# 3 Opportunities for Trans-boundary Water Sharing in The Ganges, The Brahmaputra, and The Meghna Basins

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## Introduction

The huge system of the Ganges, the Brahmaputra, and the Meghna (GBM) basins, second only to that of Amazon, is made up of the catchment areas of 1.75 million km$^2$ stretching across five countries: Bangladesh, Bhutan, China, India, and Nepal (Ahmad et al. 2001). While Bangladesh and India share all the three river basins, China shares only the Brahmaputra and the Ganges basins, Nepal only the Ganges basin, and Bhutan, only the Brahmaputra basin (see Figure 3.1 and Table 3.1). The three basins are distinctly different in characteristics; the three rivers originate and travel through different physiographic units, and have geographically distinct catchment zones with dissimilar valleys and drainage networks (Khan 2005).

Water is the single most important natural resource of the basin countries; the three river systems contribute an annual discharge of 1350 billion cubic metres (BCM), of which the Ganges contributes about 500 BCM, the Brahmaputra 700 BCM, and the Meghna 150 BCM (Ahmad et al. 2001). The three major rivers have always played pivotal roles in shaping the sustenance of life, living, and the environment. However, the countries sharing the GBM basins are beset by a number of water management problems due to gross inequalities in the temporal and spatial distribution of water, mainly floods, droughts, and dry season water scarcity. This poses a threat to infrastructure and properties, irrigated agriculture, navigation, and ecosystem sustenance. Management of water resources in the region becomes all the more challenging because of the huge population, the anticipated population growth, and the prevailing poverty situation. About 10 per cent of the world's population lives in this region, representing only 1.2 per cent of the world's land mass (Biswas 2008).

The development and management of the GBM basins have been subject to a number of geopolitical constraints in spite of having huge potential for being a great example of regional cooperation (Brichieri-Colombi and Bradnock 2003). Country-specific management options have led to water disputes, which are ranked amongst the most well-known trans-boundary water conflicts in the world. Attempts to solve these disputes have been bilateral in nature, for example, the Ganges Water Treaty between India and Bangladesh, and the Mahakali Treaty between India and Nepal.

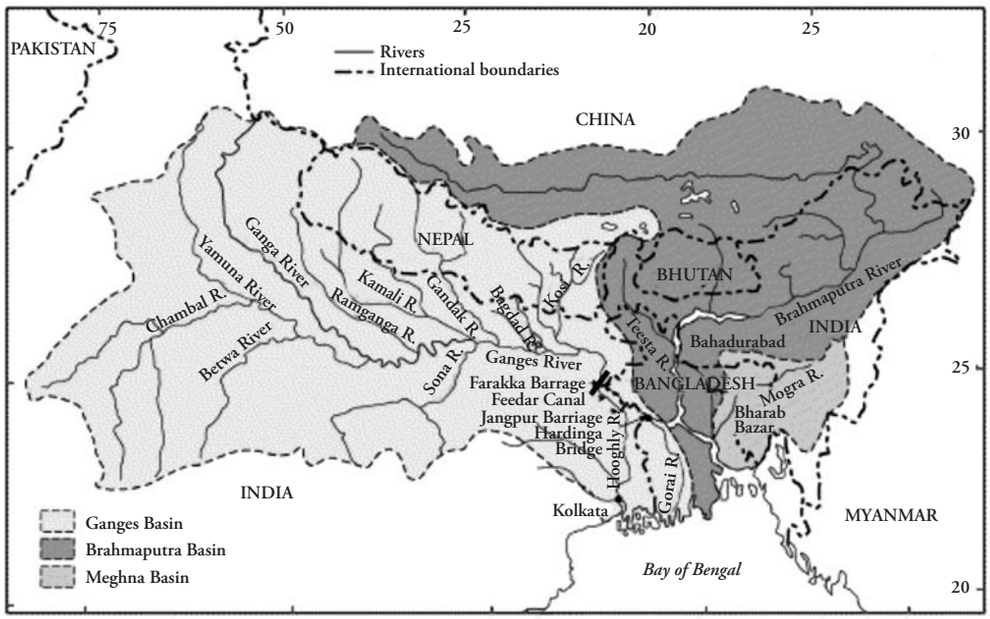


**Figure 3.1** Ganges–Brahmaputra–Meghna Basins

*Source*: Rahaman (2005).

**Table 3.1** Catchment Areas of the GBM Basins

| *Country* | *Ganges basin* | | *Brahmaputra basin* | | *Meghna basin* | |
|---|---|---|---|---|---|---|
| | *Basin area (1000 km²)* | *Percentage of total area* | *Basin area (1000 km²)* | *Percentage of total area* | *Basin area (1000 km²)* | *Percentage of total area* |
| China | 33 | 3 | 293 | 50 | | |
| Nepal | 140 | 13 | | | | |
| Bhutan | | | 45 | 8 | | |
| India | 861 | 80 | 195 | 34 | 49 | 58 |
| Bangladesh | 46 | 4 | 47 | 8 | 36 | 42 |
| Total | 1,080 | 100 | 580 | 100 | 85 | 100 |

*Source*: Rangachari and Verghese (2001); Pun (2004).

These are regarded by many as creating a climate of goodwill and mutual confidence, and offering a window of opportunity for water-based collaborative development endeavours in the region (Rahaman 2009). The close and friendly ties between Bhutan and India have created a win–win situation for both countries in the hydropower sector. Besides, some bilateral cooperation is in place, through exchange of data for the purpose of flood forecasting and warning, between India and Bhutan, India and Nepal, and India and Bangladesh.

