quantitative measurements and forecast rainfall in the upper catchment areas of the Indus River System
- Organise a series of workshops on flood-forecasting systems in the regional countries

Nepal

Flood Hazard in Nepal and the Need for Flood Forecasting in the HKH Region - Prof. K. B. Thapa, Central Department of Hydrology and Meteorology, and Mr. N. R. Khanal, Central Department of Geography, Tribhuvan University

Prof. Thapa started his presentation by recounting the floods in 1993 that devastated Central Nepal from the mid-hills to the southern plains of the *Terai*. He stated that the flood destroyed the barrage in the plains and swept away many villages. Many people were killed not only because a warning system did not exist but also because the settlements were on marginal lands vulnerable to landslides and flash floods. Thus, monitoring watershed conditions, identifying potential hazard areas, and installing warning systems are very essential to reduce the loss of lives and properties.

Prof. Thapa argued that protection and mitigation measures, quick warning systems for flood forecasting, and safe areas to escape from such disaster-prone areas are some aspects that need to be considered. Flood forecasting and warning system schemes have been initiated in Nepal by DHM. However, the extreme weather events that take place in Nepal are not only the concern of this country; the neighbouring countries are also feeling the devastating effects of floods originating from Nepal.

Thus, he stated that cooperation in the HKH region in terms of exchange of hydro-meteorological data and warning of such extreme natural events can be of great value and importance for flood preparedness in India and Bangladesh too. Some cooperation is already in place in that Nepal has been relaying hydro-meteorological data to India and this is being used for general weather forecasts. The need for further cooperation between Bangladesh and Nepal was realised after the devastating floods of 1987-88. The Koshi HYCOS project with WMO support to be implemented by DHM will help strengthen regional cooperation in flood warning and forecasting.

The Chairperson's Concluding Remarks

In his concluding remarks, Mr. A.Y.B.I. Siddiqui, Secretary, Ministry of Water Resources, Government of Bangladesh, congratulated the organisers, the sponsors, and the Government of Nepal for organising this important and significant workshop, in which, experts from various countries had assembled for the cause of humanity and for developing a regional strategy to alleviate the impact of floods on people and their property.

He said that with the combined efforts of the governments, the NGOs, and the people, timely and early warning of floods should be provided so that people and their properties can be shifted to a safer place. Referring to the varying degrees in the implementation of flood-forecasting systems in the participating countries of the region he noted that this offered the potential for mutual assistance and sharing of know-how. He also emphasised the importance of regional cooperation in sharing real-time hydrological and meteorological data for improving the efficiency of flood-forecasting services to the vulnerable people.

Mr. Siddiqui ended his remarks by expressing his confidence that the consultative meeting would be able to evolve a framework for regional cooperation in flood forecasting for the benefit of millions of people living in the region.

Technical Presentations on Flood-forecasting Systems: Part 1

A second series of technical presentations were made after the country case studies. These presentations focused on flood forecasting systems (Part 1). Regional and international experts made presentations on floods and flood forecasting. A summary of their presentations is given below.

Chairperson: Mr. Dorji Namgay: Executive Engineer, Head of Hydrology Unit, Department of Power, Bhutan

A Framework for Regional Flood Forecasting in the Ganga-Brahmaputra-Meghna (GBM) Basin - Dr. Guna Nidhi Paudyal, Regional Manager, Water Management Department, DHI Water and Environment, Bangladesh

Dr. Paudyal's presentation emphasised the need for a regional flood-forecasting network, basin hydrology and forecasting techniques, and cooperation in data exchange and knowledge sharing. Dr. Paudyal stated that a complex geo-political setting has complicated the complex hydraulic system of the GBM Region. Despite the natural endowments and a rich cultural history of the region, its people are one of the poorest in the world and face considerable challenges. The GBM basin is the second largest in the world and is shared by five nations (Bangladesh, Bhutan, PRC, India, and Nepal). It is 1.75 mil. sq. km with 0.8 million sq. km of arable land and 560 million people depend on this largest river basin. It covers 0.12% of the landmass of the world, has 10% of the world's population, and half of the world's poor live here. Flood is the main natural disaster aggravating the poverty situation and deteriorating the environment. Dr. Paudyal expressed concern about the distressing indicators of the quality of life of the GBM region. However, he also pointed out that the region was gifted by nature in terms of abundant monsoonal rainfall, great rivers, vast fertile lands, high mountains, abundant energy potential, and industrious people.

Dr. Paudyal was also concerned about the water-related disasters in the region including floods, droughts, cyclones, and glacier lake outbursts. A region so richly endowed should remain so poorly developed is a painful paradox, he noted. Dr. Paudyal suggested that in order to alleviate poverty not only funds but also information should be provided. He pointed out the technical possibilities for the GBM region through the use of information technology, space technology, knowledge management (hydrology and modelling), and education/capacity building. Some of the most important information on floods is from manual river gauging, which is common in South Asia. Real-time data is also used for rainfall forecasts and the MIKE 11 model has also been used. Warning maps from satellite pictures, etc also provide a 24-, 48-, and 72-hour flood status forecasts. The nested regional forecasting model has also been used and this increases the forecast lead-time. The outputs of the Regional Flood Model are basin hydrology, knowledge on flooding processes, identification of hot spots, and real-time flood forecasts at the regional, national, and local levels.

Dr. Paudyal pointed out that the water vision for South Asia is that the water resources will play a key role in alleviating poverty by taking the economy on a higher growth path and that information technology will play a key role in decision-making for sustainable development. Information dissemination, he said, is the key point and concluded that, *"We are living in the midst of an information revolution where numbers rule. But this revolution is a selective one - reaching only certain people with only limited information. Some numbers and their meaning are beyond our understanding and some numbers are useless. The way forward is to improve networking and if we start together technology will help us."*

Regional Cooperation in Flood Forecasting - Dr. Wolfgang Grabs, Chief, Water Resources' Division, Hydrology and Water Resources Department, WMO

Dr. Grabs opened his presentation by reminding the participants that in many parts of the world, the systems for collecting and managing water-resources related information are inadequate and often deteriorating, at a time when there is rapid increase in the demand for such information and need for regional cooperation in the assessment and management of water resources.

He explained the concept of WHYCOS by stating that it is a successful approach that aims to build the capacity for water resource assessment and management at the national, river basin, regional, and global levels. WHYCOS facilitates regional and international cooperation in the collection, transmission, processing, and archiving of hydrological data. The objectives of WHYCOS at the global level is to strengthen technical and institutional capabilities of hydrological services, establish a global network of key national stations, and promote and facilitate dissemination and use of water-related information. At the regional level, WHYCOS is implemented in regional HYCOS that are planned on the basis of common needs of hydrological information systems in the respective regions.

Some important common features of Regional Information Systems

- comprehensive collection and archiving of data and information relevant for the use of the system
- Updated information (in real-time or near real-time), based on an institutionalised framework
- User-friendly access to data and information for a large number of users without restrictions
- Regional scope

Dr. Grabs further explained that the WHYCOS concept is modelled on the World Weather Watch Programme (WWW) of WMO with two main components – a supportive component that strengthens cooperative links among participating countries and institutions and an operational component that achieves "on the ground" implementation at regional and international river basin levels.

Dr. Grabs stressed that on a technical level, WHYCOS makes use of the latest communication technology such as the WMO-supported Global Telecommunication System (GTS) and the Internet with potential for the collection and transmission of data regarding water quantity, water quality, and meteorological data required for assessment and forecasting purposes. Dr. Grabs suggested some key steps in establishing a regional WHYCOS (see box text).

Key Steps in Establishing a Regional WHYCOS

1. Reaching an agreement among participating countries to proceed with establishing a WHYCOS
2. Defining the needs that are to be met
3. Installing a real-time data collection and transmission system
4. Upgrading national data processing and archiving system
5. Establishing distributed regional databases
6. Establishing a regional telecommunication network
7. Preparing and disseminating hydrological information of national and regional interest
8. Staff training
9. Performance monitoring and follow-up
10. Development of data and information products needed to achieve the objectives of specific regional HYCOS projects.

In conclusion, Dr. Grabs noted that there is a world-wide recognition of the need for sustainable socioeconomic development that is supported by fact-based integrated management of water resources. WHYCOS is one response to the challenge. He suggested that it would be essential for National Hydrological Services to take the opportunity that WHYCOS provides. They will need to adopt new methods and approaches to their business and develop and deliver new products and services, thereby demonstrating their value to the community. Enhanced credibility will follow and, with it, growing success in seeking resources.

