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6 Management of Ganges-Brahmaputra-Meghna System: Way Forward

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6.1 Introduction

The Ganges-Brahmaputra-Meghna (GBM) system is considered to be one transboundary river basin even though the three rivers of this system have certain distinct characteristics and flow through very different regions for most parts of their lengths. Not only each of these three individual rivers are big, but each one of them have tributaries which are important by themselves in social, economic and political terms, as well as in terms of water availability and use. Many of these tributaries are also of transboundary nature (Ahmad et al. 2001; Biswas and Uitto 2001).

Therefore, in planning and management terms, it is simply impossible to consider GBM as one system because of its sheer size, complexities and multinational character. Accordingly, following the Ganges Treaty between India and Bangladesh, the main focus of bilateral negotiations between these two countries at present has been on the Teesta River, an important tributary of the Ganges. Currently, these negotiations are ongoing, and no mutually acceptable framework for the management of the Teesta River is in sight. Furthermore, Bangladesh has been so concerned with the Indian plan that is considering the interlinking of major rivers in recent months that any other issue, including a possible treaty on the Teesta, is now receiving a somewhat low priority.

Even some of the major tributaries of the Ganges, Brahmaputra or the Mekong have proved to be too complex to plan and manage. For example, the Indian Government has decided to consider managing the Yamuna River, a tributary of the Ganges and an interstate river, in parts, because it became evident that it would be very difficult to make a plan for the entire river as a whole. Even if such a plan could be prepared, realistically its implementation would be almost impossible. Accordingly, the current planning framework considers Upper Yamuna River only.

In addition, in India, like in Canada or United States, water is generally under the jurisdiction of the states, though the central government could have certain specific but limited roles, both direct and indirect, for inter-state and transboundary waters. Past experiences indicate that formulating a planning and management framework for an interstate river in India, or Pakistan, has many times proved to be as complex, cumbersome and time-consuming task, comparable to negotiations on transboundary rivers. In a few cases, negotiations on inter-state waters have even proved to be much more difficult than on transboundary rivers.

Currently, negotiations leading to successful completion of a treaty on an interstate river in India are taking an average 15–20 years. Steadily increasing water demands for various water uses in each state, availability of limited water resources, rivalries and conflicts between the neighbouring states on many development-related issues, and the presence of multiplicity of political parties who are continually fighting each other, do not contribute to the presence of an enabling environment wherein acceptable and optimal interstate water treaties can be negotiated within reasonable timeframes. In fact, some interstate treaties in India and Pakistan have taken more time to negotiate compared to transboundary treaties. For example, the Indus River Treaty between India and Pakistan (Biswas 1992) was finally signed in 1960, after four years of intensive negotiations. However, an agreement between the four provinces of Pakistan (Baluchistan, North-West Frontier Province, Sind and Punjanb), as to how to allocate the Indus water among themselves, took slightly more than 30 years before it could be agreed to by all the four parties. Even now, the political bickering between these four states as to how the Indus water has been allocated between them continues unabated. Thus, the political wrangling between the state parties concerned for the management of both national and transboundary rivers, in many instances, have continued to intensify rather than diminish.

6.2 Partnerships for Regional Development

In most Asian transboundary rivers, including the GBM Basin, agreements have been difficult to negotiate between the co-basin countries because of factors like historical mistrust and rivalries, asymmetrical power relationships, short-term requirements of the national political parties as opposed to long-tern national interests, exclusive negotiations on water issues alone (which often reduce the water allocation process to a zero-sum game), non-formulation of a negotiating framework which considers an overall development spectrum that could result in win-win results for all the concerned parties and emergence of numerous single issues, as well as vociferous and media-savvy NGOs who are more interested in promoting their own agendas and dogmas compared to improving the quality of life of people whom they claim to represent. All these constraints have seriously hampered the development of mutually beneficial projects and activities between countries like India and Nepal and India and Bangladesh. Because of the deep-rooted mutual distrust and sometimes even hostility, progress on the development of transboundary rivers has mostly been minimal. Accordingly, benefits foregone by each of these three countries from such developments have been very substantial (Verghese 2001). In reality, considering the extensive poverty that exists in all of these three countries, none of them can afford to continue with this unacceptable level of cooperation. Another factor that should be considered is that if the developments of fossil fuels or mineral resources are delayed, these resources are not lost to the nations. They stay in the ground, untouched, and the same resources can be exploited in the future whenever countries decide to do so. The benefits

will accrue whenever such resources are used. In contrast, if water is not used for hydropower generation or agricultural production, the potential benefits are gone forever: they can never be recovered.

The GBM Basin provides excellent examples of very substantial benefits that can be obtained by the countries when they decide to collaborate with each other (Ahmad 2004), and also equally the very substantial costs when the countries concerned eschew pursuit of common development goals for whatever reasons, some of which may be real but other could be imaginary. The cooperation between Bhutan and India has brought very significant benefits to these two countries. Equally, lack of collaboration between India and Nepal, and Bangladesh and India has meant that all the three countries have foregone very substantial benefits, which can never be recovered.

6.2.1 India and Bhutan: Excellent Example of Partnership

In the area of management of transboundary rivers, the positive collaboration between Bhutan and India is probably one of the very best examples from anywhere within the developing world. It shows that given enlightened leaderships, political will and mutual trust and confidence, the benefits of developing transboundary water bodies can be very substantial to all the countries concerned. Regrettably, even though Bhutan-India partnership has yielded very significant benefits to both the countries, the positive results of this collaboration are mostly unknown, even in the Indian subcontinent, let alone in the world as a whole.

The collaboration between Bhutan and India provides an excellent example as to how transboundary water bodies can be used as an engine for economic growth or development of an impoverished region with concomitant benefits to each country.

Bhutan, often known as the Hermit Kingdom, was basically inaccessible to the world until 1960. When this landlocked country, located on the Himalayan mountain range, initiated its first development plan in 1961, it had the lowest *per capita* income in South Asia and one of the lowest in the developing world. Because of the mountainous nature of its terrain, its agricultural potential is very limited. Its high mountainous location, however, provides the country with unique special advantages, especially in terms of its hydropower potential, which is estimated at 20,000 megawatts (MW), slightly less than one-quarter of the potential of its Western neighbour, Nepal. However, in terms of population, Bhutan is much smaller than any of the other GBM Basin countries. The demographic details of the four GBM countries for 2004, are shown in Table 6.1.

