Regional Cooperation in Flood Forecasting and Information Exchange in the Hindu Kush Himalayas

Mandira Shrestha

Asian Conference on Disaster Reduction
15-17, January 2003
Kobe, Japan

International Centre for Integrated Mountain Development
G.P.O Box 3226
Kathmandu, Nepal
Regional Cooperation in Flood Forecasting and Information Exchange in the Hindu Kush Himalayas

Mandira Shrestha
Water Resources Specialist, MNR Division, ICIMOD, GPO Box 3226, Kathmandu, Nepal, E-mail: mshrestha@icimod.org.np

1 Background
The Hindu Kush Himalayas (HKH) extends 3,500 km from Myanmar in the East to Afghanistan in the West across eight countries and is the one of the largest storehouses of fresh water. The mighty rivers the Ganges, Brahmaputra and the Indus all originate from the high mountains and the Tibetan plateau and are the sustenance of over 600 million people living downstream in the region meeting their needs for water supply, irrigation, hydropower, fishery, inland navigation and biodiversity. There is a wide temporal and spatial variation of the availability of water in the region. During the four months period from June through September the rivers in these basins overflow their banks. The combined effects of prolonged and intense rainfall, steep, well-developed drainage network and the fragile geology of the mountains make lowland inundation an annual event (Kattelmann, R. 1990). In South Asia forty-five percent of the population lives below the international poverty line of $1 a day, comprising about 40 percent of the world's poor (World Development Report, 2002). The high rate of poverty and rapid population growth has increased the vulnerability to flood disasters in the region. The poor people with limited resources have occupied the low lying flood plains and are highly vulnerable to flood disasters. Annually thousands of families are affected, hundreds of lives are lost and millions of dollars worth of infrastructure damaged causing negative impacts on the social and economic development of each of the countries.

Many Structural measures such as construction of dams, reservoirs and embankments have been implemented and efforts are also being made towards the non-structural approach of providing adequate early warning to reduce the impacts of floods particularly loss of lives and movable property. In the region there is limited exchange of hydrometeorological data and there is a need for timely and reliable hydrometeorological information from the entire river basin to forecast floods. Since the major rivers are transboundary there is a need to exchange information across national boundaries to provide timely warning. As yet, however, there is no regional framework for such multilateral exchange, although there are successful examples of bilateral exchange of data. Many experts have stressed the need for regional cooperation in Flood Forecasting considering it being least controversial and also cost effective.

In response, the International Centre for Integrated Mountain Development (ICIMOD) in collaboration with the World Meteorological Organization (WMO) and in cooperation with the regional partner countries from Bangladesh, Bhutan, China, India, Nepal and Pakistan has initiated a project to promote regional cooperation in flood disaster mitigation. The overall goal of the project is to reduce the flood vulnerability in the HKH region by establishing a regional flood information system and to build trust and confidence amongst the participating countries. Funding for this Project is provided by the US Department of State (Regional Environment Office of South Asia) and the US Office for Foreign Disaster Assistance (OFDA). This paper gives an overview of the problem and the regional initiative in flood data and information exchange in the Hindu Kush Himalayas. It highlights the activities that have been completed and also presents the current and proposed activities.
2 River Basins in the HKH region

The major basins in the HKH region are the Indus and the Ganges-Bramhaputra. They are the most important river systems in the region and covers a significant part of the HKH region and is shown below.

2.1 Indus Basin

The Indus River originates in Tibet from a spring called Singye Khambab which lies at an altitude of 5,500 meters north of Lake Mansarover. The principal tributaries of the River Indus from west are the Rivers Kabul and the Kurrem; the five main tributaries from east are the Rivers Jhelum, the Chenab, the Ravi, the Beas and the Sutlej. The Indus river system is one of the largest river systems in the world with a mean annual flow of about 20.96 million hectare metres at the time of emergence from the Himalayan foothills and with drainage area of about 1.17million sq.km (http://bhakra.nic.in/about/history.htm). The principal rivers of Indus system are all perennial, but the flow in each varies enormously during the year; it is minimum during the winter and floods occur in the rainy season. Its tributaries are more dependent on the monsoon rains. Most of the Indus Basin lies in India and Pakistan, and only about 13 percent of its total catchment is in Tibet and Afghanistan. Within India, the Indus Basin lies in the States of Jammu & Kashmir, Himachal Pradesh, Punjab, Haryana and Rajasthan.

