these regular activities and results will have strategic importance for a downstream country like Bangladesh.

5.3 Coordination on International Rivers between Bangladesh and India

5.3.1 The Indo-Bangladesh Joint Rivers Commission

The governments of Bangladesh and India agreed to set up a Joint Rivers Commission (JRC) in 1972 with a view toward harnessing the rivers of the two countries for the benefit of both. The initial role of JRC was mostly related to flood management and included such tasks as the development of proposals on advance flood forecasting and warning and the formulation and implementation of flood control works (the Statute of the Indo-Bangladesh Joint Rivers Commission is found in **ANNEX-IV**). An arrangement was made in 1972 for the transmission of discharge and rainfall data during the monsoon season (see below). The coverage of rivers and stations for the data transmission has slightly increased since then, but the work of JRC in the area of flood management has not gone much beyond the data transfer. The current tasks of the Bangladesh JRC, with additional responsibilities entrusted over the years, focus on the following aspects:

- Monitoring and implementation of the arrangements for sharing the dry season Ganges waters at Farakka as stipulated in the 1996 Ganges Water Treaty;
- Exchange of relevant flood-related data and information and formulation of proposals on flood warning and forecasting and cyclone warning;
- Assessment and making recommendations on development projects on international rivers inside Bangladesh;
- Monitoring and evaluating water development activities in the upstream catchments of international rivers;
- Collection of relevant data on international rivers and carrying out necessary investigation and studies with respect to water availability and demand;
- Coordination with the relevant departments and agencies in Bangladesh on flood and water management;
- Liaising with the Ministry of Home Affairs and the Ministry of Foreign Affairs on issues related to international rivers; and
- Functioning as the secretariat of Bangladesh National Committee of the International Commission on Irrigation and Drainage (ICID) and International Hydrological Programme (IHP). Acting as a focal point in Bangladesh of the Inter-Islamic Network on Water Resources Development and Management (INWRDAM).

In addition, the Bangladesh JRC is entrusted with the roles to work jointly with Nepal on the exchange of relevant data and information and formulation of proposals for flood forecasting and warning as well as on the development of common water resources for optimum utilization. Flood related data in limited catchment areas in Nepal were obtained in 2001 but FFWC is yet to respond to the JRC on the use of these

data. On the Brahmaputra river, the Bangladesh JRC is to coordinate with Bhutan to undertake research and studies on flood control and water management, which is yet to take place.

The governing body of JRC in each country comprises of the chairman, who is the Minister of Water Resources, and three Members, two of them being engineers and one representing the Ministry of Foreign Affairs. (In the Bangladesh JRC, one of the engineers is permanent Member and the other is on secondment from other government agency.) When established in 1972, JRC was a forum dominated by technical experts. With an increasing recognition of the interdependence of technical and political aspects of river planning and management, the two governments agreed in 1978 to upgrade JRC by including the relevant ministers from each side. Under JRC, the following committees and forums have been constituted to monitor or work on different issues:

Joint Committee of Experts (JCE)	Headed by the Secretary, Ministry of Water Resources in each country. Since the conclusion of the 1996 Ganges Treaty, JCE has been focusing on water-sharing of other common rivers (in accordance with Article 9 of the Treaty), as directed by JRC.
Technical Standing Committee	Headed by Member, JRC in each country. The Member can appoint four advisors depending on the issues. JRC or JCE can request Technical Standing Committee to look into certain issues when they arise.
An expert committee on the data for flood forecasting and warning	Constituted to discuss additional data and information sharing for flood forecasting and warning. The committee has not met recently.
Joint Committee for the Joint Inspection and Monitoring of the sharing of the Ganges waters at Farakka	Constituted to monitor and implement the water-sharing arrangement of the Ganges Treaty.
Joint Scientific Study Team on data discrepancies experienced on the Ganges in 1997	Established to identify reasons for data discrepancies experienced at the two measuring points below Farakka in 1997. The Team has become dormant in recent years.
Local level committees	Constituted to identify river related problems in West Bengal, Assam, Meghalaya, and Tripura, focusing on erosion and bank protection works. Headed by chief engineer of the regional BWDB office and his/her counterpart chief engineer in India. The committees meet frequently and a number of misunderstanding and problems have been solved locally. Any unresolved matters are reported/referred to JRC.

5.3.2 The Agreement and Negotiations on Flood Related Data Sharing

The original arrangement on transmission of water level, discharge and rainfall data from India to Bangladesh during the monsoon season (15 May to 15 October) was agreed in a JRC meeting in 1972. Subsequent arrangements were made on point to point transmission for the rivers that cause flash floods. The table below captures the entire aspects of the 1972 original agreement (the agreement is provided in **ANNEX-IV**).

(1) The 1972 Agreement on Flood Related Data Sharing

River	Station	Actual Levels*	Forecast Levels*	Daily Discharge*	Daily Rainfall**
Ganges	Farakka	x	x	x	
Brahmaputra	Pandu			x	
	Goalpara	x	x		x
	Dhubri	x	x		x
	Tura				x
Kushiyara (Barak)	Silchar	x	x	x	x
Teesta	Domohoni	x	x	x	x
	Coochbehar				x
	Jalpaiguri				x
	Siliguri				x
Gumti	Amarpur (P)	x			
	Sonamura	x			
	Agartala				x
Khowai	Khowai town	x			
Manu	Kailashar (P)	x			
Juri	Dharamnagar	x			

* To be communicated when either the actual or the forecast level is at or above the warning stage

** To be communicated when the daily rainfall exceeds 50mm.

(P) Point-to-Point exchange of data is to begin at these stations.

Frequency of transmission: (i) at 800hrs everyday for the water level of 2100hrs and 2400hrs of the previous day and of 300hrs and 600hrs of the day and (ii) at 2000hrs for the water level, discharge data, rainfall data as well as weather forecast of 900rs, 1200hrs, 1500hrs and 1800hrs.

The "warning stage" mentioned in this agreement is implemented in accordance with the standard set by the Indian Central Water Commission, which is one meter below the danger level. The "danger level" is determined for each point. The point-to-point data exchange at the two places (Amarpur and Kailashar) stated in the agreement has been being implemented. In addition, the following point-to-point data exchanges were agreed in subsequent JRC meetings and are under implementation:

(2) Other Point-to-Point Exchanges of Data Agreed in Subsequent JRC Meetings

River	Station	
	India	Bangladesh
Kushiyara (Barak)	Badarpur	Sylhet
Teesta	Gazoldoba	Dalia
Dharla	NH31	Kurigram
Dudhkumar	Ghugumari	Kurigram

Source: JRC

With regard to the point-to-point data from Amarpur on Gumti, Khailashahar on Manu, and Baradpur on Barak, it was agreed in an expert level meeting in 1998 that the transmission would be continuous throughout the flood season irrespective of

conditions whether the water levels are at or above the warning stage.[8]

All the data transmission except for the point-to-point exchange is done through the arrangement between the Indian Meteorological Department (IMD), Bangladesh Meteorological Department (BMD) and FFWC. IMD and BMD have a data exchange arrangement under the umbrella of the World Meteorological Organization (WMO). As mentioned in the agreement, the data are collected a total of eight times a day and transmitted twice a day through telex. Recently e-mail communication has started and both methods (telex and e-mail) are being used. Also, as the rainfall data are now available at the IMD website, FFWC does not have to rely on the IMD-BMD transmission as far as the rainfall is concerned.

For the point-to-point exchanges, the data transmission is done through wireless communication at three hours interval and is sent to Dhaka three times a day. There are sometimes delays in the transmission due to weather conditions and human factors such as lack of punctuality and insufficient knowledge on correcting problems in the wireless operation system. Other than these factors, the data transmission is being carried out in accordance with the existing agreement between the two countries. It has to be noted, however, that all of the water level stations covered by the agreement are located within 100km from the border with Bangladesh.

With a view toward increasing accuracy and lead time in flood forecasting and warning, the Government of Bangladesh through an expert-level forum of JRC in 1996 made a proposal to the Indian side for increasing the data availability (the proposal is found in **ANNEX-IV**). In this meeting, the Bangladesh side said that the existing data transmission arrangements enable Bangladesh to prepare flood forecasts and warnings with lead time of only up to 24 to 30 hours for the central part of the country, and up to four hours for the border areas. The data and information Bangladesh requested in this 1996 proposal are as follows:

(3) The 1996 Proposal by Bangladesh for the Data Exchange Improvements

i) River cross-section data at intervals of one section per 10-15 km up to the following points:

River	Point
Ganges	Allahabad
Brahmaputra	Dibrugarth
Barak	Silchar
Tista (Teesta)	Tista Bazar

ii) Three hourly water levels, daily forecast, daily discharge data, and daily rainfall data for the following stations:

[8] Record of Discussions of the Indo-Bangladesh Experts Level meeting of Flood Forecasting and Warning, Dhaka, October 24, 1998 (available in India-Bangladesh Relations Documents – 1971-2002, Volume II: Sharing of River Waters by Avtar Singh Bhasin, Geeika Publishers (New Delhi), 2003).

River/Region	Station	3 hourly water levels and daily forecast data	Daily discharge data	Daily rainfall
Ganges	Allahabad	x	x	x
	Patna	x	x	x
	Monghry	x		x
	Farakka	x	x	
	Gorakpur			x
	Champaran			x
	Darbanga			x
Brahmaputra	Pandu		x	
	Dibrugarh	x	x	x
	Tejpur	x	x	x
	Guwahati	x		x
	Goalpara	x		x
	Dhubri	x		x
	Pancaratna		x	
	Tura			x
Barak	Silchar	x	x	
Tista	Tista Bazar	x		
	Gajoldoba	x	x	
	Domohoni	x	x	
	Jalpaiguri	x		x
	Siliguri			x
	Darjeeling			x
	Kalimpong			x
	Coochbehar			x
Manas, Kopili, Jai Bhorelli, Dhansiri, Subansiri and Buri Dihang			At their outfall	
Kosi, Gandak and Ghagra			At their outfall	
Eastern Region	Karimganj, Amarpur, Agartala, Kailashar, Silchar, Khowai Town			x

iii) Water level, discharge and rainfall data from the following stations for modeling medium and flashy rivers: Mohananda, Dharla (Jaldhaka), Dudhkumar (Torsa), Nitai, Bhogai, Someswari, Kangsha, Manu, Khowai, Dhalai, Gumti, and Muhuri.

With regard to the proposal on water levels and discharge as mentioned under ii) above, the difference from the existing arrangement is that Bangladesh requested for (a) the data from other stations which are located in more upstream areas and (b) the continuous transmission of three hourly water level and discharge data regardless of whether the level is at or above the warning stage or not. The request for the daily rainfall data may no longer be relevant, as all the necessary data in India are now available on the IMD website.

According to the records of expert level meetings on flood forecasting and warning, the expert level meetings have been being held several times to review the data transmission under the existing arrangement and to discuss the proposal by Bangladesh for additional data. The JRC meeting in April 1999 specifically directed the concerned experts to meet at the earliest possible to finalize the requirements of additional data. In a expert-level meeting in 2000, the Indian side said that it would be "better to address specific points for increasing warning time for particular flood forecasting stations in Bangladesh in the bordering areas and to explore the possibilities for further improvement such as advisory forecast at Farakka."[9] The JRC meeting in January 2001 deliberated on this issue and JRC once again asked the experts' committee to look into the matter and come up with recommendations. In the same meeting the Indian side reiterated its position by saying that "in view of the complexities of these rivers due to the large number of major rivers/tributaries joining the rivers in various reaches, caution needed to be exercised so that flood forecast and warnings are reliable to ensure their credibility."[10] In short, there has been little progress on the additional data since the proposal was presented by Bangladesh in 1996.

In order for the Bangladesh FFWC to conduct useful exercises to determine the exact contribution of the data from particular stations, the river cross-section data as mentioned in i) as well as the information for iii) in the above 1996 proposal are required. Despite the unavailability of such data and information, however, FFWC in cooperation with IWM is equipped with capacities to undertake preliminary simulations using the data currently available from India and making assumptions for the data that are not yet available. Such exercise may lead to conducting meaningful discussions with the Indian counterparts based on concrete data and results, which may promote more collaborative environment for more open exchanges of data and information.

In addition to these data, the operation rule not only for water use but also for flood spill-out of the barrages in the Indian side must be made available, as described in **Section 2.5**. An appropriate cross-boundary water release warning system must be established under a collaborative framework of Bangladesh and India.

5.3.3 A Regional Flood Information System in South Asia

While the data and information from upstream areas outside Bangladesh are indispensable for the Bangladesh FFWS to maximize its effectiveness, other countries in the region will also benefit from international data and information sharing arrangements. The establishment of a "Regional Flood Information System in the

[9] Record of Discussions on the Indo-Bangladesh Experts Level meeting on Flood Forecasting and Warning, New Delhi, August 28, 2000 (Bhasin. 2003).
[10] Record of Discussions of the thirty-fourth meeting of the Indo-Bangladesh Joint Rivers Commission: Dhaka, January 13, 2001 (Bhasin, 2003).

