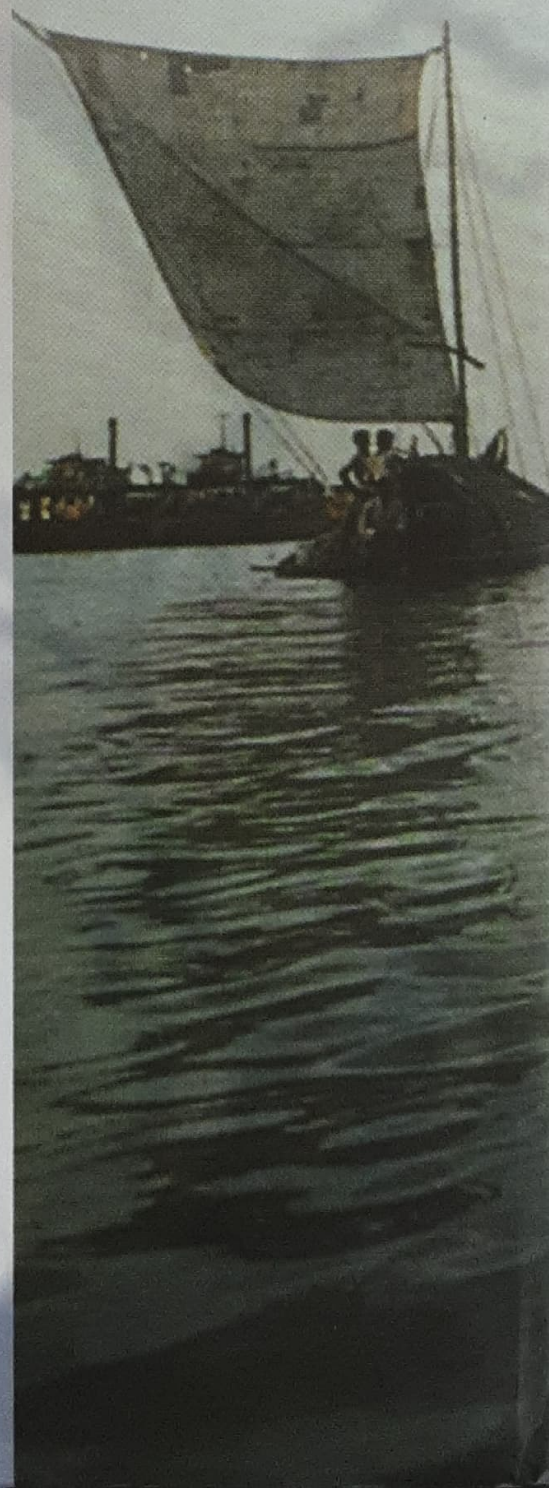
Ganges-Brahmaputra-Meghna Region

A Framework for Sustainable Development



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Preface

"Water, water everywhere,
Nor any drop to drink."

Samuel Taylor Coleridge's Ancient Mariner summed up the water situation that is currently prevalent in many parts of the world, almost correctly, and most certainly, succinctly. Recent estimates published by the various United Nations agencies indicate that nearly two-thirds of humanity will face water scarcities by the year 2025. Even though, in all probability, this may prove to be a somewhat high estimate, there is no doubt that water will become an increasingly important resource issue of the 21^{st} century. While the Ancient Mariner was concerned exclusively with the non-availability of freshwater to drink, it is now evident that water is not only necessary for the survival of human beings and ecosystems, but it is also essential for agricultural production, industrial development, electricity generation, transportation, environmental conservation, and even regional security and peace. Properly planned water development can contribute significantly to economic and social development of most developing countries. In turn, water management will be affected by economic development and evolving social norms, especially in terms of water use patterns, quality considerations and development practices.

The Ganges-Brahmaputra-Meghna (GBM) river basins are no exception to the current general global trends and considerations. In fact, if anything, this region is more dependent on water for survival, as well as for its future socio-economic development, compared to most other parts of the world.

The GBM river system is the second largest hydrologic system in the world. It covers nearly 1.75 million km^2 over 5 countries: China, Nepal, Bhutan, India and Bangladesh. The average population growth rate in the region over the past decade was around two percent per annum. The total population of the region was estimated at 600 million in 1999, which is significantly higher than that of entire North America, that is, Canada, United States and Mexico combined. Of these 600 million people, 460 millions are in India, 114 millions in Bangladesh and 22 millions in Nepal. In addition to the steadily increasing population, other factors like rapid urbanisation, urgent need for economic development for employment generation and poverty alleviation, and declining environment and resource base have meant that the standards of living of the people in the region have improved only marginally in recent years, certainly at a much lower rate than the population would like, or need. Nearly half of the total regional population currently lives below the poverty line, and despite recent advances, the total number of poor people has continued to increase. Adult literacy rates are low, (28 percent for Nepal, 38 percent for Bangladesh and 52 percent for India). Health indicators are equally abysmal, and the use of commercial energy continues to be low indicating the lower level of economic development of the area.

Fortunately, however, the region is well-endowed with good natural resources in terms of land, water and energy, which, regrettably, have not been developed or managed wisely in the past for a variety of reasons.

Since water is one of the most important natural resources of the region, it is absolutely critical that this resource be developed and managed in a rational, efficient and equitable way, so that it can act as the engine for socio-economic development of the region. Thus, development of a sustainable development framework for the region that is technically possible, economically efficient, socially desirable, politically acceptable, institutionally feasible, and environmentally sound is now even more essential than ever before in the entire history of the region.

Historically, the water requirements of the GBM region have steadily increased in the past, and, if the current trends continue, it is likely to continue to do so, at least over the foreseeable future. Rapidly accelerating human activities have meant that more and more water is being abstracted from the three river systems, especially the Ganges, with each passing year. Groundwater abstractions have continued to increase as well. Poor management practices are contributing to increasingly serious water pollution problems, especially in and around urban centres. While the need for good quality water has increased rapidly, commensurate advance in water management practices has not occurred for a variety of social, political, economic and institutional reasons. Thus, the region is regularly ravaged by floods and droughts, and now contains the largest concentration of the world's poor, more than the entire sub-Saharan Africa. Poverty has become endemic, and unless the current approaches to resources management are changed very significantly within a very short period of time, the future prospects for several hundred millions of people living in the region will continue to be bleak.

Since the region is well-endowed with natural resources, these must be developed and managed rationally so as to lift millions of people from their current poverty trap. As the current study indicates, given political will and considerable social pressure, changes in the mind-sets of the decision-makers will take place. Such needed and possible developments can no longer be considered to be a long-term dream. Political mistrust between the countries concerned which stretches over at least half a century, absence of enlightened leaderships in the past, serious perceptional differences in the development approaches between the countries concerned, legacy of inadequate water and related resources management practices, and absence of goodwill between the countries have all contributed to the present unacceptable level of development and living conditions of the people, and to a steadily deteriorating environmental base. Integrated development of the regional resources and manpower has not been possible in the past, simply because such collaborative efforts were not possible due to prevailing social, political, economic and institutional conditions.

Fortunately, however, there are signs that the conditions of the past have started to change. A climate of goodwill and mutual trust between the countries has started to develop in the recent past. An indication of these positive developments is the signing of two landmark treaties, first between India and Nepal, in January 1996, over the River Mahakali, and the second between Bangladesh and India, in December 1996, over the sharing of the waters of the River Ganges.

The real challenge facing the region at present is how to ensure its rapid social and economic transformation. The present study indicates that this can be achieved by formulating and implementing an integrated multi-sectoral and multi-dimensional sustainable development framework for the region, which would have the strong support of the governments and the peoples concerned. Such a framework for a regional development process must be based on a holistic and integrated approach, which should simultaneously consider land, water, energy, transportation, agricultural and industrial development, trade and commerce. Given active inter-country cooperation and collaboration, and popular support, it is likely that the fruits of development would no longer be perceived as a zero-sum game by the co-basin countries. Exclusive consideration of a single resource like water can only reduce the final benefits that may accrue to the co-basin countries to a zero-sum game. But when this is expanded to include other resources like land and energy, facilities like transportation and communication, and promotion of investments for agricultural and industrial development, freer trade and commerce within and outside the region, the boundary conditions and the final benefits change immediately and totally. The consideration then alters radically from a zero-sum game to a very significant win-win condition for all the countries concerned, as well as for their peoples and environments.

The framework for sustainable development of the region that is presented in this book is unquestionably a step in the right direction. We believe this will provide a long-term vision for the region, which is not only essential but is also achievable. This overall vision must be implemented in the best way it serves the people of the region. We must strive to discern what the people value most, which will determine and drive their unique visions of the future. Taking the necessary steps in a timely and cost-effective manner may not be an easy task, but it would be an essential requirement for the future socio-economic development of the region. During this process, concepts and models that are currently in fashion are likely to evolve further in an accelerated manner, and, in all probability, some are likely to disappear completely.

It is now evident that the development paradigm of the region must change, and it must change quickly. Time is no longer on our side. However, we must objectively analyse the potential prospects and constraints with respect to the future regional development issues in the light of the expected changes. These changes must be faced realistically and promptly, and should not be viewed either with a rose-coloured glass or with a dark glass. We must objectively analyse and constructively determine what are the development potentials of the region, and also what are the constraints so that these can be managed efficiently and can contribute to accelerated welfare of the people of the region. Success can only be measured by our ability to respond in a timely and proper manner. The development process that should be used, in all probability, will be new and innovative, for which a new and more open and broad mind-set will be required. Yesterday's crystal balls are unlikely to shed much light on this coming new age of accelerated and holistic regional development. Equally, the future development milieu is likely to be restless and uncertain, with diversified interests that will be awash with differing opinions, chaos, rapid technological changes, globalisation, relentless economic competition and accelerated social pressure for the much-needed development.

Never before in the history of the region, profound changes that are now essential, have occurred within a short period of time, which must take place over the next 2 to 3 decades. These changes must be identified and managed, and also felt and appreciated by the people of the region.

This would not be an easy task, but one that must be accomplished. Along the way there would be successes and failures, with emotional peaks and valleys. Development and water professionals would in all probability have to travel on many trails that are not well-worn, or even known. Along these untrodden paths, we would undoubtedly discover some short-cuts: equally we would face numerous obstacles and bumps. This is to be expected: it comes with the new uncharted territory of a new integrated development process for the region.

The process used for developing the sustainable development framework of the GBM region is worth noting. The Third World Centre for Water Management, a global think tank on water-environment-development issues, and the Committee on International Collaboration of the International Water Resources Association (IWRA) have had a long interest in the management of international waters. The two institutions have worked closely and extensively in the Middle East, Latin America and Asia on managing international rivers.

Our work in Asia started with the convening of the Asian Water Forum on International Rivers in Bangkok, Thailand, in early 1996. Three international rivers were selected: Ganges-Brahmaputra, Mekong and Salween. The three case studies represented different levels of disputes, ranging from the long-running and well-established problems over the use of the waters of the Ganges-Brahmaputra and the Mekong systems to the Salween, where the two countries do not have any entrenched positions. The results of this Forum was published as a book: "Asian International Waters: from Ganges-Brahmaputra to Mekong," with Asit K. Biswas and Tsuyoshi Hashimoto as editors (Oxford University Press, 1996). This book has now also been translated into Japanese. The Forum was supported by the United Nations University and the United Nations Environment Programme.

A main conclusion of this Forum was that the Centre and the IWRA would have more comparative advantage in working on the Ganges-Brahmaputra-Meghna system, compared to the other two river systems. Accordingly, in 1998, the Ganges Forum was organised in Calcutta, with the support of the United Nations University and the Ministry of Development Cooperation of the Government of the Netherlands. This also resulted in the publication of a book: "Sustainable Development of the Ganges-Brahmaputra-Meghna Basins", with Asit K. Biswas and Juha I. Uitto as the editors (United Nations University Press, Tokyo, 2001).

Participation in both the Asian Water Forum and the Ganges Forum was strictly restricted to the most knowledgeable experts and senior technocrats from the co-basin countries of the river systems concerned, and by invitation only. Only about 25-30 experts were invited to participate in each Forum in their personal capacities to ensure a free, frank and authoritative exchange of ideas, facts and opinions. The main objective was to organise two Forums, where even long-term adversaries during the various negotiations on the international rivers concerned could meet as friends and colleagues under informal and unrecorded conditions, away from media spotlights and without predetermined official government positions. While the interactions between the participants in both the Forums were intensive, they were constructive and without rancour.

An important conclusion of the Ganges Forum was that a window of opportunity existed for a collaborative effort between Nepal, India and Bangladesh on the sustainable development of the GBM region, which simply did not exist earlier. The Ganges Forum further recommend that the Third World Centre for Water Management should take the initiative to develop such a sustainable development framework, since it has no hidden agenda, perceived as totally independent in the region, and has a very high degree of credibility with the governments, research institutions and NGOs in the three countries concerned, as well as with the external support agencies.

The Centre accordingly initiated a study with the financial support from the Royal Dutch Embassy in Dhaka. Right from the very beginning it was unanimously agreed by all the parties that the framework should be developed by the best and the most appropriate institutions from Nepal, India and Bangladesh, with formal or informal support of the governments. In addition, the three institutions must have excellent academic credentials, reputation for being objective, impartial and multi-disciplinary, and good knowledge of the water and related resources issues of the GBM region.

It soon became very evident that the best institutions from the three countries which satisfied all the necessary requirements were unquestionably the Institute of Integrated Development Studies (IIDS), Kathmandu, Nepal; Centre for Policy Research (CPR), New Delhi, India; and Bangladesh Unnayan Parishad (BUP), Dhaka. The leaders from the three teams (Dr. Mohan Man Sainju of IIDS, Prof. George Verghese of CPR, and Dr. Q.K. Ahmad of BUP) were invited to prepare the terms of reference for the overall study at a meeting in Dhaka in early 1999. The United Nations University supported this initial meeting financially.

Following this meeting, funds from the Royal Netherlands Embassy in Dhaka were available to carry out the studies within the agreed overall terms of reference. After the completion of these studies, the three teams, and myself as the Coordinator of the study, met in Kathmandu, Nepal, to integrate the three studies. Shortly after the Kathmandu meeting, a draft report entitled "A Framework for Sustainable Development of the Ganges-Brahmaputra-Meghna Region" was prepared.

This draft was discussed at a high-level meeting in Dhaka, 4-5 December 1999. The participation in the meeting was by invitation only. It was attended by Ministers and Secretaries from the various ministries (both present and past), parliamentarians (central and state), leading water and development experts, senior technocrats, and representatives from the private sector, universities, NGOs, the media and external support agencies. Approximately 30 individuals were invited from each of the three countries.

Following the Dhaka meeting, a new semi-final draft was prepared. The results of the framework study were then presented at special GBM sessions that were organised at the World Water Congress in Melbourne, Australia, and at the Second World Water Forum in The Hague, the Netherlands. Both of these meetings took place in March 2000. The summary of the study was also presented during the Stockholm Water Symposium.

The report was finalised following extensive and intensive discussions at all these three meetings. The book is thus the final product of this consultative, participative and transparent process.

The Centre is most grateful to the Royal Netherlands Embassy in Dhaka for their support, which enabled us to carry out this study. We are especially grateful to Peter de Vries and Zahir Uddin Ahmad of the Embassy for their continuing support and encouragement. We also acknowledge the support of A.J. Diphoorn of the Dutch Ministry of Foreign Affairs, The Hague, for his continued interest and support for our GBM studies, starting from the Ganges Forum. Without the support of Messrs de Vries, Ahmad and Diphoorn, this study simply could not have been carried out.

I wish to express my very special thanks and appreciation to Dr. Q.K. Ahmad, Prof. George Verghese and Dr. M.M Sainju and their team members (especially K.B. Sajjadur Rasheed and H.R. Khan of BUP and R. Rangachari of CPR). I am especially grateful to Dr. Q.K. Ahmad, Chairman of BUP, who not only helped me to organise the two meetings at Dhaka, but also took on the difficult and complex task

of the final editing of the manuscript, and to Dr. M.M. Sainju, Director of IIDS, for organising the Kathmandu meeting. The hard and dedicated work of Messrs Ahmad, Sainju and Verghese and their colleagues, and over 350 discussants and reviewers, is primarily responsible for this extraordinary book.