Existing Regional Network and Cooperation including UNESCO's Hindu Kush-Himalayan FRIEND Project - Prof. Suresh Raj Chalise, Mountain Natural Resources' Division, ICIMOD

Prof. Chalise emphasised the need for looking at the total picture; not only where the floods occur but also where the water comes from. He also pointed out that before entering into the operational phase there would be a need to understand the causes. Prof. Chalise gave a generalised view of the Himalayan River Basin with its principal features, flood types, associated disasters, population density, and the affected population. Furthermore, he gave an account of the countries involved and affected by the river floods, namely, China, Pakistan, India, Nepal, Bhutan, and Bangladesh. He called for regional networking and cooperation in flood forecasting.

As an example of regional cooperation, Prof. Chalise introduced the HKH-FRIEND project, which was envisioned in 1989 at a regional workshop on the "Hydrology of Mountainous Areas" held in Kathmandu. The project has developed well through the years and in 1996 it was established formally. Prof. Chalise concluded by stating that the project is concerned with hydrological research in a regional context including Afghanistan, Bhutan, India, Bangladesh, Nepal, China, Myanmar, and Pakistan. The HKH-FRIEND's focal areas of research and study are database, floods, low flows, rainfall-runoff, river water quality, and snow and glaciers. The project is an example of regional cooperation in hydrological research.

The Mekong River Commission (MRC) - Mr. Lieven Geerinck, Chairperson, Task Force on Flood Management and Mitigation, MRC, and Mr. Thanongdeth Insisiengmay, Hydrology Specialist, MRC

Mr. Geerinck began by giving a brief historical overview of the MRC. According to the 1995 Agreement, MRC's role is to promote *"cooperation in all fields of sustainable development, utilisation, management, and conservation of the water and related resources of the Basin"*

Mr. Geerinck explained that some of the MRC stakeholders are donor consultative groups such as the Cambodia National Mekong Commission (CNMCs), Laos National Mekong Commission (LNMCs), Thailand National Mekong Commission (TNMCs), and the Vietnam National Mekong Commission (VNMCs). Likewise, governments of member countries, line agencies, the private sector, and the population in the Lower Mekong Basin are also the stakeholders in the MRC.

MRC's CHALLENGES - Population Pressure and Floods: The population pressure in the Mekong River Basin has not yet reached the alarming levels of many other basins. However, the population in the basin is growing rapidly at 2 % per annum. It will increase from 73 million at present to 120 million in 2025. This will certainly have negative

impacts on the availability of clean water and fishes. Urbanisation and construction of infrastructure also contribute to an increase in flood risks in the unprotected parts of the basin. The wetlands and floods have also proven to be a challenge to the MRC as annual floods are a natural phenomenon in the basin. They are important for replenishing soil fertility and to provide spawning habitats to produce abundant fishes. But they also cause deaths, damage to crops and property, and contribute to or aggravate food insecurity, health risks, and poverty. It is not only global and climatic factors that are influencing the flood patterns but also human activities.

MRC's STRATEGY - River Basin Management: In July 2000, the MRC Secretariat was restructured and reoriented towards a multi-sectoral and basin-wide programme approach, aiming at integrated river basin management. Three core programmes are the foundation for this, namely, the Water Utilisation Programme (WUP) to provide the technical framework for managing water; the Basin Development Plan (BDP) to ensure prioritisation and coordination of development activities in the Mekong Basin; and the Environment Programme to provide the knowledge and means to ameliorate adverse environmental effects.

Causes for the Flood in 2000: The causes of excessive flooding in the year 2000 were a combination of natural and human factors. These factors include early start of rains with fast surface run-off, increasing sedimentation of the riverbeds, tidal effects, and blocking of natural flood plains. However, more investigations in these causes are needed.

Existing Flood-forecasting System: MRC provides a five-day flood forecast from mid-June to mid-October every year for 15 locations along the mainstream down to Kratie (Cambodia) based on a daily data from 37 hydrological and 22 rainfall stations. For the year 2001, from Kratie to the sea, the hydrodynamic model developed by the Vietnam Hydro-met Service will be used. Forecast results will be provided on the MRC website from mid-June to mid-October at: www.mrcmekong.org

MRC Hydro-Meteorological Network: The 'appropriate hydrological network improvement project' started in 2001 and will run until 2006. Some of the ongoing activities are as follows: upgrading of 17 existing hydrological stations on the Mekong-Lancang River (2 in China, 6 in Thailand, 2 in Laos, 4 in Cambodia, and 3 in Vietnam) into real-time data transmission, automatic water-level recorders and telemetry system and discharge measuring equipment (Acoustic Doppler Current Profiler), water quality sampling, database management, capacity building, implementation of rules for water utilisation, flood forecasting, awareness building on trans-boundary issues, cooperation with WMO and MRC on the regional HYCOS under WMO's WHYCOS, and cooperation with other partners (OFDA - GTZ).

Difficulties and Constraints: The SSARR model was calibrated since the early 70s. The accuracy is limited; the one-day forecasting seems to be reasonable but the 5-day forecasting sometimes shows errors due to unreliable rainfall data and also due to the lack of real-time rainfall data in the upper parts of the basin.

Need for Improvement of the MRC Forecasting System: The forecasting stations at the main tributaries need to be added to the mainstream forecasting system. Due to weak links, data collection from the field to the regional head offices is sometimes

troublesome and the dissemination of information needs to be improved. Rainfall forecast (radar rainfall coverage, T, L, C, V), catchment modelling and channel routing, hydro-meteorological data quality (AHNIP), model updating techniques, and capacity building also need some improvements.

Summary of Key Issues

A number of issues were raised during the presentations and the subsequent question and answer sessions. The participants said that there is a need to encourage institutional cooperation among all countries in the region and to improve data/information collection, data quality, and dissemination along with modelling and forecasting. The participants further suggested that since there is already a multitude of organisations in countries of the region working independently on disaster mitigation, including floods, there is a need for cooperation in and coordination of their activities.

Other important issues that were raised are highlighted below. All countries expressed the need for improvement in the flood-forecasting systems as follows:

- Extension of hydro-meteorological networks with real-time capacity
- Full integration of weather and climate information related to modelling and forecasting
- Improvement in satellite observations, including rapid image processing and interpretation
- Improvement in dissemination of forecasts down to community levels
- Improvement of communication facilities and systems
- Mapping of flood-prone areas
- Use of advanced hydrological models for flood forecasting
- Encouragement of training and education as well as exchange of know-how
- Easier region-wide access to data and information through internet and other means
- Improvement in forecasting of flash floods in the region

Chairperson's Concluding Remarks

In his concluding remarks, the chairperson, Mr. Namgay, congratulated the presenters for providing in-depth information about successful models for regional cooperation. He noted that there is a wide variety of experience in the region which should be harnessed in the development and implementation of an HKH-regional project. He emphasised the complementary roles of cooperative models viz., cooperation in shared river basins, regional cooperation in water-related science and education, and the development of hydrological information systems. He expressed satisfaction over the keen interest of the participants to obtain more information from the presenters about their respective presentations.

chapter four

Day Three: Development of Technical Concepts for Flood Forecasting

Technical Presentations on Flood-forecasting Systems - Part 11

During this session, the invited regional and international experts made technical presentations on floods and flood forecasting systems. A summary of their presentations is given below.

Chairperson: Dr. Qin Dahe, Administrator, China Meteorological Administration, Beijing, China

Flood Forecasting in the United States – An Overview, *Richard W. Paulson, National Weather Service, USA*

Mr. Richard Paulson began his presentation with an introduction to the framework for river and flood forecasting in the United States. This framework is supported by the combined efforts of local and federal institutions. He stated that the framework for river and flood forecasting, in terms of scale, is measured on the basis of monitoring, forecasting, and warning. The National Weather Service River Forecast System (NWSRFS) and the Automated Local Evaluation in Real Time (ALERT) Systems are used to measure the state of rivers and flood forecasting. Mr. Paulson stated that at the institutional level, the NOAA/NWS provides river and flood forecasts for large rivers in the United States and also cooperates with numerous other federal, state, and local agencies and the public. Thus, there is a multi-agency effort in the US for large-river forecasting.

Mr. Paulson explained that the thirteen NWS River Forecast Centres use the NWSRFS, and multi-day river forecasts are prepared every six hours for 4,000 forecast points on large rivers. More than thirty-five NWSRFS models are used for large rivers, snowmelt, soil-moisture accounting, rainfall-runoff, channel routing, reservoir, and hydraulic models. The ALERT System is used for flash-flood rivers and the local governments install, maintain, operate, coordinate, and warn about potential floods. The National Hydrological Warning Council is organised by local government officials and this provides links among users of the ALERT system and it holds national and regional flood-warning meetings.