The Indus River is the longest of the Himalayan rivers. It covers 3199 km from its origin in Tibet to the Arabian Sea. The river length above Tarbela is about 1489 km and catchment area of 466,172 sq. km. There are five right bank and three left bank tributaries named Singhi river, Shyok river, Shiger river, Gilgit river, Astore river and Tansher river, Dras river, Siran river respectively. Most of the catchment above Tarbela is mountainous with some of the highest peaks in the world. Most of the snow melt contribution comes from the area between 3048 to 4573 meters in elevation. The river enter the plains a few kms below Attock. It has very flat slope and wide bed with large formation of deltas in the province of Sindh. The main features of the Indus River are given in Table 1.
### Table 1: Main Features of the Indus River

<table>
<thead>
<tr>
<th>River</th>
<th>Catchment Area (km²)</th>
<th>Length (km)</th>
<th>Mean Annual Discharge (m³/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ravi</td>
<td>40,145</td>
<td>900</td>
<td>151</td>
</tr>
<tr>
<td>Sutlej</td>
<td>121,988</td>
<td>1,551</td>
<td>118</td>
</tr>
<tr>
<td>Jhelum</td>
<td>63,455</td>
<td>826</td>
<td>954</td>
</tr>
<tr>
<td>Chenab</td>
<td>67,544</td>
<td>1,242</td>
<td>1,103</td>
</tr>
<tr>
<td>Indus</td>
<td>965,289</td>
<td>3,199</td>
<td>3,628</td>
</tr>
</tbody>
</table>

Source: Masud, B., 2001

2.2 **Ganges Bramhaputra Meghna Basin**

The Ganges Bramhaputra Meghna Basin covers an area of around 1.75 million square kilometers across five countries, China, Nepal, India, Bhutan and Bangladesh. In total area the GBM constitutes about 1.2 percent of the world’s total geographical area but houses about 10 percent of the total world’s population amounting to about 558 million. In terms of the water resources availability, the GBM is the second largest river basin in the world, after the Amazon river basin with an annual discharge of 1350 billion cubic meters (Rangacgari, R. and Verghese, B.G., 2001).

2.2.1 **Ganges River System**

The river has its source in the Himalayas, at Gaumakh in the southern Himalayas on the Indian side of the Tibetan border. It is approximately 2510 km long and flows through China, India, Nepal and Bangladesh. The distribution of the drainage area in each of the countries is given in Table 2. The Ganges river basin is one of the most fertile and densely populated in the world and covers an area of around 1.1 million sq km. The river flows through 29 cities with population over 100,000, 23 cities with population between 50,000 and 100,000, and about 48 towns. The Ganga system accounts to about 500 billion cubic meters of water.

### Table 2: Drainage Area of the Ganges River

<table>
<thead>
<tr>
<th>S.No</th>
<th>Country</th>
<th>Drainage Area 10⁵ km²</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>China</td>
<td>0.4</td>
<td>3.0</td>
</tr>
<tr>
<td>2</td>
<td>Nepal</td>
<td>1.4</td>
<td>13.0</td>
</tr>
<tr>
<td>3</td>
<td>India</td>
<td>8.6</td>
<td>78.0</td>
</tr>
<tr>
<td>4</td>
<td>Bangladesh</td>
<td>0.7</td>
<td>6.0</td>
</tr>
</tbody>
</table>


2.2.2 **Bramhaputra River System**

The Bramhaputra originates from Tibet and the main stem of it is known as Tsangpo in Tibet, Siang or Dehang in the upstream area in India, and Bramhaputra in the rest of India and Bangladesh. The approximate total length of the river is 2906 km. The first part flows parallel to the Himalayas from west to east. The total length in China is about 1,625 km. It then turns sharply towards south and enters the state of Arunachal Pradesh of India for about several hundred km and then turns towards west and flows through Arunachal Pradesh, Assam and Meghalaya states for a total of about 918km and then enters Bangladesh. At the border, the river curves to the South and continues on this course for a length of about 363 km to the Bay of Bengal. The distribution of the catchment area in each country is given in Table 3. The average annual discharge is about 700 billion cubic meters which is higher than that of the Ganges even though the basin area is half as much.
Table 3: Drainage Area of the Brahmaputra River