Hindu Kush-Himalayan(HKH) Region" has been proposed by International Center for Integrated Mountain Development (ICIMOD) and World Meteorological Organization (WMO). The draft project document was made available in January 2003 and consultations with participating governments in Bangladesh, Bhutan, China, India, Nepal and Pakistan are currently underway. The proposed regional arrangement aims at undertaking the following:

i) Planning and implementation of a regional HKH-HYCOS (Hydrological Cycle Observation System) focusing on the establishment of an efficient and operational flood forecasting information system based on real-time data and information.
ii) Provision of relevant data and information products for disaster preparedness and reduction plans and activities by and among participating countries.

A website titled South Asian Floods (www.southasianfloods.org) has recently been launched to provide a platform for sharing near real time data and information and for exchanging views. The project is supported by the US Department of State, USAID/US Office for Foreign Disaster Assistance (OFDA) and DANIDA. As of writing of this report, however, India's position is that it will engage only in bilateral dialogue and arrangement and not in any multilateral framework. In the meantime, the participation of Bangladesh in this arrangement will increase the chance of achieving its objectives in terms of obtaining flood related data and information.

5.3.4 The Ganges Water Treaty

(1) History

The treaty to share the Ganges water at Farraka was signed by Bangladesh and India in December 1996 (*Treaty between the Government of the People's Republic of Bangladesh and the Government of the Republic of India on Sharing of the Ganga/Ganges Water at the Farakka* – **ANNEX-IV**). It provides that specific amounts of water will be made available to each country by 10-day periods during the low water season from 1 January to 31 May every year. The treaty also enunciates a broader co-operation framework to move forward with treaties/agreements for sharing the waters of other common rivers and for shaping other mutually beneficial co-operation arrangements.

Negotiations over sharing the Ganges flow date back to 1951 when Pakistan protested to India on the proposed Farakka barrage, which was reported to divert 40,000 cusec out of a dry season average flow of 50,000 cusec into the Bhagirathi-Hooghly tributary to provide silt-free flow into the Calcutta bay. In 1957 Pakistan requested the involvement of the UN for the cooperative development of the Ganges and meetings at expert and secretary levels were held. In the meantime, India went ahead with the construction of the Farakka barrage, which was completed in 1970. In the wake of the independence of Bangladesh and against the backdrop of more cooperative atmosphere between India and Bangladesh, Joint Rivers Commission (JRC) was

established. However, specific tasks of JRC were limited to flood related data and information sharing and the solution of the Ganges water issue was excluded and was left to the prime ministers.

In 1975, the two governments agreed that during the trial operation of the Farakka barrage discharge to India would be between 11,000 and 16,000 cusec in ten-day periods from 21 April to 31 May. But India continued to divert the water at Farakka after this trial period and the diverted water reached 40,000 cusec. Bangladesh lodged a formal protest against India at the UN and after ministerial level negotiations the first Ganges Water Treaty was singed in 1977 (*Agreement Between the Government of People's Republic of Bangladesh and the Government of the Republic of India on Sharing of the Ganges Waters at Farakka and on Augmenting its Flows* – **ANNEX-IV**). The treaty provided a schedule of sharing of the water reaching Farakka from 1 January to 31 May on a 10-day basis. (During the leanest 10-day period of 21-30 April, 34,500 cusec for Bangladesh and 20,500 cusec for India were provided.) In order to address longer term issues, it was also agreed that JRC would carry out a study of schemes to augment the flows of the Ganges during the dry season.

The positions of Bangladesh and India were sharply divided as to the augmentation schemes. Bangladesh proposed to construct a number of storage dams in the upper reaches of the Ganges basin in Nepal and India, while India proposed to construct a barrage on the Brahmaputra with a gravity-link canal falling into the Ganges at Farakka. After the expiration of the 1977 treaty in 1982, the Ganges water sharing arrangement was continued under two successive MoUs concluded in 1982 and 1985. Under both MoUs it was agreed to work out schemes to address the long-term issue of the Ganges flow augmentation and then to identify alternatives for the water sharing arrangement. A Joint Committee of Experts (JCE), established under the 1985 MoU, was entrusted with the task. However, it was not possible to agree on a mutually acceptable proposal for the augmentation and till today no solution has been found in this regard. (The two MoUs are found in **ANNEX-IV**.)

The Ganges water sharing arrangement as well as the work of JCE came to a halt with the expiration of the 1985 MoU in 1988. Thereafter the Ganges River was left without any bilateral agreement until the conclusion of the second treaty in 1996. (See **Table 5.3.1** for the detailed history of the negotiations and implementations on the Ganges.)

(2) Contents of the Treaty

The 1996 Treaty provides the following formula for sharing of the Ganges water at Farakka by 10-day periods from 1 January to 31 May every year for 30 years (Article II and Annexure I):

Availability at Farakka	Share of India	Share of Bangladesh
70,000 cusecs or less	50%	50%
70,000 – 75,000 cusecs	Balance of flow	35,000 cusecs
75,000 cusecs or more	40,000 cusecs	Balance of flow

In addition, the Treaty provides that during the period from 1 March to 10 May, India and Bangladesh each will receive guaranteed 35,000 cusecs of water in alternate three 10-day periods. Thus, regardless of the availability at Farakka, Bangladesh will receive 35,000 cusecs during 11-20 March, 1-10 April, and 21-30 April, while India will receive the same during 21-31 March, 11-20 April, and 1-10 May.

The Treaty also stipulates that in the event that the flow at Farakka falls below 50,000 cusecs in any 10-day period, the two governments will immediately enter into consultations to "make adjustments on an emergency basis, in accordance with the principles of equity, fair play and no harm to either party" (Article II).

The formula given in this Treaty is more clear-cut than the one in the 1977 Treaty and the 1982 and 1985 MoUs and enables easier application. The Schedule provided in the 1977 Treaty allocates approximately 60% of the water to Bangladesh out of the 75% availability amount of the recorded flows from 1948 to 1973. But the exact percentages vary from 57% to 62%, which seems to be the result of somewhat arbitrary allocation of the shares. If the actual availability at Farakka during a 10-day period is higher or lower than the quantum shown in the Schedule, the water is "shared in the proportion applicable to the period," which means that in almost all cases the percentages have to be calculated from the figures given in the Schedule to determine the shares.

Article III of both the 1996 and 1977 Treaties refers to the section below Farakka where the Ganges River follows the border between the two countries and provides that the intake of water by India "for reasonable uses of water" cannot exceed 200 cusecs. It must be noted that in practice monitoring of such intake is not technical feasible.

Article VIII of the 1996 Treaty recognizes "the need to cooperate with each other in finding a solution to the long-term problem of augmenting the flows of the Ganga/Ganges during the dry season". The same provision was available in the 1977 Treaty. However, while Article VIII of the 1977 Treaty instructed JRC to carry out investigation and study of schemes for the augmentation and to submit recommendations within three years, the 1996 Treaty is silent in terms of concrete steps.

Articles IX of the Treaty says that the two governments "agree to conclude water-sharing Treaties/Agreements with regard to other common rivers" under the guidance of the principles of "equity, farness and no harm to either party." This is a new feature in the 1996 Treaty, which indicates improvements in the bilateral climate with regard to water resources.

Under Articles IV, V, VI and VII, the Joint Committee, consisting of representatives nominated by the two governments in equal numbers, is responsible for monitoring, recording and reporting on the daily flows. The institution and procedure of

monitoring and reporting are the same as those provided in the 1977 Treaty.

The dispute resolution mechanism provided in the Ganges Treaty is limited. Disputes are to be referred only to JRC and then, if not resolved to the two governments. This is in contrast with the Mahakali River Treaty entered into between India and Nepal in 1996, which stipulates an arbitration procedure with the involvement of a third party and if necessary the Permanent Court of Arbitration at the Hague for the appointment of the third arbitrator. (See below for the details on the Mahakali Treaty.)

(3) Implementation of the Ganges Water Sharing Arrangement

Immediately after signing the Treaty, the first meeting of the Joint Committee for the Joint Inspection and Monitoring of the sharing of the Ganges waters at Farakka constituted by the Treaty, was held and agreed on the procedures and method of functioning of the Joint Committee, procedures for sharing the Ganges waters at Farakka, setting up of the teams of Farakka and Hardinge Bridge (170km downstream), guidelines of functioning of the observation teams at the two places, selection of sites and procedures for location of verticals for discharge observations, among others. (The record of the first meeting of the Joint Committee describing these agreed matters is attached in **ANNEX-IV**.)

During the third 10-day period of March 1997, the first dry season after signing of the Treaty, the availability of Ganges flow at Farakka fell below 50,000 cusecs. In accordance with Article II of the Treaty, consultations were held between the two governments in the same month. India proposed making adjustments to Article II to reflect one of the following options: (i) sharing will be on a 50:50 basis when the flows are below 50,000 cusecs; (ii) sharing in a manner so that the minimum flow for either side does not fall below 20,000 cusecs; or (iii) sharing in a manner that the minimum flow for either side will not be reduced below 15,000 cusecs. Bangladesh responded that Bangladesh needs to receive 35,000 cusecs as guaranteed in the Treaty for technical reasons and the Treaty provisions should be maintained. The same matter was raised by India in a meeting of the Joint Committee for the Joint Inspection and Monitoring of the sharing of the Ganges waters at Farakka in 2001. Till today no solution on this issue has been found.

In another development, there was a quite substantial discrepancy between the quantum of water released at Farakka and the quantum arrived at Hardinge Bridge in 1997. To identify reasons for the discrepancies, JRC meeting in July 1997 decided to undertake a study by constituting a Joint Scientific Study Team (JSST). The study was originally planned to be completed by the end of 2000 but has not been done so yet as of writing of this report, as the activities of the study team became dormant.

Except for these problems encountered during the first year of implementation, the Treaty has been working well with regard to the sharing the Ganges flow at Farraka. Since 1998, dry season water flows that Bangladesh has been receiving at the Hardinge

Bridge are more than the indicative shares provided in the Treaty (Annexure II) (See **Table 5.3.2**). JRC in its meetings in recent years expressed satisfaction with regard to the water sharing.

(4) Other Issues in Relation to the Treaty

Little progress has been made with regard to directions and activities provided in Articles VIII (augmentation of the dry season flow) and IX (agreeing on water-sharing for other common rivers). Major issues, discussions and activities till today are summarized bellow:

a. Augmenting the Lean Season Flow of the Ganges

When concluding the Ganges Waters Agreement of 1977, the two governments agreed to carry out a study on augmentation of the dry season flows of the Ganges with a view to finding a long term solution to the water shortage problem of the lean season. As mentioned earlier, the two government had their own respective proposals for the augmentation. The Indian proposal called for the construction of a barrage on the Brahmaputra at Jogighopa with a gravity-link canal falling into the Ganges at Farakka. The gravity-link canal was to be supplemented at appropriate stages with storage on Brahmaputra and Barak rivers. The Bangladesh side proposed the construction of a number of storage dams in the upper reaches of the Ganges basin in Nepal and India.

On diverting the flows of the Brahmaputra into the Ganges, several options or combinations of options have been considered:

i) To construct a barrage on the Brahmaputra at Jogighopa in Assam supplemented by three storage and transfer waters through a link canal, crossing the Bangladesh territory and then re-entering India and outfalling upstream of Farakka;
ii) The link canal is entirely in the Indian territory, from a barrage at Jogighopa and connecting with the Ganges through the Teesta and Mahananda rivers in India (this, however, will require considerable pumping of waters); or
iii) To link the northern tributaries of the Brahmaputra (Manas, Sunkosh, Raidak and Torsa) to Teesta and further down to the Ganges above Farakka, after crossing the Mahanada. (These diversions are considered feasible in combination with storage dam projects in Bhutan.)[11]

For Bangladesh, the Indian proposal to construct a major barrage on the Brahmaputra, in addition to the existing Farakka Barrage on the Ganges, represented a threat to its development and national sovereignty. Also, the required canal system would necessitate relocation of 30-40,000 people, which

[11] Q.K. Ahmad., B.G. Verghese, et al ed., Cooperation on Eastern Himalayan Rivers: Opportunities and Challenges, Dhaka, BUP, 2001, pp. 21-22. The original ideas of diversions are described in K.L. Rao, India's Water Wealth: Its Assessment, Uses and Projections, New Delhi, Orient Longman, 1975.

will create social and political problems. Instead, Bangladesh argued that there was surplus water in the Ganges basin which can be stored in reservoirs for the needs of India, Nepal and Bangladesh and that it was not necessary to divert waters from other rivers. India, on the other hand, claimed that only a small volume of water can be stored in the Ganges basin and that India needs all the water that can be stored. The Indian government also doubted the practicality of building the reservoirs in Nepal, questioning whether Nepal would agree to a large number of reservoirs. Behind this claim was India's determination to oppose multilateral negotiations, which is continuing till today.[12]

As to the disagreement over the quantities of water needed and the quantity of water that can be stored in reservoirs in Nepal and India, Bangladesh estimated that 104 MFA could be stored, which could generate an additional flow of 310,00 cusecs, while Indian estimates suggested only 55 – 80,000 cusecs could be generated. Neither proposal explained the calculations supporting their respective estimates, and it was apparent that politics was dictating the measurements.[13]

Under the MoU signed in 1985, a Joint Committee of Experts (JCE) was established to address the issue of augmenting the dry season flow. JCE approached Nepal with a proposal to acquire data on storage sites of Nepal. When the Nepalese side raised questions about Nepal's involvement and mutuality, JCE's response was not positive and as a result the data were not made available to JCE. The work of JCE ended inconclusively.