Mr. Paulson explained further that at the international level, the US maintains boundary and water treaties with Mexico and Canada. Canada has used the Geostationary Operational Environmental Satellite (GOES) extensively and Mexico is implementing the NWSRFS of NOAA/NWS. Furthermore, the US fosters an international NWSRFS user group and shares weather and river forecasting technology with the international community, bilaterally or through the WMO.

He concluded by stating that data and forecast information is available to the public and private sector in real time at little or no cost. The benefit is value-added analysis and processing is done at no cost to the taxpayer. GOES is accessible to the data collection platform (DCP) users at no cost. Users may operate their own receiving stations. The benefit is that there are about 14,000 DCPs in operation and these provide data at no added cost to NOAA or other users.

A Geospatial Stream-flow Model for Flood Hazard Monitoring in Africa - *Dr. James Verdin, International Programme, EROS Data Centre, U.S. Geological Survey, U.S. Department of the Interior*

Dr. Verdin informed the participants how geospatial methods are being used to monitor hydrologic conditions in the countries of Africa. He explained that the Famine Early Warning System Network (FEWS NET) monitors the food security situation in 17 African states: Mauritania, Mali, Gambia, Niger, Burkina Faso, Niger, Chad, Ethiopia, Southern Sudan, Somalia, Kenya, Uganda, Tanzania, Malawi, Mozambique, Zambia, and Zimbabwe. Since the mid-1980s, drought has been a major concern, and vegetation index images from NASA and dekadal satellite rainfall estimates from NOAA have been used to supplement ground networks for agro-meteorological monitoring. The adverse consequences regarding food security due to major regional flooding were brought to the fore in the Horn of Africa as a consequence of the El Niño of 1997-1998. A new initiative at USGS emerged to apply accepted methods of hydrologic analysis on a geospatial basis, using satellite rainfall estimates, numerical weather model output, and digital maps of topography, land cover, and soils. NOAA increased the frequency of the production of rainfall estimates (blending satellite and ground station data) from dekadal to daily. Thirty years of daily rainfall grids for Africa were produced by the University of California, Santa Barbara, to create a corresponding history of modelled stream flows. Flood flow frequency analysis was applied to this time series for several hundred sub-basins of Southern Africa to provide context and a basis for evaluating modelled flows in the current timeframe. Quantitative three-day precipitation forecasts from the U.S. Air Force Weather Agency were accessed and ingested into GIS for use by the model to extend stream flow estimates into the near future. A website was established to present model

output geographically and in the form of daily time step hydrographs. The system was used to operationally monitor conditions in Mozambique and the upstream areas during the rainy season of 2000-2001. This can be updated with observed stream flows, where available, and as such is complementary to HYCOS stream-gauging networks. Dr. Verdin explained that all inputs for such a system are available on a global basis, and therefore it could be implemented for the basins in Asia.

Monitoring and Data Dissemination - Developing a Framework for Flood Forecasting in the HKH Region - *Mr. Mark N. Landers, USGS*

Mr. Landers began with a brief history of the USGS stream-gauging stations in the USA. He stated that the first USGS stream- gauging station started in 1889. Today, there is a multipurpose network with over 7,200 stream-gauging stations.

Mr. Landers noted that the use of stream-flow information in terms of resource appraisal and allocation are for water supply planning and interstate compacts. In terms of design, the stream-flow information is used for reservoirs, bridges, roads, culverts, and treatment plants. The stream-flow information is also used for flood hazard warnings, preparedness, mitigation, response, and recovery. In terms of flood hazard planning, the stream-flow information is used for flood frequency analysis and flood plain zoning. It is also used for operations such as power production and navigation. With regard to water quality, stream-flow information is used for conditions and trends, contaminant transport, and the total maximum daily loads (TMDL). For in-stream conditions, stream-flow information is used for habitat investigations, in-stream-flow requirements, and recreation.

He informed the participants that the stream-gauging network is funded by the USGS and over 800 federal, states, and local cooperators. The stream-flow monitoring is a true government function and the USGS operates the network on behalf of all and has made the data freely available.

The stream-flow monitoring in standard gauging stations are stilling wells with intake pipes to rivers, float, tape, pulley, digital recorder and/or telemetry equipment to record the water surface. The stage sensors used are float and tape, submersible pressure transducers, submerged acoustic sensors, and non-submerged radar sensors. Some features for stream gauging are 2-path plus stage, SDI -12 compatible, on-board data storage, and on board q-computation.

Mr. Landers concluded his presentation by informing the meeting that the NWIS (National Water Information System) has been distributed to 50 different working databases. Each district maintains their own data. The hydrologic data stored contains site information, time-series (flow, stage, and water quality), water quality discrete samples, ground water site inventory, water use, and peak flow. The data gives information on 1.4 million sites, 3.5 million analyses for water quality, 1.2 million sites for GW Site inventory, and 850,000 station years for time series. He presented a summary of the flow of data to users.

Summary of flow of data to users

- Data collected by field and district offices
- Processed on district NWIS system
- Real-time data released to the web
- Data quality assured for release to the public
- Data released to the web

Comments/Questions from the Participants

The participants asked questions, commented on the three presentations, and made suggestions during the question and answer sessions. In connection to Mr. Paulson's presentation of EROS monitoring in Africa, he was asked which components would be of use to the HKH region? Mr. Paulson stated that the data collection activity would be useful to the region. He further said that forecast systems such as the weather service forecast system would also be beneficial. It is, however, important for one to know more about the communication infrastructure in this area; this would be an important aspect to enable information gathering, etc. Virtually all aspects would be useful in this region. In the US there is a network of weather radars and satellites as well as gauge networks.

Questions were asked regarding flow measurement in terms of size of the stream by using the laser technique. Other questions concerned the maximum width of the channel and how much can experts accommodate this with the laser equipment. Mr. Landers explained that the key is in designing individual intakes so that it will get a static water representation and there is good information regarding how to do it. He stated that the laser technique is good for unsteady flows.

Mr. Guna Paudyal cautioned participants about the source of data they use. He stated that the data in Bangladesh came from 60-year old maps and thus they are useless. They are not accurate; large-scale infrastructure has not been put on the maps. He recommended that effort should be made by all to collect more accurate information and data.

Concluding Remarks by the Chairperson

In his concluding remarks, Dr. Qin Dahe congratulated the presenters for their excellent contributions. He highlighted in particular the successful use of satellite-based systems used for flood forecasting and the use of the Internet to disseminate data and information to a large variety of users. He said that it became clear from the presentations that the success of information systems is to a large part based on the accessibility of data and information. He noted that even though the presentations mainly focused on cases and experiences in the United States and Africa, the techniques introduced can be very helpful to countries in the HKH region for flood forecasting. He then thanked all participants for their contributions.

Break-out Session 1: Development of a Technical Concept for Flood Forecasting

Chairperson: Dr. R. R. Kelkar, Director General, India Meteorological Department, New Delhi, India

The first two break-out sessions were held on the third day of the meeting. Three groups were formed to discuss key issues relating to flood forecasting and information exchange. The details of the group outcomes and plenary discussions are presented below.

Dr. Grabs introduced the morning break-out session and proposed guidelines for discussions to the working groups. The Chairperson, Dr. Kelkar, set the timeframe for group discussions. The three groups were given three different topics to discuss.

Group 1 discussed on the topic of Cooperative Framework for Flood Forecasting focussing on cooperative links between hydrological and meteorological services in the region, existing regional cooperation mechanisms, and a conceptual framework for cooperation.

The expected deliverable for this group was an a concept outline for Regional Cooperation in Flood Forecasting with focus on institutional and practical aspects.

Group 2 discussed on Technical Requirements with focus on required hydrological and meteorological data, satellite and radar information, use of real-time data, data transmission, network requirements, and models for flood forecasting.

The expected deliverable for this group was an outline of a technical system for regional flood forecasting

Group 3 discussed on the topic of Dissemination and Use of Flood-forecasting Products with emphasis on regional exchange of data and information, regional forecasting products, dissemination of forecasts, communication facilities, institutional feedback, and river basins.

The expected deliverable from this group was an organisational concept for dissemination and use of flood-forecasting products

A summary of the group discussions is presented below.

Group 1: Cooperative Framework

In their presentation, the group focused on three key areas, which were as follows:

- bilateral and regional agreements,
- cooperation in meteorological and hydrological services in the region, and
- the conceptual framework for cooperation.