On behalf of the Centre, I would like to thank Ujjwal Prahdan of the Ford Foundation office in New Delhi. Ujjwal has always taken a keen interest in the development and management of the GBM region, and his wise counsel and support is very much appreciated. We are also most grateful to the Ford Foundation for supporting the publication and distribution of this book.

The Centre is continuing with additional activities in the GBM region as well as in other regions on development and management of international rivers. The Centre works on the basis of formal networks with prominent institutions and individuals in over 25 countries. We would welcome the comments of the readers on this book, as well as expression of interest to join our extensive network, in terms of collaboration, joint studies or information exchange.

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A FRAMEWORK FOR SUSTAINABLE DEVELOPMENT OF THE GBM REGION

Background

The present project to develop a framework for the sustainable development of the Ganges-Brahmaputra-Meghna (GBM) region is the continuation of a process that was initiated in 1996 by the Committee on International Collaboration of the International Water Resources Association (IWRA) and the Third World Centre for Water Management. In early 1996, these two institutions convened the Asian Water Forum in Bangkok, Thailand, to discuss the future management of three major international rivers: Ganges-Brahmaputra, Mekong and Salween. The Forum was supported by the United Nations University and the United Nations Environment Programme. The results of the Forum can be seen in the book "Asian International Waters: From Ganges-Brahmaputra to Mekong" (editors Asit K. Biswas and Tsuyoshi Hashimoto, Oxford University Press, 1996).

Following the Asian Water Forum, the Third World Centre for Water Management and IWRA decided to focus their activity on the GBM region, which contains a very large percentage of the world's poor. It was felt that water management could be the engine for

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This regional vision document is based on the three country papers for Bangladesh, India and Nepal included in this volume. Comments made and suggestions offered in the International Conference convened in Dhaka in December 1999 to review this document in particular, but also the country papers, have been taken into account in finalizing it. The country papers have also been similarly revised.

sustainable development of the GBM region. With this in mind the two institutions convened a Forum on the GBM region in Calcutta in early 1998. This Forum was supported by the United Nations University and the Dutch Government. Results of the Calcutta Forum has been published as a book by the United Nations University Press.

The participation in both the Bangkok and Calcutta Forums were by invitation only. Around 30 senior decision-makers, leading water experts and senior technocrats from the region, and representatives of major NGOs and international organizations participated in the Forum.

Following the Calcutta Forum, and extensive discussion in Bangladesh, India and Nepal, the Third World Centre for Water Management and IWRA invited Bangladesh Unnayan Parishad (BUP), Centre for Policy Research (CPR) of New Delhi, and Institute for Integrated Development Studies (IIDS) of Kathmandu to meet in Dhaka in March 1999 to prepare an outline for the sustainable development of the GBM region. This meeting was supported by the United Nations University.

Subsequently, BUP, CPR, and IIDS prepared the national studies, which were integral components of a holistic sustainable development framework for the region. Coordinated by the Third World Centre for Water Management and IWRA, the three national teams met in Kathmandu in November to review and integrate the national contributions. The preparation of the studies and the Kathmandu review meeting were supported by the Dutch Government.

The present document is the direct result of the Kathmandu meeting, the three national studies, and the review of the draft document in an International Conference held in Dhaka in December 1999. About 80 individuals were specially invited from the three countries and international organizations to review the framework document as well as the background papers. They included senior political figures and technocrats, leading water experts, and representatives of NGOs, the media, the public sector and international organizations, who participated in their personal capacities.

The GBM Region

The Ganges-Brahmaputra-Meghna (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 sq km - stretching 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, and Nepal only the Ganges, and Bhutan only the Brahmaputra. Growing at an average rate of about two percent per annum over the past decade, the estimated population of the GBM region has reached a level of about 600 million by 1999. India's shares in the population and the area of the GBM region are 76 and 63 percent respectively, while the corresponding shares of Bangladesh are 21 and 7 percent respectively. Nepal, whose almost entire territory is within the Ganges system, has an 8 percent share of the GBM area and 3.5 percent share of the GBM population. About 10 percent of the world's humanity lives in this region, which contains only 1.2 percent of the world's land mass.

The GBM region is characterized by endemic poverty - being home to about 40 percent of the total number of poor people residing in the developing world. The performance of the region in respect of such social indicators as economic growth, education, and health is disappointing in comparison to other regions of the world (Table 1). 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. Per capita GNP for Bangladesh, India, and Nepal is (as of 1998) US$350, US$430 and US$210 respectively; the corresponding global average is US$4,890. Adult illiteracy is still on massive scales in all the three countries, and is significantly higher compared to the average of 29 percent for all developing countries. 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. The global average is 4.8 percent of the GNP, while it is only 2.9, 3.4, and 2.8 percent in Bangladesh, India, and Nepal respectively.

Health indicators are also dismal in the region. In Bangladesh, India, and Nepal, annual average public expenditures on health (as percent of

GDP during 1990-1997) are only 1.2, 0.7 and 1.2 respectively, whereas the global average is 2.5 percent; and for the high income or developed countries it is about 6 percent. 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 past, only a limited proportion of the population, especially of those living in rural areas, has access to sanitation.

Nearly 45 percent 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. And, owing to rapid population growth, the per capita availability of arable land has steadily gone down over the past 20 years. 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) are 5.2, 3.0, and 6.5 percent respectively. These rates are much higher than those of Europe (0.5 percent), Latin America (2.3 percent), Australia (1.2 percent), the U.S.A. and Canada (1.2 percent), and Japan (0.4 percent). While the proportions of urban population in the three GBM countries are 20, 27, and 14 percent respectively, they are expected to rise to over 50 percent in the case of India and Bangladesh, and to about 22 percent in Nepal by 2025. This change in the spatial distribution and localization of population would have significant implications for water and energy demands.

In the energy sector, the GBM countries have a very low dependence on and utilization of commercial energy. Per capita energy use in the world is about 1,680 KgOE on average, while it is around 5,340 KgOE for high income countries. 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 integrated manner have never been sought by the regional countries due to past perceptional differences, legacy of mistrust, and lack of goodwill. The abundance of water in the GBM region as a shared resource is the principal driver of development for the millions of 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. The objective would be to enhance the quality of life through human development, environmental sustainability, and the evolving of efficient institutions of governance.

Table 1: GBM Region: Socio-economic Indicators

	Bangladesh	India	Nepal
Population (million)1998	128	987	24
Annual population growth rate: 1995-2000 (%)	1.9	1.8	2.5
Infant mortality rate (per 1,000 live births) 1997	75	71	83
Under-5 mortality rate (per 1,000 live births) 1997	104	88	117
Maternal mortality rate (per 100,000 live births) 1990-97	850	437	1,500
Access to safe water (% of population)1995	84[a]	85	59
Access to sanitation (% of population) 1995	35	29	20
Adult literacy rate (% of people 15 & above) 1997	50(M)[b] 27(F)	67(M) 39(F)	56 (M) 21(F)
Female (as % of labour force) 1998	42	32	40
Arable land (hectare per capita) 1994-96	0.07	0.17	0.13
Per capita commercial energy use: annual (KgOE) 1996	197	476	320
Per capita electricity consumption (KWh) 1996	97	347	39
Population below national poverty line (%), early 1990s[c]	48	37	43
Per capita GNP (US $) 1998	350	430	210

Notes: KgOE = Kilogram of oil equivalent
KWh = Kilowatt hours

a. Access to safe drinking water has since 1995 risen to 97 per cent in Bangladesh. But, recently, the success has become questionable as tubewell water, access to which is its basis, has been found to be widely contaminated with arsenic in Bangladesh.
b. The latest figure available for Bangladesh from the Bangladesh Ministry of Education is 58 percent (male and female combined).
c. The poverty estimates quoted here are from Martin Raviallion and Shaohua Chen, "What Can New Survey Data Tell Us About Recent Changes in Living Standards in Developing and Transitional Economies?", Poverty and Human Resources Division, World Bank, Washington, 1996.

Sources: (i) World Bank, Washington D.C., World Development Report 1999/2000; (ii) Human Development Centre, Islamabad, Human Development in South Asia 1999; and (iii) UNDP, New York, Human Development Report 1999. These sources differ in respect of certain figures: the main source used here is (i).

Water as Key to Prosperity

The GBM region is a water-rich region. Detailed hydrological data for the region are not available in published form, but the enormity of the water resource potential can be gauged in general terms. It is the singlemost important natural resource of the GBM regional countries, and it is widely recognized that water would be the most important vector of development towards shaping the future of millions of 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 - discharging into the Bay of Bengal. Compared to an annual average water availability of 269,000 cubic metres per square kilometre for the world, the availability in the GBM region is 771,400 cubic metres per square kilometre - which is nearly three times the world average. In addition to surface water, the GBM region has an annually replenishable ground water resource of about 230 BCM.

Water is abundant during the monsoon, but scarce during the dry season. Harnessing the bounty of the GBM rivers requires that the monsoon flows be stored and redistributed over space and time when and where required within a framework of sustainable development.

The real challenge is to utilize this resource in an integrated 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. At the advent of a new century and a new millennium, the vision concerning the development of the GBM countries should focus on options for collaborative harnessing of water resources of the region, and formulate a framework for multi-dimensional cooperation in related sectors such as energy, ecological health, flood management, water quality, navigation, and trade and commerce. Cooperation in developing the huge water resources of the GBM river systems is not a zero-sum game. Instead, all the regional partners can and should overcome the current mindset to construct the future scenarios on a win-win dispensation for all by working on all relevant perspectives, concerns, options, and trade-offs with the aim of achieving optimal benefits for all. In the absence of such a long-term vision, the GBM region would continue to stagnate, and millions of people would remain in a state of deprivation while other parts of the developing world march ahead towards prosperity. Water resources development can play a catalytic role in bringing about wider changes and promoting sustainable development in the GBM region.

Fortunately, a climate of goodwill and confidence has been created over the past few years through 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 acclaimed as landmark events, offering a window of opportunity for water-based collaborative development endeavours in the region. The time is, therefore, conducive for formulating a broad framework of regional cooperation among the GBM regional countries for the optimal, integrated development of the region. At the same time, one should not remain complacent and euphoric in the wake of these landmark treaties; it is necessary to strengthen the process through renewed commitments to a wider vision of sustainable regional development and commensurate collaborative efforts.

The Male (1997) and the Colombo (1998) SAARC Summit Declarations endorsed sub-regional cooperation within SAARC by accepting the idea of two or more countries collaborating in project-based cooperative activities within the SAARC framework. Therefore, the efforts of GBM countries to forge a common water-based development vision is consistent with SAARC principles. It may also be taken note of in this context that in the report of the SAARC Group of Eminent Persons, entitled *SAARC Vision beyond the Year 2000*, it has been envisioned that the enhancement of the quality of life and welfare of the peoples of South Asia should be pursued through "the creation of dynamic complementarities transcending national boundaries, development of managerial and productive capacity so as to exploit the internal and external economies of scale, resource complementarity and cost reduction."

The framework for sustainable development has many facets. Crucial elements are captured in the following definition that conceptualizes sustainable development as "*sustained improvements in the living conditions (welfare) of all citizens of a country in an environment (social, political, cultural, economic, and natural) characterized by equity, security, and freedom of choice.*"[1] All the invoked elements are pertinent to the vision of water-based integrated development of the GBM region. Entry through water should trigger wider development in the region. As opportunities unfold, emphasis will 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 is 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 resources.

Water Resource Utilization Issues

Floods, Riverbank Erosion, Sedimentation

The GBM countries are severely handicapped by recurrent floods, which cause damage to life, property, and infrastructure. It is the poor

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1 Q K Ahmad, *Economic Reforms, People's Participation and Development in Bangladesh*, The Asiatic Society of Bangladesh/Bangladesh Unnayan Parishad (BUP), Dhaka, July 1998, p. 5.

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 percent of annual rainfall occurring in four to five months of monsoon, often concentrated in heavy spells of several days.

In Nepal, the runoff generated by heavy precipitation cannot quickly drain out, often because of the high stage of the outfall river. Flooding in hill valleys occurs due to sudden cloudbursts which are localized in nature, but may be heavy for several days. In the higher mountains, floods induced by glaciers, i.e., Glacier Lake Outburst Floods (GLOF), are also experienced. The Nepalese *terai* region is prone to flash floods, which also produce spillover effects in northern India.

Floods have become an annual feature in the GBM plains of India. Of the total estimated floodprone area in India, about 68 percent 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 percent of the country is flooded, and up to about 80 percent 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 corollary 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 action during the high stage further accelerates the process. Riverbank erosion is manifested in channel shifting, the creation of new channels during floods, bank slumping due to undercutting, and local scour from turbulence caused by obstruction.

Riverbank erosion is responsible for the destruction of fertile agricultural lands, homesteads, and sometimes, entire clusters of villages.

The GBM rivers convey an enormous amount of sediment 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 biilion tons. Most of this sediment load passes through the country to 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.

Water Quality

In the past, the emphasis in water resource planning largely related to water supply or quantity rather than to quality. Meanwhile, water quality has progressively deteriorated due to increasing withdrawals for various uses, progressive industrialization, and insufficient stream flows to dilute the pollutants during lean flow periods. The increased use of agrochemicals and the discharge of untreated domestic sewage and industrial effluents into rivers have aggravated the problem. Given that water flows down the river systems and across countries and that there are interactions between surface and ground water, water pollution in the region has been spreading across water sources, rivers, and countries and has already reached alarming proportions.

In Nepal, water quality has deteriorated mainly due to industrial pollution. The volume of effluents generated by most industries is not large, but the concentration of pollutants is remarkably high. India had initiated an elaborate water quality monitoring programme under the "Ganga Action Plan" in late 1980s. This has recently been incorporated into a larger National Rivers Conservation Programme. In Bangladesh, the magnitude of water quality deterioration from the above mentioned causes is further compounded by salinity intrusion in the southwestern region. The reduced flow of the Ganges in the dry season, coupled with the silting of distributary mouths, has exacerbated the process of northward movement of the salinity front, thereby threatening the environmental health of the region. An additional problem is the detection of high concentrations of arsenic in the ground water in 59 of the 64 districts of Bangladesh and in some adjoining districts of West Bengal. Since the detection of arsenic and the recognition of the potential hazard of ingesting arsenic-contaminated water, water resource planners have realized that a radical shift in the strategy is necessary to ensure affordable safe domestic water supply.

Climate Change

The impact of climate change due to global warming on the water resources of Tropical Asia could be very significant. General Circulation Models have revealed that mean annual rainfall in the northeastern part of the South Asian subcontinent could increase with higher temperatures. The "best-estimate" scenarios for 2030 is that monsoon rainfall could increase by 10 to 15 percent. It is believed that increased evaporation (resulting from higher temperatures), in combination with regional changes in precipitation characteristics (e.g., total amount, spatial and seasonal variability, and frequency of extremes), has the potential to affect mean runoff, frequency, and intensity of floods and drought, soil moisture, and surface and ground water availability in the GBM countries.

Climate-change-related increases in temperatures could also increase the rate of snowmelt in the Himalayas and reduce the amount of snowfall if winter is shortened. In the event of climate change altering the rainfall pattern in the Himalayas, the impacts could be felt in the downstream countries, i.e., India (northern part) and Bangladesh. The impact of any change in the length of the monsoon also would be significant. If the monsoon is shortened, soil moisture deficits in some areas might get worse, while prolonged monsoons might cause frequent flooding and increase inundation depths. By and large, any change in the availability of water resources as a consequence of climate change could have a substantial effect on agriculture, fishery, navigation, industrial and domestic water supply, salinity control, and reservoir storage and operation. Besides, the anticipated sea-level rise in the Bay of Bengal would further compound the problem in Bangladesh through coastal submergence and enhanced drainage congestion in the floodplain.

Gender Dimension

The status of women in the GBM region has special significance with respect to water supply and sanitation because they are the principal managers of domestic water use and family health care. Women play a vital role as water collectors and water managers. It is the women who possess the knowledge of the location, dependability, and quality of the local water resources, and their indigenous knowledge of local water conditions is passed on to successive generations. Collecting water for the family is an arduous and tiring task, especially in the hilly and semi-arid regions, and not only adult women but also girl children are involved in this life of hard labour and drudgery. Women are also the worst sufferers due to floods.