However, while so much more could have been done, achievements in terms of sharing, development, and management of water resources of these rivers as well as sharing and exchange of information and data through mutual cooperation have not been encouraging thus far (Biswas 2008; Khan 2005).The recent plans of river

linking and construction of Tipaimukh dam, without consensus among riparian countries, have generated considerable concerns in Bangladesh and also widely in India. It is important to recognize that water resources must be developed and managed in a rational, efficient and equitable way, so that it can act as the engine to promote socio-economic development, shaping the future of millions of people living in this region (Biswas and Uitto 2001). A number of studies and syntheses of information have demonstrated that trans-boundary cooperation in integrated water management in the GBM basins can offer these countries greater benefits than those that can be achieved through isolated national efforts (Ahmad and Ahmed 2003; Ahmad et al. 2001; Gyawali 2001).

## Water Resources Management Issues in GBM Basins

There are a number of common water resource management issues for all countries in the GBM basins. The river systems exhibit wide variations between peak and lean flows as the major part of the basins belongs to the monsoon region, where 80 to 90 per cent of annual rainfall is concentrated in 4–5 months of the South-West monsoon. While excessive precipitation in these months is the main reason for recurrent floods, which cause damage to life, property, and infrastructure, the unequal temporal distribution of rainfall creates the problem of low water availability during the dry season and unequal spatial distribution creates water stressed conditions in some parts of the basin. Future climate change impacts may aggravate this situation further. The GBM river systems carry up to one and a half billion tons of sediments per year that originate in the foothills of the Himalayas (Ahmad and Ahmed 2003; Biswas 2008). The high rate of sedimentation of the major rivers and their tributaries has been affecting not only the carrying capacity of the rivers but has also drastically reduced their retention capacity, thus often compounding the adverse effects of floods.

Major water management problems in Nepal include floods in hill valleys due to sudden cloud bursts over several days, floods in the mountains induced by glaciers, termed glacier lake outburst floods (GLOF) (Bangladesh–Nepal Joint Study Team 1989; Ahmad et al. 2001), and overbank monsoon flooding from rivers, mainly Sapta-Kosi, Gandaki, Karnali, and Mahakali, causing immense damage in the *terai* area of Nepal (and also in adjacent areas of India). Besides, frequent rockslides and landslides aggravate the flooding and river erosion problems. Unreliable river flows coupled with inefficient management have been affecting the performance of irrigation systems and industrial pollution has been leading to deteriorating water quality.

In India, floods affect, on an average, about 7.5 million hectares of area per year (Ministry of Water Resources [MoWR] 2002). Of the total estimated flood prone area in India, 68 per cent lies in the GBM states, mostly in Assam, West Bengal, Bihar, and Uttar Pradesh. The Ganges in northern India, which receives water from its northern tributaries originating in the Himalayas, has a high flood damage potential, especially in Uttar Pradesh and Bihar. The unequal spatial distribution of rainfall means that the flows in many of the rivers in north-western, western, and southern parts are considerably less than the Himalayan parts, rendering the areas water stressed. One-sixth area of the country is drought-prone (MoWR 2002). Other water management problems in India include degrading water quality mainly due to industrial and domestic wastes (Adhikari et al. 2000), and arsenic contamination of groundwater in many parts of the northern states, particularly West Bengal.

Bangladesh, being the lowest riparian with only 7 per cent of the country lying in the GBM basins and with extensive floodplain topography bears the major brunt of widespread flooding. About 91 per cent of flood flows in Bangladesh enter from upstream catchments in India through 54 border rivers (Rashid 1991); the entire volume of the GBM river systems, about 142,000 cubic meters per second at peak periods (Rahman et al. 1990), discharges into the Bay of Bengal through a single outlet at the Lower Meghna in Bangladesh. Besides, the country is beset by flash floods in the northern and north-eastern hilly streams, and tidal floods and occasional cyclonic storm-surge floods in the coastal region. The country suffers from moderate to severe droughts spreading over 10 districts; very low dry season water availability in the southwest region due to upstream withdrawal of water at Farakka, and associated increased salinity intrusion and threatened agriculture and ecosystem including the Sundarbans;

river erosion (including riverbank, *char*, and coastal erosion) along about 75 rivers; degrading water quality due to industrialization in urban areas along major rivers; and widespread arsenic contamination of groundwater (Chowdhury et al. 1997; Water Resources Planning Organization [WARPO] 2001).

In Bhutan, the water management problems include mounting pressure on the water resources due to competing demands from different users, seasonal and local imbalances of flows, localized and seasonal water shortages for drinking and agricultural purposes, and rising fluctuation between lean season and monsoon season flows, leading to sub-optimal utilization of generating capacity of hydropower plants, and GLOFs. Besides, increasing sediment loads in rivers are affecting the expected output and economic life of the hydropower plants, as well as causing floods and landslides (Bhutan Water Partnership 2003).

## Policies and Plans

Water resources management in any country is generally governed by its policy directions, which are manifested in its national water policy document. National water policies provide the basis for formulating water management strategies and national water management plans. An examination of the national water policies of the GBM countries is imperative since it would shed light on the position of these countries with respect to regional cooperation.

The Indian Water Policy (MoWR 2002) envisions the river basin as a hydrological unit for water resources development and management and river basin organizations are given utmost importance in the context of planning for development and management of projects in a river basin as a whole or sub-basins, wherever necessary. The policy places emphasis on improving efficiency of water use through traditional water conservation practices such as rainwater harvesting, including roof-top harvesting. The policy also highlights the need for non-traditional practices, for example, inter-basin water transfers, artificial recharge of groundwater, and desalination of brackish or sea water.