Existing Bilateral and Regional Agreements

The group listed the bilateral agreements existing between countries of the region as follows.

Nepal-India: The exchange of real-time flood data has been taking place in a joint project using wireless radio. Thirty-seven stations have been established in Nepal and two sites have been selected for pilot real-time transmission. There is readiness to upgrade the system and provide more data. This will require more resources and capacity building.

Nepal-Bangladesh: A Flood Forecasting and Management Team has been constituted. The countries agreed to exchange river data and will be finalising priorities and stations for flood forecasting.

Bangladesh-India: Limited exchange of hydrological and meteorological data takes place regarding the Ganges, the Brahmaputra, and the Meghna. The two countries are in the process of increasing cooperation.

Bhutan-Bangladesh/Bangladesh-China: No agreement yet, but would like to have cooperation

Pakistan-India: The agreement in the Indus basin has been a model for bilateral cooperation. However, the exchange of and access to data is somewhat limited. For flood forecasting, there are morning telephone information sharing and 6-hourly radio contacts.

Pakistan-China: The representatives of these countries expressed their interest to enter into cooperation in information sharing.

Group 1 Participants

Dahe Qin	-	China
Kaylzang Tsering	-	Bhutan
Riaz Ahmad Khan	-	Pakistan
R.R. Kelkar	-	India
S.Y.B.I. Siddiqui	-	Bangladesh
K. Shida	-	WMO
Q.Z. Chaudhry	-	Pakistan
Anwarul Kabir	-	Bangladesh
Wolfgang Grabs	-	WMO
Rainer Loof	-	German IHP/OHP National Committee
Gabriel Campbell	-	ICIMOD
Adarsha P. Pokhrel	-	Nepal
Geerinck Lieven	-	MRC
Tauhidul Anwar Khan	-	Bangladesh
B. Bhadra	-	ICIMOD

Country Activities and Cooperation

Individual countries are pursuing activities in flood forecasting and data collection and dissemination. Some of the country activities are supported by international organisations. A summary of current activities of the countries is given below.

China

- Meteorology – in collaboration with WMO
- Flood forecasting for the Yellow River and the Yangtze River
- The Western Himalayas have very limited stations and data centres. These are mostly run by scientific institutions with no links to operational services
- Research cooperation with Nepal, Pakistan, and ICIMOD

There is a need to continue this cooperation (with Nepal, Pakistan, WMO, and ICIMOD). There is also a need to collect meteorological data from the Indian Ocean.

Bhutan

- Meteorology – Responsibility of the Ministry of Agriculture
- Hydrology – Responsibility of the Ministry of Trade and Industry (Power)
- Bhutan-India collaboration

The government is planning to set up a new hydrological system in collaboration with the Central Water Commission (CWC) of India.

Bhutan will seek membership of WMO.

India

- Valuable meteorological services provided routinely in the exchange of meteorological data and forecasting products on an international scale and in cooperation with WMO.
- Data sharing amongst hydrological services takes place in part between the states of India on rivers of common interest. Most flood forecasting for the territory of India is provided by CWC. Data sharing on an international basis has not been established in an institutionalised manner.

Suggestions

- WMO should take the lead to develop approaches for a successful regional cooperation in hydrology and water resources and, in particular, with regard to the development of flood-forecasting systems in a regional context.
- Bilateral cooperation has been successful in many cases. There is a strong need to further improve bilateral cooperation.

- The development of a flood-forecasting system in the region also needs considerable advisory services. It was made clear that the responsibility for flood forecasting lies with the institutions within a participating country and that forecasting is prepared for its territory only. The sharing of data and information takes place by making the data and forecasting information available to other users.
- Real-time data is a basic necessity for flood-operational forecasting. Focus should be given to the development of regional capacity for real-time data acquisition and dissemination.
- Websites should be used and strengthened for sharing hydrological data and information.
- The group suggested the establishment of a regional website with voluntary contributions from each country. WMO is expected to encourage and collaborate in this effort based on it's experience in WHYCOS.
- Models need validating as they are often developed outside the region and have different processes and conditions.
- A workshop on hydrological model validation was suggested. WMO is requested to assist in the development and organisation of such a workshop.

Further Information and Suggestions by the Group

The issues presented below were shared by the group and are therefore reported here.

WMO: WHYCOS is built on WMO's World Weather Watch (WWW) system which is a global system. The WHYCOS model is recommended as a basis for cooperation. Hope was expressed that existing bilateral arrangements become elements of regional coordination. There is a need to promote a political will for regional cooperation in flood forecasting within the countries of the region.

Bangladesh: Recommended linkages between existing bilateral components, i.e., to set up mechanisms for unrestricted flow of hydrological data. How much can be made open information on a website?

Pakistan: Recommended the establishment of a common regional website that is established and supervised by ICIMOD/WMO and to make certain information available to each government. The establishment of a model calibration programme was also suggested; there should not be barriers to pass on data but focus should be on data sharing during flood seasons at the initial stage. Advisory/data sharing and forecasting are the responsibilities of individual countries.

Regional Cooperation for Flood Information

Model calibrations by countries: WMO should prepare a draft proposal with pilot sites for a regional data centre on humanitarian grounds.

Conceptual framework for cooperation: The group agreed on the use of the WHYCOS concept of WMO as the basis for the development of a regional cooperative framework. The group highlighted that the concept to be developed needs to be tailored to the specific needs of the HKH region. To this end, a concept paper should be developed as a basis for discussion at both national level and in the regional context.

Additional Comments and Suggestions on the Group 1 Presentation

- There is an urgent need to set up a regional data centre to coordinate flood information sharing with the commitment of all governments.
- All initiatives must be implemented steadily so that it will take roots and be sustainable.
- Flood forecasting is the responsibility of governments. Therefore it is of the highest importance that only designated institutions with government recognition and authority should issue flood-forecasting information.
- There should be a very strong political will to ensure the implementation of what will be agreed upon at this meeting.
- If we keep waiting we will not save lives – we need to act now.

Group 2: Technical Requirements

The group discussed the topic given to them with a strong focus on the following:

- network requirements,
- use of real-time data, and
- models used for flood forecasting in the region.

Suggestions Made by Group 2

a. Hydro-meteorological Data Required: Preparation and sharing of an inventory of the hydro-meteorological data of the HKH region with the following parameters:

- location,
- station history,
- quality rating, and
- frequency of data collection.

b. Satellite Information: Regional Flood Information Centre for data acquisition, processing, and dissemination including:

- regional satellite data,
- real-time requirement, and
- frequency of data.

Group II Participants

1.	K.P. Sharma	– Nepal
2.	Gong Tongliang	– China
3.	K.B. Thapa	– Nepal
4.	Rajesh Yadav	– India
5.	A.N.H Akhtar Hossain	– Bangladesh
6.	J. Verdin	– USA
7.	Muhammad Munir Sheikh	– Pakistan
8.	Mark Landers	– USA
9.	Guna Paudyal	– DHI
10.	Li Tianchi	– China
11.	Rupak Rajbhandari	– ICIMOD
12.	P.K. Mool	– ICIMOD
13.	Richard W. Paulson	– USA
14.	Suresh Chalise	– ICIMOD
15.	Michael Ernst	– USAID/ Dhaka

c. Network requirement: Assessment of the existing network for flood forecasting (real-time network data) including:

- glacier floods,
- flash floods, and
- river floods.

d. An extension of the network is required

- An inventory of available models (access, linkage, and sharing) in use for flood forecasting
- Identify untapped resources

Comments and Suggestions on the Group 2 Presentation

- Different regions have different mathematical models. Hence the inventory of available models (access, etc) will be different.
- List of stations should be shared
- Workshop on flood-forecasting models should be organised
- There is a need to find out what is available - quality, access, etc.

Group 3: Dissemination and Use of Flood-forecasting Products

Expected Results

- Exchange of data and information
- Communication facilities
- Dissemination and use of flood-forecasting products
- Institutional feedback
- Regional forecasting products
- Regional exchange of data and information

Suggestions made by Group 3

a. Dissemination - Modes of Dissemination: Through focal points, through bilateral arrangements, and through both focal points and bilateral arrangements. (Target Groups: governments, specific departments, and the general public/flood affected areas)

b. Methods of Dissemination: Internet/e-mail/websites, telephones/fax, T.V. channels, and the print media

c. Capacity Building: Improved institutional arrangements, use of latest equipment, and organised training and field visits

d. Organisational Concepts for Dissemination and Use of Products: Timely dissemination of flood-forecasting information

Comments and Suggestions on the Group 3 Presentation

This presentation attracted a number of comments and suggestions. The major comments and suggestions are given below.