In 2000 Institute for Integrated Development Studies (Kathmandu) carried out a study to substantiate the potential for the lean season augmentation at Farakka with the construction of storage dams with multipurpose objectives in the Nepalese territory, with a view toward maximizing the benefits to the region as a whole. The study concluded that "the augmentation potential in the Ganges at Farraka with the construction of storage dams in Nepal is tremendously high, provided there is no appreciable abstraction in the downstream."[14]

The need to find a solution to the problem of augmenting the Ganges flows was again recognized in the 1996 Treaty (Article VIII). However, till today, the proposals for the lean season flow augmentation at Farakka have not yet reached a level that could be substantiated by actual data.

In the meantime, with a view toward addressing the augmentation issue, the Government of Bangladesh undertook a pre-feasibility study on a Ganges barrage, the original concept of which was in the 1964 master plan for water

[12] Ben Crow, 1995. Sharing the Ganges: The Politics and Technology of River Development, Dhaka, UPL, 1995, pp.160-184.
[13] Ibid., pp. 181-183.
[14] Institute for Integrated Development Studies (Kathmandu, Nepal), Augmenting the Lean Season Flow of the Ganges (Water Resources Development Series), 2000

resources development. The study, conducted together with the development of the National Water Management Plan (NWMP) with the financial assistance of the World Bank, was made available in 2002 as "Options for Ganges Dependent Areas (OGDA)". It concludes that the construction of the Ganges Barrage, together with its distributary link channels and if implemented as part of a wider integrated water resource management program, offers the best opportunity to resolve three major problems of the Ganges dependent areas, i.e. a widening gap between water demands and availability, increasing saline intrusion and worsening drainage congestion. It is expected to be cleared by the National Water Resources Council chaired by the Prime Minister soon. As stated in **Chapter 2.5**, however, a further study is required to determine its feasibility.

b. Teesta and Other Common Rivers

In accordance with Article IX of the 1996 Treaty, JRC in 1997 set up a Joint Committee of Experts (JCE) headed by the Secretaries of Water Resources of the two governments to work out arrangements for long term/permanent sharing of the waters of common rivers.[15]

In its first meeting in 1997, JCE discussed the sharing issues for seven medium sized rivers, namely, Teesta, Dharla, and Dudhkumar in the northwest, and Manu, Khowai and Gumti and Muhuri in the east. JCE agreed to accord priority to the sharing of the Teesta waters.[16] Agreements were reached that (i) the point of release for the purpose of sharing would be at the Indian Teesta Barrage site at Gazaldoba and the Bangladesh share would be made available at Teesta barrage site at Doani and (b) both sides would explore possibilities of augmentation of the lean season flows of the Teesta within their respective commands and wherever there is scope for mutual cooperation both sides would cooperate with each other. JCE also decided to direct the Standing Committee of JRC to examine the data on the Teesta already exchanged to determine the status of water availability and requirements in each country. With respect to the six other rivers, it was agreed to update relevant data on water availability up to 1995 and exchange the same by December 1997. Relevant data and information on

[15] In 1980s, with the completion of barrages on the Teesta and Gumti rivers in sight and construction or planning for other rivers underway in India, Bangladesh attempted to negotiate a package agreement for sharing waters of all rivers. An agreement along the following lines were considered: (i) Ganges – 60:40 (Bangladesh:India) with the Bangaldesh share not to fall below 20-25,000 cusecs in the 10 days of lowest flow; (ii) Brahmaputra – 75:25 (Bangladesh:India) justified on the basis that each country could use 25% of the flow for irrigation and the remaining 50% would be required for salinity control and environmental stability; and (iii) all other common rivers – 50:50. Ben Crow, 1995, p. 190.

[16] On the Teesta River, a tributary of the Brahmaputra, a project was proposed in 1940s to contract a barrage, a dam and a canal system. The 1947 partition of India left the dam and barrage sites in India and a major portion of the canal system in East Pakistan. Thereafter, both countries pursued their respective Teesta projects. The barrage in India was completed in 1986 and in Bangladesh in 1990. The requirement of water in India is said to be 9.22 lakh hectares and 5.4 lakh hectares in Bangladesh. But availability of water in the river is not adequate to meet these requirements. In 1991 Bangladesh presented to the Indian side an "Operational Plan of the Teesta Barrage in India for long term sharing of the dry season flows of the Teesta between Bangladesh and India."

existing and planned projects in both countries on the rivers Monu, Khowai and Gomti would also be exchanged by the same time at the Standing Committee level.[17]

During the Standing Committee meeting held in the same year, the two sides had different perceptions on the availability of waters: India considered that the data base needs to be expanded. Bangladesh said the calculation should be based on the data already exchanged. The matter was referred back to JCE. [18] After a gap of about two years, JCE met in 1999, in which India proposed joint measurements at Teesta barrage in India (Gazaldoba) and in Bangladesh (Dalia) for five years in order to have a longer series of data base for making a realistic assessment of the water availability. Bangladesh desired an interim water sharing arrangement while the measurements are in progress. India proposed the following for the interim sharing arrangement: (i) to let out 10% of the water available at Gazaldoba during the lean season to maintain the ecological requirements and river regime and to ensure that the water is not utilized for consumptive purpose in either country; and (ii) to share the remaining waters on pro rata basis in proportion to the culturable commond areas of the Stage-I of the Teesta Barrage Project of India and the irrigable areas of the Phase-I of the Teesta Barrage Project of Bangladesh. Bangladesh, in response, proposed that the remaining water be shared in equal proportion.[19]

During the third meeting of JCE in January 2000, Bangladesh placed (i) a draft TOR for a joint scientific study on availability and requirements of the Teesta waters and (ii)a draft interim Agreement for sharing of the Teesta waters. India presented another draft TOR for the joint scientific study. Being unable to reach an agreement, JCE decided to refer these two issues to JRC for guidance.[20] In a JRC meeting in January 2001, JCE was directed to finalize a mutually acceptable TOR for the proposed joint study and to submit a draft interim agreement on sharing the Teesta waters on the basis of the existing data.[21] After an interval of two years, the fourth meeting of JCE was held in August 2002, where the Bangladesh side tabled a second draft of the proposed interim agreement. The Indian side responded that they would require some time to examine the draft and

[17] Record of Discussions of the first meeting of the Joint Committee of Experts (JCE) on sharing of Teesta waters, Doani, Bangladesh, August 31, 1997 (Bhasin. 2003).
[18] Record of Discussion of the meeting of the Standing Committee of the Indo-Bangladesh Joint Rivers Commission on the Border/Common Rivers between India and Bangladesh, New Delhi, November 23, 1997 (Bhasin. 2003).
[19] Record of Discussions of the second meeting of the Joint Committee of Experts on sharing of Teesta Waters, New Delhi, July 24, 1999 (Bhasin, 2003).
[20] Record of Discussions of the third meeting of the Joint Committee of Experts on sharing of waters of the Teesta, Dhaka, January 30, 2000 (Bhasin, 2003).
[21] Record of Discussions of the thirty fourth meeting of the Indo-Bangladesh Joint Rivers Commission, Dhaka, January 13, 2001 (Bhasin, 2003).

would react to its contents before or during the next meeting.[22] Further discussions have been pending since then.

With regard to the six other common rivers, the Standing Committee of JRC in 1999 exchanged the water availability data for Manu, Khowai, Gumti and Muhuri for the period from 1986 to 1995.[23] In its meeting in 2000, the Standing Committee exchanged ten daily data from 1986 to 1995 and water availability for Jaldhaka/Dharla and Torsa/Dudhkumar rivers.[24] In the JCE meeting of August 2002, Bangladesh presented a draft work plan to expedite the further works of the JCE.[25] A response from India to this work plan is not yet available.

In the meantime, India is reported to have started withdrawing water by constructing a barrage on the Gumti river at Maharain in Tripura. Talks at the Secretary-level between the two countries on the distribution of water of common rivers including the Gumti have begun.[26]

The above illustrations show the difficulties of concluding water-sharing agreements for other rivers. While some concrete procedural steps were taken immediately after the signing of the 1996 Treaty, further progress seems to have stalled as the discussions moved on to the substance of water-sharing.

5.3.5 Bilateral and Regional Cooperation for the Management of Water Resources

Against the backdrop of the positive political climate between Bangladesh and India in the wake of concluding the 1996 Ganges Treaty, an international seminar on the "Water Resources Management and Development in Bangladesh with particular Reference to Ganges River" was held in Dhaka in March 1998. The participants included government representatives from Bangladesh, India and Nepal as well as the Mekong River Commission, the SAARC (South Asia Association for Regional Cooperation) Secretariat and development partner governments and organizations. The delegates agreed on the following three-point action plan:

i) To take up a program of dredging of the Gorai ASAP to provide some immediate alleviation of the environmental degradation on the Ganges Dependant Area (GDA);
ii) To conduct further studies to establish the basis for optimal use of the Ganges waters made available under the 1996 Treaty, identifying the water-related social

[22] Record of Discussions of the fourth meeting of the Joint Committee of Experts on sharing of waters of the Teesta and other Common Rivers, New Delhi, August 28, 2002 (Bhasin, 2003).
[23] Record of Discussions of the third meeting of the Joint Committee of Experts on sharing of waters of the Teesta, Dhaka, January 30, 2000 (Bhasin, 2003).
[24] Record of Discussions of the meeting of the Standing Committee of the Indo-Bangladesh Joint Rivers Commission on the Exchange of Data and Problems of Border/Common Rivers between India and Bangladesh, Dhaka, July 1, 2000 (Bhasin, 2003).
[25] Record of Discussions of the fourth meeting of the Joint Committee of Experts on sharing of waters of the Teesta and other Common Rivers, New Delhi, August 28, 2002 (Bhasin, 2003).
[26] Remarks of Minister of Water Resources, Abdur Razzk in Jatiya Sangsad, January 17 2000 (Bhasin, 2003).

and environmental needs of the GDA, assessing the technical and economic viability of different options, including a barrage across the Ganges; and

iii) Building on the success of the Ganges Water Treaty and the Mahakali Treaty, to continue the process of cooperation within the region over a broad range of development issues.

The study mentioned in ii) above was conducted as part of the development of the National Water Management Plan (NWMP) and was made available in 2002 as "Options for Ganges Dependent Areas" (ODGA) as mentioned above. Concrete actions to follow up on the first and third points, however, are yet to take place.