Despite such a responsibility performed by women in relation to water, they enjoy little or no authority in decision-making in water management. The knowledge and perceptions of women can be gainfully utilized in planning the water distribution network, designing and locating the water pumps, and orgainzing community management of water supply facilities. The ultimate goal concerning the gender dimension in water management is to attain and ensure equitable participation of both men and women in the allocation and use of water.

Demand Management

A sustainable water management calls for 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.

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, and an appropriate regulatory framework - conditions which are lacking at present in the GBM regional countries. The second approach, which is more realistic and partly in operation in the region, is through a system of administered control which determines water allocation and pricing according to given or chosen social, economic, and environmental criteria. An administered system has the advantage of laying down the priorities concerning access to water resources, especially of the poor and underprivileged, involving the users in conservation and quality monitoring, and determining the changes or prices to be borne by different categories of users.

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 in respect of such components as legal and regulatory aspects, implementation of rules, accountability, and responsiveness to user needs.

Water sector planning is now 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 comes the steps to develop a nexus between public and private sectors in water development and management. Public sector water institutions have a poor record of cost recovery. The involvement of the private sector under the Build-Own-Operate (BOO) mode may help reduce public sector deficiencies, improve the level of governance, and attract investment in infrastructure.

Towards Formulating a GBM Regional Water Vision 2025

The enormity of the development potential of the huge water resources of the GBM region stands out in stark contrast to the region's socio-economic deprivation. It is a direct reminder for all of us to formulate a long-term vision in order to develop a sustainable framework for water utilization. It has been already alluded to in the preceding section that, owing to the seasonal availability of water in the Himalayan rivers, harnessing the resource requires that it be stored for meeting year-round demands. Run-of-the-river projects may produce valuable energy, but do not store water. Flood control benefits cannot also be ensured without storages. In principle, there is no conflict between small, medium, and large projects since each has its unique place depending on the discharge, valley traits, and other technical and socio-econo-environmental considerations. Storage reservoirs are custom-built, and each can be designed to meet specific parameters.

The terrain of the northern and middle belts of Nepal offer excellent sites for storage reservoirs. One study in Nepal, based on available information and past studies, has identified 28 potential reservoir sties in the country. 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 Brahmaputra Master Plan of India (1986) 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.

The potential sites, referred to above, 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 has a long gestation period.

High dams and other large water resource development programmes have encountered severe criticism and opposition in recent years on 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. At its extreme, the opposition to large projects is rooted in a subjective belief that they are like demons and wicked artifacts - a belief in which the long-term benefits of development and prosperity as well as potentials for transborder cooperation are ignored. Some environmental activists are so zealously opposed to large dams as to evoke a vision of perpetually stagnating pre-industrial society. The movement against large dams is obviously motivated by sympathy for the displaced population due to submergence. No one denies the rights of the displaced or affected people to appropriate rehabilitation and compensation packages or their right to claim and enjoy equitable shares of the accrued benefits. However, blind opposition to each large water development project demonstrates a subjective appraisal psyche and failure to appreciate 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 (PAPs). The key does not lie in doing nothing, but doing differently and wisely. Lessons learned from the past mistakes could serve as one of the 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. Careful and rigorous geological and geophysical investigations are now done prior to the siting and designing of high dams. Earthquake resistant high dams, in terms of both design and construction, especially rockfill dams, with greater strength against seismic forces, are now attainable.

Similarly, the socio-econo-environmental impacts of large dams and water projects must also be addressed adequately. 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 of the PAPs and mitigation of potential negative impacts on the environment. The basic rule for the resettlement and rehabilitation exercise is that the PAPs should preferably be better off after the project. As a compensation measure, "land for land" is not always realistic in the GBM region, where the population pressure on land has been rapidly increasing. Employment creation, capability 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 crucial focus as the means of rehabilitation of the PAPs. Resettlement and rehabilitation could also be accomplished in situ, i.e., above or near the submerged area, and the programme could be a part of a broader community and area development concept. It would relieve the PAPs from the cultural trauma of relocation in alien surroundings. Besides, 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. Large water resource projects could thus find their image transformed from apparent monsters to harbingers of economic growth, social change and improvement of the quality of life.

A long-term regional water vision for the GBM region should be built on the premise that the supply is likely to remain more or less finite, while the demand will continue to rise in the coming decades and centuries at a rapid pace. In order to develop a framework for water utilization as a transboundary challenge, it is essential for the GBM regional countries to identify sectors and issues in respect of which cooperative strategies and action plans can be formulated, using water as the focal take-off point.

A number of options and opportunities exist for 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 is now favourable for such cooperation, and the remaining road blocks should be cleared through 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. 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 valuable peaking power to the adjacent thermal-based load in India. The country's three-pronged approach to hydropower development envisages 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 percent 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 percent. 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. The lone hydel plant in the southeastern hills (Kaptai), which is outside the GBM catchment areas though, has an installed capacity of only 230 MW.

It is sometimes 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 are both socially and economically undesirable. Yet, the per capita electricity consumption in these countries is minuscule in comparison to countries like Canada, the U.S.A., 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 percent 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 percent in Nepal compared to 56 percent, 73 percent and 87 percent respectively in similar mountainous countries as Norway, Sweden, and Switzerland.

Hydropower has many advantages. It is clean and does not emit greenhouse gases. 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 amortisation of the initial capital expenditure. Above all, a hydropower generation plant can and usually does generate other benefits, and it fosters a development process through opening up remote and outback areas. In view of the likely financial constraints on the development of large projects, there is a clear need to promote private investment in the hydropower sector through joint ventures and foreign direct investment (FDI). 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 an integrated approach involving cooperation 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 spelt out reservoir operation and regulation instructions, will be beneficial in moderating floods in northern, eastern, and northeastern India (particularly 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. The co-riparians should agree on 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 could 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 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. It is likely that the Indo-Nepalese detailed project report of the High Dam will soon start moving forward. 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 potential of 4,000 MW. It is proposed that 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 12,000 cusec (340 cumec) 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) and a part could reach the Ganges at Farakka. This option still awaits full environmental assessment and Bhutan's concurrence.

The issue of augmentation has direct relationship with concerns for transboundary water sharing among the co-riparians. The Ganges

Treaty of 1996 calls 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 is the Teesta - especially because the lean season flows are inadequate to meet the requirements of both countries while each country has constructed a barrage on the river. Although some ad hoc sharing ratios were proposed earlier, it may be useful to examine seriously the option for Teesta augmentation as well as whether some arrangements could be arrived at 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 frame for the region.

Linked to the issues of water sharing, lean season water availability, and augmentation options is the state of ecological health of the rivers. Environment is now recognized as a 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. All future planning for water resource development needs to take special note of this aspect.

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 just 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 ground water quality is now a matter of serious concern. Water is essential to sustain agricultural growth and productivity; it is also more vital for life and healthy living. More than half the morbidity in the GBM region stems from the use of impure 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 "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.

Inland Navigation

The Ganges, the Brahmaputra, the Meghna and their principal tributaries had served as major arteries of trade and commerce for centuries. However, in recent years, their importance has diminished 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 Calcutta (India) and Mongla (Bangladesh) ports. Potentials exist 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 would improve navigability in these channels.

The Karnali (known as the Ghagra in India) has the maximum potential for navigation - all the way from the Indo-Nepalese border to the confluence with the Ganges. The Gandaki 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 Calcutta. 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 pilotage and navigation 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. In most instances of water resource development programmes at higher elevations, soil conservation practices are initiated as a follow-up step. This need not be so. Soil conservation and management programmes could be taken up independently in vulnerable sites as well as through integrating them in the environmental management plans for water-related interventions. Soil conservation strategies should be both rehabilitative and preventive, and could only succeed with people's participation in the whole process of strategy formulation and implementation.

In the context of the fragility of the Himalayan ecosystem and burgeoning population pressure on hilly slopes, an integral part of water resource planning should be to adopt rational land use and cropping patterns, including contour ploughing, in the upper catchments. Measures to conserve soil quality and improve the ecological health of the land might be highly desirable in the context of area development programmes in upland regions which tend to be neglected or are less accessible.

GBM Regional Water Vision 2025

The framework for sustainable development of the GBM region is based on a vision of poverty eradication and sustained improvement in the living conditions of the millions of its inhabitants. 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 bedevilled the relationship among the co-riparians for nearly half a century and compounded poverty and deprivation in the region. This pernicious mindset eroded goodwill and confidence, and generated 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 absence of an institutional framework like a river basins authority is another constraint in fostering meaningful regional water development cooperation. Even if it is considered that such an authority cannot be immediately established, it is of crucial importance that efforts to that end are initiated without further loss of time. The removal of the constraints, be they attitudinal or institutional, which have stymied regional cooperation for such a long time is a sine qua non for the implementation of a vision-based 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 towns by 2025), creating increased demands for safe water, sanitation, and waste management. Technological change - manifested through adoption/innovation of new products and techniques - will enrich human capability through skill development. The GBM region might profit from transferring water-related technology from industrialized countries as well as from within the region, especially concerning irrigation efficiency, pollution control, water storage, and disaster management. The contemporary process of globalization would be another driver in the region's long-term vision for sustainable development. Globalization is a term that evokes enthusiasm and provokes reactions because there are gains to be derived from it as well as risks of serious pitfalls. 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 (BaU) approach under the assumption of status quo and "do nothing" response strategy; this approach is unsustainable in the long run. 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. A profile of the vision elements and the associated output from the GBM regional perspective is outlined in Table 2.

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 into which the entry point is water but which then expands and embraces all possible directions as it gathers momentum. Clearly, the approach is holistic and multidisciplinary and it calls for congruence of macro, meso and micro policies within each country and their coordination across the regional countries.

Table 2: GBM Regional Water Vision 2025

Vision Elements	Expected Output
Enhanced quality of life	• Nutritional self-sufficiency and access to safe water and hygienic sanitation
Poverty reduction	• A large degree of empowerment of the poor and the disadvantaged through social sector activities, skill development, and social mobilization • Poverty ratio reduced to less than 10 percent
Enhanced participation in water management	• All stakeholders involved appropriately in water management, at different spaces • In particular, women's role in water management at all levels recognized and appropriately enhanced

(continued...)

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Reversal of environmental degradation	• Sustainable use of natural resources with emphasis on conservation and participatory management, in harmony with the economic development agenda
Enhanced private sector involvement in development financing	• Establishment of a conducive environment by the government facilitating private sector participation in water sector projects as well as in other sectors • Appropriate institutional and regulatory frameworks for effective public/private sector partnership • Accountability established all round
Maximum cross-border cooperation in flood management	• Establishment of a mechanism to ensure the flow/exchange of comprehensive data required with an adequate lead time for flood forecasting and warning
Improvement of water quality in the GBM rivers	• Water quality monitoring ensured in all major and medium sized rivers • Inter-country standardization of water quality parameters • Evolution of a mechanism for real time water quality data exchange between co-riparians
Sharing of all data related to water resource development	• All co-riparians would share/exchange with each other all data/information related to water resource development interventions in the region
Interconnected hydroelectricity grid	• With the development of the hydroelectric potentials of the Himalayan rivers, an interconnected energy grid established to ensure optimal use of clean energy throughout the region

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Dry season flow augmentation in the Ganges, and transboundary sharing of all common rivers	• All options - including storage reservoirs - examined and their technical, social, economic, and environmental costs assessed, and the viable ones materialized or in advanced stages of materialization towards addressing the problem of dry season water scarcity in the Ganges • Equitable agreements reached for the sharing of all common rivers, with full consideration given to the environmental needs of the river regimes
Development of storage potentials in the upper catchments	• A number of prioritized multipurpose projects developed with a view to producing hydroelectricity, moderating downstream floods, augmenting dry season flows, providing irrigation, and facilitating navigation • Displaced population from submerged areas fully rehabilitated
A GBM River Basins Authority	• A GBM regional river basins authority created to act as the water management steward for the region

GBM REGIONAL WATER VISION: BANGLADESH PERSPECTIVES

Q K Ahmad, Ahsan U Ahmed,
H R Khan and K B S Rasheed

The Country Context

Broad Physical and Socio-economic Characteristics

Bangladesh is a small country with a large population. Located in the northeastern part of the South Asian subcontinent, it is bordered by India on three sides - west, north and east, by Myanmar on the southeast and by the Bay of Bengal on the south. The total area of the country is 147,570 sq km, 6.7 percent of which consists of rivers and inland waterbodies. Some 88 percent of the country's total area belongs to the GBM region.

A critical problem faced by Bangladesh is the large size of its population. The population pressure on natural resources, including water, has contributed to their over-exploitation. However, the country has succeeded in significantly reducing the population growth rate over the years. In 1973, the total population was 74 million, increasing at a rate of 3.0 percent per annum. The population growth rate was down to 2.17 percent by 1991 and, currently, it is below 2 percent. But, in absolute terms, the population has increased by 52 million or more in 25 years since 1973. The national goal is to reach a zero population growth status by 2045. The estimated population of the country, as of 1999, is about 128 million with a population density of about 860 persons per sq km. Despite steadily declining fertility as a result of intensified population control efforts, the country's population is expected to exceed 176 million by 2025, when the population density will rise to about 1,200 persons per sq km. The effects of population growth will continue to be most severely felt in the urban sector, where the growth rate during the past two decades has been between 5 and 6 percent per annum and is likely to be similar for many years in the future. Currently, the urban population accounts for about 20 percent of the total national population; and the proportion is expected to rise to 53 percent by 2025. (Figure 1.)

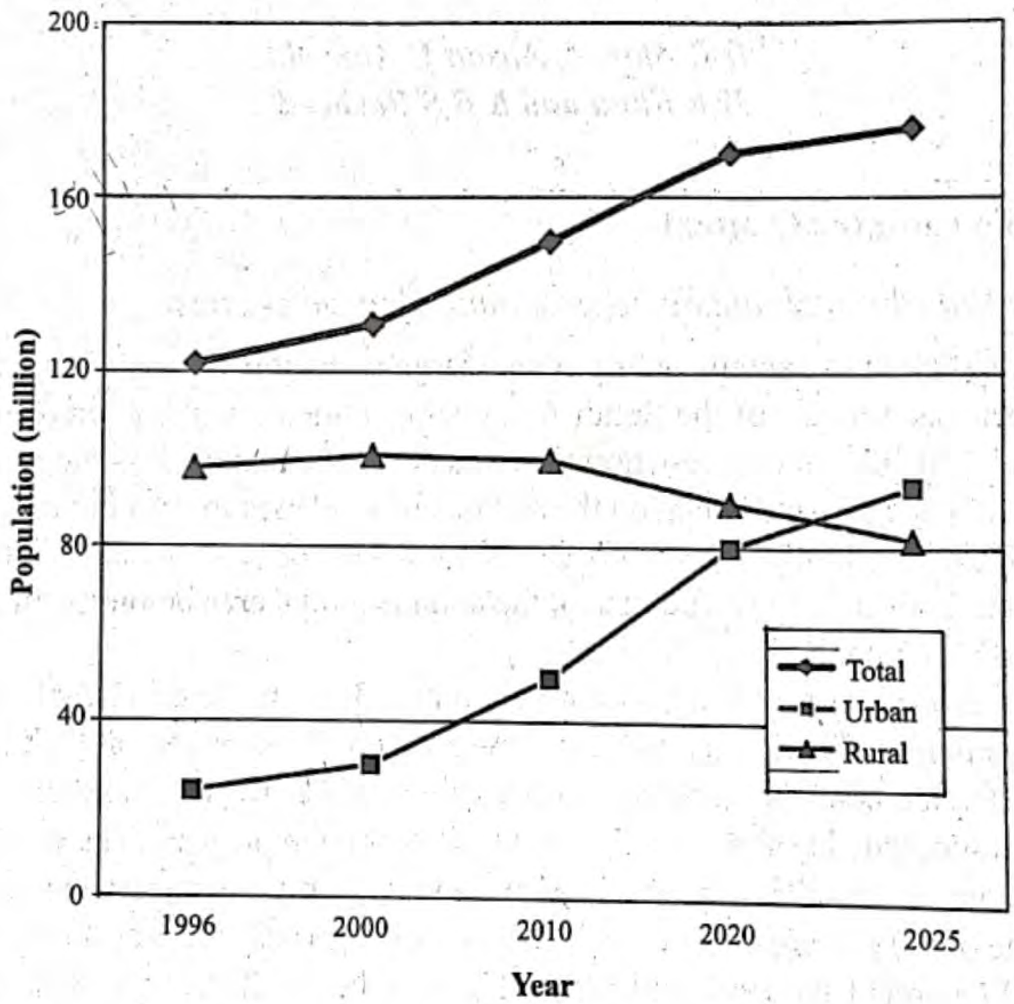

Figure 1: Population Projection for Bangladesh up to the Year 2025.