- Radio dissemination is also important in areas where TV is unavailable.
- Capacity building should take place along with dissemination. However, if the information is disseminated directly to the population there might be, for example in India, a language problem.
- A community that has gone through a catastrophe is not the same. Communities are different and they act differently; some live on islands and some in the mountains, etc. Let individual governments deal with their communities.

Group I1I Participants

1.	Liang Jiazhi	– China
2.	S. B. Srivastava	– India
3.	D.C. Goswami	– India
4.	M. Akram Kahlown	– Pakistan
5.	A.K.M. Shamsul Islam	– Bangladesh
6.	Thanongdeth Insisiengmay	– MRC
7.	Kamal Kishore	– ADPC
8.	Dorji Namgay	– Bhutan
9.	Asaduzzaman Khan	– Bangladesh
10.	Chen Guangwei	– China

- There is a lot of room for improvement in community information dissemination.
- WMO runs a programme that has a large capacity building component. Help could perhaps be provided to governments to develop some dissemination systems and provide technical advice to improve their dissemination methods.
- People should not be confronted with several sources of information, it confuses them and leads to lack of credibility.
- A regional centre should be given the mandate to disseminate flood-related information to the first-hand target group, which is the government. The centre could help the government to improve dissemination of information. However, some problems do exist despite various bilateral agreements.
- Dissemination through the Internet could be problematic in that most people in the villages do not know what the Internet is and even fewer have access to the Internet. However, we should use these technologies to our best advantage.
- Many countries have problems communicating flood forecasts to the communities. It would be most logical for a regional organisation to disseminate information.
- The large diversity in terms of communities and languages makes dissemination from a regional organisation very difficult.
- If information does not reach the people it is of no use. There is a need to sort out the language problems and other differences to save lives.

Chairperson's Remarks

The chairperson congratulated all the groups for their valuable inputs to shape the framework and technical content for the proposed regional flood-forecasting information system. He noted, in particular, that the central governments and local governments are responsible for flood forecasting and response. It is therefore imperative that these institutions are supported to help their communities. In this respect, the ultimate responsibility for flood forecasting rests with national authorities. The decisions of these authorities will be largely improved by the proposed regional flood forecasting information system which will provide both national and regional meteorological and hydrological services.

Break-out Session II – Development of a Strategy for Regional Cooperation in Flood Forecasting

Chairperson: Mr. Riaz Ahmad Khan, Chairperson, Federal Flood Commission, Pakistan

The second break-out session was held in the afternoon of the third day. The three groups that were formed to discuss the key issues relating to flood forecasting and information exchange in the morning were asked to continue in the same groups and follow-up the morning process by developing a strategy for regional cooperation in flood forecasting. The details of the group outcomes and plenary discussions are given below.

Introduction

Dr Grabs introduced the afternoon break-out session and proposed guidelines for group discussions. Mr. Riaz Ahmad Khan, the Chairperson for the session, outlined the time required for the groups to complete their tasks and report back to the plenary for presentations. The groups comprising of the same members as in the morning carried out the afternoon tasks. The groups' tasks are outlined below.

Group 1: Framework for cooperation (country support, institutional cooperation, project development, coordination, mutual information, etc.)

Group 2: Data and information exchange mechanism (selection of priority basins, networks, observation platforms, hydrological and meteorological information, application of WMO Resolutions 40 and 25, exchange of technologies and know-how, transmission of data and communication)

Group 3: Operational regional flood-forecasting system (development of system components, forecasting products, etc.)

Group 1 - Framework for Cooperation: Next Steps

The discussion of the group focussed on the development of a:

- conceptual agreement,
- working arrangement, and
- governmental framework.

Group 1 Suggestions

To this end, the group recalled its suggestions during the morning session to prepare a concept paper outlining the justification, proposed working agreement, regional framework, and deliverables of the proposed regional cooperation.

The group made the following specific recommendations/guidelines with regard to activities leading to the formulation of a model for a regional cooperative framework using the WHYCOS programme:

- not to transgress government domain responsibilities as a guiding principle,
- no forecasts to be directly disseminated to communities from the regional system,
- enhance/improve existing network and flood-forecasting capacities,
- establishment of an institutional framework by the participating countries (WMO as facilitator),
- development and establishment of flood information on a regional web-page, and
- establishment of a consultative panel to assist in the development of a governmental framework.

Comments and Suggestions on the Group 1 Presentation

The main recommendation was that a follow-up meeting be organised by WMO and ICIMOD.

Group 2 - Data/Information Exchange Mechanisms: Next Steps

The first step was to identify the agencies in each country that would undertake data sharing. The group suggested that it is the responsibility of the government to make flood forecasts. As there are differences between flood-forecasting systems in these countries, standards should be developed to ensure effectiveness in forecasting for each country.

Group 2 Suggestions

a. Suggestions for data development and information exchange

- Set up a flood information centre
- A regional approach to exchange data to be adapted
- Identify focal points for data exchange
- Encourage bilateral exchange of data

- Establish uniform standards of data
- Flood data communication in NMO

Comments and Suggestions on Group 2 Presentation

The main comments and suggestions made during the presentations by Group 2 is highlighted below:

- Establishment of specific stations in the major rivers; would it be of much benefit?
- Select specified stations to collect real-time data
- As a pilot project the most important stations should be used to collect real-time data.
- Details are too early to suggest; before consultation with the respective governments more specific suggestions cannot be come up with.
- Flood forecast information from other countries is not very essential. The need is to know the rain position; how much rain is coming and how that will affect our rivers, etc.
- The need is for meteorological data, snow data, river data, and precipitation data.
- Can we exchange hydro-meteorological data? The WMO Resolution 40 has been effective in this regard but WMO Resolution 25 has not been so effective.
- Data exchange mechanisms are required so that the flow coming into the country can be calculated
- There is a problem as data may not be uniformly available from all countries
- Create one accessible website where all information is available. This should be updated by a centre that is paid to do it.
- We should choose three pilot rivers: the Ganges, the Indus, and the Brahmaputra.
- Real-time collection should preferably be three-hourly and if not possible at least a daily update.
- Everything cannot change at once. We should let things develop over time.

Group 3 - Operational Regional Flood-forecasting System: Next Steps

Group 3 discussed the topic at length and made the following suggestions.

Group 3 Suggestions

- Review the existing system
- Improve information collection
- Encourage real-time data collection
- Encourage screening of data
- Improve processing of data (modelling)
- Improve flood forecasting
- Encourage the transmission/sharing of data
- Strengthen existing implementation systems
- Pass on information to flood-prone areas
- Build capacities of institutions dealing with flood forecasting

Comments and Suggestions on the Group 3 Presentation

- There are many models on flood-forecasting systems, however they may not be suitable to all regional countries. Therefore various options should be taken into consideration.

- The consultative process between the European countries is working because they have a long history of scientific cooperation.
- Regional forecasting is difficult but at the same time it is necessary. At present, there is a lack of capacity and hence one cannot trust the data.
- The flood forecast and other related flood information would be available on the regional website and the information should be relatively reliable.

Chairperson's Concluding Remarks

In his concluding remarks, Mr. Khan highlighted that the Group One had presented their work on the conceptual framework to be presented to the respective governments. The group suggested that the document should be developed by WMO and proposed that this should be circulated by November this year. They assumed that after getting feedback the framework would be likely to be adopted. Group Two raised an important point concerning the standardisation of the formats to be used for collecting, storing, and disseminating data in order to ensure uniformity. The chairperson noted that the meeting agreed to address this concern. He pointed out group three's concerns about the quality of information and the necessity of having reliable data transmitted from one country to another. He stated that every sovereign state at the meeting had demonstrated a spirit of mutual cooperation. He therefore believed that all the countries represented at the meeting would make an effort to disseminate quality data to other countries. He suggested that there might be some capacity building required in certain countries where the facilities may not be up to the mark. Mr. Khan reminded the participants of the importance of the discussions noting that the participants had discussed the institutional arrangements within their respective governments. He reminded the participants that a panel of experts would also be constituted to do the initial work towards a legal government framework for the implementation of whatever recommendations that the meeting makes. He also noted that the meeting had agreed that a regional webpage would be developed by March 2002. The focal point for the activities is the WMO and follow-up meetings will be held as and when appropriate. In conclusion, Mr. Khan thanked all the groups for their excellent presentations.