<table>
<thead>
<tr>
<th>S.No</th>
<th>Country</th>
<th>Drainage Area $10^5$ km²</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>China</td>
<td>2.93</td>
<td>50.5</td>
</tr>
<tr>
<td>2</td>
<td>India</td>
<td>1.95</td>
<td>33.6</td>
</tr>
<tr>
<td>3</td>
<td>Bhutan</td>
<td>0.45</td>
<td>7.8</td>
</tr>
<tr>
<td>4</td>
<td>Bangladesh</td>
<td>0.47</td>
<td>8.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5.80</td>
<td>100.0</td>
</tr>
</tbody>
</table>


3 Floods in the HKH region

3.1 Floods in the Indus Basin

Riverine flood are one of the most devastating environmental hazards in the Indus River Basin caused by heavy precipitation. Floods are either due to snowmelt in the upper catchments or due to heavy monsoon rains in the middle or lower catchments of the river. All the five major tributaries of the Indus are vulnerable to floods. Since 1947 both India and Pakistan have incurred damages due to floods in particular the 1973 and the 1992. Data on damage due to floods in the Indian Territory was not available hence only the damage incurred in Pakistan is described. In the year 1973, more than three million homes were destroyed and 160 persons lost their lives. The 1976 floods demolished over 10 million houses while 425 lives were lost with losses amounting to Rs. 6 billion. In August and September 1988, various areas in western part of Pakistan experienced heavy rainfall resulting in flash floods (ESCAP, 1989 ESCAP Data Sheet). The unprecedented flood affected 7545 villages, 3.8 million people and left 346 dead inflicting about Rs. 17 billion worth of damage to the country. The recent catastrophic flood of 1992 surpassed all the previous records and is estimated that Pakistan lost 3 % of its total GDP (Mustafa D. et al, 1997).

Reports indicate that since 1947 Pakistan has suffered about twenty major floods and the ten most intense floods are given in the Table 4.

Table 4: Historical floods and its Damage in Pakistan

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of Villages affected</th>
<th>Lives Lost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950</td>
<td>10,000</td>
<td>2,910</td>
</tr>
<tr>
<td>1955</td>
<td>6,945</td>
<td>679</td>
</tr>
<tr>
<td>1956</td>
<td>11,609</td>
<td>160</td>
</tr>
<tr>
<td>1957</td>
<td>4,498</td>
<td>83</td>
</tr>
<tr>
<td>1958</td>
<td>2,459</td>
<td>90</td>
</tr>
<tr>
<td>1959</td>
<td>3,902</td>
<td>88</td>
</tr>
<tr>
<td>1973</td>
<td>9,719</td>
<td>474</td>
</tr>
<tr>
<td>1976</td>
<td>18,390</td>
<td>425</td>
</tr>
<tr>
<td>1988</td>
<td>16,816</td>
<td>396</td>
</tr>
<tr>
<td>1992</td>
<td>13,185</td>
<td>1332</td>
</tr>
</tbody>
</table>

Source: Mustafa, D. and Westcoat, J.L., 1997

3.2 Floods in the Ganges Brahmaputra Basins

The headwaters of the Ganges Brahmaputra Basin lies in Tibet and in Nepal and due to its terrain and topography is vulnerable to flash floods. They are mainly caused by rapid melting of snow and ice in high mountain areas, glacial lake outburst in the high himalayas and failure of landslide/debri flow dams. An example of flash flooding from Landslide dam failure is the recent event of the Zhamulonngba
landslide that dammed the Yigongzanbu River in the Tibetan Autonomous Region of China in June 2000. The landslide dam overtopped and breached creating extensive flash flooding downstream all the way to Arunachal Pradesh, India and further down. The dam failure resulted in the death of 30 people with more than 100 missing affecting more than 50,000 people and resulting in an economic loss of more than US $22.9 million.

The Mahakali, Karnali, Narayani and the Saptakoshi are the four major river basins of Nepal that feeds into the Ganges and derives flow both from rainfall and snowmelt. The entire country lies within the Ganges basin and contributes about 70% of the dry season flow and 45% of its average annual flow at the Farrakka barrage. Nepal is prone to landslides and flood disasters. In the high mountains glacial lake outburst floods are experienced some examples of which are the Zhangzangbo-Cho GLOF in the headwaters of the Sun Kosi River in 1981 and the Dig Tso GLOF in 1985 which destroyed a 3 million dollars nearly completed hydropower plant and loss of lives. There are many others Glacial lakes which are potential threats to the people living downstream. Due to the steep topography and incised channels the areas that are prone to floods and inundation are mainly in the southern areas. In the low lying terai areas floods due to incessant rain as well as occasional cloudburst is common. Severe flooding in the Ganges Basin is frequently associated with heavy precipitation in Nepal.