Bangladesh has three broad types of land: floodplains (80 percent), terraces (8 percent), and hills (12 per cent). The precipitation is dominated by monsoonal characteristics. The average annual rainfall varies from 1,200 mm in the extreme west to over 5,000 mm in the northeast, with 80 percent of the rainfall concentrated in the monsoon months: June - October.

Bangladesh is predominantly an agrarian society. Nearly 75 percent of the population is directly or indirectly dependent on agriculture, although this sector contributes only about 30 percent to the national GDP. Agriculture is still the main user of water, and its share in water demand will further increase concurrently with efforts to attain food security. Land is the most basic resource in Bangladesh, being the main factor in crop production. The country has about 8.74 million hectares of cultivated land, which is about two-thirds of the total area. Of the net cultivable area, 33.3 percent is single cropped, 45.0 percent double cropped, 11.5 percent triple cropped, and 10.2 percent cultivable waste and currently fallow. The overall cropping intensity is 176 percent. The three cropping seasons approximately coincide with the three meteorological seasons: *Kharif* I (pre-monsoon), *Kharif* II (monsoon) and *Rabi* (winter or dry). *Aus*, *aman* and *boro* are the three rice varieties grown respectively in these three cropping seasons. The crop calendar (grain-based) is presented in relation to temporal distribution of rainfall and temperature in Figure 2. *Aman* is the leading rice crop, occupying about 56 percent of the total area under rice, followed by *boro* (27 percent), and *aus* (17 percent). A notable aspect of the pattern of growth in crop agriculture during the past two decades has been the increasing area covered by dry season HYV *boro* rice - a trend that is likely to continue.

As a result of growing landlessness and lack of employment opportunities in the rural areas, pauperization has increased and there has been a steady stream of rural to urban migration. Because of lack of access to resources and income earning opportunities, a large number of people, 60 million or more, are in a continuous state of food vulnerability, about 30 million critically so. A World Bank assessment based on the 1995-96 Household Expenditure Survey found 53 percent of the country's population to be poor (below minimum calorie intake). The Bangladesh Bureau of Statistics (BBS) estimates the food poverty ratio to be relatively lower at 48 percent as of 1995/96. Poverty

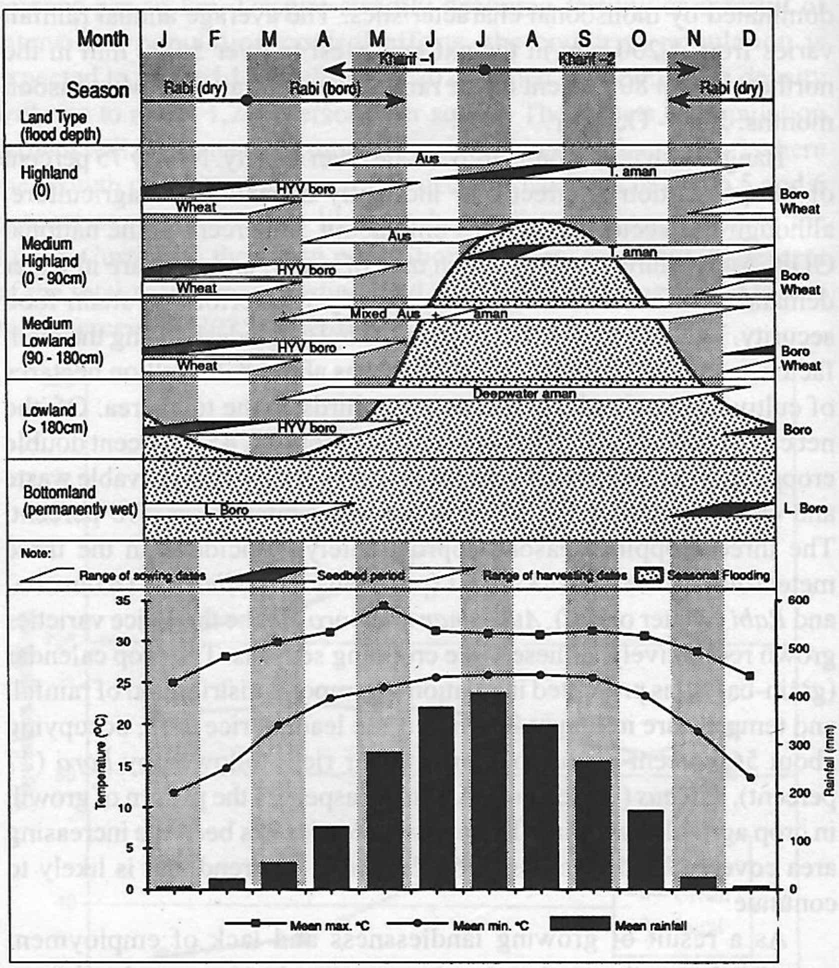

Figure 2 : Crop Calendar in relation to Seasonal Flooding, Rainfall and Temperature.

alleviation efforts, therefore, constitute a major thrust in the country's development agenda. But, the impact remains limited and poverty persists at a high level as just indicated. In fact, despite various anti-poverty programmes being implemented by various government agencies and non-governmental organizations, socio-economic inequality, which is the main cause of poverty, not only remains high but has been accentuating further in the wake of the free-market-based development strategy, pursued in the country since the 1980s. Other countries of the region are also pursuing similar development strategies, in keeping with the trend around the globe. There is, therefore, scope for the regional countries to learn from one another and to work together to modify their development strategies to suit the realities prevailing in the particular countries, so that accelerated growth and commensurate poverty alleviation can be achieved simultaneously and on a sustained basis.

The overwhelming majority of women in Bangladesh are not only poor, but are also heavily disadvantaged compared to men in terms of social, political, and legal status. Traditionally, socio-cultural norms have limited their access to education, skill training, health care, and employment. Only in recent times, the socio-economic status of women can be seen to be slowly changing, though gender equality is still a distant goal.

Bangladesh shares these socio-economic characteristics with other countries of the GBM region, and the GBM Water Vision, therefore, has to be shaped and advanced in the context of the overall regional development goal of poverty alleviation, sustainable development, and social progress.

Water Ecosystem

The water ecosystem of Bangladesh comprises the tributaries and distributaries of three major river systems: the Ganges, the Brahmaputra, and the Meghna; and numerous perennial and seasonal wetlands like *haors*, *baors* and *beels*. All the three major river systems originate outside the country. In fact, out of some 230 rivers in the country, 57 are transboundary rivers - 54 coming from India and 3 from Myanmar. A map of Bangladesh showing the major rivers is presented in Figure 3.

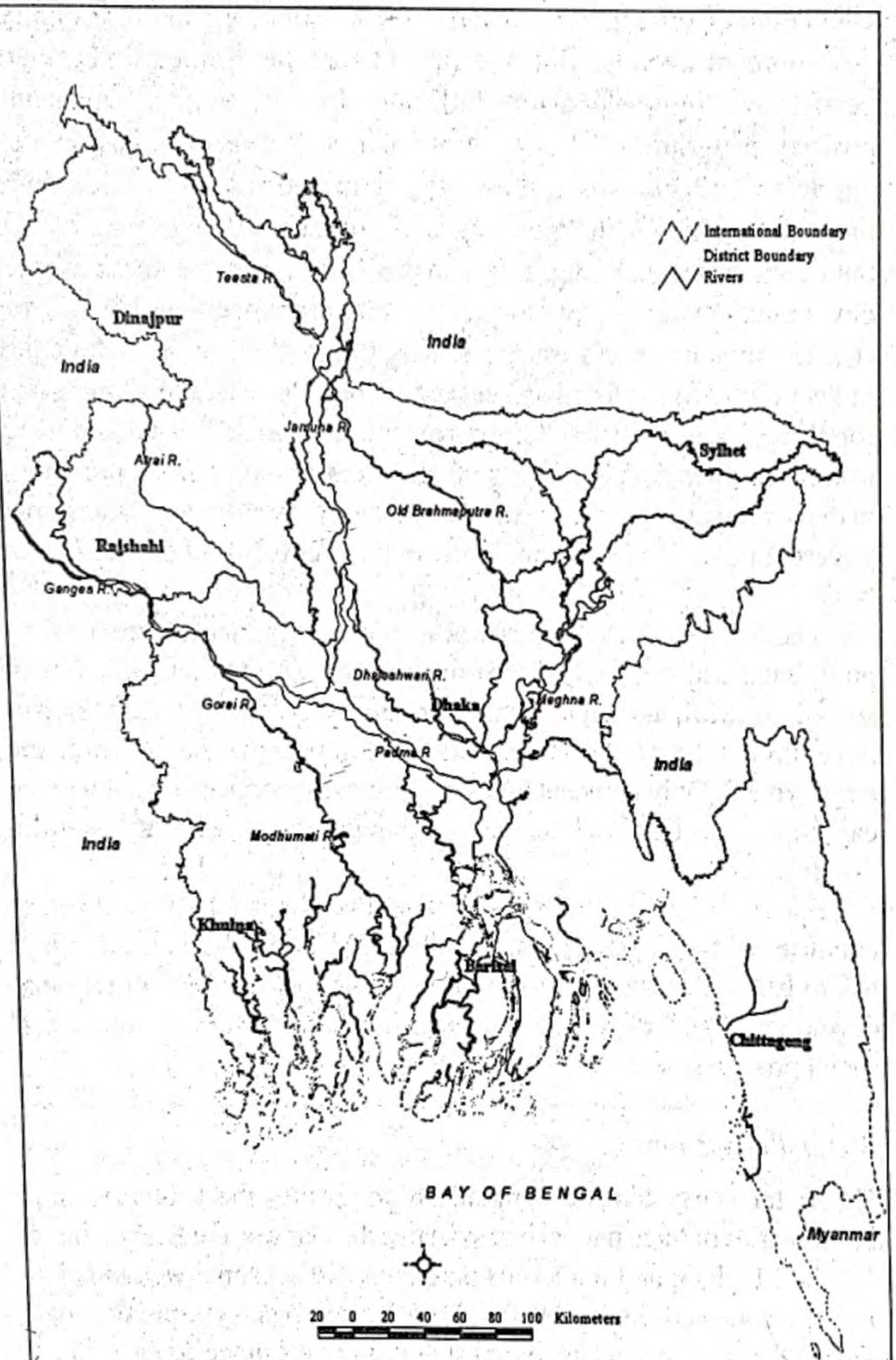

Figure 3 : Map of Bangladesh Highlighting the River Systems.

The hydrographs of the main rivers are characterized by monsoonal features as well. The peak discharges are reached in July or August, the lowest in March/April. The range between high flow and low flow is significant: the average flood flow of the Brahmaputra reaches 20 times and that of the Ganges up to 30 times of the respective dry season flows. In spite of the significantly smaller catchment area, the Meghna, too, reaches remarkable discharge figures in the monsoon.

The following particular hydrological features result from the unique geographical situation of Bangladesh.

- About 7 percent of the catchment areas of the Ganges, the Brahmaputra and the Meghna are located within Bangladesh, 64 percent in India, 18 percent in China, 8 percent in Nepal, and 3 percent in Bhutan.
- Of the total annual stream flows in Bangladesh - 85 percent occurring between June and October - about 67 percent is contributed by the Brahmaputra, 18 percent by the Ganges, and about 15 percent by the Meghna and other minor rivers. About 93 percent of the annual flows of the river systems originate outside the country.
- The annual volume of surface water in Bangladesh would form a lake of the size of the country having a depth of 10.2 meters.
- Bangladesh has to drain water from an area which is 12 times its size.
- One-third of the area of Bangladesh is influenced by the tides in the Bay of Bengal.

Water Resource Development Issues in Bangladesh

National Water Planning

Water resource planning and management must take into account the dual problem of flooding and water shortage along with the competitive demands of various water using sectors including agriculture, domestic purposes, fisheries, industry, navigation, and environment. National water planning in Bangladesh dates back to 1964 when a 20-year Master Plan was prepared with emphasis on large-scale flood control, drainage and/or irrigation projects. The World Bank conducted a land and water sector study in 1972, which advocated small and medium-scale projects through minor irrigation technology. In 1983, the government initiated a National Water Plan (NWP) preparation exercise, which was completed in 1986, and later updated in 1991. After the devastating floods of 1987 and 1988, a five-year (1990-95) Flood Action Plan (FAP) was launched with focus on flood mitigation. The FAP comprised regional planning studies, project preparation studies, supporting studies, data collection and analysis, and pilot projects. Although flood control and drainage (FCD) rather than integrated water management was the dominant theme, its scope was more comprehensive than national water planning exercises preceding it. Attention was paid to urban FCD and non-structural flood proofing, though agriculture remained the main focus of regional plans. Detailed guidelines for Project Assessment, Environmental Impact Assessment, and Social Impact Assessment were produced. Despite changes in water sector policy and strategy since the FAP formulation, its regional plans provide a useful basis for integrated water resource planning at the regional level and as inputs for national planning. However, the FAP has faced a range of criticisms from a number of experts, which relate to (a) technical solutions proposed by FAP; (b) coordination problem between different components of FAP; and (c) flaws in disseminating knowledge acquired by FAP studies. Following a FAP recommendation, the preparation of a comprehensive National Water Management Plan (NWMP) was initiated in March 1998, and the plan (to the year 2025) is expected to be completed by September 2001.

The NWMP will produce a Water Sector Development Strategy for the next 25 years, formulated in accordance with the National Water Policy which was adopted in January 1999 and other related government policies. Based on these strategies, a Water Sector Development Programme will be formulated with a short-term action plan of activities and projects for the period to 2005, and a long-term investment programme for the period to 2025.

National Water Policy

The National Water Policy adopted in early 1999 lays down the broad principles of development and rational utilization of water resources.

It provides directions for all agencies working in the water sector and institutions that relate to the water sector in one form or another for the achievement of specified objectives. Broadly these objectives are:

- to address issues related to the harnessing and development of all forms of surface water and groundwater and management of these resources in an efficient and equitable manner;
- to ensure the availability of water to all elements of the society including the poor and the underprivileged, and to take into account the particular needs of women and children;
- to accelerate the development of sustainable public and private water delivery systems with appropriate legal and financial measures and incentives, including delineation of water rights and water pricing;
- to bring institutional changes that will help decentralize the management of water resources and enhance the role of women in water management; and
- to develop a state of knowledge and capability that will enable the country to design future water resources management plans by itself with economic efficiency, gender equity, social justice and environmental awareness in order to facilitate achievement of the water management objectives through broad public participation.

The National Water Policy will be reviewed periodically and revised as necessary.

Problems of Water Resource Development

The critical physical/natural problems that Bangladesh will encounter in developing a water management strategy are flooding, riverbank erosion, sedimentation/siltation, water scarcity and salinity management.

FLOODS

Floods are a recurring phenomenon in Bangladesh. Even in a normal year, 20-30 percent of the country is flooded. About 60 percent of the country is submerged by a flood of about 100-year return period

(Table 1). Up to 80 percent of the country is considered flood-prone. The coverage, intensity, and timing of floods vary from one part of the country to another and from one year to another.

Table 1: Areas Affected by Flooding

Return period (in years)	Affected areas (% of the country)
2	20
5	30
10	37
20	43
50	52
100	around 60
500	around 70
Mean	22

Source: WB, 1989.

Flooding in Bangladesh is the result of a complex series of factors. These include a huge inflow of water from upstream catchment areas coinciding with heavy monsoon rainfall in the country, a low floodplain gradient, congested drainage channels, the major rivers converging inside Bangladesh, tides and storm surges in coastal areas, and polders that increase the intensity of floodwater outside protected areas. Different combinations of these various factors give rise to different types of flooding.

Normally floods begin with flash floods in the hilly areas during the pre-monsoon months of April and May. The monsoon generally arrives in June. The Meghna and the Brahmaputra tend to reach their peaks during July and August; the Ganges usually reaches its peak in August and September. Severe flooding occurs if the peaks of the Ganges and the Brahmaputra coincide.