Summary of Key Issues Raised on Day Three

There was a general acknowledgment regarding the increasing problems caused by floods and the havoc it wreaks on a large number of people in the region by destroying lives and property.

Key Outcomes from Group Discussions

Morning Session

- Information is shared under different bilateral agreements on flood forecasting
- Flood information sharing rather than flood forecasting should be the starting point
- Regional cooperation for flood information is important
- Preparation of a proposal by WMO with pilot sites serving as regional data centres on humanitarian grounds was suggested.
- Preparation and sharing of an inventory of hydro-meteorological data of the HKH Region
- Establishment of a regional centre for data acquisition, processing, and dissemination
- Assessment of the existing network for flood forecasting (real-time data network)

- Capacity building to improve institutional arrangements and the use of the latest equipment will be essential
- Organisational concepts for dissemination and use of products to ensure effective dissemination of flood forecasts
- Information dissemination to the communities to be left to national governments

Afternoon Session

An Action Plan was suggested for the establishment of a forum for coordinating regional cooperation on flood information sharing. With HKH-HYCOS as the focal point the following steps were suggested.

- Preparation of a concept paper (justification, proposed working agreement, regional framework, deliverables to be prepared on a consensus basis) – **Draft 11/2001**
- Work on the model for flood data processing using the WHYCOS programme.
- Establishment of an institutional framework for networking by the participating countries (WMO as facilitator) by **5/2002**
- Development and establishment of flood information on a regional web-page by **3/2002**
- Establishment of a consultative panel to assist in the development of a governmental framework by **10/2001**

Establish Data/Information Exchange Mechanism

- To identify the national focal points for data exchange
- To exchange standards for data and information
- To exchange real-time data on water levels, flows, extent of snow cover, precipitation, and area of inundation
- To establish one regional website as an information exchange mechanism

Establish a Priority of Basins: The Indus, the Ganges, and the Brahmaputra basins were identified as priority basins

Operationalising a Regional Flood-forecasting System

- Review of existing system and improvement in information collection, transmission/sharing of data, and data screening
- Improve processing of data (modelling), flood forecasting, and strengthen existing implementation system
- Pass on information to flood-prone areas and capacity building

chapter five

Day Four: Development of an Action Plan for the Establishment of a Regional Flood Forecasting System

Chairperson: Dr. J. Gabriel Campbell, DG, ICIMOD, Nepal

Action Plan Presentation

The last day of the consultative meeting began with a presentation by the Director General of ICIMOD on a draft Action Plan for Regional Cooperation for Flood Information Exchange. Dr. Campbell was also the chairperson for the first session of the fourth day of the meeting. The action plan was prepared using information provided by the break-out groups during the morning and afternoon sessions (See Table 4.1.).

Comments and Suggestions from Participating Countries and Observers

Dr. Campbell expressed the view that the objective of the day was to get a clear outlook of how all the participants would move forward in helping to implement the recommendations made during this meeting.

He asked representatives from each country to make comments and suggestions that would help carry the next stages of the process forward. Representatives from four countries (China, India, Nepal, and Pakistan) made observations and comments.

TABLE 4.1.

Revised Action Plan for Regional Cooperation for Flood Information Exchange

Events/Activities	Specific Outputs	Completion Date	Responsible	Remarks
Workshop Proceedings	▼ Preparation	June 2001	ODC/WMO/ICIMOD	
	▼ Draft to be circulated to participants	June 2001	ICIMOD/WMO	
	▼ Feedback from participants	August 2001	Participants	
	▼ Revise Proceedings	September 2001	ICIMOD/WMO	
Constitute Consultative Panel	▼ Panel Member Nominated	October 2001	Each Country Delegate	
	▼ Panel Meeting	June/July 2002	ICIMOD/WMO/UNESCO/HKH-FRIEND	
HKH–HYCOS Formulated	▼ Draft concept paper for Regional Cooperation for Flood Information Exchange	November 2001	WMO/ICIMOD/ UNESCO/ HKH-FRIEND	
		January 2002	Participants	
	▼ Feedback on Draft concept paper	February 2002	WMO/ICIMOD	
	▼ Draft final concept paper	May 2002	Participating Countries	
	▼ Endorsement by participating countries	June/July 2002	Participating Countries/WMO/ICIMOD	
	▼ Development of Project Document			
Regional Information Exchange	▼ Web page prepared and open system database established	March 2002	Participating Countries/ICIMOD/WMO	
Preparation of Technical Papers	▼ Technical papers developed by selected experts from the Region on: - Vulnerability to flood - Data and Information (Information needs and costs, standardisation of data from acquisition, transmission, processing, archiving, to access) - Other studies	May/June 2002	ICIMOD/WMO	
Follow-up	▼ Conducting follow-up technical meeting	June/July 2002	ICIMOD/WMO	
Technical Meeting and HKH-HYCOS Consultative Meeting	▼ Conducting HKH-HYCOS consultative meetings	June/July 2002		

Notes: WMO: World Meteorological Organisation; ICIMOD: International Centre for Integrated Mountain Development; ODC: Organisation Development Centre

The following observations were made by the participants.

Chinese Participants

- Data exchange should be given importance, especially meteorological data.
- Importance should also be given to flood information exchange, especially real-time data.
- Willing to sign other regional cooperation treaties.
- ICIMOD and sponsors deserve thanks for a successful meeting and we would like to particip ate in future workshops.
- We strongly endorse the Action Plan to move ahead in this direction.

Indian Participants

- The idea of the website is good because it belongs to everybody and it is apolitical. Other participating countries should also get a chance to contribute to the web page.
- The Action Plan is good.
- The action now should be to save lives.
- Recommendations should be given on something that does not get lost.
- It is good to have technological arrangement for sharing information but there must be a continuous technical upgrading of websites.

Nepalese Participants

- The main point is that the Action Plan should be implemented with support from the governments otherwise the process will be very slow.
- Consultation regarding the website should take place among the countries.

Pakistani Participants

1. The meeting has been a good initiative, including preparation of documents.
2. The final draft report needs approval from the government.
3. The concept paper should be based on the delegates' opinion.
4. Since monsoon is approaching, as a starting point in cooperation, data regarding flood forecasting, etc. should be exchanged through e-mail/telephone.
5. ICIMOD should sponsor small projects in flood forecasting.
6. More funding should be provided for training and capacity building.

Comments from Observers

In addition to representatives from participating countries, international experts, and representatives from the sponsors, there were observers who made some comments. These are summarised below.

1. The full agreement that everyone has come to on the Action Plan is welcome and a great achievement.
2. Quite a lot of information is available on the websites.
3. In terms of future work, care should be taken not to exaggerate the damages caused by floods. Sometimes there is a tendency to project an unrealistic and exaggerated picture of the destruction caused by floods to get more funds. But this might backfire in the long run.
4. People should be informed about floods. There is no access to e-mail/internet for people at the grass-roots level and many others. In Bangladesh, NGOs are now invited to collaborate for establishing links with the population.

5. Representatives of some donor agencies observed that the meeting was very encouraging and that they were interested and willing to help reduce the risks of floods. They also informed that they were supporting small projects and whatever techniques have been developed are being used in reducing vulnerability.
6. The best practices should be shared. However, while exchanging information the suitability should be taken into account since some have mountains and others have the plains.
7. If clear data were provided NOAA would be more than happy to help and provide support.
8. It has also been realised that there is a large component of technology that needs to be tested.
9. Cost sharing issue should be documented. Capacity building should take place in terms of training and education and every country's needs should be taken into consideration with regard to this.
10. The action plan is good. We should all be excited about this very positive atmosphere and outcome of the meeting. Focus should be on each stage in moving ahead and not on all of them to prevent being overwhelmed by the tasks ahead.
11 Related people from other sectors also need to be informed about flood forecasting.
12. If we do a study of experiences and practices the technical papers could be made better.
13. We must use this commitment to move forward. The action plan has been unanimously accepted.

Concluding Remarks by the Chairperson

In his concluding remarks, Dr. Gabriel Campbell stated that the organisers were fortunate to have the support of all the participants. He remarked that a milestone had been achieved by the meeting. Dr. Campbell remarked with pleasure that the meeting had actually succeeded in establishing a road map for developing regional sharing of flood forecasting information. This would have been impossible without the commitment shown by all the participants. He suggested that the process should be promoted through leadership in the respective countries. Dr. Campbell concluded that there are other challenges ahead before what has been agreed to at the meeting can be realised. He emphasised that the optimism displayed at the meeting should be imbued with commitment to follow through in each country. He concluded by expressing confidence that the countries of the region will give full support to this initiative and thanked the participants for their vision and cooperation.