5.3.6 "Second Track" Approaches

(1) "Track II"

Given the difficulties in negotiating agreements to enable equitable and reasonable use of water and sustainable development of river basins in the region, non-governmental research institutions in Bangladesh, India and Nepal have been taking initiatives to promote common understanding on management of water resources and a cooperative atmosphere for establishing the necessary institutional frameworks. Bangladesh Unnayan Parishad (BUP = Bangladesh Development Council), a research institute in Bangladesh, Center for Policy Research (CPR) in India, and Institute for Integrated Development Studies (IIDS) in Nepal joined hands in 1990 toward this end. When the BUP-CPR-IIDS project was initiated, mutual mistrust among Bangladesh, India and Nepal was prevalent, causing impasses in talks on the Ganges waters between Bangladesh and India and on various projects between India and Nepal. Their efforts in conducting research, dialogue, advocacy involving academics, experts, journalists and other stakeholders at the non-governmental level came to be known as "Track II," and helped facilitating the dialogue at the government ("Track I") level, which led to the finalization of the Ganges Waters Treaty and the Mahakali Treaty in 1996. Their research and dialogue are described in the following publications:

- "Converting Water into Wealth: Regional Cooperation in Harnessing the Eastern Himalayan Rivers" (edited by Q.K. Ahmad, B.G.Verghese, Ramaswamy R. Iyer, B.B. Pradhan, and S.K. Malla, 1994)
- "Cooperation on Eastern Himalayan Rivers: Opportunities and Challenges" (edited by K.D. Adhikari, Q.K. Ahmad, S.K. Malla, B.B. Pradhan, Khalilur Rahman, R. Rangachari, K.B. Sajjadur Rasheed, and B.G. Verghese, 2000)
- "Ganges-Brahmaputra-Meghna Region: A Framework for Sustainable Development" (edited by Q.K. Ahmad, Asit K Biswas, R. Rangachari, and M.M. Sainju, 2001)

The 2001 publication is the result of the follow-up activities of the Ganges Water Forum held in Calcutta in March 2003, with the support of the United Nations University and the Government of the Netherlands. This Forum coincided with the international seminar on "Water Resources Management and Development in

Bangladesh with particular Reference to the Ganges River" held in Dhaka in the same month (see above). An important outcome of this Forum was that a window of opportunity was recognized for a collaborative effort between Bangladesh, India and Nepal on the sustainable development of the GBM region. During the forum it was recommended that the Third World Center for Water Management should take the initiative to develop such a sustainable development framework. BUP, CPR and IIDS were selected as appropriate institutions in the three countries to undertake detailed studies. The draft studies were presented at a high-level meeting in Dhaka in 1999, where approximately 30 individuals including government representatives and leading water experts participated. A similar meeting was held in Kathmandu also in 1999 where the "Kathmandu Declaration" was adopted, recommending the governments of the GMB region (including Bhutan) to establish an institutional framework, under the auspices of SAARC or otherwise, to further GBM regional cooperation in sustainable water based integrated development. The result of the consolidated study was then presented at a special session on GBM at the World Water Congress in Melbourne and at the Second World Water Forum in the Hague in 2000. The studies also led to the development of "GBM Regional Water Vision 2025," which encompasses the following aspects:

- Enhanced quality of life with nutritional self-sufficiency and access to safe water
- Poverty reduction with the social and economic empowerment of the poor and disadvantaged
- Enhanced participation in water management emphasizing the role of women
- Reversal of environmental degradation
- Enhanced private sector involvement in the water sector development
- Maximum cross-border cooperation in flood management with the establishment of a mechanism of comprehensive data transfer/exchange for improved flood forecasting and warning
- Improvement of water quality in the GBM rivers
- Sharing of all data related to water resource development among all co-riparians
- Interconnected hydroelectricity grid to ensure optimal use of clean energy
- Dry season flow augmentation in the Ganges and transboundary sharing of all common rivers through exploration of all possible options and based on the principle of equity and environmental needs
- Development of storage potentials in the upper catchments through prioritized multipurpose projects
- Creation of a GBM River Basins Authority to act as the water management steward

As a first step for making progress toward the achievement of these goals, BUP, CPR and IIDS recommend free and wider sharing of all relevant information and data on the common rivers and projects thereon. It was proposed that WARPO in Bangladesh, the National Water Resource Council in Nepal and perhaps the Central Water Commission and National Water Development Agency in India could meet and exchange notes

about their activities and perspectives. The underlying assumption is that sharing of information and experiences, establishment of common databanks, and other activities such as organizing mutual visits to projects and institutions will build contacts and confidence among the concerned nations, which will lead to formulation and implementation of joint research and projects and an agreement on frameworks for the management of the GBM water resources.

Despite these positive developments in the late 1990s, the political momentum seems to have faded away and been replaced by inactions and mistrust, as the impasse on the talks on sharing of other common rivers have shown. The Indo-Bangladesh JRC has not met since January 2001 despite repeated requests from Bangladesh.[27] In the meantime, India announced the plan to link 37 rivers within its territory in 2002, which was again stated publicly in August 2003 (see **Section 5.1** above).

(2) Other On-going and Planned Activities

Newly proposed activities of BUP, CPR and IIDS to follow up on the GBM Regional Water Vision 2025 as well as on-going and planned activities of other non-governmental organizations are described in **Table 5.3.3**. These initiatives aim at promoting international and/or interdisciplinary exchanges and understanding on water resources issues among stakeholders including current and future policy makers in South Asia. Regular activities with specific goals will help building trust and confidence and creating an environment that would lead to positive developments at the government level negotiations and policy formulations for comprehensive development and management frameworks for the GBM as well as other water resources in South Asia.

5.4 International Water Law

5.4.1 International Water Agreements

There are more than 260 international rivers in the world. Historically, human beings have been managing international rivers in one way or another. The United Nations Food and Agriculture Organization (FAO) counted more than 3,600 treaties on international water issues between the years 805 and 1984, majority of which deal with navigation.[28] After Second World War, many treaties were negotiated on non-navigational issues of international rivers such as water allocation, hydro-power development, flood control and water quality management. A recent endeavor has identified around 300 international treaties on non-navigational issues of water management, flood control, hydroelectric projects, and allocations for consumptive

[27] It is reported that JRC will meet during September 2003. An important agenda on the part of Bangladesh would be the river link project announced by India.
[28] FAO, Systematic Index of International Water Resources Treaties, Declarations, Acts and Cases by Basin, 1978.

and non-consumptive uses of international rivers since 1945.[29] The Transboundary Fresh Water Disputes Project (TFWDP), a comprehensive and interdisciplinary analysis of international surface water conflicts, has created a systematic computer compilation of international water treaties, which currently includes 140 treaties.[30] Principal focuses of these treaties by region and the number of the treaties are summarized as follows:

Principal focus	Eurasia	North America	South America	Africa	Total
Water supply	33	3	2	12	50
Flood control	11	2			13
Hydropower	22	11	6	11	50
Industrial uses	2		2	6	10
Pollution	4				4
Navigation	1		2	3	6
Fishing	1				1

5.4.2 Historical Development of International Water Law

Historically upstream riparians often claimed the "doctrine of absolute sovereignty," which aruges that a state has absolute rights to water flowing through its territory. (This principle is referred to as the Harmon Doctrine, named after the nineteenth century US attorney-general who suggested this position regarding a dispute with Mexico over the Rio Grande river.) This doctrine was eventually rejected by the US courts and never implemented in any water treaty, nor invoked as a source for judgment in any international water ruling. On the other hand, downstream riparian countries in a humid watershed often argued for the "doctrine of absolute riverain integrity," suggesting that every riparian has entitlement to the natural flow of a river system crossing its borders. Downstream riparians in an arid watershed claimed "historic rights," which is also called the "doctrine of prior appropriation," meaning that rights are acquired through using an older water infrastructure. These are extreme doctrines which often caused clashes among many states who share transboundary rivers.[31]

Overtime, these extreme positions were moderated with responsibility, giving limitation to "rights-based" approach. The "doctrine of limited territorial sovereignty" was developed, reflecting rights to reasonably use the waters of an international river, while acknowledging that one should not cause harm to any other riparian state. The balance between the principle of "reasonable and equitable use" and the "obligation not to cause significant harm" are often difficult to achieve.

[29] A.T. Wolf, International water conflict resolution: Lessons from comparative analysis, Water Resources Development 13, 1997.

[30] Heather L. Beach, Jesse Hamner, J. Joseph Hewitt, Edy Kaufman, Anja Kurki, Joe A. Oppenheimer, and Aaron T. Wolf, Transboundary freshwater dispute resolution: Theory, practice, and annotated references, United Nations University, 2000.

[31] Aaron T. Wolf, International Water Conflict Resolution: Lessons from Comparative Analysis, International Journal of Water Resources Development, Vol. 13, No.3, 1997, pp 335-336.

Upstream riparians tend to advocate for the "equitable use," since the principle gives consideration to the present needs as well as the past needs. Downstream riparians argue for emphasis on "no significant harm." Among the international water law community a consensus seems to be emerging to give priority to "no appreciable harm" over "equitable use". For example, the World Bank, which must follow prevailing principles of international law, will not finance a project which causes harm without approval of all affected riparians.[32]

It has to be noted that the development of international water law has taken place as part of the development of the international environmental law. In fact, international water law can be considered as a sub-set of international environmental law. The joint principles of the right to use resources within a country and a duty not to cause harm to other states were recognized in the Stockholm Declaration of 1972, which was later succeeded by the Rio Declaration of 1992. Principle 21, the key statement of the Stockholm Declaration says:

"States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other states or of areas beyond the limits of national jurisdiction."

The same principle was adopted in the 1992 Rio Declaration as Principle 2 with only two words being added: "and developmental" between "environmental" and "policies." Extreme positions represented by the theories of "absolute territorial sovereignty" and "absolute territorial integrity" or "historic rights" no longer have the importance and have been replaced by the concept balancing rights and obligations in the current thinking of international water law.[33]

5.4.3 Helsinki Rules (1966)

The International Law Association (ILA) adopted *the Helsinki Rules on the Uses of the Waters of International Rivers* (**ANNEX-IV**) at its fifty second conference held at Helsinki in 1966. The Rules comprise the following six chapters:

Chapter 1: General
Chapter 2: Equitable Utilization of the Waters of an International Drainage Basin
Chapter 3: Pollution
Chapter 4: Navigation
Chapter 5: Timber Floating

[32] Ibid.

[33] Peter Beaumont, The 1997 UN Convention on the Law of Non-navigational Uses of International Watercourses: Its Strengths and Weaknesses from a Water Management Perspective and the Need for New Workable Guidelines, International Journal of Water Resources Development, Vol. 16, No.4, 2000, pp. 478-479.

Chapter 6: Procedure for the Prevention and Settlement of Dispute

One of the highlights of the Rules is the concept of a "drainage basin," which represented a departure from the traditional channel-based concept. Article II defines the drainage basin as "a geographical area extending over two or more States determined by the watershed limits of the system of waters, including surface and underground waters, flowing into a common terminus." This concept encompasses a broader spatial area, taking forest areas and slopes of mountains that receive precipitation into consideration as well.[34]

Guidelines for "reasonable and equitable" sharing of a common waterway, with no less than eleven factors being listed as factors for consideration for the determination of "reasonable and equitable" are provided in Articles IV and V. An important shift in legal thinking manifested in the Helsinki Rules is that they address the right to "beneficial use" of water, rater than water per se. The definition of "reasonable and equitable use" was used to define water use in the formation of agreements by the Mekong Committee.[35]

In 1970, Finland introduced a resolution in the United Nations General Assembly (UNGA) on the laws for international watercourses, suggesting that the Helsinki Rules should be considered as a model. The UNGA passed a resolution deleting the reference to the Helsinki Rules as a model due to reservations expressed by some states[36] and directed the International Law Commission (ILC), the UNGA's advisory body, to study the "Codification of the Law on Water Courses for Purposes other than Navigation."

5.4.4 1997 United Nations Convention

It took about 20 years for the ILC to complete a report on the proposed law. Responses to a questionnaire sent by the ILC in 1974 were given only by a total of 32 member countries by 1982 out of the 147 UN members. The most contentious issue is the drainage basin concept. Approximately half supported the concept (Argentina, Finland and the Netherlands), while the other half were either negative (Austria, Brazil and Spain) or ambivalent. Given this difference, the ILC decided to focus on the formulation of general principles and presented a draft in 1991. After six years of discussing the ILC draft, the UNGA accepted *the United Nations Convention on the Law of the Non-navigational Uses of International Watercourses* (**ANNEX-IV**) in May 1997. While 106 countries voted for the Convention, Brundi, China and Turkey

[34] CTI Engineering International Co., Ltd. and Nippon Koei Co., Ltd, The Study on Hydro-Meteorological Monitoring for Water Quality Rules in Mekong River Basin: Existing Agreement for Water Utilization, March 2002, p.7.
[35] Peter Beaumont, 2000, p.336.
[36] The reservations expressed were that (i) the rules were formulated by a professional organization which did not represent nation-states; (ii) the rules were based on a drainage basins approach, rather than the traditional channel-based approach, and could present a threat to national sovereignty. Asit K. Biswas, Management of international waters: Opportunities and constraints, Sustainable development of the Ganges-Brahmaputra-Meghna basins, The United Nations University, 2000, p.11.

voted against and Argentina, Egypt, Ethiopia, France, India, Israel and Pakistan abstained. The Convention comprises of the following seven parts:

Part 1: Introduction
Part 2: General Principle
Part 3: Planned Measures
Part 4: Protection, Preservation and Management
Part 5: Harmful Conditions and Emergency Situations
Part 6: Miscellaneous Provisions
Part 7: Final Clauses

The concept of a "river basin" provided in the Helsinki Rules was replaced by the concept of a watercourse under the UN Convention, suggesting that the use of an international watercourse is chiefly concerned with the utilization of a river channel, surface water and groundwater. Article 2 provides that "'(w)atercourse' means a system of surface waters and groundwaters constituting by virtue of their physical relationship a unitary whole and normally flowing into a common terminus" and that "'International watercourse' means a watercourse, parts of which are situated in different States"

Other than this concept, the Convention includes language very similar to the Helsinki Rule. The balance between an **obligation of not to cause significant harm** and "**reasonable and equitable use**" within each watercourse state "**with a view to attaining optimal and sustainable utilization thereof and benefits therefrom**" are provided in Article 7 and Article 5 respectively. In a similar way as in the Helsinki Rules, seven factors are listed for consideration of "reasonable and equitable use" (Article 6). Related to the concept of balancing is Article 10 which says that "(i)n the absence of agreement or custom to the contrary, no use of an international watercourse enjoys inherent priority over other uses" (Paragraph 1) and that "in the even of a conflict between uses of an international watercourse, it shall be resolved with reference to articles 5 and 7, with special regard being given to the requirements of **vital human needs**."