Bhutan realized sometime ago that one of its main natural resources is water, and if the country is to develop economically, it must wisely and efficiently develop its water resources. Since nearly all of its water is transboundary in character, it really has no alternative but to cooperate closely with India to develop these resources. It further recognized the following issues:

- Water development is not an end by itself, but only a means to an end, where the end is to improve the lifestyles of the people of the nation through a variety of complex interrelated socio-economic pathways.
- It cannot develop by itself its water resources efficiently and quickly because the country lacks investment capital and adequate technical and management expertise.
- Even if its water resources are developed, it will not be able to take full advantage of the resulting benefits within the national territory because of its small and very decentralized population. In other words, the country simply does not have enough absorptive capacity for all the benefits that may be generated.

Table 6.1. Population details of the GBM countries

Countries	Population (millions)			Annual population growth rate 1975–2004 (%)	Urban population as % of total 2004
	1975	2004	2015 (estimate)		
Bangladesh	73.2	139.2	168.2	2.2	24.7
Bhutan	1.2	2.1	2.7	2.1	10.8
India	620.7	1087.1	1260.4	1.9	28.5
Nepal	13.5	26.6	32.7	2.3	15.3

Source: Human Development Report 2006, UNDP, New York, pp 299

Accordingly, Bhutan embarked upon a very different path, compared to either Bangladesh or Nepal, to develop its transboundary water bodies. It concluded that its most optimal solution would be to develop its water resources in close collaboration with, and the support of, its southern neighbour, India, with whom it shared its transboundary waters.

Around 1980, Bhutan initiated a plan to develop the hydropower potential of the Wangchu Cascade at Chukha, in close cooperation with its much bigger neighbour. Following extensive consultations, India agreed to construct a 336 MW run-of-the-river project at Chukha, on the basis of a 60% grant and 40% loan. The estimated cost of the project was Rs. 2,450 million. It was commissioned in stages from 1988 onwards. The project was so successful that it had paid by itself by 1993. The generating capacity was later increased to 370 MW. Because of the Indian support to plan and construct the project, Bhutan agreed to sale the excess electricity from the project which is cannot use, to India at a mutually agreed rate. A 220-kilovolt (kV) transmission line was constructed which linked the Bhutanese capital, Thimpu, and the city of Phuntsholing on the Indian border, from where electricity was subsequently supplied to four Indian states.

The agreement between the two countries is that the electricity generated will be first used to satisfy Bhutan's own internal needs. Before the construction of the Chukha plant, electricity was generated by diesel and mini-hydro plants. Thus, total electricity generated was very limited. Transporting diesel to a landlocked and

mountainous country was an expensive and complex process. It was also inefficient. Not surprisingly, in 1980, *per capita* energy consumption in Bhutan was only 17 kWh, which was less than 10% of that of India, at 173 kWh (see Table 6.2).

Table 6.2. *Per capita* GDP, GDP growth rates and electricity consumption for South Asian countries

Countries	GDP (US$) *per capita* 2004	GDP Growth rate (%) 1975–2004	Electricity consumption *per capita* (kWh)	
			1980	2003
Bangladesh	406	1.7	30	145
Bhutan	751	4.0	17	218
India	640	3.4	173	594
Nepal	252	2.0	17	91
Pakistan	632	2.9	176	493
Sri Lanka	1,033	3.3	113	407

Source: Human Development Report 2006, UNDP, New York, pp 332, 333, 354, 355

Bhutan's *per capita* electricity consumption has steadily increased since the Chukha project became operational. For example, by 2002, compared to 1980, *per capita* energy consumption had increased by a factor of nearly 14–235 kWh. During the same period, India's *per capita* electricity consumption increased by a factor of "only" 3.3 at 569 kWh (see Table 6.2).

The unit cost of hydropower generation has steadily declined since the Chukha plant was first constructed because of higher and more economic scale of production and increasingly more efficient management. The electrical network has steadily expanded to different parts of Bhutan, which has meant reduced use of fuelwood than what might otherwise have been the case, as well as that of diesel which had to be imported from India. Reduced fuelwood use has had a beneficial impact on the forests and the environment.

The electricity produced in excess of the requirement of Bhutan is purchased and used by India as peak power through its eastern electricity grid. Initially, the two countries agreed to have two different pricing patterns for firm and secondary power. Later on, the two tariffs were amalgamated into one, and subsequently, the tariff initially paid by India was revised upwards four times. The revenue that Bhutan has been receiving from its electricity sales to India not only has serviced its debt load for the Chukha project without any difficulty, but also has left enough surpluses to finance other development activities, and support some social services, including increasing the salaries of its civil servants. In addition, electricity provided the impetus for Bhutan's industrialization.

Since the construction of the Chukha project proved to be beneficial to both the countries, they have agreed to expand their collaborative efforts to other new hydropower projects. Bhutan realized that the revenues from the development, use and export of its hydropower potential can accelerate the economic and the social development processes of the country, and can contribute very significantly to poverty alleviation. The arrangement has also been beneficial to energy-thirsty

India, whose electricity requirements have been increasing in recent years at 8–9% per year, compounded. The decision for mutual collaboration which led to the development of transboundary water bodies, has proved to be an important win-win situation for both the countries.

India and Bhutan have subsequently collaborated with the funding and construction of a 45-MW run-of-the-river hydropower station at Kuri Chu. Similar collaborative efforts have taken place, or are under active consideration, for Chukha II (1,020 MW) and Chukha III (900 MW, with a storage dam). In addition, the two countries signed an agreement in 1993 to study the feasibility of a large storage dam on the Sunkosh River. When all these projects are completed, and assuming the unit price paid by India for electricity will continue to be revised upwards periodically, Bhutan can easily earn over $100 million annually in the foreseeable future from the sale of hydropower alone to its neighbour. Considering its present population is only little over 2 million, this sale of hydropower to India means a very substantial income for this relatively small country, which will accrue regularly, year after year. Because of this success, not surprisingly, Bhutan's development framework, Vision 2000, envisages careful and progressive utilization of its 20,000 MW hydropower potential as an important means to propel the country forward and upward so as to ensure a better quality of life for all its citizens.