There are five land categories affected by floods (Table 2). Land type FO is not flooded, whereas land type F4 is flooded for more than nine months of the year with a maximum flood depth of more than 1.8 meters. About 6 million hectares of cultivable land are affected by floods. Of this about 3.3 million hectares are subjected to flood depth of 30 to 90 centimeters. An area of about 0.076 million hectares has a flood depth of more than 1.8 meters, which remains under water for more than nine months in a year. During catastrophic floods about two-thirds of the country may be affected simultaneously.

Table 2 : Land Types Based on Flood Depth

Land type	Description	Flood depth	Nature of flooding
FO	Highland	Not flooded	Intermittent or flooded up to 30 cm
F1	Medium	30 to 90 cm highland	Seasonal
F2	Medium	90 to 180 cm lowland	Seasonal
F3	Lowland	Over 180 cm	Seasonal (<9 months)
F4	Lowland/ very lowland	Over 180 cm	Seasonal (>9 months) or perennial

Source: MPO, 1986.

Four main types of natural floods occur in Bangladesh: flash floods, river floods, rainwater floods, and storm surges. Flash floods rise and fall rapidly, usually within a few days. They are caused by run-off during exceptionally heavy rainfall occurring in neighboring upland areas. They occur most frequently - sometimes several times a year - at the foot of the northern and eastern hills of Bangladesh. The spatial distribution of different types of floods in Bangladesh is presented in Figure 4.

Flash floods in Bangladesh cause extensive damages to crops and property. For crops, it is their timing which is usually most important. Early floods (in April-May) generally cause severe damages: damages to *boro* rice are reported in some part or other of the eastern foothill regions virtually every year. Damages to property - especially road and railway embankments and bridges, and buildings alongside river channels - occur during exceptionally high flash floods. Flood embankments along some eastern rivers, especially the Khowai, are breached by floods almost every year. Cultivated land and land adjoining foothill streams sometimes get buried under sand.

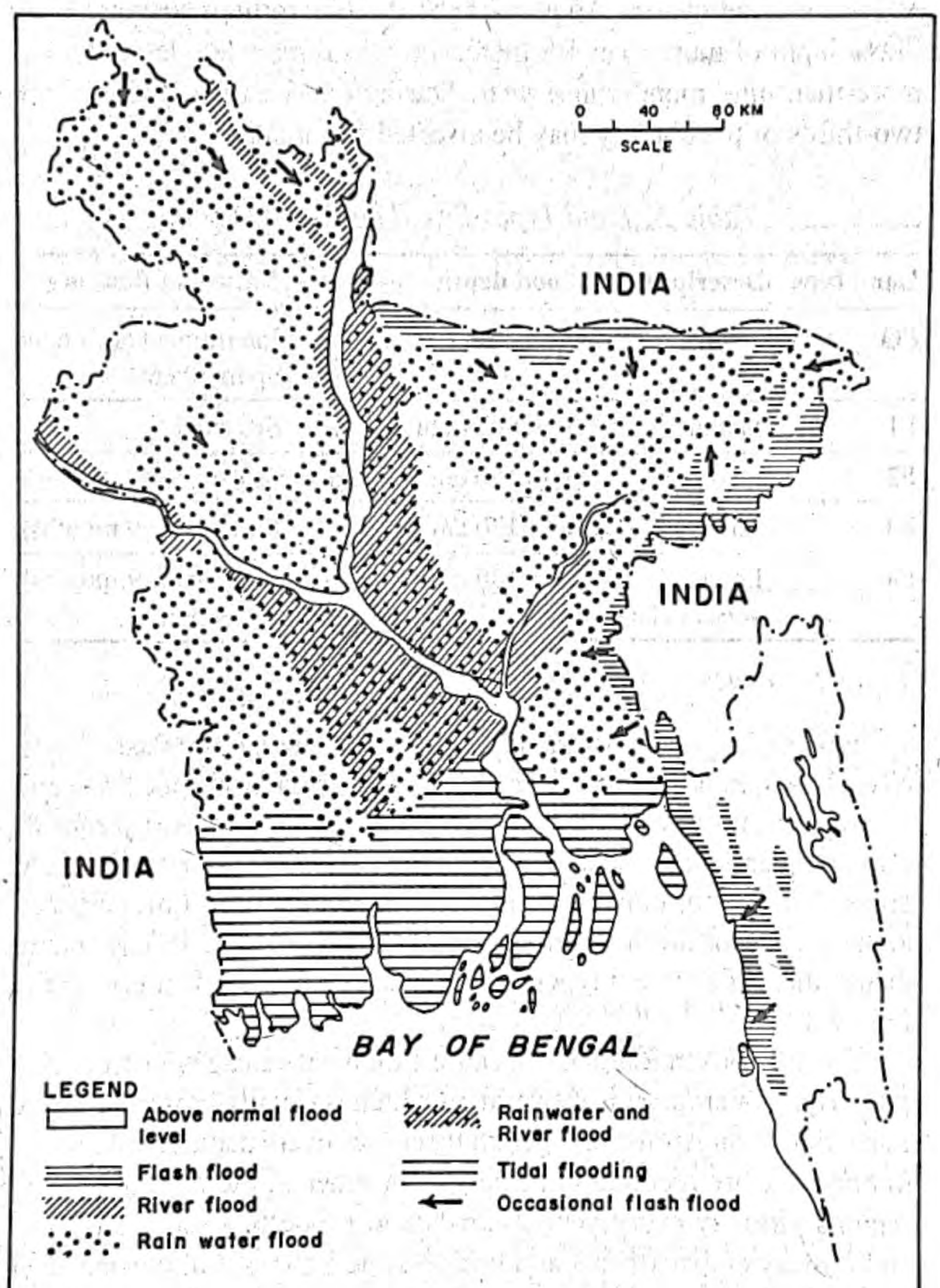

Figure 4 : Spatial Distribution of Different Types of Floods in Bangladesh.

River floods result from snow-melt in the high Himalayas and heavy monsoon rainfall over the Himalayas, the Assam Hills, the Tripura Hills and the upper Brahmaputra and Ganges floodplains outside Bangladesh. They particularly affect active river floodplains. In years when river levels rise earlier or higher than 'normal', river water also extends to varying distances over neighboring river meander floodplains that are normally flooded by rainwater.

At an average interval of about 3-4 years, river floods extend beyond the active floodplains and damage crops in parts of the adjoining meander floodplains, mainly alongside distributary channels. The timing of the flood (whether early or late) and sometimes the duration of flooding are as important determinants of crop damage as is the absolute height reached by a particular flood. Sediments deposited in channels reduce the drainage capacity of minor rivers, road and railway bridges and culverts, as well as irrigation and drainage canals. Severe floods, which cause extensive damages to crops and some damage to property, especially roads, occur at intervals of about 7-10 years. Catastrophic floods, occurring at intervals of 20-50 years or more, almost totally destroy crops in adjoining floodplains, and also cause considerable damages to houses, roads and other infrastructure. The 1988 and 1998 floods are rated as 50-100 year events. But as a consequence of climate change now occurring, the return period of such floods may become much shorter in future. The damages caused by the 1998 flood are summarized in Table 3. The areal extent of the catastrophic flood in 1998, as observed from a satellite, is shown in Figure 5.

Rainwater floods are caused by heavy rainfall occurring over floodplain and terrace areas within Bangladesh. Heavy pre-monsoon rainfall (April-May) causes local run-off to accumulate in floodplain depressions and in the lower parts of valleys within the Madhupur Tract. Later (June-August), local rainwater is increasingly ponded on the land by the rising water levels in adjoining rivers. Thus, the extent and depth of rainwater flooding vary within the rainy season and from year to year, depending on the amount and intensity of local rainfall and on contemporary water levels in the major rivers which control drainage from the land.

Table 3 : The 1998 Flood: Extent and Damages

Extent/damage	**Number, unless otherwise indicated**
Area affected	68 percent of the land area of the country
Number of districts affected	52 out of 64
Number of upazilas affected	314 out of 460
Paved roads affected	15,000 km
Embankments affected	2,000 km
Cropland affected	1.56 million ha
Houses affected	550,000
Tubewells in rural areas affected	300,000
Tubewells in urban areas affected	2,225
Bridges and culverts affected	20,500
Educational institutions affected	24,000
Industrial units affected	11,000
Deaths caused	About 1,000

Source: Local Government Engineering Department (LGED), Dhaka.

Rainwater flooding is characteristic of meander floodplains, major floodplain basins, and old piedmont and estuarine floodplains. The interior parts of tidal and young estuarine floodplains are also flooded mainly by rainwater. The severe 1987 flood in northwestern parts of Bangladesh was mainly caused by excessive rainfall occurring over the north of the area almost throughout the monsoon; but it was aggravated at times by flash floods passing down the Teesta and other rivers entering from the northwest, and by high levels in the Jamuna and the Ganges rivers.

The southwestern parts of the country are flooded by tidal water (where they are not empoldered). Tidal water is mainly fresh in the monsoon months; flooding within polders is by rainwater. Flood damage occurs occasionally at high spring tides, especially if the water is saline.

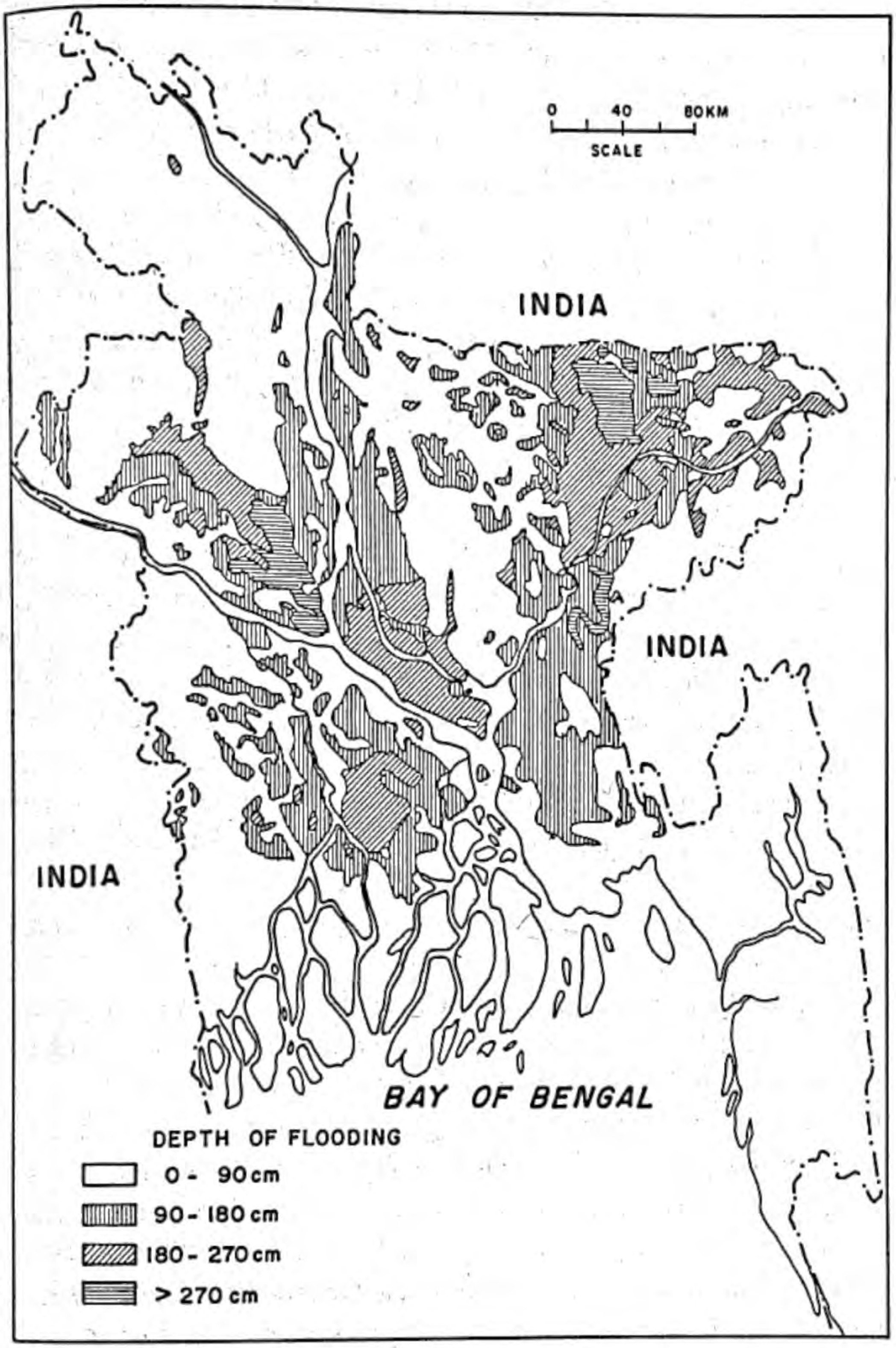

Figure 5 : The Areal Extent of the Catastrophic Flood of 1998 in Bangladesh.

Storm surges refer to onrush of water of high amplitudes, caused by a combination of low barometric pressure and strong onshore winds associated with tropical cyclones. They cause sudden, but temporary, flooding of coastal areas with sea-water or brackish estuarine water for a few kilometers inland during the passage of cyclones, and are responsible for most of the casualties caused by cyclones. Exceptionally, as in May 1965, storm surges extend along the Meghna estuary as far inland as the south of the Sylhet Basin, flooding adjoining land with non-saline river water. Surges of high amplitude during the November 1970 cyclone wrought widespread devastation in the coastal zones, causing loss of more than 300,000 lives.

RIVERBANK EROSION

Most of the rivers of Bangladesh flow through unconsolidated sediments of the Ganges-Brahmaputra-Meghna floodplain and delta. The riverbanks are susceptible to erosion by river current and wave action. River erosion includes channel shifting, the creation of new channels during floods, bank slumping due to undercutting, and local scour from turbulence caused by obstruction. The Brahmaputra, Ganges, Meghna, Teesta, and Surma-Kushiyara rivers flow within well-defined meander belts on extensive floodplains where erosion is heavy. Sudden changes are common during floods that cause rapid bank erosion. In lower deltaic areas, river bank erosion is caused by tidal currents and storm surges from the sea.

The Brahmaputra-Jamuna has changed course completely after 1762. This is a highly braided river, has steadily migrated westward in recent years, eroding the old floodplain and creating new sections of floodplain on its east bank. The Ganges, with larger areas of resistant clay on its older floodplain, is more stable than the Brahmaputra. The Bangladesh Water Development Board (BWDB) has estimated that about 1,200 kilometers of riverbank is actively eroding and more than 500 kilometers face severe problems related to erosion. Satellite-image studies of the Ganges-Brahmaputra-Meghna rivers show that an area of 106,300 hectares was lost due to erosion between 1982 and 1992, while the accretion amounted to only 19,300 hectares. The net area of 87,000 hectares lost, most of it agricultural land, is equivalent to an annual erosion rate of 8,700 hectares. Erosion of border riverbanks is serious because it can cause loss of land to neighbouring countries.

SEDIMENTATION

Bangladesh is the outlet of all the major upstream rivers and the average annual sediment load that passes through the country to the Bay of Bengal ranges between 0.5 billion to 1.8 billion tons. All rivers in Bangladesh are alluvial and highly unstable. Alluvial channel beds consist primarily of deposited sediment that originated upstream. Constant interactions occur within the suspended sediment load of the channel, leading to significant changes in channel geometry. A part of the sediment load is deposited on the floodplain, gradually changing its topography and often severely reducing the water conveyance capacity and navigability of the drainage channels.

Sediment rating curves developed by the Master Plan Organization (MPO) for its National Water Plan, Phase I (1980) and Phase II (1991), indicated an increase in sediment load in the Ganges and the Brahmaputra between the two periods. There was a sediment discharge increase of 16 percent at Bahadurabad (Brahmaputra) and 46 percent at Hardinge Bridge (Ganges). Not all of the sediment that flows into the country travels down to the Bay of Bengal; a part is deposited within the channels. The consequence is progressive siltation and decrease of channel depth, thereby increasing the vulnerability of the alluvial plain to floods.

SALINITY MANAGEMENT

Salinity is a major problem in Bangladesh. The coastal zone directly affected by salinity is extensive and is inhabited by a large population. The zone includes major urban centres of Khulna and Chittagong (the latter is, however, outside of, but adjacent to, the GBM region).