A crucial part of the Convention is its insistence on the "**obligation to cooperate**," which is spelled out in both Article 5 and Article 8. Article 9 calls for "**regular exchange of data and information**." In particular, Paragraph 3 states that "(w)atercourse States shall employ their best efforts to collect and where appropriate, to process data and information in a manner which facilitates its utilization by the other watercourse States to which it is communicated." Part III deals with **information exchange and consultation concerning planned measures**. Article 12 says that "(B)efore a watercourse State implements or permits the implementation of planned measures which may have a significant adverse effect upon other watercourse States, it shall provide those States with timely notification thereof." The rest of Articles provides for rules and procedures for notification and consultations and lack thereof.

Article 33 provides for **disputes settlement** procedures. Mediation or conciliation by a third party, making use of any joint watercourse institution if available, or submission of the dispute to arbitration or the International Court of Justice are provided in Paragraph 2. Paragraph 3 says that if the concerned parties are unable to settle their dispute after six months from the time of the request for negotiations. Any party of the dispute can request for an impartial fact-finding, with the involvement of the UN Secretary General for the appointment of a chairman of the fact-finding committee if necessary (Paragraphs 3, 4 and 5).

The UN Convention has been signed and ratified or approved, in accordance with the respective domestic procedural requirements, by a total of 20 countries as of 15 August 2002.[37] The Convention requires ratification by 35 members, and therefore, has not been entered into force yet. Bangladesh, till today, has not completed the ratification procedure yet.[38]

In the absence of taking effect of the Convention, the international water law, as it stands today, represents customary international law or "soft law," that has been codified and progressively developed by private organizations and advisory bodies and have been implemented partially, if not entirely, by some states in bilateral or regional agreements. The 1997 UN Convention as of today does not legally bind any state. But it represents the accumulation of wisdom and principles developed overtime and provides states with general but important guidelines for the development and management of international rivers.

5.4.5 Revision to the Helsinki Rules

The International Law Association (ILA) has been making attempts to revise the Helsinki Rules. A preliminary draft for the revised "Rules on Equitable and Sustainable Use in the Management of the Waters" was made available in March 2002.[39] The draft considers an entire drainage basin, as in the original Helsinki Rules, and aims at promoting integrated basin management. An interesting feature is the inclusion of provisions on cooperation on flood control and drought.

For example, Article 30 of the preliminary draft stipulates the following on flood control:

1. States shall, individually or jointly, together with or through competent international organizations, cooperate in measures for flood control, having due regard to the interests of other States likely to be affected by the flooding.

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[37] The countries that have signed the Convention are: Cote d'Ivoire, Finland, Germany, Hungary, Iraq, Jordan, Lebanon, Luxembourg, Namibia, Netherlands, Norway, Paraguay, Portugal, Qatar, South Africa, Sweden, Syrian Arab Republic, Tunisia, Venezuela, and Yemen. Hungary and Syrian Arab Republic registered some reservations as they signed the Convention. (http://www.internationalwaterlaw.org/IntlDocs/Watercourse_status.html)

[38] It is reported that the Ministry of Water Resources has reservations particularly about the definition of "international watercourse."

[39] http://www.internationalwaterlaw.org/IntlDocs/Helsinki_Rules.html.

2. States likely to be affected by flooding shall communicate among themselves and with competent international organizations as soon as possible regarding any events likely to create floods or dangerous rises of water levels in their territory, establishing:
   (a) an effective system of transmission in order to fulfill this obligation;
   (b) measures to ensure priority to the communication of flood warnings in emergency cases; and
   (c) a special system of translation, if necessary, between the basin States.
3. States shall, together with competent international organizations, jointly develop contingency plans for responding to foreseeable flood conditions.
4. In addition to contingency plans, cooperation with respect to flood control should, by agreement between basin States, include among other matters:
   (a) the collection and exchange of relevant data:
   (b) the preparation of surveys, investigations, and studies, and their mutual exchanges;
   (c) the planning and designing of relevant measures, including flood plain zoning and flood control works;
   (d) the execution, operation and maintenance of flood control measures;
   (e) flood forecasting and communication of flood warnings;
   (f) enacting or strengthening necessary legislation and developing or strengthening institutions appropriate for achieving these goals; and
   (g) the setting up of a regular information service charged to transmit the height of water levels and the discharge quantities.
5. States shall maintain all flood control measures in good order, and shall ensure the prompt execution of repairs or other emergency measures taken to assure the minimization of damage from flooding.
6. The use of the channel of rivers and lakes for the discharge of excess waters shall be free and not subject to any limitation provided such discharge is not incompatible with the object of flood control and does not adversely affect the rights or interests of other states."

5.4.6 Examples of Water Treaties

As mentioned at the outset in **Section 5.1**, agreements with co-riparian, upstream countries, particularly with India, are vital for Bangladesh in order to undertake effective river management within its boundary. The scope of such agreements should ideally be as comprehensive as possible as declared in the National Water Policy of 1999, encompassing water sharing, data exchange, resources planning and management of water resources to address water related problems including flood, water shortage, sedimentation, salinity and pollution among others. Practical experiences around the world, however, show that it is very difficult to implement comprehensive, multi-purpose management schemes taking into consideration a broad range of hydrological, ecological, and social and economic issues and linkages into a single framework. Countries have responded, instead, by down-scaling management

activities and focusing on a narrower range of issues.[40]

In this section, several major water treaties in the world will be reviewed focusing on aspects that may have relevance to the issues experienced in the GBM region. Treaties with focuses on flood control, water allocation, water quality, and sustainable development of a river basin have been selected for this purpose.

(1) Flood Control

The Regulation of the Alpine Rhine (Austria and Switzerland, 1892)

The Alpine Rhine is the most upstream section of the Rhine having a length of 90 km. The residents of the boundary valley of the Alpine Rhine in Austria and Switzerland were plagued by inundation for centuries. Flood protection was done locally on both sides of the river. The principal protective measures were solid groins or short levees erected to deflect the river current towards the opposite side of the river. A "tit-for-tat" of constructing levees on both sides of the rivers continued, which ended up harming both sides. Since the 16th century, the concerned riparian municipalities had tried to solve the situation by concluding agreements that no municipality was allowed to construct levees without the consent of the municipality on the opposite bank. However, in the absence of an authority capable of enforcing compliance, the agreements turned out to be ineffective. When the frequency of floods dramatically increased in the 18th and 19th centuries as a result of continuous sedimentation, it began to be recognized that floods were a regional problem that required a bilateral solution. Attempts for solutions were made in the 18th century with the work of engineers who developed plans for regulation works including canals and cutoffs through river meanders. But it took until 1892 for the two countries to establish the *International Rhine Regulation* (IRR) to serve as their common institution for flood control. Since then the Alpine Rhine valley has not suffered any more floods.

The problem in this case is mutual, where the two concerned countries share similar situations and problems. In other situations, where one country is in upstream and the other in downstream, the problems become one-sided. Cooperation between the concerned states is a lot easier to emerge and be implemented where problems are mutual. In the case of the Alpine Rhine, however, since the Swiss municipality (St. Gallen) was negotiating with the Austrian Empire, the lack of political authority and financial ability on the part of the Swiss and resulting asymmetric bargaining positions made it difficult to negotiate a solution. With the commitment of the Swiss national government that finally came forward in the mid 19th century, negotiations on regulation schemes started to make progress. Under the IRR, which was later incorporated in the *Treaty between Switzerland and Austria for the Regulation of the Rhine from the Mouth of the River III to Lake Constance* in 1954, the Joint Rhine

[40] Frank Marty, Managing International Rivers: Problems, Politics and Institutions, Peter Lang AG, Bern, 2001, p.24-25.

Commission (JRC) was constituted as the steering body responsible for implementing the necessary construction, maintenance and monitoring works. The JRC enjoys significant decision making powers and can decide on most activities and projects independently from the two governments, as long as the decisions fall under the mandate given by the treaty. The political commitment of the two countries and the institutional set up of the IRR and JRC have been major contributing factors for the successful operation of the treaty.[41]

The Rio Grande Rectification Project (United States and Mexico, 1933)

The problem of the Rio Grande in the US-Mexico boundary valley of the cities of El Paso (in Texas, the US) and Ciudad Juarez (in Chihuahua, Mexico) is similar to that of the Alpine Rhine. Due to sedimentation processes the bed of the river was rising progressively, exposing adjacent lands to dangers of floods and inundation. Prior to the second decade of the 20th century, floods occurred periodically but did not cause major damage as socio-economic activities in the valley area were limited. From the 1910s, with the construction of a dam and reservoir complex in the upstream of El Paso/Ciudad Juarez (in the US), hydrologic characteristics of the river and the socio-economic patterns of the valley lands started to change. A major irrigation project started and settlement and cultivation were intensified as a result. As intended the dam controlled the variability and magnitude of the flow downstream and kept back sediment. But it was not effective against flood waters and sediments carried into the Rio Grande river by many small tributaries coming down the mountains below the dam. As the capacity of river channel to contain peak discharges declined due to sedimentation, inundation became more frequent. After a major flood in 1921, the American and Mexican sides tried to protect themselves by unilateral measures. But it was soon learned that acting independently on both sides was not effective at all. The work of engineers identified that a comprehensive rectification project would be the only effective solution, which was also efficient from an economic point of view. Despite unsmooth relations between Mexico and the U.S. around that time, the federal governments of the two countries immediately interested in the matter and took actions. Based on a series of investigative reports, which were supplemented by studies by the International Boundary Commission[42], the two governments signed the *Convention between the United States and the United Mexican States for the Rectification of the Rio Grande in the El Paso-Juarez Valley* in 1933. The flood control regime as embodied in this Convention was developed in a matter of about ten years and implemented without much controversy, which makes it a success story in the experiences of international flood control.[43]

[41] Ibid., pp. 73-116.

[42] The International Boundary Commission of the U.S. and Mexico was established in 1889 with the aim of having a permanent body to administer a boundary convention of 1884 and to examine and decide over questions arising on the joint boundary. It was replaced by the International Boundary and Water Commission in 1944. Ibid., p.154.

[43] Ibid., pp. 127-153.

(2) Water Allocation

The Nile Waters Agreement (Egypt and Sudan, 1959)

The water allocation issues on the Nile came to the attention of the riparian and colonial power countries in the 1920s, when the British announced a comprehensive water development plan along the Nile with the construction of the Sennar dam (outside the Egyptian territory). The Nile Waters Agreement between Egypt and Sudan was signed in 1929, agreeing to allocate the Nile flows based on the 1920 estimate. After the Second World War, the independent Egyptian government proposed the Aswan High Dam. While Egypt was initially considering an option of building the dam as a unilateral project, rather than a cooperative project with Sudan, negotiations, Sudan's unilateral raising of the Sennar dam (in repudiation of the 1929 agreement) and coming to the power of the military regime in Sudan finally led Egypt to take a conciliatory approach to conclude the *United Arab Republic and Sudan Agreement for the Full Utilization of the Nile Waters* in 1959.

The Agreement specifies 48 BCM (10^9 m^3) for Egypt and 4 BCM for Sudan as the acquired rights. The remaining benefits of approximately 22 BCM, to be gained from the project, are divided by a ratio of 7.5 BCM for Egypt and 14.5 BCM for Sudan per year. If the average benefits increase from these figures, the increase would be divided equally. If there is a significant decrease, a technical committee will take up the matter. As Sudan could not absorb the allocated amount of water at the time, it was agreed that that Sudan would "loan" up to 1,500 MCM (10^6 m^3) per year to Egypt through 1977. Also, Egypt agreed to pay Sudan 15 million Egyptian Pounds in compensation for flooding and relocations. A Permanent Joint Technical Committee was established to resolved disputes if any and to determine allocations in the event of exceptionally low flows.[44]

The Indus Water Treaty (India and Pakistan, 1960)

This is a river-sharing agreement, which is often cited as an example of tackling the difficult question of sharing a common river with political commitment and effective facilitation of a third party. The offer of the international community to finance the concerned projects also provided inducements to both countries. The agreement was reached after ten years of negotiations. (It was more difficult for the provinces within Pakistan to agree among themselves on water-sharing of the Indus and the tributaries.)

Irrigation in the Indus river basin dates back centuries and was the most extensive in the world by the late 1940s. As the Government of India Act of 1935 put water under provincial jurisdiction, disputes started to arise. The partition into India and Pakistan aggravated the situations. In the early 1950s, triggered by interest expressed by the then Indian Prime Minister Nehru to the former chairperson of the Tennessee Valley

[44] Heather L. Beach, Aaron T. Wolf et al, 2000, pp. 111-114.