The win-win approach used by Bhutan and India is a good example of how transboundary water bodies can be successfully managed by the co-basin countries for regional economic development, which can directly contribute to the improvements in the quality of the people of both the countries through income generation, poverty alleviation and environmental conservation.

Viewed from any direction, the collaboration between the two countries has been mutually very beneficial, including enhancement of regional peace and stability. These water-based developments have meant that Bhutan's *per capita* GDP has increased from being the lowest of any south Asian countries in 1980, to being the second highest (only Sri Lanka has a higher *per capita* GDP) in the region at present, within a very brief time span of only a little more than two decades. If the current trends continue, and there does not appear to be any reason as to why this should not, by 2015, Bhutan is likely to have by far the highest *per capita* GDP in the south Asian region, all primarily because of its farsighted and enlightened approach to develop collaboratively its transboundary water bodies with its neighbour, India.

6.2.2 India and Nepal: A Missed Opportunity

In contrast to the approach of Bhutan and India, which has resulted in significant benefits to the two co-basin countries because of managing transboundary water cooperatively in a constructive spirit, the last 20 years have proved to be a missed opportunity for India and Nepal because of continuing mistrust, and perhaps to a certain extent, the presence of big-country-small-country syndrome. It is a good case which graphically illustrates the validity of the perceptive views

of Jawaharlal Nehru, the first Prime Minister of independent India, who urged the people to override national conflicts. Nehru further deplored the inability to overcome not only the "narrow boundaries of geography but, what is worse, of the minds."

Had the two countries approached jointly the planning and management of transboundary rivers that flow from Nepal to India in a positive and constructive spirit, the benefits to the two countries in terms of regional development, poverty alleviation and improvements in the quality of life of the people of the region most certainly would have been very substantial. Regrettably, this did not happen, partially because of political uncertainties that clouded the negotiations and partly because of asymmetrical interrelationships between the two countries. Much of these constraints should have been overcome by the Gujral doctrine of the mid-1990s, which very specifically eschewed absolute reciprocity in India's interrelationships with its smaller neighbours. While this new doctrine produced a burst of enthusiasm and activities between the two countries, this momentum could not be sustained for many different reasons. Accordingly, this proved to be a missed opportunity for both the countries. In retrospect, it perhaps has hindered the progress and economic development of Nepal, which has far fewer development options compared to India.

The overall situation of the region is not encouraging, since half the population of this region currently live currently under the poverty line. In fact, in spite of recent economic advances, the total number of poor people in this region (Nepal and the neighbouring states) has continued to increase. Not surprisingly, the various health and the social indicators for the countries are still poor, as indicated in Table 6.3.

Table 6.3. Selected social indicators

Countries	Adult illiteracy rate 2004	Infant mortality per 1,000 live births 2004	Physicians per 100,000 people 1990–2004	Population without access to improved water sources (%) 2004
Bangladesh	58.9	56	26	26
India	39.0	62	60	14
Nepal	51.4	59	21	10

Source: Human Development Report 2006, UNDP, New York, pp 293, 303, 317

Since the current development situation in Nepal and the Indian territories adjacent to Nepal are poor, and water is one of the few resources this region has which can promote economic development, the two countries need to formulate and implement cooperative strategies and joint action plans where water could act as the catalyst for economic take-off (Onta 2001). A number of options and opportunities have existed for decades for collaborative efforts in areas like hydropower generation, flood management, drought mitigation, and agricultural development. However, progress has been slow, even though the two countries managed to sign a Treaty for the Mahakali River in January 1996. Nearly ten years have since

passed, but the implementation of the Mahakali Treaty has made very limited progress because the two countries still do not see many issues eye-to-eye.

Let us consider hydropower development, where the potential for Nepal is significantly higher than in Bhutan. The country's theoretical hydropower potential is estimated at 83,000 MW, of which already identified economically feasible potential is about 40,000 MW. Nepal's *per capita* electricity consumption is very modest: it was only 62 kWh in 2002. Thus, if Nepal can generate additional electricity, not only can its people have access to more commercial energy (in contrast to high use rates of non-commercial electricity, mainly biomass), but also sell any excess electricity to India, and possibly to Bangladesh and even to Pakistan. Nepal's hydropower can serve as an expensive peaking power for use in the neighbouring Indian states. Hydroenergy is not bankable. What is not generated is lost forever. The income and benefits from such lost electricity generation can never be used for poverty alleviation or other productive development purposes.

While the recent NGO movements against the construction of large dams have had perceptible impacts on both India and Nepal, the fact remains that Nepal has developed only 0.6% of its total hydro potential, compared to nearly 87% in Switzerland, 73% in Sweden, 68% in Japan, 56% in both Norway and the United States, 52% in Canada, and 14% in India. Viewed in another way, the dams on the Colorado, Mississippi and Columbia rivers store many times their annual average flows. In contrast, Nepal has so far stored not even one percent of its annual runoff. Even if the nine currently identified large storage dams are constructed in the tributaries of the Ganges, they would account for less than 20% of the annual average discharge of the Ganges. A monsoon country, with a very seasonal rainfall, simply cannot meet its water requirements at such a low level of storage.

The Mahakali Treaty can be considered to be a framework agreement, whose centrepiece is the Pancheswar Dam. It establishes the general parameters within which binational cooperation could be developed. However, the progress on the implementation of this Treaty has been agonisingly slow. The joint detailed project report is still not ready, some 10 years after the treaty was signed. If and when the dam is constructed, it would have major positive development impacts on the underdeveloped far-west region of Nepal, and Pithoragarh District of Uttar Pradesh in India, which is also a backward area. The concept should be to integrate the hardware of the hydropower development with the software of area development, like education, health services, nutrition, employment generation, transportation, communication and gender empowerment. Combination of this hardware and software has the potential to revolutionize the lifestyles of the people of the region within one generation (Verghese 2001).

There is no doubt that much of the momentum and enthusiasm that were generated by the Mahakali Treaty have now been mostly lost. The cooperation between the two countries has become a hostage to mutual mistrust and small- country-big-country syndrome. There is a strong perception in Nepal that it got a raw deal from India on the earlier projects on the Sharda, Kosi and Gondak rivers. India does not subscribe to this view. Whatever may be the actual facts, it is the overall perception that shapes the national opinions, which then often dictates political actions and the approaches adopted by the bilateral negotiators.