About 68 percent of the flood prone areas lie in the Ganges Bramhaputra Basin. The rivers from Nepal distribute waters to large parts of Uttar Pradesh, Bihar, Assam and West Bengal. The average area affected by annual floods within India's flood prone regions are: Uttar Pradesh 8.1%, Bihar 8.2%, West Bengal 9.4% and Assam 13.1% (Hofer, T. 1998). Intense precipitation in the headwaters results in flooding in the Indian Territory. Flooding conditions also arise from drainage congestion because of inadequate waterway at railway or waterway crossings near the confluence of streams when the main river is in high stage and backs up in the tributaries (Shah, R. B., 2001).

Flooding is a recurrent phenomenon in Bangladesh. About 80% of the country is flood prone while about 30% of the land area is inundated during monsoon even in a normal year. In 1987 about 39% and in 1998 about 60% of the total land area suffered flooding. In the 1998 floods, Bangladesh experienced the worst flood in the living memory. Out of the 64 districts, 53 were inundates to varying degrees and almost half the populations was directly affected by flood.

### 4 Extent of Damage in the Region

The extent of damage caused by floods in the region is very high. Since 1995 due to floods alone more than 27,000 people have lost their lives and more than 100 million affected. A summary of the statistics on the extent of damage in the countries in the HKH region is given in Table 5.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Killed</td>
<td>Affected</td>
<td>Killed</td>
<td>Affected</td>
</tr>
<tr>
<td>Afghanistan</td>
<td>229</td>
<td>80,450</td>
<td>8,603</td>
<td>307,231</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>1,073</td>
<td>47,154,238</td>
<td>6,537</td>
<td>169,223,513</td>
</tr>
<tr>
<td>Bhutan</td>
<td>200</td>
<td>1000</td>
<td>22</td>
<td>600</td>
</tr>
<tr>
<td>India</td>
<td>10,354</td>
<td>183,941,610</td>
<td>12,094</td>
<td>201,399,410</td>
</tr>
<tr>
<td>Nepal</td>
<td>1,547</td>
<td>302,520</td>
<td>1,412</td>
<td>969,807</td>
</tr>
<tr>
<td>Pakistan</td>
<td>2,005</td>
<td>3,893,749</td>
<td>2,126</td>
<td>20,752,153</td>
</tr>
</tbody>
</table>

Source: EM-DAT: The OFDA/CRED International Disaster Database
5 Flood Forecasting Status
A review of the current flood forecasting status of the countries is necessary to understand the current capabilities of each country to find out the gaps and to be in a better position to share experience, data and information, technology between countries.

5.1 Bangladesh

The Bangladesh Water Development Board (BWDP) is a public statutory body established in 1972 constituted under an Act of the parliament. It has the sole responsibility for Flood Forecasting and Warning (FFWS) as well as Flood Management in the country. It collects, processes and disseminates all types of hydrological geo-hydrological, morphological data including formulation of flood forecasts and their dissemination.

After experiencing two disastrous floods in successive years (1987 and 1998), Bangladesh felt it necessary to improve its flood forecasting and warning system. Since 1992 it started to modernize its FFWS, initially with NAM and System 11 and then with hybrid MIKE 11 model. Currently, it is updating it FFWS with MIKE Zero having GIS interface covering almost all the flood prone areas of the country with 85 monitoring stations (Hossain, A, personal contact). A review of the flood forecasting methods has revealed that Bangladesh and India are using similar technologies for data observation and transmission. A lot of effort in Bangladesh is being put into improving its forecasting and dissemination methodologies with a view to disseminate the flood information well in advance to the concerned authorities and the communities in the flood prone areas.