The National Water Policy of Bangladesh (MoWR 1999) articulates the need to undertake essential steps for realizing basin-wide planning for development of the resources of rivers entering its borders. The endeavours will include: agreements with co-riparian countries for sharing the waters of international rivers; establishment of a system for exchange of information and data on relevant aspects of hydrology, morphology, water pollution, and ecology; joint assessment of the international rivers for better understanding of the potentials of the overall basins; and harnessing, developing, and sharing the water resources to mitigate floods and augment flows of water during the dry season. The policy gives directions on comprehensive development and management of the main rivers through a system of barrages and other structural and non-structural measures, and development of water resources of the major rivers for multipurpose use.

The Water Resources Strategy (WRS) of 2002 and the National Water Plan (NWP) (WECS 2006) of 2005 of Nepal ask for river basins to be treated as fundamental planning entities. Both the Strategy and the Plan emphasize, among others, cost-effective hydropower development for domestic use and export, enhanced water-related information systems, regional/bilateral cooperation framework/norms for substantial mutual benefits, and appropriate institutional mechanisms for water resources management. Sharing of water resources benefits among the riparian countries on equitable basis, establishment and enhancement in cooperation with neighbouring countries in data exchange and information systems, encouragement of joint investigation into GLOF with China, and promotion of international cooperation for flood forecasting and warning system, are underscored in the policy for mutual benefits.

The National Water Policy of 2003 of Bhutan (Bhutan Water Partnership 2003) also considers water resources management to be based on natural river basins, and hence highlights the need for appropriate institutional structures at the basin level. The policy recognizes the tremendous potential of hydropower for socio-economic development as well as its potential for earning revenues from exports. As articulated in the policy, trans-boundary water issues are to be dealt with in accordance with international law and conventions to which Bhutan is a signatory and taking into consideration the integrity of the rivers as well as the legitimate water needs of riparian states. Cooperation in information sharing and exchange, appropriate technology in water resources development and management, flood warning, and disaster management are to be initiated at the national, regional, and global levels.

While the water policies/strategic plans of the co-riparian countries draw heavily upon the concept of integrated water resources management, and articulate the need for basin-wide management of water resources, there are obvious differences in each country's stance on a number of issues. The Indian Water Policy does not touch upon regional cooperation with other riparian countries or sharing the basins for mutual benefits. Sharing or distribution of water is discussed when it comes down to allocation among states that share a particular basin. Regional cooperation received foremost recognition in the water policy of Bangladesh, with exchange and sharing of information and data, and joint assessment of the basins' potentials being among the major objectives outlined in the policy. Nepal too recognizes the potential for sharing water resources 'benefits' on equitable terms, and seeks to enhance regional cooperation in sharing and exchange of data, and improving disaster forecasting and warning systems. The water policy of Bhutan expresses similar pledges with regards to regional cooperation.

## History of Regional Cooperation

There has been a history of conflicts in the GBM basins, but there has also been a history of attempts (bilateral in nature) to resolve these conflicts. This shows that, in spite of a significant number of conflicting issues in the region, compounded by the geopolitical complexity (for example, imbalance in hegemony or economic power among the countries), the countries did at least show interest in cooperation to resolve issues.

### Nepal–India Water Cooperation

The water sharing disputes between Nepal and India date back to early twentieth century, and attempts to resolve the issues started with the Sarda Barrage Agreement in 1920, followed by several agreements through 1950s (Kosi river agreement in 1954; Gandak agreement in 1959). However, the story of success was far from being smooth; and the agreements were viewed by Nepalese people as favouring India (Uprety 2006; Salman and Uprety 2002; Biswas 2008). More recently, a number of Water Resources Development projects have been executed by India in cooperation with Nepal on rivers common to both the countries and a number of projects are also under negotiation with Nepal. The Mahakali Treaty has been signed, and negotiations are continuing for two important projects, Pancheshwar Multi-purpose Project on river Mahakali (Sarda in India) and Sapta-Kosi High Dam on Kosi River and Sun Kosi Storage cum Diversion Scheme.

#### *Mahakali Treaty and the Pancheswar Project*

The Mahakali Treaty signed between India and Nepal in January 1996 includes three components: the Sarada Barrage, the Tanakpur Barrage, and the Pancheshwar Project. While the first two projects have already been executed by India at Mahakali on the Indo-Nepal Border, the Pancheshwar Project involves new construction of a 315 metre high dam called the Pancheshwar on the Mahakali. The project is expected to generate 6480 MW of power for supply to India's northern power grid and to also provide the Gangetic plains with large volumes of regulated waters for irrigation. The provisions of the treaty constitute that India is willing to join hands with Nepal in the development of water resources for the common benefit for her people, and according to the principles of equity (Uprety 2006). The Treaty incorporated some principles to accommodate the divergent needs and interests of both riparian countries.

Implementation of the treaty has faced a great deal of difficulty. The treaty was met with resistance in Nepal, and was ultimately passed with specific strictures or conditions. Disputes still exist on the issues of defining consumptive use of the countries and fixing the selling price of Nepal's excess share of electricity to India. In addition, the treaty enactment is also contingent on the completion of the Detailed Project Report (DPR) for the Pancheshwar Project. A separate commission was formed for this project, and it was only in 2010 that the environmental impact assessment was prepared. During the second meeting of the Joint Standing Technical Committee (JSTC) held on 30–31 March 2010, it was decided to prepare a definite work plan along with the cost estimates to undertake the identified field works within two months so that decisions could be taken regarding funding (Central Electricity Authority [CEA] 2011).