To a certain extent, the fact that Nepal perceived that it did not receive a fair deal from India for the earlier development projects is reflected in its new Constitution that was approved in 1990. It incorporates a new article which requires parliamentary ratification by a two-third majority for any agreements on transboundary water bodies. In spite of this high bar, the Mahakali Treaty with India was approved by the Nepalese Parliament.

The Mahakali River forms a major stretch of the Western Nepalese border with India. A high dam is to be constructed at Pancheswar on the border. The project will have two powerhouses of equal capacity on each bank. Each country will also have equal entitlement for utilising the waters of the river without prejudice to existing consumptive uses. The costs of the project will be shared by the two countries in proportion to the benefits they will receive. Irrigation benefits will be estimated by the incremental value of agricultural production, and flood control benefits by damages averted.

The 315 m high rockfill dam at Pancheswar is expected to have a generating capacity of 6,480 MW. India is obliged to purchase any excess electricity that Nepal wishes to sell at a mutually agreed price. While there has been considerable discussion on what could be a fair price that will be acceptable to both parties, there has been no agreement so far. The absence of an agreement is primarily because of lack of confidence between the two countries, and the presence of an environment where the issue is not given high enough priority by either of them. And yet, Nepal requires electricity for improving the quality of life of its people and also export earnings and investment funds to promote its social and economic development. Equally, India currently cannot meet its electricity requirements, as a result of which regular blackouts are a fact of life in many parts of the country. Thus, even though there are demonstrable needs from both sides to proceed with the construction of the Pancheswar Dam, which will bring considerable benefits to both the countries, political will has simply not been there in recent years to cut through the misgivings, and entrenched mistrust. One can even argue that national sentiments can sometimes become the enemy of rational solutions which can hinder national progress and development. This appears to have happened in this particular case.

6.2.3 India and Bangladesh: Need for a Regional Approach

The GBM River systems constitute the second largest hydrologic region in the world. The total drainage area of the GBM region is about 1.75 million km^2, tretching across five countries: Bangladesh, Bhutan, China, India (16 states in the north, east and northeast, in part or fully), and Nepal. While Bangladesh and India share all the three river systems, China shares only the Brahmaputra and the Ganges, Nepal only the Ganges, and Bhutan only the Brahmaputra. About 10% of the world's population live in this region, representing only 1.2% of the world's land mass.

The GBM region is characterized by endemic poverty. It is home to about 40% of the poor people of the developing world. The performance of the region with

respect to such social indicators as economic growth, education, and health is disappointing in comparison to other regions of the world. About two-fifths of the developing world's poor people (with a daily calorie intake of less than 2,200–2,400 Kcal) live in this region; and even though there has been a decline in the poverty ratio in recent years, the absolute number of poor people has increased due to population growth. Adult illiteracy is still very high. The situation is worse in the case of women, compared to men. The three countries spend a lower share of public expenditure on education, compared to the world average.

Health indicators are also dismal in the region. Infant (under 1 year) and child (under 5 years) mortality rates in these countries are much higher than those of other developing countries as well as the world average. Although access to safe water has significantly improved in the recent years, only a limited population have proper access to sanitation.

Nearly 45% of the land of the GBM region is arable, but *per capita* availability of arable land is very small - around one-tenth of a hectare, which is almost half of the global average. One other crucial element to be taken into consideration in envisioning a sustainable development framework for the GBM region is the trend in urbanization. In Bangladesh, India, and Nepal, annual urban growth rates (1995–2000) were 5.2, 3.0, and 6.5% respectively. These rates are much higher than those of Europe (0.5%), Latin America (2.3%), Australia (1.2%), the US and Canada (1.2%), and Japan (0.4%). While the proportions of urban population in the three GBM countries are 20, 27, and 14% respectively, they are expected to rise to over 50% in the case of India and Bangladesh, and to about 22% for Nepal by 2025. This change in the spatial distribution and localization of population would have significant implications for water, energy and other related demands for natural resources.

In the energy sector, the GBM countries have a very low dependence on and utilization of commercial energy. *Per capita* average energy use in the world is about 1,680 KgOE. In comparison, the corresponding figures for Bangladesh, India, and Nepal are 197,476, and 320 KgOE respectively. It is also reflected in similarly lower than world average rate of *per capita* electricity consumption in these GBM countries.

Despite the poor socio-economic status of the region, it has rich natural endowments of water, land, and energy. It is indeed an agonizing paradox. The development and utilization of these natural resources in an efficient manner have never been sought by the countries due to past perceptional difference, legacy of mistrusts, and lack of goodwill. The abundance of water in the GBM region as a shared resource could be a principal driver of development for the millions of poor people living in the region. The shared river systems can be optimally developed only through collaborative efforts. It is imperative, therefore, to formulate a framework for the sustainable development of this region in a long-term time frame on a cooperative basis. The objective would be to enhance the quality of life through accelerated human development, environmental conservation, and efficient institutions for governance.

The GBM region is a water-rich region. Water is the single-most natural resources of the GBM regional countries. Properly harnessed, water could be the

most important factor for development. This could very significantly improve the quality of life of millions of poor people living in this region.

The average annual water flow in the GBM region is estimated to be around 1,350 billion cubic metres (BCM), of which nearly half is discharged by the Brahmaputra. The three rivers constitute an interconnected system which ultimately falls into the Bay of Bengal. Compared to an annual average water availability of 269,000 m^3/km^2 for the world, the availability in the GBM region is 771,400 m^3/km^2, which is nearly three times the world average. In addition to surface water, the GBM region has an annually replenishable groundwater resource of about 230 BCM.

Water is abundant during the monsoon but scarce during the dry season. Harnessing the GBM rivers will require storing the monsoon flows and redistribute the water available over space and time, when and where required (Shah 2001).

The real challenge is to utilize this resource in an efficient manner. It offers the most promising entry point for achieving a social and economic transformation in Nepal, northern, eastern and northeastern India, Bangladesh, and Bhutan. This will require formulation and implementation of a framework for multidimensional cooperation in related sectors such as energy, environment, health, flood management, water quality, navigation, and trade and commerce. In the absence of a long-term cooperative vision, the GBM region would continue to stagnate and millions of people would remain in a state of deprivation. There is no question that water resources development can play a catalytic role in bringing about wider changes and promoting sustainable development in the GBM region.