5.2 India

In India, the Central Water Commission (CWC) is responsible for issuing flood forecast and warning. It has 157 stations of which 132 are of rivers stage forecasts and 25 for inflow forecasts. The network covers 62 river basins/sub-basins on 8 major river systems in the country. Almost 73% of the total flood forecasting centers are located in the Ganges and the Brahmaputra system. In the Ganges river system, which includes the tributaries, there are 80 flood-forecasting stations. Along the main stream of the Ganges from Haridwar to the Farkha near the border of Bangladesh, there are 19 stations in total. In the Brahmaputra and its tributaries there are 27 stations (Central Water Commission Reports, 2000 and 2002).

Hydrological and hydrometeorological data from over 700 stations located in 62 river basins are daily collected analyzed and used for making flood forecasts. The CWC field staff is doing most of the hydrometeorological data collection and observation. The Flood Meteorological Officer (FMO) of Indian Meteorological Department (IMD) supply the daily rainfall data including 24 hours forecast of heavy rainfall to the flood forecasting centers of CWC. During the flood seasons from June to October, the transmission of data to the forecasting centers is done through VHF/HF wireless sets. At present, there are 450 wireless stations of CWC for communication of flood data. Whenever available, email services are also being used to relay data and information.

In the flood forecasting centers the hydrometeorological data made available is checked for accuracy and used to make forecast using various techniques including mathematical models and computer facilities as well as conventional methods. The MIKE II model is being used in the Damodar and Godavari basins for inflow forecast. After the formulation of the forecast it is issued immediately to the concerned authorities.
Efforts to improve the forecast and provide reliable and timely warning, is always ongoing. The methodology of flood forecasting data transmission, data analysis and formulation of forecast are frequently reviewed and updated. In the mid-eighties a Central Water Commission (CWC)-Danish Hydraulic Institute collaboration scheme was initiated with the aim of technology transfer of mathematical modeling using MIKE II. This was first tested in the Damodar basin and based on its performance has been extended to the Godavari basin. For further modernizing and inputs from remote sensing was also tested in the Godavari Basin.

Many computer models such as SSARR, HEC IF, NAM-SIIF, NLC and CWC FFI, have been tested and used. A database management system computer program to store and retrieve hydrometeorological data for use in the above-mentioned models has also been developed.

CWC with the assistance from World Bank has recently completed a project to modernize inflow forecasting system in Mahanadi and Chambal Basin with a view to improve the quality and accuracy of the forecast and to increase the lead time. The scheme included installation of automated data collection and transmission systems, use of satellite based communication, improvement of flood forecast formulation technique using computer added modeling and modernization of monitoring and forecast system through V-SET communication.

5.3 Nepal

The responsible organization for flood forecasting and warning in Nepal is the Department of Hydrology and Meteorology (DHM) of His Majesty’s Government. In 1962 with the support of USAID a nation wide hydrological data collection system was established. Flood Forecasting Project was conceptualised and initiated in 1984. In December 1987, a joint Nepal-India Flood Forecasting Scheme was launched based on the secretary level meeting between Nepal and India. Under this project it was planned to operationalize 42 rainfall and 23 stream gauging stations with facilities for high frequency transmission and receiving systems for providing real time data to India during the monsoon period. Currently there are 17 hydrological stations and 23 rainfall stations providing real time data to the Flood Forecasting Centre located at Patna on a regular basis. Even though Nepal is providing real time data to India, Nepal is yet to establish a flood forecasting and warning system of her own. However, there are some efforts being made towards the establishment of such a system (Sharma, K.P., Personal communication).

A meteor burst system has been established to provide early warning to the people as well as to a hydropower plant located downstream of the Tscho Rolpa Glacier lake. The warning system uses VHF ground waves and meteor burst for the transmission and reception of signals.

After the catastrophic flood of 1993 a need for a flood forecasting and warning system was urgently felt. On the recommendation of the Japanese Disaster Relief Team, DHM and the Disaster Prevention Technical Centre, in co-operation with the Home Ministry and the Department of Irrigation jointly developed a project proposal on flood forecasting and warning system for the Bagmati basin. The proposed project envisaged the establishment of a flood forecasting and warning system consisting of flood warning networks to provide early warning to minimize human losses during floods on the Bagmati. The proposed system included the establishment of five water level gauging stations and 14 rain gauging stations and data transmission by VHF/wireless and telemetry system (IIDS, 2001 and Poudyal M.B. et al 2001).

The DHM is also exploring the use of forecasting models such as the ones used in Bangladesh and India with the technical assistance from the Danish Hydraulic Institute. It is also looking into the installation of
an INSAT imagery and data receiving unit at Kathmandu with cooperation from India for providing meteorological forecasts. The availability of the INSAT weather data and imagery will help support the flood forecasting and warning. This is hoped to be in effect by the monsoon of 2003.