Concluding Session: Framework for Regional Cooperation in Flood Forecasting and Management - Results and Conclusions

Chairperson: Mr. Mahesh Man Shrestha, Secretary, Ministry of Science and Technology, HMGIN

Presentation and Approval of Results

During the second part of the concluding session a summary draft report of the four-day proceedings was presented for discussion and approval. A press release was also read and approved.

A Summary Report of the Four-day Proceedings

The report began with a brief overview of the one-day field trip to the Chinese Border (see Annex 1). It was a trip for participants to experience the effects of flood on some of the most affected areas of Nepal and to see what organisations such as ICIMOD was doing to support communities in selected watershed areas of central and eastern Nepal.

The working sessions of the meeting were held over three days and covered a variety of subjects on flood forecasting and information sharing. The meeting attracted over sixty participants from six countries of the HKH region including Bangladesh, Bhutan, China, India, Pakistan, and Nepal as well as representatives from donor agencies and international scientific organisations. About hundred participants, observers, and guests attended the opening session, which was officiated by the Honourable Minister for Science and Technology, Mr. Surendra Prasad Chaudhary. The Honourable Minister reminded the participants of the importance of working together to arrive at a consensus on developing a practically-workable agenda for flood forecasting for the region in order to enable the participating countries to better manage and mitigate the adverse impacts of floods within the region in a spirit of genuine cooperation and good will. Other speakers also made reference to the need for effective information sharing on flood forecasting in the region.

The first day's working session began with presentations of cases by participating countries and international experts. They outlined flood-related issues in their own countries and emphasised the need for information sharing and effective flood forecasting in the HKH region. In all the presentations it was agreed that floods continue to create havocs in all countries of the HKH region and that there is a need for further cooperation and coordination of their activities. All countries expressed a need for improvement in flood forecasting systems in hydro-meteorological networks with real-time capacity and data quality.

Day two started off with three technical presentations by international experts. The session continued with two break-out sessions (morning and afternoon), followed by plenary presentations. There was general acknowledgement of the increasing problems of floods and the havoc it wreaks on a large number of the region's population. There was also a suggestion that there should be flood information sharing rather than flood forecasting. An Action Plan for the establishment of a forum for the coordination of regional cooperation in flood information sharing, with WHYCOS/ICIMOD as the focal point, was proposed.

The final day began with the presentation by the Director General of ICIMOD on a draft Action Plan for Regional Cooperation for Flood Information Exchange. The action plan was prepared using information provided by break-out groups during the morning and afternoon sessions and was endorsed unanimously.

Concluding Remarks by Dr. Wolfgang Grabs, Chief, Water Resources' Division, WMO

In his closing remarks, the representative of WMO, Dr. Wolfgang Grabs, noted that the efficient exchange of data and information and improvements in flood-forecasting capacities are the priorities of WMO's programme on Forecasting and Applications in

Hydrology and the implementation of regional projects of the WHYCOS. WMO, therefore, welcomed the consensus of the participants to jointly develop a project for flood information exchange in the HKH region. In this regard, he assured the participants of the sincere commitment of the WMO Secretariat to support regional and national activities in the development of HKH-HYCOS, tailored to the needs of the countries in the region.

The cooperative spirit demonstrated by all participants and the valuable contributions provided by the invited technical experts were essential to successfully achieve the objectives of the meeting. The tangible expression of this success is the agreement on activities and milestones to be achieved within the next twelve months. He thanked the donors of the meeting and the hosts, namely, ICIMOD and the Department of Hydrology and Meteorology of HMG/N, for their efficient handling of the meeting and cordial hospitality.

Concluding Remarks by Dr. Binayak Bhadra, Director of Programmes, ICIMOD

Dr. Bhadra recollected how the discussions on WHYCOS and regional cooperation on flood forecasting had started at the 2nd Steering Committee Meeting of the HKH-FRIEND in April 2000, which was sponsored by UNESCO and ICIMOD. He thanked the participants of this meeting for giving shape to the idea and for initiating the process by endorsing the Action Plan. He furthermore thanked all the participants present for their assurance of support for implementing the Action Plan and stated that a milestone had been achieved by the meeting. He noted further that the last three days had succeeded in developing a commitment among the participants to establish regional sharing of information for flood forecasting. The need now is to use this commitment to move forward and to make the Action Plan unanimous. Dr. Bhadra cautioned participants to be aware that there is a large component of technology that needs to be tested, and that there are challenges ahead, for example, in establishing effective institutional linkages among national institutions of the participating countries. There is, therefore, the need to promote this process through leadership in the respective countries.

Chairperson's Concluding Remarks

In his concluding remarks, the chairperson of the concluding session, Mr. Shrestha, commended all participants for the efforts they had put into making the meeting such a success. He stated that there are extensive flood problems in all the countries in the HKH region and pointed out that these floods which occur every year during the monsoon rains cause extensive damages to life and property in all the countries of the region. Mr. Shrestha suggested that there should be a way of forewarning flood-prone communities of such disasters before they are overwhelmed by them. He echoed the need for better quality data collection and careful planning in order to share information and data on a real-time basis. Mr. Shrestha concluded that all the participants through their active involvement in the plenary sessions as well as the group discussions had showed commitment. He therefore remarked that *'where there is a will there is a way'* and modern information technology will make it possible. He concluded by reminding participants that it is their collective responsibility to ensure the successful implementation of the action plan. They should therefore make efforts to help implement the action plan.

chapter six

Conclusions and Key Achievements

Conclusions

The realisation and concern that, in addition to extreme floods, annually occurring floods in almost all parts of the HKH region continue to be a major impediment for the economic development in many river basins by causing loss of lives and property, damage to infrastructure, and loss of productive capacity mainly in agriculture and industry, provided impetus and background to the meeting. The improved management of floods is therefore a high priority within the context of integrated water resource management and basin development in the region.

The consultative meeting was attended by high-level country representatives from Bangladesh, Bhutan, China, India, Nepal, and Pakistan, technical experts, and observers, including representatives from donor agencies. The meeting created a unique opportunity to exchange knowledge and know-how in flood forecasting in the HKH region. The participants agreed that further initiatives are required to improve flood forecasting in the entire region, in particular in improving hydro-meteorological networks, telecommunication and dissemination of real-time data and information, forecasting techniques and reliability, access to data and information, and capacity building.

It became clear during the deliberations that the existing and successfully-implemented bilateral agreements between countries could be the basis for the development of a regional framework for collaboration which would allow

for exchange of data and information beyond the limitations of bilateral agreements in the context of regional and even global interests. Technically, the participants agreed to focus on the development of a regional flood information system, including the areas for improvement mentioned above. Regional and global frameworks for cooperation for weather forecasting and the detection of climate variability and change are successfully operated within the World Weather Watch Programme of WMO. In the field of hydrology and water resources' management, the WHYCOS of WMO is presently developing into a similar system, promoting regional and global cooperation along specific interests that are identified by the regional partners. If implemented in the HKH region, the system could also be scientifically complemented by the HKH-FRIEND, which is being implemented under the auspices of UNESCO.

The participants agreed on the aims and objectives for the development of a regional flood information system based on the WHYCOS concept. The aims and objectives of a regional flood information system would be implemented through an HKH-HYCOS. The participants also agreed on an 'Action Plan' for the development of regional cooperation and the development of a draft project proposal to be discussed during the Second High-level Consultative Meeting on the Establishment of a HKH - Flood Information System planned for July 2002. To support these activities, the participants also agreed that a Consultative Panel should be established to assist ICIMOD and WMO in further developing the regional framework for cooperation and to promote the concept of an HKH-HYCOS project at the decision-making level in all participating countries in the region.

Key Achievements

The following mark the key achievements of the meeting.

- Exchange of knowledge and know-how in flood forecasting in the region and examples from outside the region
- Information on existing concepts for regional cooperation in hydrology
- Identification of the aims and objectives of a regional flood information system
- Agreement on the implementation of a regional flood information system using the WHYCOS concept of WMO and scientific support through the HKH-FRIEND project under the auspices of UNESCO
- Adoption of an action plan and the establishment of a consultative panel
- General commitment by participants to further support and assist in the development of this important regional initiative

ANNEXES

annex I

The Field Visit to Kodari

Field Excursion to the Border Areas of Nepal and the Tibet Autonomous Region of China

The Objective of the Field Trip

The four-day consultative meeting began with one full-day field excursion to Kodari in the border area of Nepal and the Tibet Autonomous Region of China and some other places en route to the east of Kathmandu. The excursion took participants through the key towns of Bhaktapur, Dhulikhel, Tatopani, and Kodari following the route along the banks of the Bhote Koshi River. This was organised to offer participants an opportunity to observe the impact of disastrous floods on some of most affected areas in the headwater regions as well as to familiarise them with the works of ICIMOD and other agencies with regard to mitigation of floods, glacial lake outbursts, and flash floods along with the early warning systems and community-based landslide control activities.