A climate of goodwill and confidence was created during the late 1990s with the signing of the Mahakali Treaty between India and Nepal, in January 1996, and the Ganges Water Sharing Treaty, between Bangladesh and India, in December 1996. These treaties are landmark events which offered a window of opportunity for water-based collaborative development endeavours in the region.

Properly managed, and given political will in all the co-basin countries, water could act as an entry point to trigger economic and social development in the region. As opportunities unfold, emphasis could shift from more irrigation to sustainable agricultural productivity, from electricity production to energy grids and industrialization, from flood control to flood management, and from inland navigation to inter-modal transport. The ultimate goal should be to attain a mutually beneficial synergy between national interests, people's well-being and regional prosperity, initiated through the best possible utilization of the huge potential of the region's water resource.

Floods, Riverbank Erosion, Sedimentation

The region is severely handicapped by recurrent floods which cause serious damages to life, property, and infrastructure. It is the poor who occupy the more floodprone areas and constitute the bulk of the victims. The general flooding pattern is similar in all the three countries, characterized by some 80% of annual rainfall occurring in four to five monsoon months, often concentrated in heavy spells of several days, or even hours.

Floods have become an annual feature in the GBM plains of India. Of the total estimated floodprone area in India, about 68% lies in the GBM states, mostly in Assam, West Bengal, Bihar and Uttar Pradesh. The Ganges in northern India, which receives waters from its northern tributaries originating in the Himalayas, has a high flood damage potential, especially in Uttar Pradesh and Bihar. Likewise, the Brahmaputra and the Barak (headwaters of the Meghna) drain regions of very heavy rainfall and produce floods from overbank spilling and drainage congestion in northeastern India.

Bangladesh, being the lowest riparian, bears the brunt of flooding in the GBM region. Even in a normal year, up to 30% of the country is flooded and up to about 80% of the land area is considered floodprone. Flooding in Bangladesh is caused by a combination of factors like flash floods from neighbouring hills, inflow of water from upstream catchments, overbank spilling of rivers from in-country rainfall, and drainage congestion. The conditions could be disastrous if flood-peaks in all the three rivers synchronize.

A natural result of flooding is riverbank erosion, especially in the Brahmaputra system. Large seasonal variations in river flows and the gradual loss of channel depth cause banks to erode and river courses to change. Wave actions during high flows further accelerate the process.

The GBM rivers carry an enormous amount of sedimentation load from the mountains to the plains, which compound the adverse effects of floods. The Kosi and some tributaries of the Brahmaputra are particularly notable in this regard. Bangladesh is the outlet for all the major rivers and receives, on average, an annual sediment load varying between 0.5 billion and 1.8 billion tons. Most of this sediment load ends in the Bay of Bengal, but a part of it is deposited on the floodplain during overbank spilling. This process gradually changes the valley geometry and floodplain topography, often reducing the water conveyance capacity and navigability of the drainage channels.

Demand Management

Efficient water management requires a comprehensive, cost effective, market-oriented, and participatory approach to water demand management. Nepal has formulated liberal policies for strengthening the economy and made corresponding changes in the role of the state and the market in its water resources policy. The National Water Policy of India, adopted in 1987, defines priorities for different water-using sectors, treats water as an economic good, and proposes the use of water pricing in a manner that would cover the costs of investment, operation, and maintenance. The National Water Policy of Bangladesh, approved in January 1999, emphasizes the principle of accessibility of water to all, and proposes to develop sustainable public and private water delivery systems, including delineation of water rights and guidelines for water pricing (Huda 2001). However, all these policies need to be efficiently implemented.

Two types of demand-side approach are feasible. The first is entirely market-based, dependent on a market-determined price mechanism for economic use of water. This requires certain prerequisites like an efficient water distribution

system, full dissemination of information relating to water demand and supply, appropriate regulatory conditions, and absence of corruption, all of which are mostly lacking at present in the GBM region. The second approach, which is partly in operation in the region, is through a system of administered control which determines water allocation and pricing according to social, economic, and environmental criteria. This approach still continues to be inefficient.

Institutions and Governance

Institutions and the manner in which they foster good governance determine the long-term ability of a country to manage its water resources. Institutions which are responsible for implementing water policies and strategies suffer from serious deficiencies and drawbacks in the region. They lack efficiency, or perform sub-optimally, with respect to such components as legal and regulatory aspects, implementation of rules, accountability, and responsiveness to the needs of the users.

Water sector planning in the region is slowly changing from a top-down technocratic approach to a bottom-up grassroots approach. The goal is to establish a genuine participatory water management environment. Along with the participatory approach come the steps to develop a nexus between public and private sectors in water development and management. Public sector water institutions of this region, like in most of the developing world, have a poor record of cost recovery. The involvement of the private sector may, to some extent, help to reduce public sector deficiencies, improve the level of governance, and attract investment in infrastructure.

6.2.4 Towards a GBM Regional Vision

The enormity of the development potential of the huge water resources of the GBM region stands out in stark contrast to the region's socioeconomic deprivation (Ahmad et al. 2001). It is a direct reminder to formulate a long-term vision in order to develop a regional development framework for water utilization. Because of the seasonal availability of water in the Himalayan rivers, harnessing the resource requires that it be stored for meeting year-around demands. Run-of-the-river projects may help, but they can not store water. Flood control benefits cannot accrue without storages. Thus, good storage schemes are essential for economic and social development of this region.

The terrain of the northern and middle belts of Nepal offer excellent sites for storage reservoirs. Nepal has identified 28 potential reservoir sties. Nine of them are classified as large, with an aggregate gross storage capacity of 110 BCM, and each site having a gross storage capacity of over 5 BCM. The 1986 Brahmaputra Master Plan of India has identified 18 storage sites in northeastern India, five of which are classified as large, having a total gross storage capacity of 80 BCM. In the Meghna (Barak) system, one large storage site (Tipaimukh), with gross storage potential of 15 BCM, has been identified (Mohile 2001).

These potential sites provide the opportunity to construct dams for storing excess water in the Himalayas for a variety of downstream uses. Hence, by definition, they are multipurpose in nature, providing benefits (beyond national borders) in such areas as power generation, flood moderation, dry season flow augmentation, irrigation, and navigation. The hydropower potential of these reservoir sites is the most significant aspect of water development in the GBM region, especially since *per capita* energy consumption in the region is among the lowest in the world. However, the construction of such storage dams involves high costs and requires long gestation periods.