5.4 **Pakistan**

A central authority, the Federal Flood Commission (FFC) was established in 1977 to handle the problems incurred by frequent occurrence of floods. A National Flood Plan was prepared in 1978 and updated in 1987. It gave equal importance to both structural and non-structural measures. In the National Flood Plan a review of the flood forecasting system was done with specific recommendations to modernize the system. The Federal Flood Commission prepares the flood protection plan for the country, approves the flood control protection schemes, recommends principles of regulation reservoirs for flood control, measures improvement of flood forecasting and flood warning system as well as evaluates and monitors progress of implementation of the national flood protection plan (ESCAP, 1989).

The Water and Power Development Authority (WAPDA) collects and supplies real-rime data to the Pakistan Meteorological Department (PMD) as input for flood forecasting and warning system. The Flood Forecasting Division under the PMD is handling the flood forecasting. The PMD in collaboration with WABDA has been using models for flood forecasting and warning system. The resulting warnings are issued individually to various concerned agencies as prescribed in the Irrigation practice manual. Floods in 1988 and other subsequent floods paved way to full-fledged activities for the further strengthening of the flood forecasting system (FFS). The system went through many improvements and is now sufficiently comprehensive but efforts are still underway to make it more self-contained.

Although the output of presently used forecasting models is overall satisfactory, there is inadequacy of the existing flood forecasting and warning system in the upper catchments of the four Indus tributaries of rivers Jhelum, Chenab, Ravi and Sutlej. In the case of flash flood, the existing flood forecasting system suffers from insufficient forecast lead-time due to the very short time to peak after the storm precipitation.

The usual approach of using the enhanced Quantitative Precipitation Forecast (QPF) is also not reliable on account of the tremendous spatial and temporal variability of the rainfall in tropical/weather system like monsoon. The present flood warning system in place is overall satisfactory as well as effective and direct communication from the flood forecasting office to the Government and local authority is available. However, it is felt that the flood forecasting models can be further improved.

5.5 **Bhutan**

In Bhutan, the authorized organization for the presentation and interpretation of hydrological and meteorological data is the Hydromet Service Division, which is under the Department of Energy (DoE) Ministry of Trade and Industry of the Royal Government of Bhutan. It collects hydrological river flow data for hydrometric purpose and meteorological data for meteorological and weather forecasting. It is also responsible for flood flow observation for flood warning especially to India. Bhutan currently has 14 hydrological and 12 meteorological stations collecting hydrometeorological data. The stations are located in various river basins with the longest record being 15 years in the Dangmechu Basin at Deothang. Bhutan, however, does not have a flood forecasting model for flood forecasting and warning.

5.6 **China**

In China, there is a fairly complete system of flood forecasting and warning with more than 8,500 hydrological stations. In the flood forecasting system, there is a management system at various levels,
which are the Central Government, river basin agencies, province (municipality and autonomous region) authorities and prefect authorities. For the central management department, Water Information Centre under Ministry of Water Resources is responsible for flood forecasting services. For the river basins agencies, there are hydrological information and forecasting divisions. For large scale water conservancy project management agencies there are hydrological information and forecasting groups. These units are in charge of receiving, processing, storing, retrieving and using hydrological information.

Based on real-time hydrological information processing, the hydrological information and forecasting units at various levels, some management units of large water conservancy projects and more than 1000 basic hydrological stations all make flood forecasting. In China, the management agencies for the major rivers all have the operational forecasting schemes with certain precisions and lead time. The common hydrological forecasting methods can be divided into two types:

To make experienced correlation of parameters according to the various hydrological information and various effecting factors, which will be compiled into the chart of forecasting schemes.

To establish hydrological forecasting models according to formation-cause analysis result. Various different models are used according to the size of the river. China is also using computerized forecasting system which is suitable for the hydrological agencies in central government, river basins authorities, provinces and some water conservancy projects.