#### *Sapta-Kosi High Dam Project and Sun Kosi Storage cum Diversion Scheme*

For Sapta-Kosi High Dam Project and Sun Kosi Storage cum Diversion Scheme, the Government of Nepal

submitted an inception report in 1992. Crucial issues were discussed in the meeting of the Indo-Nepal Joint Team of Experts held in 1997. A Joint Project Team was formed for assessing the work load and preparing the estimates for investigations. The administrative approval and expenditure sanction have been conveyed by India for carrying out field investigations, studies and preparation of DPR of the Sapta-Kosi High Dam Multipurpose Project and Sun Kosi Storage cum Diversion Scheme jointly with Nepal by February 2013 (CEA 2011).

## Bangladesh–India Water Cooperation

The major issues to be resolved between Bangladesh and India are the ones of sharing water of the common rivers. The major dispute has been on the sharing of the Ganges water during the lean period since the Indian plan for construction of Farakka barrage has been implemented.

### *Ganges Water Treaty*

In 1961, the Indian government decided to construct a barrage across the Ganges river at Farakka, 11 miles upstream from the border with East Pakistan (later Bangladesh), to divert water to the Hooghly river to solve the siltation problems at the Calcutta port. The Pakistan government protested with an argument that adequate amount of flow did not exist in the Ganges to meet the water demands of both countries and that flow diversion from the main channel of the Ganges would result in adverse impact on the agriculture, ecology, and economy of East Pakistan (Crow et al. 1995). Construction of the barrage with a diversion capacity of 40,000 cubic feet per second of flow was completed in 1975, after the independence of Bangladesh in 1971, and a new phase of negotiations (1971–7) focussed on dry season flow division. During this period, a 40-day interim agreement for water sharing was also attempted. During the next phase of discussions (1977–82), a five-year water sharing agreement was signed between the two countries with an understanding of augmenting the Ganges flows at Farakka. A joint committee, Joint River Commission (JRC), was established under the agreement clause, which would be responsible for observing and recording at Farakka, the daily flows below Farakka Barrage and in the feeder canal in India, as well as Hardinge Bridge point in Bangladesh, and for implementing the water sharing arrangements and examining any difficulty arising out of the implementation of the sharing arrangement and of the operation of the Farakka Barrage. A mechanism was provided for the settlement of disputes. The agreement also instructed the JRC to look into a long-term solution of the dry season flow augmentation of the Ganges water. The flow augmentation proposal from the Bangladesh side included the construction of storage reservoirs in Nepal to harness the monsoon flows upstream, which would also facilitate hydropower generation. The proposal from India included import of water from the Brahmaputra through a 209-mile long link canal connecting the proposed Jogighopa barrage across the Brahmaputra in Assam and the Farakka barrage (Asafuddowlah and Khondker 1994). A memorandum of understanding (MoU) was signed in 1982 to extend the 1977 agreement excluding the 'guarantee clause',[1] which finally expired in 1988 after two similar extensions. Negotiations for a permanent water sharing agreement continued in the subsequent years while both the countries focused more on the national river development initiatives including river linking projects and barrages on the Teesta, Ganges, and the Brahmaputra. After a period (1989–96) without any agreement, the Ganges Water Treaty was signed between the two governments in 1996 to share the dry season flow of the Ganges and to seek ways for flow augmentation.

[1] In the 1977 agreement, the Ganges water sharing at Farakka from the 1 January to 31 May every year was based on 75 per cent availability calculated from the recorded flows of the Ganges at Farakka from 1948 to 1973. The actually available flow was divided on a 10-day basis between Bangladesh and India in an overall ratio of about 60 per cent for Bangladesh and about 40 per cent for India. If during a particular 10-day period the flow at Farakka came down to such a level that the actual share of Bangladesh would be lower than 80 per cent of the share calculated in the agreement for that 10-day period, this minimum flow would be released to Bangladesh during that 10-day period. Thus this clause guaranteed Bangladesh a minimum of 80 per cent of its share during each period whatever low the flow of the Ganges during that period. This is widely known as the 80 per cent 'guarantee clause'.

Although the main purpose of water diversion at Farakka was to improve siltation and navigation problems at the Calcutta port, Crow et al. (1995) indicate that the efficacy of the project was technically doubtful due to uncertainties in assessment of the flow and sedimentation processes in the lower Hooghly. Sir Arthurs Cotton's concerns in 1853 regarding the consequences of large-scale water diversion from the Ganges were not considered during implementation of the project. It was rather a political decision to proceed with the project.

The Ganges Treaty did improve the flow into Bangladesh, but it was lower than the flow that was available during earlier agreement periods, and lower by a considerable extent, for example, 40 per cent of natural state during March and April, as analysed by Chowdhury (2005) and Chowdhury and Datta (2004). A recent concern is that Bangladesh is getting lower volume of water than it should get as per the Treaty. One of the reasons is the decrease in flows arriving at Farakka because of upstream water uses (Chowdhury 2005). Although it seems unlikely that the flows to be received as per the Treaty would solve the water crisis in the dry season in the southwest region and recover its lost resources, it has ushered in a new era of cooperation between Bangladesh and India. This 30-year long Treaty has provided Bangladesh an opportunity for environmental restoration of the Ganges Dependent Area (GDA) (WARPO 2002).