High dams and other large water resource development programmes have encountered severe criticism and opposition in recent years due to a variety of technical, social, and environmental considerations. This sensitivity ranges from concerns for seismic hazards, submergence, population displacement, loss of farmland, forests and biodiversity, and downstream physical impacts. It should be noted that development and environment are complementary aspects of the agenda for poverty eradication. In the past, things have gone wrong in certain instances due to lack of knowledge, experience, and coordination, use of wrong technology, inefficient/poor implementation and management, corruption, and insensitivity towards project affected persons. The key does not lie in doing nothing, but doing differently and wisely. Lessons learnt from the past mistakes could serve as one of the most important building blocks in the context of promotion of sustainable development.

With respect to dam construction in the Himalayas, which is a dynamic tectonic region, the seismicity issue deserves serious consideration. The GBM regional countries should monitor seismicity and understand the Himalayan tectonics comprehensively. That would help in identifying the potential zones of seismic activity.

The environmental impacts of large dams and water projects must also be addressed adequately (Mukherhee 2001). The national guidelines of the GBM regional countries and the norms of international funding agencies are both specific and stringent in matters of resettlement and rehabilitation and mitigation of potential negative impacts on the environment. The basic rule for the resettlement and rehabilitation exercise should be that the people should preferably be better off after the project. Employment creation, capacity improvement to shoulder new responsibilities in work places, and self employment (income-generating) opportunities, with emphasis on education and skill development, may therefore constitute the areas of critical focus as the means of rehabilitation. In addition, the dam sites which are generally remote and inaccessible would witness the development of transport routes and other infrastructure that would open up the area and, in turn, foster mobility, market access, and all-round development. Properly planned, such developments could be harbingers of economic growth, social change and improvement of quality of life.

A number of options and opportunities exist for regional collaborative efforts in such sectors as hydropower development, flood management, dry season flow augmentation and water sharing, water quality improvement, navigation, and

catchment/watershed management. Policy environment in the region has to be favourable for such cooperation, requiring mutual confidence-building measures.

Hydropower Development

Energy consumption is often a useful index of a country's level of development and standard of living. The GBM region's consumption of energy is very low. The energy economy of the region's countries is highly dependent on non-commercial sources, mainly biomass. This is not a sustainable situation, especially in view of the growing energy demands of a rising population and expanding economic activity. Yet, the hydropower potential of the region is vast. In the past, efforts have been made by each of the regional countries to develop hydropower within its own borders to meet domestic needs. But cooperative efforts to produce and trade hydropower have not been pursued.

Nepal's theoretical hydropower potential is estimated at about 83,000 MW. However, the identified economically feasible potentials are about 40,000 MW (Kayastha 2001). Given its modest load curve, Nepal's energy market lies in the northern and eastern regions of India as well as in Bangladesh, and possibly even in Pakistan. Nepal's hydropower could serve as peaking power to the adjacent thermal-based load in India. A three-pronged approach to hydropower development is necessary: small decentralized projects to meet local needs, medium scale projects for national needs, and large scale multipurpose and mega projects to meet transborder regional demands. The installed capacity of hydropower generation in India is about 22,000 MW, which is only 25% of the country's total installed power capacity. The demand for electricity in India is growing at an average annual compound growth rate of 8–9%. In order to reduce the current imbalance in the hydro-thermal mix and the general consensus to go more for environment-friendly water-based power, the future planning would incorporate a need to exploit maximally the GBM region's hydropotential through a regional grid. Bangladesh had an installed power capacity of about 3,000 MW as of 1997–98. The country's hydropower potential is limited by its flat terrain.

Some have argued that Nepal, India and Bangladesh are inefficient consumers of electricity owing to system loss through transmission/distribution anomalies, and pilferage; and, hence, production of more power from large hydroelectric projects is both socially and economically undesirable. Yet, the per capita electricity consumption in these countries is minuscule, compared to countries like Canada, US, Norway, Sweden or Switzerland. It is also difficult to accept the contention that Nepal, India, and Bhutan should refrain from undertaking large storage schemes to produce electricity, when all the identified future storages would together harness a little more than 10% of the annual flows. A more striking comparison would relate to the proportion of the installed hydropower to total hydro potential, which is only 0.6% in Nepal compared to 56%, 73% and 87% respectively in similar mountainous countries like Norway, Sweden, and Switzerland.

Hydropower has many advantages. It is a renewable source of energy without any recurring fuel cost which also obviates uncertainties relating to future costs of inputs. It exhibits a declining unit cost of generation over time with amortization

of the initial capital expenditure. Above all, a hydropower generation plant can, and usually does, generate other benefits: it fosters a development process through opening up remote areas. Interconnecting the various national power systems through a regional grid could open up the power market, and enable Nepal and Bhutan to export surplus electricity to India and Bangladesh.

Flood Management

The recurrent floods in the GBM region demand a regional approach requiring co-operation among all the co-basin countries. Both India and Bangladesh have undertaken certain in-country measures for flood mitigation during the past four decades. These include embankments, river training, and channel/drainage improvement. Upstream storage reservoirs can play a vital role in flood management. Multipurpose reservoirs on the Ganges and Brahmaputra systems, with provision for a dedicated flood cushion and well planned reservoir operation and regulation instructions, will be beneficial in moderating floods in northern, eastern, and northeastern India (particularly in Uttar Pradesh, Bihar, West Bengal and Assam) as well as in Bangladesh.

Among the non-structural flood management approaches, the greatest potential for regional cooperation lies in flood forecasting and warning. Currently, bilateral cooperation exists between Nepal and India, and between India and Bangladesh, for transmission of flood-related data, which needs to be strengthened further. More reliable forecasts with additional lead time would be possible in Bangladesh if real time and daily forecast data are available from additional upstream points on the three rivers. Such effective flood data sharing arrangements are also necessary with upper riparians, Nepal and Bhutan, for providing Bangladesh with greater lead time to undertake disaster preparedness measures. A review of the current status of flood forecasting methods in India and Bangladesh shows that both countries are using similar technologies for data observation and transmission. This provides an excellent opportunity to exchange expertise and experiences between the two countries for mutual benefit.