6 Existing Agreements for Flood Data Exchange in the HKH region

The Government of Nepal and India initiated a joint Nepal-India flood forecasting scheme in the late 1980s to provide flood data on a real time basis. It was envisaged that forty two rainfall stations and twenty three stream gauging stations of the Department of Hydrology and Meteorology (DHM) with facilities for high frequency transmission and receiving systems proved data to India. As of today there are 23 rainfall stations and 17 stream gauging stations transmitting data to the flood-forecasting center in Patna on a regular basis during the monsoon. Coordination for the project is maintained between India and Nepal through various inter-governmental meetings.

After the historical 1987 and 1988 floods in Bangladesh, which caused damage exceeding two billion US dollars, the need of cooperation between Nepal and Bangladesh in the field of flood forecasting was realized. The cooperation has taken a firm shape following a few meetings including a summit level meeting between Nepal and Bangladesh. The joint Indo-Bangladesh Commission in Dhaka is the responsible agency in Bangladesh for the Nepal India joint cooperation in flood forecasting. His Majesty’s Government of Nepal has designated DHM as its counterpart agency in Nepal (Poudyal M.B et al, 2001). At present data from two stations in the Kosi and Narayani rivers are being shared with Bangladesh (Sharma K.P, personal contact).

As reported by the XINHUA NEWS AGENCY a Memorandum of Understanding (MoU) was signed recently by the Indian Minister for Water Resources to help in monitoring and forecasting flood caused by Brahmaputra and other rivers flowing from the Tibetan Autonomous Region of China into India. The MoU was signed with China to monitor water levels of river flowing through China to India to forecast flood effectively in order to mitigate damage on the Indian side. According to the agreement, China already has set up three flood monitoring stations within its territory to monitor water levels of Brahmaputra and other major rivers. The Indo-China coordination in flood forecasting will benefit India as all its major rivers originate in China.
Bhutan is collecting and transmitting rainfall and river-flows data from selected sites of the tributaries of the Brahmaputra originating in Bhutan, like the Puthimari, Pagladiya, Manas, and Sunkosh. At present data from five stations are transmitted to Cooch Bihar in West Bengal and further data are transmitted to Barpeta/Nalbari in Assam from seven civil wireless and hydromet stations in Bhutan (Gyalshen 1997).

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

7 Need For Cooperation

Floods are not avoidable but the damage they inflict can be minimized through the provision of appropriate and timely information. It has been recommended by several experts that regional cooperation in flood forecasting should be given highest priority and has the highest potential for cooperation. Although these bilateral agreements for transmission of flood related data exists a need for strengthening these have been felt to enable more reliable forecasts with additional leadtime (Ahmad, Q.K. et al, 2001). Flood Data sharing arrangements from upper riparians are necessary to provide reliable forecasts with additional leadtime. It is absolutely necessary to extend, strengthen, and modernize the flood forecasting system and the network covering Nepal, Bhutan, India and Bangladesh for the benefit of all countries (Shah, R.B.,2001). It is recommended that installation of adequately equipped satellite ground stations throughout the region should be considered for providing reliable and timely early warning. Compared to structural measures for mitigating flood disaster Flood Forecasting is considered to be a non-controversial area of mutual cooperation not needing a heavy financial investment, but which benefit the large population in the region. Hence it is recommended that regional cooperation in flood forecasting be given top priority.

8 ICIMOD’s Initiative

8.1 Past and Current Activities

Recognizing the need for promoting regional cooperation in flood disaster mitigation the International Centre for Integrated Mountain Development (ICIMOD) in collaboration with the World Meteorological Organization (WMO) has initiated a project with the overall goal of reducing the flood vulnerability in the HKH region. The project seeks to establish a regional flood information system based on the proven concept of the World Hydrological Cycle Observing System (WHYCOS) of WMO. The first step of this project was initiated in May 2001 when high level delegates from Bangladesh, Bhutan, China, India, Pakistan and Nepal met at a High Level Meeting on “Developing a Framework for Regional Cooperation in Flood Forecasting and Information Exchange” in Kathmandu. The meeting was organized by ICIMOD in collaboration with WMO and was sponsored by the US department of State (Regional Office for South Asia), Office of US Foreign Disaster Assistance (OFDA), and Danida. The meeting created a unique opportunity for high-level government representatives, directors of national hydrological and meteorological services, technical experts from the region and international organisations to share information on the extent of flood problems in the region and to discuss organizational and technical approaches to flood forecasting and mitigation of flood related damages. The meeting agreed on an action plan for the next steps in developing regional co-operation for timely flood forecasting information exchange to save lives and property in the HKH region. The meeting also recommended a formation of a Consultative Panel comprising of high level government officials to provide guidance and advise for the
proper implementation of the Project and to develop a website to facilitate sharing of flood data and information.