All the rivers of Bangladesh, except for those in Chittagong in the extreme southeast, combine to form a single, broad, and complex estuary. The greatly diminished flow in the dry season allows salinity to penetrate far inland through this estuarine river system. Salinity limits opportunities for supplemental irrigation of *aus* crops in freshwater areas and damages the same crops by flooding during very high tides.

The upland progression of saline water during the dry season eliminated surface water potentials for significant land areas in the southwest, south-central, and southeast regions.

Fresh groundwater for human and industrial consumption is also affected by salinity. The shallow coastal aquifers in fact have high salinity. Therefore, water supply wells must penetrate 250 meters or more to find water of acceptable quality. The recharge zones of these deep coastal aquifers are located away from coastal zones in Jessore, Kushtia, Faridpur, and Comilla areas and perhaps further north. Activities which decrease recharge in these upland areas, such as flood prevention, will affect the dynamic balance within these aquifers between the salt water interface, withdrawals, and recharge.

Environmental degradation caused by salinity intrusion is a major problem in southwestern Bangladesh. The reduced flow of the Ganges in the dry season has exacerbated the process of northward movement of the salinity front, thereby threatening the environmental health of the region..

Water Availability and Demand

The natural surface water resources in Bangladesh are mainly obtainable from the country's dense network of river systems, which include a combination of upstream inflows and runoff generated from rainfall within the country. The NWP Phase I (1986) and Phase II (1991) did extensive studies to assess the available water resources in Bangladesh by using a number of mathematical and simulation models. Preliminary estimates indicate that cross-border annual flows into the country amount to around 1,010 billion cubic meters (BCM), and an additional amount of 340 BCM is generated from local rainfall, averaging 2,300 mm. Of this total quantum of available water (1,350 BCM), about 190 BCM of water is lost in the atmosphere through evaporation and evapo-transpiration, while the balance of 1,160 BCM is available for use or flows into the Bay of Bengal. Eighty per cent of this huge flow of water, as pointed out earlier, is concentrated in the five-month monsoon period of June to October.

Streamflows are only a part of the surface water availability, and a complete picture, incorporating surface inflows, rainfall, evapo-transpiration, percolation to underground aquifers, diversion for irrigation and other consumptive uses, can only be obtained through hydrologic simulation in a water balance model. The model used in the NWP 1991 showed the minimum dry season water availability as 3,710 million cubic meters in March, and the maximum availability in August as 111,250 million cubic meters.

The quaternary alluvium of Bangladesh constitutes a huge aquifer with reasonably good transmission and storage properties. Heavy rainfall and annual inundation help the groundwater to be substantially recharged annually. The first assessment of groundwater was made in 1984. Subsequently, the MPO made three estimates in 1991: potential, usable, and available recharge. These estimates suggested that the available recharge of groundwater was 21 BCM. More recently, the National Minor Irrigation Development Project (NMIDP) developed models to forecast growth in minor irrigation through groundwater, using less conservative assumptions from recharge than under the NWP. It acknowledges, however, that information on groundwater is still inadequate to make reliable projections beyond the next 10-15 years.

A correct picture of water availability can only be obtained through an understanding of conjunctive water use planning. In Bangladesh, six sectors are the major users of water, viz., agriculture (for irrigation), domestic or municipal, fisheries, navigation, industry, and environment (including salinity control). The National Water Plan of 1991 took into consideration the water demands of all these sectors. However, the plan did not attempt to make reliable estimates of water demand other than for agriculture and domestic uses. Demands for navigation, fisheries and salinity control - which are difficult to estimate in quantitative terms - were grouped into a single category.

The 1991 plan projected a water demand for all purposes (domestic, irrigation, fisheries, navigation, industrial, and salinity control) for the year 2018 at 24,370 million cubic meters during the critical dry month of March. The supply from regional and domestic sources in terms of both surface and ground water for March 2018 was estimated at 23,490 million cubic meters - producing a shortfall of 880 million cubic meters. In terms of specific sectoral demands, agriculture accounts for 58.6 percent; navigation, salinity and fisheries for 40.7 percent; and domestic and industrial uses for 0.7 percent. The NWMP is expected to make more detailed estimates of projected demand and supply of water for the year 2025 (as of March). Projected supply for this time frame might not be too different from that for 2018, while the projected demand will surely be higher on account of population increase and economic growth. However, the rate of increase in demand is expected to show a declining trend in response to improved water use efficiency, conservation, and recycling.

Despite the expected decline in the rate of increase in demand, the increase in the absolute size of the population over the next 25 years will progressively reduce per capita water availability in Bangladesh. With a total quantum of 1,350 BCM water available annually, the annual per capita water availability in 1991 was 12,162 cubic metres. It will decline - as population increases - to 10,305 cubic metres in 2000, and to 7,670 cubic metres by 2025 (Table 4, Figure 6). The real picture, however, will be more sombre because the available supply will be much less in the dry months, while demand for irrigation will continue to rise.

Table 4 : Population Growth and Annual Per Capita Water Availability

Year	**Population (million)**	**Per capita water availability (annual) m^3**
1991	111	12,162
2000	131	10,305
2010	150	9,000
2020	170	7,941
2025	176	7,670

Source: Study Team estimates.

A sustainable water management goal requires a demand-side approach that is comprehensive, cost-effective, market oriented, and participatory. The more realistic approach for Bangladesh is water

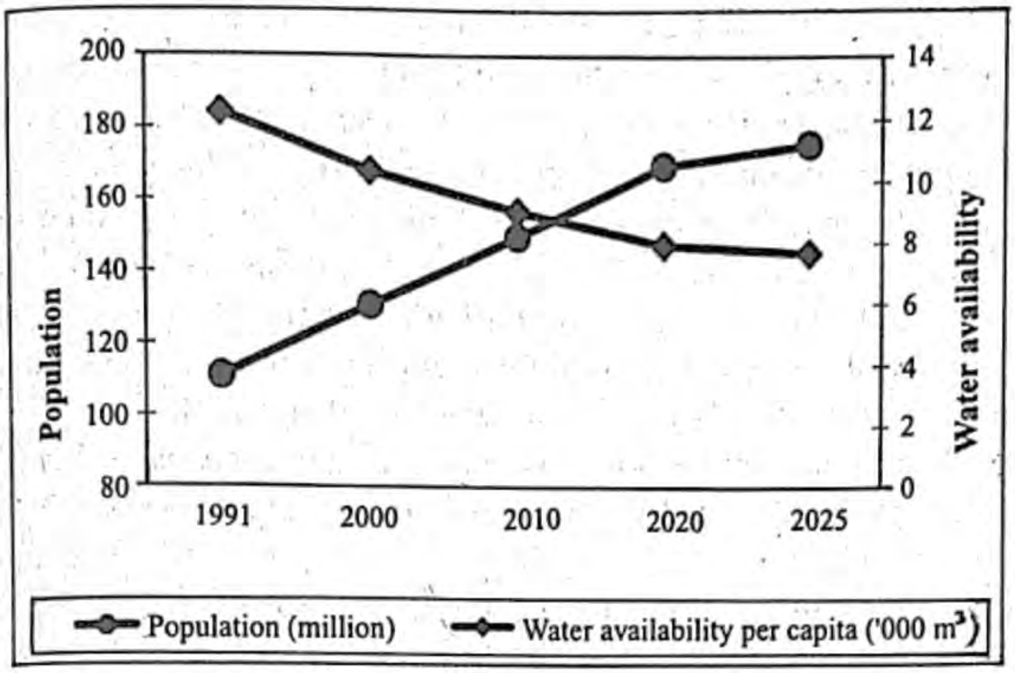

Figure 6 : Decrease in Per Capita Annual Water Availability with Time.

management through an administered arrangement that determines water pricing and allocation (for different types of users) and also facilitates evolution of a water market with measures in place to safeguard the interests of the poor and underprivileged.

Climate Change Impact

Global warming and the resultant climate change could have profound effects on the water resources of Bangladesh (both surface and ground water). General Circulation Models have revealed that the mean annual rainfall in and around Bangladesh could increase with global warming. The 'best-estimate' scenario for the year 2030 is that monsoon rainfall could increase by 10 to 15 percent. This would be reflected in the flow regimes of the rivers of Bangladesh. Increased flooding and drainage congestion, therefore, are the expected consequences of increased rainfall from a warmer and wetter condition. The increased runoff would also aggravate the existing drainage problems and create new ones.

The changes in the height and timing of peak flood levels due to increased rainfall could have far reaching impacts on crop production. In fact, increased flooding would alter the relative proportions of the different land types based on flood depths, viz., FO, F1, F2, F3 and F4. The implication is that the proportion of FO (highland) would decrease, while the other land types (F1 to F4) would increase through a cascading effect of re-categorization of land types of different flood depths.

Aside from the increased run-off due to an increase in monsoon rainfall, the phenomenon of sea-level rise in the Bay of Bengal as a result of global warming would further compound the problem. The rise in sea level would impede the drainage of the additional runoff and exacerbate flood vulnerability in inland Bangladesh.

Since climate projections do not indicate any appreciable increase in winter precipitation, dry season conditions could also evince adverse impacts of global warming. Increased evaporation and evapo-transpiration due to warmer temperature would result in much more pronounced moisture stress for soil, crops, and vegetation. The implications of such conditions, however uncertain, have to be weighed seriously in making assessments of future water availability.

Gender Dimension

In Bangladesh, women play a vital role as water collectors and water managers. They have the responsibility to collect and manage water for domestic use as well as to oversee the sanitary arrangements. It is the women who possess the knowledge of the location, dependability and quality of the local water sources, and women's expert knowledge of local water conditions is passed on to successive generations. Collecting water for the family is an arduous and tiring task, often requiring several trips a day; in this task not only adult women but also girl children are involved. Despite such close association between women and water use, women enjoy little or no role in decision-making in water management in Bangladesh. They are virtually absent in public sector agencies that deal with water, nor are their views, needs, and perceptions recognized and considered in planning the location of water collection points, designing the water pumps, and organizing community management operations in respect of water facilities.

One of the objectives of the National Water Policy is to enhance the role of women in water management. Mainstreaming women in water resource development and utilization will yield significant positive impacts on the environment because women in Bangladesh have traditionally displayed a strong sense of understanding of the conservation strategy of natural resources. Following the Fourth World Conference on Women held in Beijing (September 1995), the government has prepared a National Action Plan (NAP) for the implementation of the Platform for Action adopted at the Beijing meeting. The NAP outlines a range of activities required to promote gender equality, including greater involvement of women in water management. In specific terms, the NAP envisages such activities and programmes as (a) policy formulation to address women's role in irrigation and water management; (b) initiation of proposals by the Law Ministry for amendment of laws with respect to property and inheritance rights in order to establish women's legal access to water bodies; (c) ensuring women's involvement in wetland conservation programmes; and (d) involving local government bodies (where women have a mandatory representation) in water quality monitoring and waste disposal. The ultimate challenge concerning the gender dimension in the water sector is to attain and sustain equality for both the sexes in the allocation and use of water resources.

Towards Formulating Water Vision 2025: Sectors and Issues

DOMESTIC SECTOR

The National Water Policy gives top priority (in allocation terms) to domestic water supplies. By 1997, a total of 1.21 million tubewells were sunk through the joint efforts of the Department of Public Health Engineering (DPHE) and NGOs. It is estimated that an average of 105 people or 20 households are served by one tubewell in rural areas. Hand tubewells are supplemented - as drinking water sources - by deep set shallow tubewells or Tara pumps and deep tubewells, which are primarily meant for irrigation. The progress has been significant; almost 97 percent of the rural population now has access to tubewell water.

In urban areas, however, the situation is more critical, and the problem is going to be even more so in future due to the growth of the urban population at an annual rate of 5-6 percent. In Dhaka - a city with a current population of about nine million - 71 percent of the households have access to piped water. Given a current daily water demand of some 1,420 million litres in Dhaka, and assuming an increase of one percent in consumption and a doubling of the population, the projected daily demand by 2025 will reach around 2,660 million litres. In Chittagong (population: 3 million), only 38 percent of households have access to piped water. With the proportion of urban population accounting for 53 percent of the total population of the country by 2025, as against the current ratio of 20 percent, herculean efforts will be needed to extend access to safe potable water for all in all urban centres.

Since almost 95 percent of drinking water in Bangladesh is derived from groundwater sources, increased abstraction to meet increasing demands might cause environmental problems like lowering of the water table and saline intrusion. An additional problem is the recent detection of arsenic contamination of groundwater, which has necessitated a re-thinking of the strategy to supply safe water from underground sources. The potential linkage between arsenic and heavy abstractions of groundwater, if demonstrated, would radically alter the strategies for ensuring supply of safe drinking water. The challenge before the water planners is, therefore, a very difficult one in the coming years. Even more challenging is the task of providing full hygienic sanitation services by 2025; the problem is compounded partly by rural behavioral patterns characterised by insensitivity relating to sanitation and partly by cost considerations. The current proportion of households using sanitary latrines is only 44 percent, and it is important to motivate the people to invest in such latrines.

AGRICULTURE SECTOR

Achievement/maintenance of food self-sufficiency is a key national goal in Bangladesh. The introduction of HYV rice and the expansion of irrigation have both contributed to increased food production over the past two decades. However, in a normal year, the country is still deficit in foodgrain production by 1.5 to 2 million tons. There is, therefore, a clear need for Bangladesh to expand foodgrain production as the total population continues to increase.

Essentially, a major strategy to increase foodgrain production will be through the expansion of irrigation coverage in terms of installed capacity, improvement in capacity utilization, and increase in cropping intensity. Irrigation, therefore, is expected to contribute heavily to a surge in water demand in the next 25 years. Of the total irrigable land in the country (7.6 million hectares), only 4.0 million hectares were irrigated in 1996/97. Based on the 1991 National Water Plan estimates of irrigation expansion, the irrigated area would reach its maximum potential by 2025. However, in reality, this target does not seem attainable. Hence, other means of achieving/maintaining national food security may, in addition, be explored and adopted as appropriate.

The main source of irrigation water in recent years has been groundwater (68.5 percent in 1996/97). This is a risky over-dependence, and as such a balanced conjunctive use of surface and ground water should be encouraged. This option would be pragmatic in view of the arsenic problem in groundwater.

ENVIRONMENT SECTOR

Most of the country's environmental resources are linked to the water ecosystem. Hence, a water vision - both national and regional - must envisage options and strategies for attaining a sustainable environment.

In Bangladesh, the freshwater requirements for environmental protection fall into the following categories with regard to the purposes: (a) prevention of saline intrusion; (b) conservation of the Sundarbans; (c) maintenance and resuscitation of wetlands; (d) dilution of pollutants and effluents; and (e) maintenance/restoration of channel morphology.

In December 1996, the Governments of Bangladesh and India signed a Treaty on the dry season sharing of the Ganges waters. The Treaty is for a duration of 30 years, renewable on the basis of mutual consent. Under the Treaty, specified quantities of water are to be released at Farakka for downstream flow into Bangladesh between 1 January and 31 May. This Treaty has provided Bangladesh with an opportunity for environmental restoration of the Ganges Dependent Area (GDA), i.e., southwestern Bangladesh. A pilot Gorai River Excavation activity was initiated in 1998 to maintain a link of the Gorai with the Ganges during low flow months to ensure that it does not become cut off permanently. A feasibility study for Gorai River Restoration on a longer term basis through a combined strategy of dredging and training and related works is now underway. The ultimate aim of this project is to prevent further environmental degradation and to ensure, through freshwater flows, salinity control, enriching of delta ecology and biodiversity, and improvement of water supply and navigation in the GDA.

Assured in-stream flows in the Ganges, resulting from the Ganges Treaty, has offered Bangladesh the potential for surface water augmentation in the GDA through the construction of a barrage on the Ganges between the Hardinge Bridge and the Ganges-Brahmaputra confluence. The option is to construct the barrage at Pangsha - 60 km downstream of the Hardinge Bridge - to pond the Ganges and force its backwaters into the Gorai river. The government has accorded high priority to the Ganges Barrage for the environmental regeneration of the southwest, especially because the Gorai dredging alone cannot be enough for its restoration due to siltation proneness at its intake point. Although barrage construction has a long gestation period, this would be the most potential means for effective utilization of the Ganges through maintaining the dry season water level in the barrage pond at a controlled height at or near bank-full level and resuscitation of the shrinking distributaries in the GDA. This project should be an integral part of the long-term vision for the GBM region.