As a broader vision, the flood forecasting and warning system needs to be integrated with the overall disaster management activity, both nationally and regionally. This will require free flow of data relevant to flood forecasting amongst them on a real time basis. The importance of satellite observation, especially for early warning of heavy rainfalls, should be recognized; and, for that purpose, the installation of adequately equipped satellite ground stations throughout the region should be considered.

Flow Augmentation and Water Sharing

The dry season flows of the GBM rivers, particularly of the Ganges, are inadequate to meet the combined needs of the GBM countries. As early as 1974, the Prime Ministers of India and Bangladesh had recognized the need for augmentation of the dry season Ganges flows. The Ganges Water Sharing Treaty of 1996 also includes a provision for the two governments “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." With Uttar Pradesh, Bihar, and West Bengal in India also seeking additional water to meet their requirements, the issue of augmentation deserves serious attention. The Calcutta port authorities are concerned that the Ganges Treaty has diminished lean season diversions into the river Bhagirathi, which would affect drafts requiring increased dredging.

One possible option for substantial augmentation of the Ganges flows, which could benefit Nepal, India, and Bangladesh, would be to construct large storages on the Ganges tributaries originating in Nepal. A highly favourable project from this perspective is the Sapta Kosi High Dam in Nepal, the revived third phase of the original Kosi project. The Kosi Dam will have a significant storage capacity that should provide both north Bihar (India) and Bangladesh with flood cushion and augmented dry season flows after meeting Nepal's full irrigation requirements.

One other option for augmenting dry season flows could be the proposed Sunkosh Dam in Bhutan, with a power generating potential of 4,000 MW. Water stored behind the dam could be released into a canal, designed to provide a two-stage link to the Teesta and Mahananda barrages in West Bengal. Augmentation of about 340 m^3/s is expected, a part of which could supplement the water needs of the two Teesta barrages (one in West Bengal and the other in Bangladesh) while another part could reach the Ganges at Farakka.

The issue of augmentation has direct relationship with concerns for trans-boundary water sharing among the co-riparians. The Ganges Treaty of 1996 called on India and Bangladesh to make efforts to conclude water sharing agreements with regard to other common rivers. One river which has received priority in the water sharing negotiations has been the Teesta, especially because the lean season flows are inadequate to meet the requirements of both the countries. Each country has constructed a barrage on the river. Although some *ad hoc* water sharing ratios were proposed earlier, it is necessary to examine seriously the option for Teesta augmentation as well as whether some arrangements could be made to operate the two barrages in tandem. In such a case, parts of Bangladeshi land lying outside its barrage's command area could be irrigated by extending canals from the barrage in India.

In the same track of regional cooperation, various other arrangements for augmentation and sharing could be conceived in the backdrop of probable trade-offs between the two countries. One such possibility is westward diversion link (through Indian territory) between the Brahmaputra and the Ganges, with provision for diversion along a lower alignment to augment Teesta waters in Bangladesh, or a further alignment southward to revive derelict streams and link up with the Ganges above the proposed barrage site at Pangsha. Some of these options are futuristic in nature, yet they deserve consideration within a long-term time development for the region.

Linked to the issues of water sharing, lean season water availability, and augmentation options are the state of environmental health of the rivers. Environment is a recognized stakeholder in the water demand nexus. Hence, apart from meeting the requirements of irrigation, power generation, domestic supply, and other

consumptive uses, a reasonable quantity of water must be available in the rivers in order to sustain the channel equilibrium as well as to maintain acceptable water quality standards. This question of setting aside a proportion of water in the river received attention in past Indo-Bangladesh negotiations relating to the sharing of the Brahmaputra and Teesta waters (Nishat 2001). All future planning for water resource development needs to take special note of this requirement.

Following the 1996 Ganges Treaty, Bangladesh now has the opportunity to plan for environmental regeneration of its southWestern hydrological system. One option is to construct a barrage on the Ganges at Pangsha to pond the river and force its backwaters into the Gorai River (the principal distributary of the Ganges in Bangladesh). India has offered to assist in the feasibility study for such a venture and extend whatever technical support it can towards its construction. However, several international funding agencies have expressed reservations about such an intervention and stressed that Gorai resuscitation through dredging with the aim of helping a rejuvenation of a network of moribund channels, ox-bow lakes, and other wetlands in the southwest could be sufficient. Work on Gorai restoration and associated studies are now in progress. An options study for the best utilization of the water available as a result of the Ganges Treaty, including a barrage on the Ganges, has recently been initiated. In spite of Gorai dredging, siltation proneness at its intake point from the Ganges necessitates additional measures like the Ganges Barrage to supplement the flows in the Gorai and other channels for achieving long-term environmental sustainability.

Water Quality

In all the GBM countries, the deterioration of both surface and groundwater quality is now a matter of serious concern. Water is essential to sustain agricultural growth and productivity. More than half the morbidity in the GBM region stems from the use of non-clean drinking water. Safe water supply and hygienic sanitation are basic minimum needs which the GBM countries are yet to meet in both rural and urban areas. A holistic approach is required to monitor the water quality in each country together with regional initiatives both to prevent further deterioration and bring about improvement in the quality of water.

The mitigation of the additional problems of salinity and arsenic in Bangladesh involves special action plans. Saline intrusion in coastal areas could be addressed through dry season flushing of channels by means of such methods, cited earlier, as storing monsoon water and resuscitating moribund channels. The Bangladesh Arsenic Mitigation Water Supply Project (BAMWSP) funded by the World Bank/Swiss Development Corporation is presently engaged in assessing the extent, dimensions, and causes of the arsenic problem with a view to developing a long-term strategy for supplying arsenic-free water.

The monitoring of water quality in the GBM rivers is not as extensive as it should be except in the case of the Ganges in India and the Buriganga in Bangladesh. The GBM countries need to set uniform standards relating to water quality parameters along with establishing an effective water quality monitoring network. The countries should review their existing water quality/pollution laws, and make

efforts to enforce the polluter pays principle. At the regional level, they should also coordinate their actions to deal with transboundary transmission of pollution, and evolve a mechanism for real time water quality data exchange, which could then lead to efficient water quality management.