The participants of the First High Level Meeting recommended the establishment of a website for the exchange of flood data and information. As per the recommendation [www.southasianfloods.org](http://www.southasianfloods.org) domain was registered and the website developed and launched in May, 2002 prior to the Consultative Panel Meeting. This website provides links to all the regional partners as well as International organizations working with disaster particularly floods. The website has regional pages where each country can contribute flood related data and information including photographs of flood related damages. The website is in a developing stage and is subject to continuous update and modification with input from regional countries. Since its launch, the website has received encouraging responses from several individuals and organizations/institutions who have expressed interest in being a part of the website and expand on the current network and audience served.

As per the recommendations of the participants of the 1st High Level Meeting consultative panel comprising of high level officials from each of the participating countries was constituted. In May 2002 the first meeting of the panel was held. The main objective of the meeting was to discuss the concept paper on the establishment of the regional flood information system and to advice ICIMOD and WMO in the further development of the Project. The meeting was successful in agreeing to the concept document which outlines the framework and the implementation strategy of the Project. It was agreed that the project would build on the bilateral agreements and would not substitute them. The participants of the Panel meeting agreed on the establishment of an effective transmission and dissemination systems for sharing Hydrometeorological data and information. The Panel agreed on the need to identify potential pilot studies to test the technical feasibility of the project. The Panel recommended a number of activities, including soliciting information from national agencies for use on the website [www.southasianflood.org](http://www.southasianflood.org), identifying the need for capacity building, and increasing governmental support of the project. The Panel agreed on a short, medium and long term action plan for regional cooperation in flood forecasting and information exchange.

8.2 Future Activities

A 2nd High Level Meeting on the Development of a Regional Flood Information System is being organized in Kathmandu in March 2003 where High level delegates from each of the participating countries are invited to attend. The objective of the meeting is to discuss the Project document that has been jointly prepared by the WMO and ICIMOD for the implementation of the Project and to get governmental support.

As a step towards the implementation of an operational regional flood information system a comprehensive assessment of the national and regional flood forecasting and information exchange will be conducted through national level consultations in each country. It will assess the technical and institutional requirements of national institutions for real time data exchange. The consultations will focus on the identification of the hydrological and meteorological network, observations and transmission systems within each country and how they can be upgraded to achieve a near real time data exchange.
It is also planned to test and demonstrate the technical feasibility of all components of the proposed flood information and communication system.

9 Conclusion
The program so far has been successful in bringing together the high level people working on flood forecasts and disaster management from the countries of the HKH region to sit down together to learn of current and new approaches and to discuss possible new directions for more effective collaboration. The program has been successful in initiating as well as promoting sincere dialogues between the upper and lower riparian countries and have brought together and involved senior policy and decision makers. It has also been successful in continuing the dialogue towards promoting regional cooperation and has provided sincere efforts towards building confidence and trust amongst the participating countries. This has indicated the success of effective partnerships of ICIMOD, WMO, the collaborating institutions of each of the regional countries as well as the donors and international organizations working with flood related programs.

The Project is a step towards promoting regional cooperation in improving integrated river basin management specifically by managing floods and thus contributing on to the minimization of the adverse impacts of floods. This would reduce the number of lives lost and the damage to moveable property as well as poverty reduction and the acceleration of socio-economic development in shared river basins affected by recurring floods in the HKH region.
References:


World Bank Development Report, 2002

[http://bhakra.nic.in/about/history.htm](http://bhakra.nic.in/about/history.htm)


Masud, B. 2001, *Flash Floods on the Indus River in Pakistan*, ICIMOD Newsletter, No 38

ESCAP, 1989, *Floods in Pakistan*, Water Resources Section, National Resources Division, ESCAP


Hofer, T. 1988 *Floods in Bangladesh A Highland Lowland Interaction* University of Berne, Switzerland Institute of Geography


Flood Forecasting and Warning and Disaster Management,(2001) Institute for Integrated Development Studies, Kathmandu


K.P. Sharma, Department of Hydrology and Meteorology, Personal communication

Cooperation on Eastern Himalayan Rivers, Opportunities and Challenges, Institute for Integrated Development Studies (IIDS), Kathmandu