Authority (TVA) in integrated river management along the lines of the TVA, the then President of Eugene Black of the World Bank started to be involved. Black outlined the following principles: (i) the water resources of the Indus basin should be managed cooperatively; and (ii) the problems of the basin should be solved on a functional not on a political plane, without relation to past negotiations and past claims. The two countries accepted Black's initiative and met for the first time in Washington in 1952. During the subsequent meetings which did not progress much, Black concluded that the ideal goal of integrated watershed development was too ambitious at this stage of political relations and proposed, instead, to allocate the entire flow of the eastern rivers (Ravi, Beas, and Sutlej) to India and the all of the western rivers (Indus, Jhelum, and Chenab) to Pakistan. (This kind of sharing the water system is not possible on the GMB rivers, where the only solution is to share common rivers.) While Pakistan's initial response was suspicion, additional proposals by Black to create more storage on the western rivers, for which India would bear the costs partially, led the two countries to agree on the terms. Black also effectively mobilized nearly $900 million from the international community. The *Indus Waters Treaty* was thus concluded in 1960. The main points of the treaty are as follows:

- Pakistan will receive unrestricted use of the western rivers, which, with minor exceptions, India will allow to flow unimpeded;
- Three dams, eight link canals, three barrages and 2,500 tube wells will be built in Pakistan;
- During the transition period from 1960 to 1970, water will continue to be supplied to Pakistan according to an agreed schedule;
- India will provide financial contribution of $62 million based on an agreed schedule;
- The countries promote cooperation in the development of the waters of the Indus system including flood control works and watershed management;
- Any engineering works on any of the tributaries must be notified to the other on its plan and related data must be provided upon request;
- The Permanent Indus Commission will be established; and
- A dispute can be solved by appointing a neutral expert.[45]

Under the Treaty, each country has unrestricted "non-consumptive" use of the waters of the rivers allocated to it (with certain exceptions specified), that is for "navigation, floating of timber or other property, flood protection or flood control, fishing or fish culture, wild life or other like beneficial purposes." There has been a dispute over the definition of "non-consumptive use" in relation to the construction of a barrage by India on Wular Lake on the Jhelum. India claims that the barrage is for keeping the river within the Indian territory navigable during the lean season and is permissible

[45] Ibid., pp.101-106. Mikiyasu Nakayama, Success and Failures of International Organizations in Dealing with International Waters, International Journal of Water Resources Development, Vol. 13, No. 3, 1997, pp.367-370. B.G. Verghese, Toward Agreements on Eastern Himalayan Rivers, Asian International Waters: From Ganges-Brahmaputra to Mekong (ed. Asit K. Biswas and Tsuyoshi Hashimoto, Oxford University Press, 1996 (Japanese translation published in 1999.)

under the treaty as it is non-consumptive use of the water. But Pakistan argues that the barrage has affected downstream use of the Jhelum in the Pakistan territory and has constrained the development of river schemes. Against the backdrop of the recent political tensions between the two countries, India in December 2001 raised openly the possibility of revoking the 1960 Treaty. It was reported that the Indian Cabinet Committee on Security identified the cutting of a major water supply as a threat to use against Pakistan.[46]

(3) Water Quality

The Danube Convention (All riparian states of the Danube,1994)

The original agreement on the Danube was concluded in 1856 (the Treaty of Paris) to establish free navigation along the Danube for all the riparian countries. By the mid-1980s it became clear that issues other than navigations were gaining importance, particularly water quality. With the increasing awareness of the seriousness of the situation, in 1985 eight riparian countries (at the time) signed the Declaration of the Danube Countries to Cooperate on Questions Concerning the Water Management of the Danube (called the Bucharest Declaration), which led in turn to the *Convention on Cooperation for the Protection and Sustainable Use of the Danube River* signed by all the (by then) 16 riparian countries in 1994.

The 1985 Bucharest Declaration committed the participating countries to a regional and integrated approach to water basin management. Accordingly, a basin-wide unified monitoring network was established. In 1991, a plan for protection of the water quality of the Danube was elaborated by the riparians. An Environmental Program for the Danube River Basins was developed for support national actions for the restoration and protection of the Danube river. The principle of **"participation"** has been taken seriously in the work of this Programme. Each riparian country was responsible for identifying two individuals to help coordinate activities: a "country coordinator," usually a senior official as a liaison with the country's political organs and a "country focal point" to coordinate actual activities. One of the first activities was to produce national reviews of data availability and priority issues within each country. It was agreed to use the collected information for pre-feasibility studies. Under a Strategic Action Plan, preparation of which was agreed by the riparians in 1993, it was agreed to strengthen consultation procedures with public participation. This approach is based on the thinking that internal politics should not be treated as a "black box" but all levels in each country need to be consulted so that an international agreement to be concluded will reflect the needs of and inputs from domestic stakeholders. The 1994 Convention that resulted from these processes and approaches agreed on a series of actions including:

- cooperating on fundamental water management issues and taking all appreciate

[46] Harun Ur Rashid. "Possible Indo-Pak tension on Indus water sharing?" The Daily Star, 14 August 2003.

legal, administrative and technical measures to at least maintain and improve the environmental and water quality conditions of the Danube;
- setting priorities as appropriate to strengthen and coordinate measures to be taken at the national and international levels throughout the Danube basin for its sustainable development and environmental protection; and
- striving to achieve the goals of a sustainable and equitable water management including conservation and rational use of surface waters and groundwater.

The cooperative arrangement for the Danube river is perhaps the most active and successful in terms of its scale, if not the first such program. It is also the first basin-wide international body that actively encourages public and NGO participation throughout the planning process.[47]

(4) Sustainable Development of a River Basin

The Amazon Cooperation Treaty (All riparian states of the Amazon, 1978)

Under the *Treaty for Amazonian Cooperation* in 1978, the eight riparian countries committed themselves to the promotion of the harmonious development of the Amazon region, ensuring an equitable distribution of the benefits of the development so as to raise the standard of living of the peoples in the region. The scope is comprehensive ranging from free navigation, water use, water quality and sanitation, transportation and communication networks, tourism, flora and fauna, ethnological and archeological conservation, and other social and economic development. It is an overall framework under which certain principles and basic actions were agreed including:

- undertaking studies on means for eliminating physical obstacles to affect free and unimpeded navigation
- carrying out joint or coordinate research and development programs
- creation and operation of research institutions or centers
- organization of seminars and conferences and exchange of information

The highest decision making body of the Treaty is the forum of the Ministers of Foreign Affairs, who rotate the roles of hosting meetings. An Amazonian Cooperation Council, established by the Treaty and comprising of top level diplomatic representatives, which meets once a year, is responsible for carrying out the decision taken at meetings of Foreign Affairs Ministers.[48]

The Mekong River Basin Cooperation Agreement (Cambodia, Laos, Thailand, and Vietnam, 1995)

The process for the joint management of the Mekong was interrupted mainly due to the change in the political situations in Cambodia in the 1970s and 80s. But overall, the

[47] Heather L. Beach, Aaron T. Wolf et al, 2000, pp. 84-87.
[48] CTI Engineering International Co., Ltd. and Nippon Koei Co., Ltd, 2002, pp. 15-16.

political consensus among the four lower riparians was relatively easy to achieve thanks to foresight and effective facilitation by a third party (the UN) and the willingness of the participants.

A 1957 study by the UN Economic Commission for Asia and the Far East (ECAFE) noted that harnessing the main stem of the Mekong would allow hydropower generation, expansion of irrigated land, a reduction of the threat of flooding and the extension of navigability as far as northern Laos. As in earlier studies, the ECAFE report emphasized the need for comprehensive development of the river and close cooperation between the riparians on projects and river management. The report suggested the establishment of an international permanent body that would be responsible for coordinating joint management of the Mekong basin. Following this recommendation, the Committee for Coordination of Investigations of the Lower Mekong (Mekong Committee), made up of representatives of Thailand, Cambodia, Laos and Vietnam, was established in 1957 with support from the UN. With rapid agreement between the riparians, extensive international support came forward, amounting to $14 million to fund field surveys. By 1965, a total of more than $100 million had been pledged by various international organizations. The Secretariat was funded by a grant by UNDP. The Mekong Committee's first five-year plan consisted almost entirely of data-gathering projects, effectively precluding data disputes in the future and allowing the riparians to get used to cooperation and trust. Under the oversight of the committee, networks of hydrologic and meteorologic stations were established and programs for aerial mapping, surveying and leveling were implemented. Navigation has improved along the main stem of the river. The committee's work helped overcome political suspicion, resulting in transboundary projects such as the Nam Ngum power development between Thailand and Laos. In 1970, an Indicative Basin Plan was developed, marking the shift from the planning state to large-scale implementation. A Joint Declaration on Principles was issued setting out the committee's objectives and principles for the implementation of the Plan, including the principle of "reasonable and equitable use" based on the 1966 Helsinki Rules. The momentum of the Mekong Committee, however, began to subside with the withdrawal of Cambodia from the committee in 1978. The committee, then, became a three member "interim committee." It was not until 1991 when Cambodia returned to the arrangement in the wake of the Paris Peace Agreement. A new agreement (*Agreement on the Cooperation for the Sustainable Development of the Mekong River Basin*) was signed in 1995, in which the Mekong Committee was transformed into the Mekong Commission.[49]

Areas of cooperation under the 1995 agreement are comprehensive ranging from "sustainable development, utilization, management and conservation of the water and related resources of the Mekong River Basin including, but not limited to irrigation,

[49] Heather L. Beach, Aaron T. Wolf et al, 2000, pp. 107-110. Mikiyasu Nakayama, 1997, pp.370-373.

hydro-power, navigation, flood control, fisheries, timber floating, recreating and tourism" with a view toward optimizing the "multiple-use and mutual benefits of all riparians and to minimize the harmful effects that might result from natural occurrences and man-made activities" (Article 1). To this end, the countries agreed to promote joint and/or basin-wide projects and programs and to formulate jointly a basin development plan that would be used to identify, categorize and prioritize the projects and programs (Article 2). Framework mechanisms to ensure reasonable and equitable utilization of the waters are provided in Article 5 for both the wet season and dry season. Articles 7 and 8 require the participating states to make every effort to avoid, minimize and mitigate harmful effects to the water quantity and quality and other environmental conditions and to take joint actions to determine relevant facts, causes, damages and responsibility to address any harmful effects in conformity with the principles of international law.

What makes the Mekong Agreement most unique is the institution of the Mekong River Commission. The Mekong River Commission consists of three permanent bodies: Council, Joint Committee, and Secretariat. The Council, composed of one member from each participating state at the Ministerial and Cabinet level, makes policies and decisions and provides necessary guidance to implement the Agreement (Articles 15-20). The Joint Committee consists of one member from each state at no less than the head of the Department level and is responsible for implementing policies and decisions of the Council, formulating a basin development plan, conducting other appropriate studies, and implementing issues (Articles 21-25). The Joint Committee is also responsible for preparing rules for water utilization and inter-basin diversions for approval of the Council (Article 26). The Secretariat provides technical and administrative services to the Council and Joint Committee, assists the Joint Committee on details of the implementation of projects and programs, maintains databases, among others (Articles 28-33). In the event of a dispute, the Council makes every effort to resolve the issue. If it is unable to resolve the dispute in a timely manner, the issue will be referred to the governments, who will in turn seek for resolution through diplomatic negotiations. The governments may agree to request the assistance of mediation of a third party and proceed in accordance with the principle of international law (Articles 34-35).

China, the upstream riparian, as well as Myanmar are not signatories to the Mekong agreement. In order to achieve the objectives of the agreement in the entire basin, their involvement in the regime will be crucial and present a future challenge for the organization.[50]

[50] It is reported that Yunnan province is planning up to 14 dams on the upper Mekong, which would have a total installed capacity of 7,700MW. China has also proposed plans to divert water from the Mekong into the Yellow River to meet Northeast China's growing water demand. The Mekong agreement specifies that the watershed nations have neither the right to veto the use nor the unilateral right to use the water of the Mekong. As China does not want interference with its upper Mekong

5.4.7 Other Water Related Agreements and Co-operations in South Asia

The Indus Water Treaty, described above, is a major water agreement concluded between South Asian countries in spite of political obstacles. This section will review other agreements and cooperative arrangements in South Asia with the intention of stock-taking experiences and lessons.

The Kosi Treaty (India and Nepal, 1954)

The Treaty is mainly for flood control, irrigation and generation of hydroelectric power, with the principal structures located in Nepal. As the agreement provided little to Nepal in compensation for the adverse effects of the project such as submersions and relocations, it was very unpopular in Nepal and subsequent negotiations led to an amendment in 1966 clarifying the undertakings by India and withdrawal of water by Nepal. The layout of the barrage, the areas within afflux banks, flood embankments, and other protective works, canals, powerhouse and the lines of communication were shown in the amended plan. It was also provided that any construction and other undertaking by India in connection with the project shall be planned and carried out in consultation with Nepal.