Inland Navigation

The Ganges, Brahmaputra, Meghna and their principal tributaries had served as major arteries of trade and commerce for centuries. However, in recent years, their importance has diminished, especially as traffic has moved away from waterways to road and railway nodes. Yet, even today, the lower part of the GBM system is dependent on waterways, especially in Bangladesh and northeastern India.

For landlocked Nepal, Bhutan, and northeastern India, an inland water outlet to the sea is of great significance. The establishment of links with the inland water transport networks of India and Bangladesh would provide Nepal access to Kolkata (India) and Mongla (Bangladesh) ports. Potential exists for the development of water transport in Nepal in all the three major rivers (Karnali, Gandaki and Kosi) which are tributaries of the Ganges. Construction of high dams on these rivers could improve navigability in these channels.

The Karnali River (known as the Ghagra in India) has the maximum potential for navigation, from the Indo-Nepalese border to the confluence with the Ganges. The Gandaki River is an important waterway serving central Nepal and has the navigation potential to serve eastern Uttar Pradesh and eastern Bihar in India if it is linked with India's National Waterway No.1 in the Ganges, running from Allahabad to Haldia, below Kolkata. The upper reaches of the Kosi River is too steep for navigation, but river training works could facilitate the operation of shallow draft barges. Among the multiple benefits to be derived from the proposed Sapta Kosi High Dam is the provision for a navigational channel with a dedicated storage. The principal focus for Nepal's navigational development would be to gain exit to the sea through the Ganges, and obtain linkages with the inland ports of India en route. The strategy should be to ensure that structures constructed under water development projects do not impede the development of inland water routes.

With a view to reviving the past significance of inland water routes, India has already designated the Ganges between Allahabad and Haldia (1,629 km) as the National Waterway No.1, and the Brahmaputra between Sadiya and Dhubri (891 km) as the National Waterway No.2. The maintenance and further development of the requisite minimum navigable width and depth coupled with provision of navigation aids and terminal facilities would enhance the navigation potential in the GBM region. India and Bangladesh have a bilateral protocol, renewed every two years, for India to use the Ganges-Brahmaputra-Meghna riverway for water transit between West Bengal and Assam. The potentials of these routes (not optimally used at present) could expand through channel improvement, better piloting and navigational aids, and simplification and standardization of rules and regulations. A dedicated willingness to integrate the waterways network in the GBM regional countries would benefit all the countries in the long run.

Catchment Management

The geographically interlinked character of the major rivers in the GBM region warrants an integrated regional approach to the care and management of the catchments. Sound basin-wide catchment management is an essential long-term strategy to combat the threat of floods and erosion and to preserve the ecosystem. The sediment load in the rivers, which is largely the consequence of geomorphologic processes in the upper catchment areas, tends to increase with the progressive removal of vegetative cover on slopes.

Soil conservation and reforestation in the upper catchments of Nepal and India, and also within Bangladesh, could help in substantially reducing sedimentation.

6.2.5 Looking Forward

The framework for sustainable development of the GBM region can be based on a vision of poverty eradication and sustained improvement in the living conditions of the millions of its inhabitants (Biswas et al. 2004). The world's largest concentration of economic misery is to be found in this region. There is no reason for such abject poverty here, given the rich bounty of its natural resources, especially water, waiting to be harnessed.

But a lack of trust and transparency has consistently bedevilled the relationship among the co-riparians for nearly half a century and compounded poverty and deprivation in the region. This pernicious mindset has eroded goodwill and confidence, and has generated mutual mistrust and suspicion. The situation is further compounded by the failure of political leadership in creating a public opinion in favour of developing a vision for regional cooperation.

The drivers which would influence the conditions towards achieving the regional vision include population growth, urbanization, technology, globalization, governance, and environment. The demographic factor in the GBM region would be a very important determinant of the total *quantum* of water needs, implying the necessity of conservation and demand management. A related driver would be rapid urbanization (with more than half of the total population in India and Bangladesh living in urban areas by 2025), creating increased demands for safe water, sanitation, and management of solid and liquid wastes. Technological changes, manifested through adoption/innovation of new products and techniques, can enrich human capability through capacity development. The GBM region might benefit from transferring water-related technology from industrialized countries as well as from within the region, especially concerning irrigation efficiency, pollution control, water storage, disaster management, and management information systems. The contemporary process of globalization could be another driver in the region's long-term vision for sustainable development. The GBM region should benefit from trade liberalization, greater capital mobility, and technology transfer; but, at the same time, it is important to be vigilant against potential instability and the risk of greater inequality in income distribution. To address this issue effectively, it is necessary to establish good governance at all levels of society,

reflected in accountability, rule of law, elimination of corruption, and participatory approaches. The governance challenge in the water sector calls for transparency and community participation in water resource development from the planning to the operational phases, which is so important towards ensuring a humane society. The vision driver of environment aims at ecological harmony, which should be addressed by way of mitigation of negative impacts, adaptation to changes, enhancement of the ecosystem, and water conservation.

The regional vision formulation can be approached under three scenarios: pessimistic, optimistic, and plausible. A scenario is a possible course of events. The pessimistic scenario is basically a business-as-usual approach under the assumption of *status quo* and "do nothing" response strategy. This approach is unsustainable and unacceptable for the long term. The optimistic scenario is the other extreme, which is overly ambitious, utopian and an unrealistic goal to pursue. In between lies the plausible scenario. It is pragmatic to seek to attain sustainable water resource management for the region through genuine cooperation and collaboration.

The overriding goal in water vision formulation for the GBM region is sustainable human development for peace, stability, and an enhanced quality of life to be achieved through water-based regional cooperation, i.e., a regime of regional cooperation of which the entry point is water but which then expands and embraces all possible directions as it gathers momentum. Clearly, the approach has to be holistic, multidisciplinary and integrative. It requires congruence of macro, meso and micro policies within each country and their coordination across the regional boundaries. It will be not easy to formulate and implement an approach that will be acceptable socio-politically to all the co-basin countries concerned, especially under the existing political conditions, institutional frameworks, and inter-country tensions and misunderstandings. However, on a longer timeframe, the region simply has no other choice if poverty alleviation, economic development and environmental conservation are to be objectives of all the countries concerned.

Acronyms

BAMWSP	Bangladesh Arsenic Mitigation Water Supply Project
GBM	Ganges-Brahmaputra-Meghna

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