### *Negotiations for Other Trans-boundary Rivers*

India and Bangladesh share 54 rivers, however, the Ganges Treaty is the only water sharing agreement that exists today between Bangladesh and India. Article IX of the Ganges Treaty stipulated that, guided by the principle of equity, fairness, and no harm to either party, both Bangladesh and India would conclude water sharing treaties/agreements with regard to other trans-boundary or common rivers. The Joint Committee formed after the signing of the Treaty to implement this had prioritized seven rivers at the initial stage, viz. the Teesta, Dharla, Dudhkumar, Manu, Khowai, Gumti, and Muhuri rivers. Later the JRC recognized that the long-term sharing of waters for the Feni river should also be examined along with the other seven rivers. Recent media reports in both Bangladesh and India suggest that sharing agreements for Teesta and Feni rivers have been drafted, which might be signed by the end of 2011.

### Bhutan–India Water Cooperation

The regional cooperation between India and Bhutan has worked very well, with India, which has a power shortage, providing both technical and financial assistance to develop numerous hydropower projects in Bhutan. India benefits from Bhutan's hydroelectric energy resource to meet a part of its huge power demand while Bhutan benefits from the revenues earned from the export of power. The hydropower cooperation between Bhutan and India started with the signing of the Jaldhaka agreement in 1961. The development of first major hydroelectric project started in 1974 when a bilateral agreement was signed between India and Bhutan for the construction of the 336 MW Chukhahydel project across river Wangchu in Western Bhutan for meeting internal power demand and exporting the surplus electricity to India (Biswas 2008). The project was commissioned in 1986–88. A number of mini and medium sized hydropower projects followed in later years. The Tala hydroelectric project of 1020 MW installed capacity and 860 metres gross head has been recently completed (Tshering and Tamang 2004).

The cooperation between Bhutan and India has also been with respect to the establishment of hydro-meteorological and flood forecasting network on rivers common to India and Bhutan. A scheme titled 'Comprehensive Scheme for Establishment of Hydro-meteorological and Flood Forecasting Network on Rivers Common to India and Bhutan' is in operation. The network consists of 35 hydro-meteorological/meteorological stations located in Bhutan and being maintained by the Royal Government of Bhutan with funding from India. The data received from these stations are utilized in India by the Central Water Commission for formulation of flood forecasts. A Joint Expert Team (JET) consisting of officials from the Government of India and Royal Government of Bhutan continuously reviews the progress and other requirements of the scheme (National Portal of India 2011).

## Water Management Interventions and Regional Implications

Water management interventions in the GBM basins have already altered the natural flow distributions and

have largely challenged the opportunities for transboundary and regional water sharing. The following sub-sections summarize the major water management interventions and their regional implications.

## Ganges Water Diversion

Ganges water diversion at Farakka has caused adverse impacts in the Ganges dependent areas in the lowest riparian country Bangladesh (see Hoque et al. 1996; Crow et al. 1995; Asafuddowlah and Khondker 1994; Richardson 1994; Simons 1994; and Abbas 1984). Crow et al. (1995) present a detailed cause-and-effect diagram to explain the short and long-term consequences of flow diversion. The more direct consequences include changes in the hydraulic, hydrological, and morphological characteristics of the Ganges and its distributaries, resulting in a drastic decline in the river stage. This, in turn, has caused excessive siltation in the rivers, formation of new charlands, and reduction in conveyance capacity. The off take of the Gorai, the main distributary of the Ganges in Bangladesh, is blocked in the dry season due to siltation. Apart from adversely affecting navigational and industrial water availability, the reduced dry season flow has also caused water shortage for irrigation. One of the largest irrigation projects in Bangladesh, the Ganges—Kobadak Project, was shut down several times due to the drop in water levels. The decline in dry season river water level has also caused lowering of the groundwater level and affected the year-round water balance. Reduction in river flow has caused the salinity front (both surface and groundwater) to move further inland, resulting in crop damage, water shortage for drinking and industries, and adverse health effects. Reduced river flow and increased salinity have caused changes in the hydro-ecological condition in the lower reaches of the Ganges and its distributaries. Consequently, there have been major adverse impacts on the ecosystems, fisheries, forestry, and livelihoods.

## River Linking Project in India

The National River Linking Project (NRLP) of India aims at transferring water from the Ganges and Brahmaputra basins to the water deficit areas of western and southern India. The overall goals of the NRLP are to increase irrigation potential, increase hydropower production, and control floods. Through this project the National Water Development Agency (NWDA) envisages achievement of food security and self-sufficiency by increasing area of arable land, increase in electricity production, and reduction of reliance on coal as an energy source, as well as moderation of floods, especially in the Ganges basin. The Himalayan component of the NRLP, consisting of 14 links, will have storage reservoirs on the main Ganges and the Brahmaputra rivers and their principal tributaries in India, Nepal, and Bhutan. Links of this component will transfer surplus flows of the Kosi, Gandak, and Ghagra to the west, and augment flows of the Ganges. Interlinking of the Ganges and Yamuna are anticipated to transfer the surplus flow to the drought prone areas of Haryana, Rajasthan, and Gujarat. The component is also expected to provide irrigation benefits to large areas in south Uttar Pradesh and south Bihar (Sarma 2003). Detailed information on the links compiled from different sources (for example, Government of Bihar [GoB] 2003; NWDA 2005) can be found in SANDRP (2007). The peninsular component of the NRLP will consist of 16 links proposed by the NWDA.

