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.