The Sundarbans, the largest mangrove forest in the world, can only be conserved and protected through augmenting freshwater flows into the channels of the southwest. The natural ecosystem of this forest is threatened by freshwater flow reduction from the north and migration of the salinity front from the south. Dry season surface water flow augmentation will be essential to combat this degradation. Flows will also be required to restore and maintain the shrinking wetlands throughout the country, and to improve water quality through dilution of suspended solids and industrial and agro-chemical pollutants in high density zones. The 1991 NWP had allocated about 40 percent of the total national water requirements to salinity control, together with fisheries and navigation sectors. The NWMP is expected to estimate water demands for specific environmental parameters by using hydrodynamic models.

FISHERIES SECTOR

In Bangladesh, fishes flourish in rivers, *beels*, floodplain depressions, ox-bow lakes and ponds. Certain minimal conditions are required in each location for optimum fish production. These requirements often conflict, however, with flood control, drainage, and irrigation strategies adopted to augment agricultural production.

Capture fishery output has continued to decline over the past 15 years, partly due to flood protection schemes and partly due to increased salinity and unregulated fishing and over-exploitation. The National Water Policy specifically states that water development plans shall not interrupt fish migration. The policy also stresses the need to preserve wetlands and to ensure their linkages with perennial flows.

Water requirements for fisheries comprise the requirements for riverine and floodplain capture fisheries, freshwater aquaculture, and brackish water shrimp and prawn production. Estimate of water requirements for capture or open water fisheries is a complex task because of the pronounced seasonal variation in fishing grounds. Related to this task is the principal question as to whether culture or pond fisheries should be encouraged to replace capture fisheries progressively in order to halt the trend of diminishing fish output. The answer to this question is dependent on a clear policy decision relating to the formulation of a water demand scenario for the fisheries sector.

INLAND NAVIGATION SECTOR

Bangladesh's dense waterway network has traditionally provided a vital means of transportation. This is especially true in remote areas of the country where roads are non-existent or in extremely poor condition and in many other areas during the monsoon when alternative transportation networks become unusable due to floods. Of late, flow reduction and siltation have reduced the navigability of many channels. Specific amounts of water are required to maintain the Least Available Depths (LAD) in classified routes for inland navigation. The main issues concerning inland navigation are the allocation of stream flows to maintain navigation depths and the control or avoidance of activities which restrict or otherwise impair navigation. Estimating water demand for navigation is not an easy task. For a required draft, water supply is not the only criterion but river hydraulics and sedimentation are also critical factors.

INDUSTRIAL SECTOR

Industrial plants obtain water from various sources. Some industries receive water from municipal supplies through the urban distribution network, and, hence, the 1991 NWP had grouped domestic and industrial water requirements under one component. Certain industries, however, have provisions of supply installed in situ from surface or ground water sources; and these industries often tend to pollute water by discharging untreated effluents.

Increasing salinity in surface and ground water in the southwestern region has become a serious constraint on industrial growth. Accessibility of some industries to usable river water for cooling has been disrupted as a result; and large quantities of fresh water have to be imported by barge for industrial use. Freshwater flow, therefore, must be increased to push the salinity front south and dilute the effluents if a sustainable water ecosystem is to be ensured for industrial development.

The National Water Policy has highlighted the effluent discharge problem as a critical water management issue. It is expected that industrial expansion (including energy production) over the next 25 years will increase demand for water in this sector. Besides strict enforcement of effluent disposal requirements, it is expected that - following the National Water Policy guidelines - zoning regulations will be established and enforced for industrial location, with due consideration given to freshwater availability.

Regional Cooperation in GBM Water Vision: Potential Sectors

The GBM region is characterized by endemic poverty and progressive environmental degradation. Yet, there are enormous possibilities for the region's development - to be pivoted around its huge water resources. Water indeed is the principal vector of development towards shaping the future of millions of people in this region. What is needed is a visionary perspective to develop an effective framework for cooperative development of the GBM region.

A long-term regional water vision, involving the GBM countries, should be built on the premise that the supply side is likely to remain largely finite while the demand will continue to rise in the next century at a rapid pace. In order to meet the challenges of water utilization as a transboundary resource generated by the GBM river systems, it is imperative for the GBM countries to identify sectors and issues in respect of which cooperative strategies and action plans can be formulated, using water as the focal take-off point to bring about an outcome that is positive-sum, win-win for all. A number of options and opportunities exist for collaborative efforts in such sectors as flood management, equitable apportionment of water, dry season flow augmentation, hydroelectricity trade, water quality improvement, and inland navigation. Mutual mistrust, lack of effective dialogues, and differences in perception have so long impeded the development of a long-term regional water vision and appropriate strategies. The policy environment in the region has undergone changes in recent years, and a 'window of opportunity' has emerged in favour of cooperation in the region, following the 1996 signing of two landmark water treaties: the Ganges Water Sharing Treaty between Bangladesh and India and the Mahakali Treaty between India and Nepal. As a result, it is now possible to envision progressively strengthening cooperation on water-based integrated regional development. For that to materialize, though, there needs to be a sustained favourable political will in all concerned countries guiding the cooperative process.

Flood Management

The principal rivers of the GBM systems rise in the Himalayas and after traversing through the plains of India and Bangladesh join the sea. Bangladesh, being the terminus of all the three major river systems, and acting as a funnel for the enormous runoff generated mostly outside its boundaries, faces the brunt of the fury of floods. In fact, the entire GBM region has been experiencing floods since ancient times, and the poor segments of the population, who often occupy the low lying and vulnerable areas, constitute the bulk of the sufferers. Appropriate flood management, therefore, demands an integrated approach involving regional cooperation among all the co-basin countries.

In order to mitigate the impact of floods and minimize the damages, both Bangladesh and India have undertaken certain measures on their own - mostly physical in nature - during the last four decades. These in-country structural measures for flood management include (a) embankments, (b) channel and drainage improvement, and (c) river training. The construction of upstream storage reservoirs (outside Bangladesh) are technically and economically feasible provided there are suitable reservoir-regulation arrangements. Such storage reservoirs for only flood moderation purposes may not be economically justified; but such projects may become strongly justified if they are planned and constructed as multipurpose reservoirs to provide additional benefits such as hydropower generation and irrigation and dry season flow augmentation. Potential reservoir sites do exist in the GBM region; their exploration and construction of reservoirs at appropriate sites should form part of a long-term regional flood management vision.

In Bangladesh, embankment construction has been a major activity as part of the comprehensive water resource development and management strategy. Embankments of a total length of more than 8,300 km have been constructed since 1959, many of which have periodically failed primarily due to operation and maintenance problems. The tying up of embankments on common rivers along the borders of Bangladesh and India will ensure coordinated flood mitigation approaches between the two countries.

Among the non-structural options adopted within Bangladesh are flood proofing measures (to avoid the loss of human life and minimize disruption of normal activities) and floodplain zoning (to avoid vulnerable and unwise use of the floodplain). The principal non-structural flood management approach which has a great potential for regional cooperation is flood forecasting and warning. When an advance warning about the intensity of an approaching disaster is available, preventive and protective measures can be undertaken to save life and property. As the lowest riparian, Bangladesh has much to gain from a collaborative arrangement within the region if it ensures that Bangladesh receives real time data concerning flood forecasting and warning.

The Flood Forecasting and Warning Centre (FFWC) established in 1972 under the Bangladesh Water Development Board (BWDB) has since undergone a series of restructuring and upgrading, both organizational and technical, to meet the existing and emerging challenges. After the devastating flood of 1988, the Government of Bangladesh took the initiative to modernize the operation of the FFWC. The present flood forecasting and warning system in operation is composed of four main elements, which are:

- real-time rainfall and water level data collection;
- meteorological forecasting;
- flood forecasting; and
- flood warning dissemination.

At present, there exists bilateral cooperation between Bangladesh and India for transmission of flood related data. Cooperation with India needs to be strengthened further and cooperation with other countries like Nepal and Bhutan also needs to be established to acquire more data for improvement of flood forecasting and warning capability in Bangladesh. Existing arrangements for data availability in Bangladesh from stations in India do not provide a lead time of more than 24-30 hours for the central part of the country, while it does not exceed even four hours for some areas near the border. Currently, actual and forecast data are transmitted to the FFWC in Dhaka from five stations in India, viz., Farakka on the Ganges, Dhubri and Goalpara on the Brahmaputra, Domohani on the Teesta, and Silchar on the Barak-Meghna. Besides, point to point communication of flood time data through wireless has been established for the flashy rivers: Teesta, Kushiyara, Manu and Gumti. These stations operate during pre-monsoon and monsoon periods - i.e., from 1 April to 15 October. Rainfall data are received by the Bangladesh Meteorological Department from seven stations in India, viz., Goalpara, Dhubri, Tura, Coochbehar, Siliguri, Jalpaiguri and Agartala. Data transmission from India starts whenever the water level and rainfall are at the warning stage, i.e., when the water level reaches one meter below danger level and rainfall exceeds 50 mm.

Since 93 percent of the total GBM catchment area lies outside Bangladesh, flood forecasting and warning would be an incomplete and inadequate exercise without meaningful cooperation among all co-riparians. Increased lead time to make more reliable forecasts can be achieved through the following arrangements:

- Three-hourly real-time and daily forecast level data transmission between May and October, irrespective of the warning stage;
- Real-time and forecast data transmission from further upstream stations such as Monghyr, Patna, and Allahabad on the Ganges; Guwahati, Tejpur, and Dibrugarh on the Brahmaputra; and Teesta Bazar, Gajaldoba, and Jalpaiguri on the Teesta; and
- Joint calibration of hydrodynamic simulation models by Bangladesh and India for increased accuracy of lead time and forecasts.

These arrangements were part of the suggestions made in the flood studies undertaken by Bangladesh bilaterally with India, Nepal, and Bhutan between 1988 and 1990.

A review of the current status of development of flood forecasting methods in Bangladesh and India shows that both countries are using similar technologies for data observation and/or transmission. They use similar methods for processing data concerning flood forecasts, mostly based upon statistical correlation between base stations and forecasting stations. Automatic water level recorders have been installed at a number of sites in the Ganges Basin, both in Bangladesh and India. Many of the hydrological stations in both countries have facilities for the observation of other parameters such as rainfall, humidity, temperature etc., which are usually taken into consideration in mathematical models used for flood forecasting.

Futher improvement in model development for effective flood forecasting in Bangladesh is possible if data exchange arrangement with India is reached in respect of the following:

- River cross-section data of upstream stretches on the Ganges, the Brahmaputra, the Meghna/Barak, and the Teesta;
- Three-hourly water levels and daily forecast for several upstream stations on the four above mentioned rivers;
- Daily discharge data at these stations and at the outfalls of Kosi, Gandak, and Ghagra;
- Daily rainfall data of several upstream stations in all the four systems: the Ganges, the Brahmaputra, the Meghna/Barak, and the Teesta; and

- Water level discharge and rainfall data from representative stations along medium and flashy rivers in the northwest, north, and east of the country.

Such exhaustive data sharing with India, Nepal, and Bhutan will enable Bangladesh to develop a dynamic river-routing model for its river systems, and this could generate a state-of-the-art flood forecasting scenario to benefit the flood-prone population of the GBM region.

Dry Season Flow Augmentation

The GBM river systems experience wide seasonal variability of water flows and volumes. The dry season flows, particularly of the Ganges, are inadequate to meet the combined needs of Bangladesh and India. As early as 1974, the Prime Ministers of the two countries had recognized the need for augmentation of the dry season Ganges flows. Augmentation could be achieved in two ways: (a) by diversion of surplus water from one river system to another; or (b) through the creation of surface water storage facilities for use within the system and/or for diversion to the neighbouring systems. Also, some positive results can be achieved through demand management, focusing on conservation and recycling, for example. All three options could form parts of the long-term vision of water management.

The Ganges Water Sharing Treaty of 1996 recognized the need for augmenting the dry season flows of the Ganges, urging 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."

The northern tributaries of the Ganges contribute substantially to the flows of the Ganges obtaining in the lean season in the lower region. A major option for significant flow augmentation in the Ganges river system - which can benefit Nepal, India and Bangladesh - would be to construct large storages on the tributaries originating in Nepal. The terrain of the northern and middle belts of Nepal offer excellent sites for storage reservoirs.

Studies in Nepal have identified 28 potential reservoir sites, nine of which are classified as large, each having live storage capacity of over three billion cubic metres. From the Bangladesh perspective, the storage project in Nepal which has the maximum potential for augmenting the flows at Farakka is the Sapta Kosi High Dam Project. This potential reservoir envisages a live storage of about nine billion cubic metres, and the stored water behind the High Dam could augment the lean season Ganges flows and benefit both India and Bangladesh. It must be repeated here that storage reservoirs in the Himalayas would have to be multipurpose in order to be economically justifiable.

The issues of population displacement and seismic hazard have often been raised against the schemes for large reservoirs in the Himalayas. Needless to say that these socio-environmental issues are very important and cannot be ignored. Yet, they can be constructively and equitably addressed during project planning and implementation, and need not hold back the pursuit of long-term visionary goals.

Sharing of Common Rivers

Three large interacting river systems stretching over several countries would necessarily contain issues or problems relating to the sharing of transboundary water flows among the upper, middle, and lower riparians. In the GBM region, Bangladesh is the lowest riparian with 54 rivers entering the country from India. Since Bangladesh receives the residual flow after upstream utilization, shortage of flow in the dry season has always been the critical issue in water sharing negotiations with India. Of the 54 common rivers, sharing arrangement has been agreed upon only in the case of the Ganges. The Ganges Water Sharing Treaty of 1996 states in Article IX that both Bangladesh and India should endeavour to "agree to conclude water sharing Treaties/ Agreements with regard to other common rivers".

Following the 1996 Treaty, the Indo-Bangladesh Joint Rivers Commission (JRC) agreed to set up a Joint Committee of Experts (JCE) to work out arrangements for long-term/permanent sharing of the waters of common rivers between the two countries in phases. There exists, therefore, a favourable climate for negotiating arrangements for sharing of all common or transboundary rivers between Bangladesh and India.

It was agreed by the JCE to examine and negotiate the sharing issues in phases. In the first phase, seven medium sized rivers are being considered, viz., Teesta, Dharla, and Dudhkumar in the northwest, and Manu, Khowai, Gumti, and Muhuri in the east. However, the JCE accorded priority to the sharing of the Teesta river - especially because both countries have constructed barrages on this river, and since both of these are based on the natural flows of the river, and the dry season flows are inadequate for the combined needs of the two countries. Some progress on the sharing issue has been achieved. Meanwhile, the tying up of the embankments along the Teesta right bank at the border has been completed.

Although protracted sharing negotiations in the past had often ended in a quagmire, the expectation now - following the 1996 Treaty - is that there will be equitable sharing of the lean season flows of not only the Teesta, but also of other common rivers. Since the Teesta, by itself, has insufficient flows to meet the requirements of the two projects (one on each side of the border), it may be useful to examine seriously the option for Teesta augmentation as well as coordination in the operation of the two barrages. Parallel with the sharing issue the co-riparians should also agree on an arrangement whereby all the countries are kept informed of any intervention in the international rivers so that there is a transparent and trusted partnership among all. This will also facilitate a continuous assessment of cooperative activities, thereby helping shape more constructive future trade-offs for strengthened regional cooperation.

Hydropower

The hydropower potential of the GBM region is vast. Yet, ironically, the per capita energy consumption in the region is among the lowest in the world. The energy economy of the GBM countries is highly dependent on non-commercial sources, largely based on biomass. In the past, efforts have been made by each of the regional countries to develop hydropower within its own territories to meet the domestic needs. But cooperative efforts to produce and share hydropower have not been pursued.

Nepal is the leading country in the GBM region in terms of hydropower potential. It has a theoretical potential of 83,000 MW, and an economic potential of about 40,000 MW. In India, the relevant parts (i.e., parts within GBM basins) of the country have an identified potential of over 45,000 MW, while Bhutan's hydropower potential is put at over 20,000 MW. Bangladesh does not have topographic conditions favourable for hydroelectricity generation. The country's lone hydel plant in the southeastern hills (which is, however, geographically outside the GBM region) has an installed capacity of only 230 MW.