The NRLP has faced a lot of review and scrutiny within India. Most 'donor' states have posed against the project although the conflict between 'donor' and 'receiver' states has not been a major issue. Major opposition emanated from a large number of observations raised by the prominent water professionals across India (for example, see Iyer 2003; Bandyopadhyay and Perveen 2002; and Singh 2003). A letter and a memorandum signed by 58 eminent professionals were sent to the prime minister to reconsider the project (ibid.). The validity of the basic principle of having 'surplus' water in some rivers, on which the NRLP was conceptualized, was questioned by some researchers on the argument of the need for a balance between the natural flow and ecosystem requirement (Bandyopadhyay and Perveen 2002). Drought mitigation is seen to be a local problem requiring local solutions. External water transfer will address only a small part of the arid regions leaving out most areas for augmentation of local resources. While efficacy of the project in flood control remains doubtful, large-scale constructions under the NRLP including big dams, reservoirs, and conveyance systems are likely to cause substantial environmental impacts and displacement problems. At the same time, the value of traditional water management systems and

demand management through efficient water use may be undermined (Iyer 2003; Singh 2003).

Bangladesh, being the lowest riparian country, is likely to face adverse impacts on hydraulics and river morphology, water resources, agriculture, domestic water supply, fisheries, forestry, navigation, industry, biodiversity, and socio-economy. Chowdhury (2005) indicates that large-scale modifications may occur in the temporal distributions of the Brahmaputra and the Ganges. Reduced flow in the Lower Meghna as a result of reduction in Brahmaputra flow will increase salinity intrusion in the Lower Meghna, with a disastrous possibility of salinity intrusion into the freshwater wetland (locally called *haor*) ecosystem. Chowdhury (2005) also indicates problems of storing water in the wet season, and transferring water from one basin to another during different flood phases. Khalequzzaman et al. (2004) estimate that very low flow remaining in the Brahmaputra following withdrawal during the lean season will cause detrimental effects on the environment and ecosystem of the downstream areas in Bangladesh. Reduction in the Ganges flow due to transfer of Ganges water to the Indian peninsular region is likely to worsen the existing environmentally-stressed condition of the southwest region of Bangladesh.

### Tipaimukh Dam in India

The proposed Tipaimukh dam across the Barak river in Manipur state in India is planned to be constructed primarily for flood control and power generation, envisaging secondary benefits including irrigation. A barrage is also planned to be constructed across the Barak at Fulertal, 100 km downstream of the dam site, to provide irrigation water for the Cachar Irrigation Project. The major environmental issues of the project emerging from an Environmental Impact Assessment (EIA) study include biodiversity conservation, rapid deforestation, and community participation for environmental planning and management (North-Eastern Electrical Power Corporation Ltd, NEEPCO 2000). There is a strong opposition to this project from both within and outside India (Institution of Engineers Bangladesh [IEB] 2005). The major likely impacts of this project inside India include loss of homes, lands, and livelihoods, loss of state and reserve forests, submergence of wildlife sanctuaries, and adverse impacts on fisheries, biodiversity, and navigation. In Bangladesh, flow alteration of the Barak will adversely affect the biodiversity of the freshwater wetlands (haors), increase the probability of flash floods that cause damage to the Boro rice, and retard the drainage of wetlands in the post-monsoon season. Implementation of the project will alter the natural flow regimes, water quality, nutrient and sediment load, temperature, salinity level. Consequently, fish spawning routes and habitats, and wetland ecosystems and biodiversity may be severely affected.

### Water Diversion Plan from the Tibetan Plateau in China

The Chinese government has been considering a plan to dam or redirect the southward flow of water from the Tibetan plateau, the starting point of many international rivers, including major rivers like the Brahmaputra, the Yangtze, and the Mekong. In the context of trans-boundary flow in South Asia, the important rivers include the Brahmaputra, the Indus, the Sutlej, the Arun, and the Karnali. The plan includes diverting the waters of the Yangtze, the Yellow river, and the Brahmaputra to China's drought-prone northern areas, through huge canals, aqueducts, and tunnels. One of the water diversion routes, more specifically the southern component of the route cutting through the Tibetan mountains, will divert waters of the Tsangpo for a large hydroelectric plant and irrigation use. The planned water diversion will have adverse consequences in the downstream areas. Implementation of the plan will result in loss of land and ecosystems due to the submergence of a huge area in the Tibetan region. Flow control for power generation and irrigation during the dry season, and water release during the flood season may pose a serious threat to the flood management, dry season water availability, and ecosystem preservation of northern India and Bangladesh.

## Regional Cooperation—The Way Forward

There are huge potentials of regional cooperation in the GBM basins on a number of issues, including sharing of major rivers during lean period, augmentation of flow of the lean period, hydropower generation and distribution, cooperation in flood management, sharing of data for flood forecasting, cooperation in navigation system, water quality improvement, and

watershed management. However, lack of mutual trust and confidence among the co-riparian countries has played a major role in the long-standing disputes or conflicts surrounding trans-boundary rivers. The GBM countries have much to learn from the experiences of international treaties and river basin organizations, which underscore the importance of common or shared interests of nations, the perception of huge mutual benefits, usefulness of sharing of benefits, and the importance of basin-level management.

## Water Resources Development Opportunities

Water resources development options could be a combination of cooperative non-structural (for example, sharing or exchange of data and information) and structural (for example, dams or reservoirs at 'suitable' locations) measures. Creation of storage reservoirs by dams for hydropower generation has been rather common in upstream riparian countries, especially India. However, storage projects for a single purpose are hardly economical and practical, and hence are less attractive. Storage projects need to be seen from the multipurpose point of view in a regional context to derive benefits from flood control, irrigation, navigation, hydropower generation, and enhanced economic condition of the people. Such structural interventions will need to be evaluated in terms of technical, social, and environmental considerations (seismic activity, submergence, population displacement, impact on land and ecosystem, physical impact downstream, and the equity issue in sharing costs and benefits).