The Gandak Treaty (India and Nepal, 1959)

This is an agreement to construct a barrage, canal, head regulators and other works for the purpose of irrigation and development of power for India and Nepal. As in the Kosi Project, the principal structures of this project are within Nepal, although the Gandak barrage is now located on the border line by accident. In addition to little compensation received on the part of Nepal, the country had even been prohibited from diverting its own waters upstream of the barrage in order not to affect the flows diverted at the barrage for irrigation in India. The agreement was amended in 1966 to correct the inequities.[51]

The Mahakali Treaty (India and Nepal, 1996)

The agreement is for the construction of a high dam on the Mahakali for flood moderation, irrigation and power generation. India proposed to Nepal in the 1970s to support the construction of a dam and reservoir complex on the Mahakali River at a site called Pancheshwar where the river forms the boundary of the two countries. Nepal, while showing little interest in the beginning, changed its mind later in the

development, it will be difficult for the country to join the agreement. World Resources Institute, World Resources 2000-2001, UNDP, UNEP and World Bank, pp.207-209.

[51] The experiences on the Kosi and Gandak agreements deepened mistrust among the Nepalese people with regard to water sharing arrangements with India. Such adverse national sentiment led to the inclusion of a provision in the new Constitution (enacted after the restoration of multi-party democracy in 1990), which makes it mandatory for any agreement with another nation about sharing natural resources to be ratified by a two-thirds majority of the Parliament. Frank Marty, 2001. Managing International Rivers: Problems, Politics and Institutions, Peter Lang AG, European Academic Publishers, Bern, 2001, pp. 162-203.

1980s as the country began to harness its water resources for development purposes. After carrying out further studies, the two countries reached agreement in 1996 in the *Treaty for the Integrated Development of the Mahakali River Including Sarada Barrage, Tanakpur Barrage and Pancheshwar Project.* The project is aimed at power production, the storage of water for irrigation, and flood control.

The Article 1 of the treaty confirms an agreement of 1920 on water rights of the two countries to the flow from the Sarada Barrage (constructed in India in 1928). The Article 2 permits India to extend the eastern end of the Tanakpur Barrage (constructed in India in 1989) across the border and fix it to the Nepalese river bank, while entitling Nepal to a certain amount of power from the Tanakpur Power Station and water diverted from the barrage. Article 3 concerns the Pancheshwar Project, setting down principles and rules on the sharing of the water of the Mahakali River and the implementation of the Project. The following are covered in the provisions of the Article 3.

- the project will be designed to produce the maximum total net benefits with respect to power, irrigation and flood control;
- power plants of equal capacities will be located on each side of the river and the energy generated will be shared equally;
- project costs are born by the parties in proportion to their respective benefits; and
- Nepal sells a share of energy to India at a price to be mutually agreed upon.

Article 9 provides for the establishment of a bilateral Mahakali River Commission, whose functions include recommendations for the conservation and utilization of the river, evaluation of projects, and examination of differences between the parties concerning interpretation and application of the Treaty. Article 10 provides for the possibility of forming a joint entity for the development and operation of the Pancheshwar Project. Arbitration procedures (Article 11) provide that a dispute is to be handled by a tribunal of three arbitrators, with the third arbitrator appointed jointly presiding over the tribunal, the decisions of which are to be final, definitive and binding. It further says that in the event that the parties are unable to agree upon the third arbitrator within ninety days, either party may request the Secretary-General of the Permanent Court of Arbitration at the Hague to appoint such arbitrator. The treaty is valid for 75 years and is subject to review at 10 year intervals. The provision of this arbitration procedure is in a stark contrast to the Ganges Water Treaty, under which disputes are to be referred only to the bilateral JRC and then the two governments.

The conclusion of the Mahakali Treaty, along with the Ganges Water Treaty which was also agreed in 1996, was hailed as a significant step forward for solving international water problems in South Asia. Immediately after the signing of the Mahakali Treaty, however, an issue began to arise regarding the interpretation of the provision in Article 3 which says that both parties are equally entitled to the flow of the river "without prejudice to their respective existing consumptive uses of the Mahakali River." This clause is not clear as to whether equal entitlement means that both parties have the

right to half of the total river flow provided that splitting the flows in equal parts does not affect the existing consumptive uses of either side, or whether equal entitlement refers to the flow of the river which remains after India and Nepal have secured their existing consumptive uses. As it turned out, the Nepalese parliament took the first interpretation, which was immediately rejected by India, insisting on the second interpretation. The successive governments in Nepal did not become active in resolving the issues and the planning on the joint project has been stalled since then.[52]

Cooperation on Flood Forecasting and Warning System – India and Nepal (late 1980s)

Cooperation between India and Nepal on the front of flood forecasting and warning is at an advanced stage. In 1987 the two governments agreed to expedite the implementation of facilities to provide for an efficient flood forecasting system on major tributaries of the Ganga that flow from Nepal into India. In the following year, 20 hydro-meteorological and 25 meteorological sites in Nepal were identified. A list of additional equipment to make these 45 stations fully operational was prepared. It was also agreed that India would provide Nepal with the hydrological data at two points downstream of the border (in India) of rivers entering from Nepal into India.

In 2000, India-Nepal Joint Committee on Water Resources (JCWR) was formed following the decision taken by the Prime Ministers of the two countries. JCWR, among other aspects, focused on the ongoing joint flood forecasting scheme. Recognizing the importance of flood forecasting as one of the effective non-structural measure for flood management, a Committee on Flood Forecasting (CFF) to review the existing system and to prepare a Comprehensive Flood Forecasting Master Plan (CFFMP) was set up. The plan would include proposals for upgrading the data transmission system and exchange of hydrological and meteorological data for an integrated flood management. The draft CFFMP was developed by a Joint Task Force formed under the CFF, and was finalized during a third meeting CFF meeting in April 2003.

Cooperation between Bhutan and India

Bhutan and India have an agreement on a comprehensive scheme of collection and transmission of real-time hydro-meteorological data from selected sites located on tributaries to the Brahmaputra originating in Bhutan, such as Puthimari, Pagladiya, Manas and Sankosh. In addition, the two countries have been cooperative arrangements to harness hydropower potential of Bhutan through the Chukha (336MW) and Tala (1,020MW) hydroelectric projects (with financial assistance from India) as well as new projects which are in various stages of preparation. Autonomous

[52] Frank Marty, 2001. The author, while recognizing that Nepal's decision to co-participate in the project strengthened their bargaining position, is critical of their national pride, which hindered rational assessment of costs and benefits for the country. The power supply which they are supposed to receive from the project is beyond their actual need and the investment costs just for the sake of controlling the power benefit are not justifiable.

authorities specially set up for the projects, with high representation from both India and Bhutan, are responsible for the project implementation.

5.5 Recommendations

5.5.1 Flood Forecasting and Warning

In relation to the current FFWS study, effective flood forecasting and warning in Bangladesh requires acquisition of additional data and information from India and their incorporation into the modeling system of FFWC. It is without saying that under the best practice principles of international water law, riparian countries have "obligation to cooperate" and should be engaged in "regular exchange of data and information" in a manner which facilitates its utilization by other watercourse states.[53] However, in light of the slow progress of the JRC talks with regard to the proposal made by Bangladesh in 1996 and in view of records of JRC and expert level meetings and subsequent exchanges between the Bangladesh JRC and FFWC, FFWC is advised to take the following actions:

a. To collect all the data and information transmitted from India through the point-to-point exchange arrangement on a continuous basis;
b. To incorporate all the data and information sent from India, i.e. those coming through the IMD-BMD arrangement, the point-to-point exchange data, the rainfall data obtained from the website, and any other relevant information into the modeling system of FFWC; and
c. To conduct simulations using the available data from India to determine their usefulness and limitation and present the results to the Bangladesh JRC for further negotiations with the Indian side.

In addition, the operation rules and records of barrages on key rivers in India should be made available and a transboundary water release warning system must be established as essential measures to mitigate artificial flood damage. MOWR is advised to take initiatives to (re)include these issues in the JRC agenda.[54]

While pursuing further dialogue and negotiations at the government level, supplemental efforts at the non-governmental level would be useful for building trust and understanding between Bangladesh, India and Nepal. The "Track II" approach, based on its achievements made so far, can be supported for this purpose with a particular focus on flood management. Detailed technical level dialogue and exchanges involving government engineers of the three countries to the extent possible in unofficial meetings and forums will help promote an environment for similar exchanges at the government level, as it was experienced in the 1990s leading up to the

[53] Articles 5, 8, and 9, the UN Convention, 1997.
[54] It has come to the knowledge of the FFWS study team that the issue was raised to the Indian JRC as early as in the mid 1970s in the context of monitoring water flows on key rivers during the dry season. The operation rules and records are needed to prepare for and mitigate any artificial flood damage as well.

conclusion of the 1996 Ganges Treaty.

5.5.2 Comprehensive Management Frameworks for the GBM Rivers

In addition to flood management, other issues such as water shortage, water quality, sedimentation, bank erosion, ecology and environment need urgent, coordinated attention throughout the river basins. Discussions between Bangladesh and India have so far been focusing on water-sharing and augmentation on the Ganges and water-sharing on other seven medium rivers. Cross-border bank erosion issues have been being addressed in the Local Level Committees of JRC to some extent.

While the talks on the augmentation of the Ganges date back to the 1970s, no breakthrough seems to be on the horizon yet. In the meantime, attention has shifted to the construction of the Ganges barrages as well as barrages on other rivers within Bangladesh in efforts to address the water shortage issue during the dry season without relying on measures that require international agreements. However, the proposed schemes identified in the draft National Water Management Plan require future, detailed studies. In particular, as mentioned in **Section 2.5** the Ganges barrage requires an in-depth study to determine its feasibility in view of the very low EIRR (around 4%) identified in the OGDA report.

While undertaking further studies on the proposed river schemes within Bangladesh, efforts aiming at long-term, rational solutions looking at the entire river courses need to be pursued. Negotiations on not only flood-related data sharing and water-sharing arrangements but also comprehensive management frameworks for the GBM rivers should be promoted. Such frameworks, reflecting the basic principles of international water law as described in **Section 5.4** above, will enable the best possible use and control of water throughout a river basin, ensuring optimization and equitable distribution of economic, social and environmental benefits and costs in the entire watercourses.

The first step that is needed toward such a direction is to conduct **an objective study to determine water balance in the GBM**, based on which a master plan can be developed. Simultaneously, free and wider sharing of all relevant information and data on the common rivers and projects and interventions thereon needs be promoted. The experiences of the Mekong Committee to use joint data gathering as the fist major cooperative tasks, which worked to overcome suspicion and build trust among the participating riparians, present a good example. The Track II type, non-governmental level dialogue and activities and a skilled and neutral intervention of a third party would be required to facilitate the process.

5.5.3 Domestic River Management

Domestic river management issues as identified in **Sections 2.4** and **2.5** must be addressed as part of efforts toward international river management. For instance, as mentioned in **Section 5.2** above, the data on water level, discharge, sedimentation,

groundwater, water quality, salinity among others should be consistently analyzed, monitored and reported at least on key rivers. This will help identify exact problems encountered in international rivers, which will in turn enhance the negotiation capacity and position of Bangladesh vis-à-vis co-riparian countries.

PART-III FEASIBILITY STUDY

CHAPTER 6 BASIC APPROACH TO THE FEASIBILITY STUDY

6.1 General Approach

This Chapter presents the general approach to the Feasibility Study for the FFWS undertaken in this JICA Study. The work flow chart is given in **Figure 6.1.1** and a brief explanation of the contents of each work item is presented below.

(1) Framework Plan and Selection of Optimum Plan

As explained in **Chapter 4**, the Framework Plan of the FFWS was initially prepared during which a number of alternatives were developed. From these an optimum plan (candidate plan for the feasibility study) was tentatively selected by the Study Team. The acceptability of this plan was subsequently confirmed with the Bangladesh Government through detailed discussions.

The alternative plans focused on two areas, namely I) organizational strengthening, i.e. **Regional Management System** through the establishment of regional offices of FFWS and **Central Management System** with some modification in the current organization, and II) strengthening of the hydrological observation system, i.e. **Manual Observation System, Automatic Observation System,** and **Combined Observation System comprising both manual and automatic networks**.

As outlined in **Chapter 4**, the JICA Study team recommended the **Regional Management System** in conjunction with **Combined Observation System** as being the optimum plan.

This overall scheme was selected as being both practical and realistic after detailed discussion with the Bangladesh Government and taking into account the possibility of re-organization or organizational improvement.