The energy demand in each of the GBM countries is steadily rising. Against this backdrop, it is essential that the region formulate a vision and develop an integrated plan of action for hydroelectricity development and sharing on a mutually beneficial basis. The hydrocarbon fuels are non-renewable resources, and their continued use would keep adversely affecting the environment. Hence, the use of environment-friendly, clean, and renewable energy like hydropower should be part of a vision for sustainable development in the GBM region.

The economic justification of reservoirs in the Himalayas for flood moderation and flow augmentation is increased manifold when they also produce electricity for the region. Such projects will not only cater to the needs of Nepal or Bhutan, but may also focus on the vast and growing energy market in northern India as well as in Bangladesh. As a matter of fact, the GBM countries can share the costs and benefits of such multipurpose reservoir projects on agreed terms. It is necessary, therefore, to visualize and plan for the establishment of an inter-country energy grid stretching across the GBM countries. This interconnected grid would facilitate the integration of different power systems across the region and allow Nepal and Bhutan to export excess hydropower to India and Bangladesh.

Water Quality

Over the years, the quality of both surface and ground water has deteriorated to such an extent that it has now become a matter of serious concern in all the countries of the region. Since surface and ground water interact, the quality of water in one regime has implications for that in the other. Hence, a holistic approach is needed to monitor the water quality in each country together with regional initiatives in preventing its further deterioration.

Due to the geographical location of Bangladesh as the downstream riparian in all three catchments (the Ganges, the Brahmaputra, and the Meghna), there are specific cross-border water quality issues that Bangladesh faces. The quality parameters that are of concern to Bangladesh as well as to the entire region include sediment load, industrial effluents, agrochemicals, and domestic wastes. The amount of sediment in the Brahmaputra has increased in recent years, with indications that its composition has been getting coarser, with a higher percentage of sand and lower proportion of organic matter. The probable cause is environmental damage in the upper catchments in China and India, where removal of vegetative cover has intensified gully erosion. A similar process may also be active in the Nepalese Himalayas, triggering sediment load generation in the Ganges system. This problem can be addressed through regional initiatives - under an appropriate institutional structure - for integrated catchment planning and management.

Pollution caused by industrial effluents, agrochemicals, and domestic wastes get diluted in the monsoon, but often rise to alarming proportions in the low flow season, especially in densely populated zones. Industries that use or produce chemicals, paper/pulp, sugar, dyes, and various metals, and large urban centres that discharge untreated wastes into nearby rivers are often responsible for not only within-country but also cross-border water quality problem. A regional approach in meeting the challenge of cross-border water quality issue through awareness building, data exchange, and mutual assistance in pollution control will enhance the prospects for maintaining water quality in transboundary streams.

For Bangladesh, there are additional problems of salinity and arsenic in groundwater. Low flow in the dry season in the southwest has led to increased saline intrusion inland; its solution requires monitoring as well as long-term measures to store monsoon water, resuscitate channels, and enhance the dry season flushing. Careful monitoring against overextraction of groundwater in coastal areas is also required as a precautionary step to prevent saline intrusion.

High levels of arsenic (over 0.05 mg/l) in groundwater have been detected in 59 of the 64 districts of Bangladesh, especially in the southwestern, south-central, and southeastern regions. This has serious implications for domestic water supply as well as for the agriculture sector because of possible transfer of arsenic into the food chain through irrigated crops. It is, therefore, necessary to review the strategy of depending on groundwater for the supply of safe water. The alternative is to revert to surface water for domestic consumption - an alarming spectre in the context of health hazards and morbidity, given the high levels of surface water contamination. The government has launched a four-year Bangladesh Arsenic Mitigation Water Supply Project (BAMWSP) with a view to providing arsenic-free water supply to rural and urban communities. The 44.4 million US dollar project is funded by the World Bank and Swiss Development Corporation. The BAMWSP will assist the government in (a) identifying the causes of arsenic contamination, (b) determining alternate sources of water supply, (c) awareness building about the arsenic hazard, and (d) preparing detailed proposals for a national programme for arsenic mitigation. The project outcome could be of use to India as well, as there are areas in West Bengal which also suffer from high arsenic levels.

At the regional level, several measures are needed over the medium and long terms. These would include (a) standardization of water quality parameters for different users; (b) coordination of water quality monitoring at cross-border sites; and (c) a mechanism for data/ information exchange on pollution status.

Inland Navigation

The Ganges, the Brahmaputra, and the Meghna/Barak have served as major arteries of trade and commerce for centuries. In recent decades, their importance has diminished as traffic has moved away in the region from the waterfront to the alternative modes of road and rail. Nonetheless, the GBM countries can look forward to rejuvenating this natural asset under an integrated and coordinated scheme for the development of inland navigation throughout the region.

As a landlocked country, Nepal has a vital interest in securing access to the sea through the rivers. The establishment of links with the inland water transport networks of India and Bangladesh will provide Nepal access to Calcutta (India) and Mongla (Bangladesh) ports. The proposed Pancheswar, Karnali, and Kosi high dams in Nepal will facilitate the development of deep waterways connecting Nepal with the Ganges. Of them, the Kosi navigation channel offers the best potential for securing the shortest water route to the sea. Under an existing protocol between Bangladesh and India, the latter uses the Ganges-Brahmaputra-Meghna river systems for water transit between West Bengal and Assam. These routes are not used optimally at present; but channel improvement, better pilotage and navigation aids, and increased efficiency in handling and movement will enhance the utilization of these navigation routes. It is not too much to expect that, given a dedicated willingness to integrate the water networks in the GBM region, all the countries would benefit in the long term. As an important step in that direction, a regional body should be established and entrusted with such tasks as improving physical facilities; standardizing rules, customs regulations, and security needs; and developing ports and terminals.

Constraints

The maximum exploitation of the potentials outlined above can be achieved through creating an enabling environment for the purpose in the region. At the moment, the flourishing of such an environment is hindered by constraints in several respects. However, as pointed out earlier, there has, in recent years, emerged a favourable environment for cooperation among the GBM countries; hence, there is now a general expectation that the constraints can be gradually removed.

The first and foremost constraint that has to be overcome is the existing mindset in the region. This mindset is not only characterized by an endemic absence of goodwill, but also by a lack of mutual confidence, mistrust, suspicion of motives, and differences in perception. All of these are inherited from past experiences which were often bound up with confidence-eroding steps and failure to transcend narrow and short-term perspectives.

In order to mitigate/remedy these persisting bottlenecks, it is necessary that there should be greater, wider, and more frequent interactions among the policy makers, opinion leaders, and professionals of the GBM countries with the goal of creating an enabling ambience for regional cooperation.

Inadequacy of data is another impediment in the process of formulating a long-term regional water vision. It is true that a large number of water-related data sets have been generated in each country during the past two or three decades. But there has been no coordination in exchanging and/or compilation of these data sets at the regional level. Even at the national levels, data generated by different agencies are used or stored in a disjointed fashion. Added to this problem are the legacy of lack of transparency and the unwillingness on the part of the countries to exchange data. The problems of non-transparency and lack of data exchange in fact exist among the countries relating to their water sector activities and within each country among different government and non-government agencies. Free and unfettered flow of data and information throughout the region along with the generation of new baseline data are essential prerequisites for vision realization.

One other constraint, presumably a by-product of the mindset, is more political in nature. There appears to be a total failure on the part of the political leadership in each of the regional countries to mould public opinion in favour of developing a vision for regional cooperation. Any national consensus on the benefits of regional cooperation remains elusive and the issues remain contentious. The onus of removing this constraint lies with the political leadership in each country, and success will depend, first, on an attitudinal shift in favour of regionalism on their own part and, then, on their political acumen and capability to motivate others.

Another constraint that has prevented meaningful and durable regional cooperation among the GBM countries is the lack of an institutional framework. At the national levels, each country has its own institutions for water resource planning and management. Regional or cross-border issues have been dealt with bilaterally - often on ad hoc basis. The Joint Rivers Commission has succeeded to some extent in its tasks, but it has its own limitations, given its mandate. In order to bring to fruition a truly integrated water resource management for the GBM system, an apex body should be established with a mandate to develop, utilize, and manage the vast potentials of the water resources in the GBM region.

Objectives and Mission

The foregoing commentary on baseline conditions in Bangladesh and cooperation potentials in the GBM region would enable one to focus on the goals and objectives for a GBM regional water vision. The GBM region offers opportunities for mutually beneficial water-based development through cooperative efforts. Lack of trust and transparency, which bedevilled the relationship among the co-riparians for nearly half a century, has only compounded poverty and environmental degradation. Over the past few years, a willingness to cooperate has dawned on the horizon, and a new approach to regional cooperation has emerged encompassing the four GBM countries: Bangladesh, Bhutan, India and Nepal. The Male Declaration (1997) and the Colombo Declaration (1998) of the SAARC Summit endorsed the concept of sub-regional cooperation by accepting the idea of two or more countries collaborating on project-based development efforts within the SAARC framework. It has thus laid the ground for the above-mentioned four GBM countries to forge a common approach to water-based development. The specific objectives of the GBM water vision may be summarized as follows in a regional framework:

- Overall development of the GBM region, with its water resources as the entry point, in which an integrated and coordinated development and management of water and also land and other resources would be aimed at.
- Sustainable development and utilization of water resources to accelerate sustainable economic growth and ensure food self-sufficiency at the national level and/or food security at national and household levels, and poverty alleviation.
- Generation of substantial employment/income opportunities as a crucial element in the poverty reduction strategy.
- Transformation of the social structure to ensure equitable access of all to resources and opportunities and remove gender disparities.
- Development of infrastructure in order to ensure protection from floods, provide clean and sufficient water, generate electricity, and offer cheap transport with the ultimate goal of maximizing social and economic welfare.

All the above objectives can be encapsulated in a programme designed for poverty alleviation. During the 7th SAARC Summit, held in Dhaka in 1993, the Dhaka Declaration stipulated that each SAARC country would prepare a pro-poor plan and an action programme for eradicating hard-core poverty by 2002. This idea was later reinforced during the 8th SAARC Summit in New Delhi in 1996. Taking cue from this stated goal of SAARC concerning poverty eradication, the mission underlying the GBM Water Vision 2025 can be stated as sustainable growth, poverty eradication, and human capability development through judicious and optimal utilization of the region's water resources.

Water Vision 2025

The GBM Regional Water Vision 2025 outlined below has been formulated keeping Bangladeshi perspectives in view. The basic premise in formulating this GBM Regional Water Vision is that freshwater supplies are finite and that increasing competition for it from multiple uses would require conservation of water, supply augmentation at places and times as required, and demand management. And an integrated water resource management in the region would aim at the visionary goal of integrated human development, characterized by improved quality of life and living standards, sustainable environment, and safe and stable society.

The vision development exercise can be approached under three probable scenarios: pessimistic, optimistic, and plausible. A scenario is neither a projection nor a forecast. It is merely a possible course of events leading to the realization of particular goals in the future; alternate scenarios would yield different images.

The pessimistic scenario is basically a business-as-usual (BaU) approach under the assumption of the usual way of doing things in terms of responses to the existing and potential stresses in society in general and the water sector in particular. This scenario is unsustainable in the long run where the dissemination of newer technologies is either absent or very slow, and society remains vulnerable to natural and socio-economic adversities.

At the other end of the spectrum is the optimistic scenario, which assumes overly ambitious, almost utopian progress in terms of technological improvements, increases in efficiency, and the fullest attainment of integrated water management. Given the current state of the water ecosystem and the trend in its management, the optimistic scenario appears an unrealistic goal to pursue, i.e., merely a dream.

In between the two extremes lies the plausible scenario - one which is pragmatic and attainable. This scenario consists of policies and actions leading to a sustainable water resource regime for the region, with strong commitment to genuine cooperation and collaboration aimed at improved human development throughout the region.

The drivers which would influence the conditions towards achieving the goals set out in the vision exercise are: population, technology, socio-economy, environment/ecology, and governance. The Bangladesh Water Vision 2025 has been formulated taking into account the key elements under each of these drivers, keeping GBM regional dynamics in view. It is shown in Table 5.

Table 5: Bangladesh Water Vision 2025
(Keeping GBM Regional Dynamics In View)

Vision Elements	**Expected Output**
Poverty ratio of less than 10%	• Focus on poverty alleviation as a development process component, with emphasis on social (education, health) sectors focusing on the poor in particular, skill development, assistance towards capital accumulation, and social mobilization
Food security for all	• Access to food ensured for all, with the calorie intake being at least the minimum required for healthy living - the ultimate objective being a balanced diet for all
Food self-sufficiency in all GBM countries	• In each of the GBM countries, food produced locally - including protein sources - is sufficient to meet national requirements

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Literacy, both men and women	• Compulsory and free education for all up to the age of 15 years • Adult illiteracy (both male and female) eradicated through incentive-oriented programmes, involving local government bodies and voluntary agencies
Population stabilization	• Zero population growth status achieved through enhanced investments (financial and programmatic) in population control
Enhancement of participation in water management	• All stakeholders involved appropriately in water management, at different spaces • In particular, women's role in water management at all levels recognized and appropriately enhanced
Provision for clean, safe water for all	• Access of all urban households to piped water; and in the remaining (as of 2025) urban slums at least sufficient number of community tubewells, if not piped water • Reduction in the extraction of groundwater to prevent arsenic hazard • Community-based surface water treatment in rural areas and access of all rural households to safe drinking water
Hygienic sanitation for all households	• Sewerage connection to all urban households • Community-based sanitation coverage in the remaining (as of 2025) urban slums through comprehensive slum improvement projects • Availability of affordable water sealed latrines and their installation in all rural households

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Near-full (at least 90% of the labour force) employment	• Basic skill training, appropriately upgraded over time • Creation of non-farm employment for the rural poor on a large scale • Promotion of small and medium industries to provide employment opportunities for rural-urban migrant job-seekers • High-tech skill development and training as appropriate
Annual GDP growth rate of over 8%	• Faster growth of non-agricultural sectors, particularly industry and energy, with agriculture achieving/ maintaining optimal growth
Sustained agricultural growth	• Sufficiently increased coverage of HYV crops • Increased use of sustainable agricultural biotechnology • At least 50 percent irrigation efficiency achieved • Crop diversification in order to increase net economic returns and offset losses from climatic extremes like floods and drought • Appropriate and adequate agrarian reforms introduced
Reforestation of denuded areas to obtain tree cover in at least 20% of the land area	• An implementable Forestry Master Plan in operation • Full enforcement of regulations against illegal logging • Large scale tree planting schemes launched through social forestry projects • Catchment management, especially on steep slopes, for effective soil conservation

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Restoration of all degraded wetlands	• Reclamation of all freshwater wetlands which have degraded due to unsustainable interventions • Conservation of all wetlands as the habitats of wide varieties of flora and fauna, involving local communities for their sustainable management
Prevention of over-exploitation of groundwater together with state-of-the-art technology in aquifer recharge	• Overdependence on groundwater reduced through conjunctive use of surface and ground water • Natural recharge of aquifers from annual flooding increased through the use of modern technology
High degree of waste and effluent management	• Regulatory and macro-institutional framework for effective solid waste management strengthened, including involvement of community-based organizations • Full enforcement of regulations relating to the control and management of industrial effluents • Adequate provision for treatment and recycling of waste water in large urban centres
Dry season flow augmentation in the Ganges	• All options - including storage reservoirs - examined and the feasible ones materialized in order to meet the dry season water scarcity in the Ganges, which will otherwise continue to aggravate as population increases
At least five multipurpose storage reservoirs in the upper catchments	• Five prioritized reservoir sites developed in Nepal with a view to producing hydroelectricity, moderating down-stream floods, augmenting lean season flows, and providing irrigation

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Equitable sharing of all common rivers	• Equitable agreements reached for the sharing of all transboundary rivers
Maximum cross-border cooperation in flood management	• Fullest cooperation among all co-riparians ensured in the flow/ exchange of comprehensive data with adequate lead time required for flood forecasting
Agreement to share all data relating to water resource development	• All co-riparians will share with each other all data/ information relating to water resource development within the GBM region
Interconnected hydroelectricity grid	• With the development of the hydroelectric potentials of the Himalayas, an interconnected energy grid established to ensure optimal supply of clean energy throughout the region
A GBM Regional River Basins Authority	• A multinational river basin authority for the GBM region created with a mandate to act as the water management steward for the region • This will provide the institutional framework to oversee the planning, coordination, joint implementation, and conflict resolution in water management activities of the region

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