Geographical and hydrological characteristics make Nepal the most suitable site for construction of multi-purpose reservoirs (Uprety 2006). Nepal has magnificent gorges where high dams can be built and the Himalayan waters stored (Bangladesh–Nepal Joint Study Team 1989). The prospects of construction of reservoirs in the Ganges basin in India have mostly been exploited; the middle and lower sections of the system in northern India have no physical dam sites to store monsoon flows (Adhikari et al. 2000), and the floodplain topography of Bangladesh is unfavourable for the construction of reservoirs. Since the tributaries flowing from Nepal contribute the major flows of the Ganges (about 40 per cent of the annual flow and 70 per cent of the dry season flow) (Malla et al. 2001; Tiwary 2006), tapping the flow in Nepal and harnessing the water under a multilateral framework among Nepal, India, and Bangladesh for a number of co-riparian benefits seems to be the most feasible option. Besides hydropower generation, the storage reservoirs are likely to mitigate floods in the downstream reaches of the Ganges. At the same time, the monsoon water stored in the reservoirs will be available for dry season augmentation of flow thus increasing dry season irrigation potential and also the possibility of river navigation.

The Bangladesh–Nepal Joint Study Team (1989) identified and recommended 30 potential reservoir sites in Nepal, nine of which were classified as large, each having live storage capacity over three BCM, with an aggregate gross storage capacity of 110 BCM. The total storage capacity of high dam projects in Nepal would regulate over 95 per cent of the total annual flow. Augmentation potential in Nepal during the dry season can range from 2400 to 4950 metre$^3$ per second, which is more than four times the present lean season flows in the Ganges at Farakka. From the Bangladesh perspective, as outlined in the Bangladesh–Nepal Joint study, the Sapta-Kosi High Dam Project has the maximum potential for augmenting the flows at Farakka, which could benefit Nepal, Bangladesh, and India (Ahmad et al. 2001; Adhikari et al. 2000). It is important that the planning and design for the Sapta-Kosi High Dam, now at an advanced stage of planning exercise between India and Nepal, takes into full consideration the concerns of Bangladesh as a co-riparian and that Bangladesh is allowed to equitably share the augmented dry season flows and hydropower through joint collaboration during implementation.

Considering the vast hydropower potential of the GBM basins, a thorough cooperative effort is needed to produce and share hydropower. Nepal and Bhutan, the two neighbouring countries of India, have rich hydropower potential far in excess of their domestic requirement; they have huge potential of earning rich revenue to boost their economy by selling it to other countries. Nepal leads the countries in terms of hydropower potential with a theoretical potential of 83,000 MW and an economically acceptable potential of over 42,000 MW (Uprety 2006; Onta 2001; and Biswas 2008). Bhutan, too, has a potential of about 20,000 MW. Cooperation between Nepal and India in this respect has been limited with the exception of

the recently initiated Sapta-Kosi Dam, while there are close ties between India and Bhutan with regard to hydropower development. An integrated plan for hydroelectric development and sharing through an interconnected grid across the borders is becoming all the more essential.

River navigation connected with the sea plays an important role in the development process of the basin countries. The flow regulation through creation of multi-purpose reservoirs in the upper reaches of the rivers will open opportunities for inland river navigation in the downstream reaches. Nepal, a landlocked country, could benefit through the establishment of links with the inland water transport networks of India and Bangladesh; allowing Nepal access to Kolkata (India) and Mongla (Bangladesh) ports (Ahmad et al. 2001).

The major potential for regional cooperation lies in non-structural management measures, more specifically, flood forecasting and warning. After the disastrous floods in Bangladesh in 1988, the Indian Government showed interest in regional co-operation for flood mitigation in both the countries through a joint action plan. Through bilateral cooperation, Bangladesh receives water level and rainfall data from a number of stations (Ahmad and Ahmed 2003). There also exists cooperation between Bangladesh and Nepal, with Bangladesh receiving water level data from four stations in Nepal. Limited flood related data at three stations on the Chinese section of the Brahmaputra have also been transmitted from China to Bangladesh since 2006. There exists bilateral cooperation between India and Nepal and also between India and Bhutan in respect of sharing of data for flood forecasting. However, there is still a significant scope for strengthening the existing cooperation and extending it further in a regional perspective.

## Shared Vision

There is a strong need to stimulate a mutual trust and confidence among the basin countries, which requires development and maintaining of 'common' or 'shared' vision or interests. The GBM countries may learn from the fact that agreements between economically and politically disparate countries were possible in the cases of the Indus Treaty, Mekong River Agreement, and Nile Basin Initiative. The Indus Treaty of 1961 was made possible because both India and Pakistan could perceive the huge advantage of the development of the waters of the Indus system. The Mekong River Agreement of 1995 was made possible because the four countries saw a common interest in jointly managing their shared water resources and developing the economic potential of the river. The Nile Basin Initiative of 1999 is another example of a 'shared vision' by the basin countries to achieve sustainable development through equitable 'sharing of benefits', with the focus not on water but on a win–win situation of regional development.

## Sharing of Benefits

Shared vision of the co-riparian could best be achieved if sharing of 'equitable benefits', not 'water' itself, is seen as a negotiating approach. Traditionally, co-riparian states have focused on water as a commodity to be divided—a zero-sum, rights-based approach. Precedents now exist for determining formulae that equitably allocate the 'benefits' derived from water—a win–win, integrative approach. In fact, it is at the root of some of the world's most successful institutions (United Nations Educational, Scientific, and Cultural Organization [UNESCO] 2003). Examples of the 'sharing of benefits' approach date back to the 1909 Boundary Waters Agreement between USA and Canada, and the Columbia treaty between USA and Canada relating to the cooperative development of the Columbia River Basin in 1964 (United Nations Environment Programme [UNEP] 2002; cited in Rahaman and Varis 2007). The Nile Basin Initiative is perhaps the best example of a shared vision by the basin countries to achieve sustainable development through equitable sharing of benefits, with the focus not on water but on regional development.