(2) Feasibility Study of the Selected Project Scheme

A Feasibility study was then conducted for the nationwide FFWS. This covered the entire area of Bangladesh and incorporated the following 5 steps:

1) Feasibility Design of FFWS Facilities
2) Feasibility Design of Evacuation System
3) Institutional Strengthening Plan
4) Project Evaluation
5) Selection of Priority Project and its Implementation Plan

I. Feasibility Design of FFWS Facilities

FFWS Facilities should include a) hydrological observation system, b) data transmission system, c) flood forecasting analysis system and d) flood warning and dissemination system. In addition to the study conducted during the Basic Study Stage at the commencement of this Project, the following studies were

undertaken in greater detail.

a) Hydrological observation system
- Detailed reconnaissance of the gauge sites specifically for the proposed telemeter gauges
- Feasibility design of the gauging stations to evaluate the most suitable gauge type and equipment

b) Data transmission system
- Digital data transmission system for manual observation system
- Alternative study and design of data transmission system for telemeter system
- Feasibility design of the data transmission system

c) Flood forecasting analysis system
- Review of computer system to determine if upgrading or improvement was required
- Improvement of warning message

d) Flood warning dissemination system
- Detailed study on the measures for flood warning message dissemination
- Improvement of flood warning dissemination system to ensure warnings reach the end users/beneficiaries and the message is clearly and readily understood
- Feasibility design of flood warning dissemination system

II. Feasibility Design of Evacuation System

a) It is assumed feasibility design of the evacuation system will be conducted by DMB, the authority mandated to implement overall disaster management and relief in the country. A Study in this regard is now being undertaken with the assistance of UNDP.

b) The JICA Study provides recommendations for the improvement of the existing evacuation system taking into account the current problems and required changes.

III. Institutional Strengthening

a) In the opinion of the Study Team the most critical issue for the improvement of the FFWS and its more effective operation is related to institutional matters.

b) The Study includes organizational, regulatory and budgetary requirements for operation and maintenance of the FFWS, the latter being extremely important given the current shortfalls in budget allocation and manpower requirements.

IV. Project Evaluation

a) Economic evaluation

The FFWS is an integral component of the basic national strategy for disaster management. Usually, economic feasibility for this kind of project is not conducted. However, in order to promote the FFWS improvement in Bangladesh with the mutual consent of all related agencies, its economic evaluation has been undertaken as a trial case. It is noted that, because of limited data availability, the economic feasibility study was incorporated even though it has necessarily been limited to qualitative analyses with some quantitative assessments, albeit based on a large number of assumptions. Much of the information used in the quantitative analysis was obtained through interview surveys of O&M divisional officers within the BWDB.

b) Social impact evaluation

The social impact of the FFWS is extremely difficult to quantify and was limited to a certain degree to a qualitative evaluation. Again, much of the information used in this evaluation was based on interview surveys of O&M divisional officers of BWDB.

c) Environmental impact evaluation

Basically, FFWS does not result in any adverse environmental impacts. Rather, they are positive, through mitigation of flood damage. Conceivable environmental impacts were taken into account as much as possible in the evaluation.

V. Selection of Priority Project

a) The Framework Plan provides a basic outline for the nationwide FFWS covering the entire area of Bangladesh. The selected candidate project for the Feasibility Study also provided coverage of the same area.
b) Existing restraints on financial capability and available manpower were considered when formulating the proposed project. As a result, the priority project was selected on a regional/divisional basis to ensure its implementation taking into account necessary funding, available manpower, etc.
c) The Implementation plan was drafted based on the studies outlined above.

6.2 Technical Approach

From the technical viewpoint, studies of the following components of the priority project were undertaken with basic designs to feasibility level carried out.

i) Observation System

- Selection of gauge type and adoption of manual observation and/or telemeter gauging stations taking into account site conditions

- Convenience for operation and maintenance

ii) Data Transmission System

- Digital communication system
- Radio propagation analysis
- Inter-agency information system

iii) Flood Forecasting Analysis System

- Computer system in the regional office in the case of regional FFWS
- Upgrading of flood warning message including recommendations for necessary topographic surveys

iv) Flood Warning Dissemination System

- Flood warning system for inhabitants
- Flood warning system for river structures
- Point-to-point warning system

v) Evacuation System

- Evacuation center/shelter
- Recommendation to the DMB for further study on evacuation system

6.3 Institutional Approach

From the institutional analysis presented in **Sections 2.8, 3.8** and **4.3**, it is apparent that BWDB is not functioning properly. BWDB is fully aware of this with the Annual Report of BWDB (2001-2002) stating: *"With the passage of time, the inherent conflicts and contradictions within the system and operational methodology of the Board gradually surfacing as the works progressed and more insight gained. Most of the completed projects were in miserable conditions due to lack of repair and maintenance and delivering (the services) sub-optimally. One of the main reasons was the maintenance of a huge redundant project staff even after project completion leaving little or no resources for project maintenance."* (Chapter 1, page 2).

One of the major problems of BWDB is centralized operation. BWDB is also fully aware of the necessity of de-centralization. The same report also mentions: *"While the concept of water management was shifting its focus globally from central control to demand driven joint management with stakeholders at the grassroots, BWDB failed to update itself by adaptation and continued with traditional top-down modus operandi. This created a big gap between authority and the beneficiaries who were shying away from taking any responsibility of a project in their locality with the result that projects were becoming more and more dependent on meager government resources for upkeep"* (Chapter 1, page 2).

Another major problem of BWDB is segregation of work responsibility. The Annual Report of BWDB mentioned: *"Lack of coherent policy backed by a holistic framework has been responsible for fragmented efforts in the sector causing more harm than*

good" (Chapter 1, page 2).

In line with the observations of the Study Team obtained through the course of the Study and also of the BWDB, the proposed basic institutional approach will revolve around decentralization and integration of existing work practices.

For the institutional approach, the following components were evaluated.

i) Central Disaster Management System

- Improvement of the organization
- Task and duty of the central office

ii) Local Disaster Management System

- New organizational set-up of local disaster management system
- Task and duty of the regional office

iii) Organizational Setup

- Organization chart
- Required manpower / Number of staff by grade

iv) Law and Regulation

- Mandate of regional office
- Recommendation on improvement of evacuation system to DMB

v) Budget Allocation

- Estimate of necessary annual budget for operation and maintenance of FFWS
- Recommendation on the budget allocation

6.4 Project Evaluation

(1) General

Project evaluation included economic evaluation, social impact assessment and environmental impact assessment as outlined below.

(2) Economic Evaluation

(a) Benefits attributable to the FFWS include the following:
- Saving of human lives
- Protection of movable assets in the household
- Early harvest of agricultural crops
- Mitigation of damage to infrastructure
- Mitigation of traffic congestion

(b) Benefit-cost analysis was undertaken based on IRR and current economic conditions (future economic development was not incorporated)

(3) Social Impact Evaluation

(a) Social impacts associated with FFWS operation were determined

qualitatively on the basis of interview surveys

(b) No quantitative analysis was undertaken

(4) Environmental Impact Evaluation

(a) No negative impact to the natural and social environment is considered likely

(b) Positive impact through mitigation of flood damage is considered to be a benefit

(c) Only qualitative evaluation of the impacts was possible

CHAPTER 7 FEASIBILITY DESIGN

7.1 Optimum Scheme Subject to Feasibility Study

The proposed optimum scheme is presented in **Figure 7.1.1**, and summarized below:

Control System

a) Central Control System: Dhaka

b) Regional Control System:
   - Northeastern (NE) Region (Control Station: Sylhet)
   - Northwestern (NW) Region (Control Station: Rangpur)
   - Southeastern (SE) Region (Control Station: Chittagong)
   - Southwestern (SW) Region (Control Station: Barisal)
   - North-central (NC) Region (Control Station: Dhaka)

Manual-Telemeter Combined Observation System

The number of manual and telemetric hydrometeorological gauging stations to be assigned for each region is tabulated below:

Number of Hydrometeorological Gauges by Region

Region	NE	NW	SE	SW	NC	Total
Control Station	Sylhet	Rangpur	Chittagong	Barisal	Dhaka	
Water Level	***18***	***22***	***9***	***17***	***25***	***91***
Manual	11	17	7	12	21	68
Telemeter	7	5	2	5	4	23
Rainfall	***14***	***15***	***11***	***15***	***13***	***68***
Manual	7	10	9	10	9	45
Telemeter	7	5	2	5	4	23
Total	**32**	**37**	**20**	**32**	**38**	**159**

7.2 Observation System

7.2.1 Exact Locations of Proposed Telemetric Gauging Stations

The reconnaissance survey at the sites of the 23 proposed telemetric gauging stations was conducted by the Study Team and counterpart personnel and their exact locations selected. In evaluating the preferred locations the following factors were considered:

- The location which coincide with or close to that of FFWC's present observatories to keep the continuity between the records of the existing and proposed gauges,
- The location which may not be influenced by wave effect largely,
- The location which has suitable structure (bridge, revetment, etc.) to fix the automatic water level gauging equipment properly,
- The location which has enough space for the installation of gauge house in which the recording equipment are set, and
- The location which has enough clearance for proper rainfall observation.

Since those kinds of information have been mostly collected through the inventory survey conducted through the First Works in Bangladesh of the Study, the main purpose of the reconnaissance was to gather more detailed information for execution of the feasibility design of the gauging stations.

The information about extracted location of proposed telemetric stations is listed in **Table 7.2.1**.

7.2.2 Proposed Types of Gauging Equipment

Rainfall Gauging Equipment

As for the rainfall gauging equipment, tipping bucket type rainfall gauge is proposed. In this type, the precipitation is converted to the electronic signal by tumbling down of the bucket filled up by the rain water. The tipping bucket type rainfall gauge is widely used all over the world.

The tipping bucket type rainfall gauges are proposed to be installed on the rooftop of the gauge house, principally.

Water Level Gauging Equipment

Conventional float-well type gauging stations have been constructed at the majority of sites of automatic water level gauging stations of BWDB. Although this requires rather extensive civil construction works, they are sustainable and reliable if the gauge is installed at stable or hard points in the river course. However, due to severe course shifting of many of the rivers in Bangladesh, a significant number of automatic water level gauging stations are currently not operational.

Taking this situation into account, following types of automatic water level gauge are considered as alternatives:

- Float-well type (conventional)
- Sensing pole type (Float without gauging well)
- Water pressure type (crystal type)
- Supersonic sensor type (No-contact type)

Outlines of above types of auto-gauges are summarized in **Table 7.2.2**. The life time of all those equipment is 5 to 10 years in average. Considering the characteristics of the rivers in Bangladesh, installation of large scale permanent structures is inappropriate.

The sensing pole float type is selected as the most suitable method for the sites with severe river course shifting after the consultation of counterpart personnel for the following reasons.

- Since sensing pole is removable from the supporting pillar, the maintenance and replacement of the sensor is easier than the case of other types.
- This type is the most flexible for the shifting of the gauge location according to the river course change.

As for the observation sites at which suitable structures such as bridge are available, supersonic sensor type gauging equipment is recommended because of its economical efficiency and easy maintenance. Since significant shifting of the river course may not occur at these sites, the supersonic sensor type equipment can allow sustainable observation by giving a little flexibility of sliding of sensor along bridge beam.

Schematic sketch of the layout plan of sensing pole type and supersonic sensor type automatic water level gauging equipment/facilities are shown in **Figures 7.2.1** and **7.2.2**, respectively. Maximum water level range which can be covered by single unit of sensing pole is 3.5 m. Several units of sensing pole therefore should be installed at the location in which difference in low and high water levels is more than 3.5 m. Allowable maximum distance between the supersonic sensor and water surface is about 13.5 m.

For data transmission method between water level sensor and gauge house, the application of wireless data transmission system by a solar battery with a power saving function is proposed. Since the allowable maximum direct distance between sensor pole and gauge house is about 1 km, it may be useful for the sites with frequent river course shifting.

For observatories using the supersonic sensor (sonar) type, the relocation range of the sensor is likely to be limited to within 40 ~ 50 m (one span of bridge pier) along the bridge superstructure. Data and power transmission using cables is therefore possible. Based on a preliminary comparison of cost effectiveness, the following criteria were established:

- The cable transmission system is applied if the designed cable length is 500 m or less.
- The wireless transmission system is applied if the designed cable length is more than 500 m.

Range of Water Level to be Covered by Automatic Gauge

As an independent water level observation facility, it is obviously preferable if the single automatic gauge system can cover both low water level (LWL) and high water level (HWL), namely the water level throughout a year. However, considering the situation of dry season that there is often no surface flow in some proposed stations, it is concluded as the practical way, through the discussion with counterpart personnel, that at least the water level of the current model operation period (from May to October) should be covered by the automatic gauging system.

Table 7.2.3 shows the recorded highest and lowest water level by station together with recorded lowest water level between May and October.

Selection and Preliminary Design of Gauging Facilities

Based on the above consideration, the selection and preliminary design of the gauging facilities was carried out for each site. The sketches of the layout plan of facilities and