Dhulikhel and PARDYP Presentation

The excursion began on the morning of 15th May with about 50 participants. The first stop for the participants was at the Dhulikhel town in Dhulikel District. The Mayor of Dhulikhel town welcomed the participants and thanked them for coming together to discuss issues of great importance to the countries of the HKH region. The Director General of ICIMOD, Dr. Gabriel Campbell, who

accompanied the participants to Dhulikhel also welcomed the participants and encouraged them to get to know other participants during the trip.

A well-illustrated presentation was made by a team from the People and Resource Dynamics Project (PARDYP) of ICIMOD. The presentation focussed on the participatory integrated watershed management works being carried out by the project in the Jhikhu Khola watershed of Kavre Palanchok District close to Dhulikhel. The project activities included hydrological studies that would help mitigate the impact of flood disasters in the watershed area; improved management of land and water; soil conservation; and improved agricultural and other land uses for poverty alleviation. The lessons learned from the project were also presented and discussed.

Visits to Bhote Koshi Hydropower Plant and the Friendship Bridge

After the briefing on PARDYP, the participants proceeded to Kodari which is a town in the border area of Nepal and the Tibet Autonomous Region. On the way to Kodari, the participants visited the Bhote Koshi hydropower plant. They also observed the bridges damaged by recent floods and the new Friendship Bridge on the Bhote Koshi River and the other one at Fulping which were constructed after their destruction by the disastrous glacial lake outburst floods originating from across the border some years back. The group returned to Kathmandu in the evening.

annex II

Agenda and Programme of the Meeting

CONSULTATIVE MEETING ON Developing a Framework for Flood Forecasting in the Hindu Kush-Himalayan Region

Programme Agenda

Monday, 14 May Arrival of Participants

17:00 – 18:30	Registration (Hotel Himalaya)

Tuesday, 15 May

07:30 - 17:30	Field excursion to Kodari, Nepal-Tibet (China) border

Wednesday, 16 May

Venue	Hotel Himalaya
09:00 – 09:30	Registration
09:30 – 10:20	OPENING SESSION
10:30 – 11:30	Group Photo / Tea Break

11:30 – 18:00 WORKING SESSION

11:30 - 16:00 Session I

Theme: Assessment of the status and needs for regional cooperation in flood forecasting

Chair: Bangladesh: Mr. A.Y.B.I. Siddiqui, Secretary, Ministry of Water Resources

11:30 Explanation of the programme agenda and expected results of the meeting, W. Grabs

11:35 Adoption of the Agenda

Case Study Presentations

Bangladesh

11:40 Flood forecasting activities in Bangladesh and the recent floods in the Southwest Region, A.N.H. Akhtar Hossain

Bhutan

12:00 Flood impact on investment and life - A presentation of the report on Dutekhla and Pasakha (Barsachhu) floods in Phuentsholing, Dorji Namgay

China

12:20 Recent flood events and proposal for an early flood warning system in the Chinese Himalayas, Qin Dahe

12:40 The important role of hydrological data in flood forecasting in the Tibet region, Gong Tongliang

13:00 Lunch break

India

14:00 Flood forecasting in India: Meteorological aspects, R.R. Kelkar
State-of-art flood forecasting – Advancement and issues, S.B. Srivastava and Mr. R. Yadav

14:20 Flood forecasting in the Brahmaputra River, India: A Case Study, Dulal C. Goswami

Pakistan

14:40 Flood-forecasting system in vogue in Pakistan with a case study on the 1992 flood in the Jhelum River (Indus River Basin), Md. Munir Sheikh

15:00 Floods and flood forecasting in the Indus Basin: A case study from Pakistan, Md. Akram Kahlown

Nepal

15:20 Flood hazard in Nepal and that need for flood forecasting in the HKH Region, K.B. Thapa & N. R. Khanal

15:40 Discussion and Chairperson's Remarks

16:00 Tea Break

16:15-18:00 Session II

Theme: Assessment of the status and needs for regional cooperation in flood forecasting (continued)

Chair: Bhutan: Mr. Dorji Namgay, Executive Engineer, Hydrology Unit

16:15 A framework for regional flood forecasting in the Ganga-Brahmaputra-Meghna (GBM) Basin, Guna Paudyal

16:40 Regional cooperation in flood forecasting, W. Grabs

Existing regional network and cooperation including UNESCO's HKH-FRIEND project, S. R. Chalise
The Mekong River Commission, L. Geerinck and T. Insisiengmay

17:40 General Discussion and Chairperson's Remarks
18:00 Meeting Adjourns
19:00 Reception/Dinner hosted by the DG of ICIMOD at Hotel Soaltee

Thursday 17 May

09:00—10:30 Session III

Theme: Technical presentation on flood forecasting systems:
Chair: China: Dr. Qin Dahe, Chief Administrator, China Meteorological Administration

9:00 Review of the previous day's activities, M. D. Manandhar
9:10 Flood forecasting in the United States - An Overview, Richard Paulson
9:30 Geospatial stream flow model for flood hazard monitoring in Africa, James Verdin
9:50 Monitoring and data dissemination: developing a framework for flood forecasting in the HKH region, Mark Landers
10:10 Discussions on the presentation
10:30 Tea break

10:45-13:00 Session IV

Theme: Development of a technical concept for regional flood forecasting
Chair: India: Dr. R.R. Kelkar, Director General, India Meteorological Department

10:45 Introduction to the tasks of three proposed break-out groups - W. E. Grabs
Group 1 Cooperative framework
Cooperation of meteorological and hydrological services in the region
Bilateral and regional mechanisms
Conceptual framework for cooperation
Group 2 Technical requirements
Network requirements
Use of real time data
Models used for flood forecasting in the region
Group 3 Dissemination and use of flood-forecasting products
Exchange of data and information
Communication facilities
Dissemination and use of flood forecasting products
11:00 – 12:00 Group discussion of the break-out groups
12:00 Results of break-out groups and general discussion
13:00 Lunch Break

14:00– 17:15 Working Session V

Theme: Development of a strategy for regional cooperation in flood forecasting

Chair: Pakistan: Mr. Riaz Ahmad Khan, Chairperson, Federal Flood Commission

14:00 Steps for development of a strategy for bilateral and regional cooperation for flood forecasting in the HKH, W. E. Grabs/S.R. Chalise

14:10 Work in break-out groups:

Group 1 Next steps for development of a framework for cooperative arrangements

Group 2 Next steps for development of data and information exchange mechanisms related to flood forecasting

Group 3 Next steps for development of an operational, regional flood forecasting system

15:30 Tea Break

16:00 Results of the break-out groups and general discussion

17:00 Concluding Remarks by the Chairperson

Friday, May 18

09:00-12:00 Session VI

Theme: Development of an Action Plan for the establishment of a regional flood-forecasting system

Chair: Dr. J. Gabriel Campbell, Director General, ICIMOD

09:00 Review of the previous day's activities - Ken Afful/M.D. Manandhar

09:10 - 10:10 Elements of an action plan for collaborative flood forecasting systems
a) Suggestion from Principal Delegates
Bangladesh, Bhutan, China, India, Nepal, Pakistan
b) Suggestions from Observers

10:10 – 11:00 General Discussion and Chairperson's Remarks

11:00 – 11:30 Tea break

11:30–13:15 Session VI: Concluding Session

Theme: Framework for regional Cooperation in Flood Forecasting and Management: Results and conclusions

Chair: Nepal: Mr. Mahesh Man Shrestha, Secretary, Ministry of Science and Technology

11:30 Presentation of the summary of draft report, M.D. Manandhar/K Afful

11:50 Comments and Endorsement

12:10 Concluding Remarks by W. Grabs/Kuniyuki Shida

12:20: Concluding Remarks by Binayak Bhadra

12:30 Concluding Remarks by the Chairperson

12:40 Lunch

14:00 End of the Meeting

For all the sessions:

Moderators: M.D. Manandhar and Ken Afful, Organisation Development Centre (ODC)

Rapporteurs: ODC

annex III

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