In the GBM basins, the concern is the sharing of benefits from water use—whether from hydropower, agriculture, flood control, navigation, trade, tourism, or the preservation of healthy aquatic ecosystems. Nepal has the potential to supply hydroelectric power and water storage benefits to India, while India has the potential to supply navigation and transit facilities and to provide financing and expertise to Nepal. India has the potential to grant secure expectations of minimum flow to Bangladesh, while Bangladesh has the potential to permit navigation and transit access to India. Nepal has the potential to supply hydropower and

storage benefits to Bangladesh, while Bangladesh has the potential to provide navigation and transit access to Nepal. Bhutan has the potential to supply hydroelectric power and water storage benefits to India, while India has the potential to provide financing and expertise to Bhutan.

## Multi-lateral Cooperation

It will not be possible to materialize the huge potentials of 'sharing of benefits' in a sustainable way under a bilateral regime since bilateral negotiations are likely to exclude the positive and negative externalities (Crow and Singh 2009). Construction of storage reservoirs for a variety of multipurpose uses (dry season flow augmentation, irrigation, flood mitigation, navigation, and hydropower generation) concerns the interests of more than two countries, and can be achieved only through multilateral dialogues and cooperation among the co-riparian countries. Multilateral resolution, though not the most common of methods, is an ideal way to reach a permanent, fair, and effective agreement through its greater levels of participation and tendency for more permanent and effective agreements.

## Basin-wide Approach

Multi-lateral cooperation has the potential of coming up with basin-wide approaches to dispute resolution, where all the riparian states organize a committee for the organization of the use of the waterway. While national water policies of the GBM countries emphasize the importance of basin-wide management approach, the planning and management of water resources have often been geared towards national interests, with very little acknowledgements of regional interdependency. Shared vision of the co-riparian states on equitable sharing of benefits can best be achieved through basin-wide management of water resources. Lessons may be drawn from the prevailing basin-wide management of trans-boundary rivers, for example, Rhine, Mekong, Danube, and Nile.

## Resilient Institutions

Despite the potential for dispute in trans-boundary basins, the record of cooperation historically overwhelms the record of acute conflict over international water resources. There is a huge importance of resilient institutions, which is reflected in their roles in diffusing tensions in basins with large numbers of water infrastructure projects (for example, in the Rhine and Danube basins). As UNESCO (2003) points out, 'some of the most vociferous enemies around the world' have been able to negotiate and maintain water agreements because of resilient institutions that stood firm over time and during periods of otherwise strained relations. Examples are the Mekong Committee, which functioned since 1957 and exchanged data throughout the Vietnam War, the Indus River Commission which survived through two wars between India and Pakistan, and the Nile Basin Initiative in which all ten Nile riparian states have engaged in negotiations over cooperative development of the basin. Efforts are needed to have a similar resilient institution in the GBM region with sufficient authority and mutual trust among the representatives of the basin countries.

## Participatory Fact Finding Mission

There are disparities among the countries with regards to hegemony and economic power. Given the political realities of the development of trans-boundary waters, a big question now is how to eliminate the mistrust among the GBM countries and create an environment in which the countries can see and materialize their 'shared' or 'common' interests. Experiences from Mekong and Nile elucidate the urgent need to stimulate a participatory process to allow, facilitate, and support stakeholder involvement in water resources planning process in the GBM region. Uitto and Duda (2002) observe that initial, strategic joint fact-finding projects among participating nations can serve as an important catalytic tool for achieving a shared vision and commitment among the riparian nations. All relevant stakeholders including national governments, civil society organizations, academia, research institutions, NGOs, and donors need to work together in joint research to address the challenges ahead. This proactive stakeholder participation will help build transparency and facilitate identification of options for win–win solutions to the existing problems in the GBM river systems. This, in turn, will serve as preventive diplomacy by generating political support and allowing the co-riparian nations to go ahead of the crisis curve through preclusion of future disputes or crises in the long run.

## Multi-track Diplomacy

It is increasingly recognized that skills other than technical engineering expertise are required to facilitate and enable the trans-boundary water negotiation process. Diplomatic and negotiation skills are needed together with an understanding of the technicalities. Multi-track diplomacy often comes handy in complex negotiations between countries. Track I diplomatic efforts by the concerned governments in India and Bangladesh have been made for a long time through the Joint River Commission. Track II diplomatic efforts have also been pursued to enhance the effectiveness of the Track I efforts. One example is the signing of the Ganges Water Treaty in 1996, where Centre for Policy Dialogue (CPD) of Bangladesh and Centre for Policy Research (CPR) of India took the initiative to bring the two sides closer to each other by organizing meetings on Indo-Bangladesh relations where various issues, including trade and water sharing, were discussed. However, with growing complexities of water sharing issues and because of the highly politicized nature of discussions between the co-riparian countries, it seems that a Track III diplomacy approach is warranted, in which dialogue and advocacy efforts will be led by civil society organizations, with the aim to stimulate progress at more formal levels (Track I and Track II). The Track III approach will result in an open environment that enables listening to each other and understanding each other's view points, not hampered by political or other power oriented position.

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