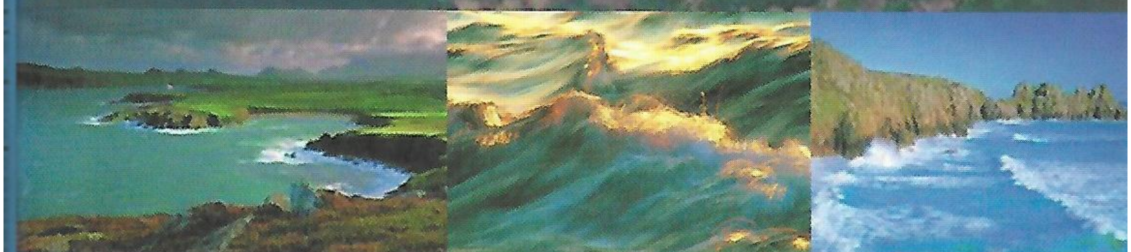
OXFORD

sustainable development of the Ganges-Brahmaputra-Meghna basins



edited by
asit k. biswas
juha i. uitto

Sustainable development of the Ganges-Brahmaputra-Meghna basins

Edited by Asit K. Biswas and Juha I. Uitto

United Nations University Press
TOKYO • NEW YORK • PARIS

OXFORD
UNIVERSITY PRESS

OXFORD
UNIVERSITY PRESS

YMCA Library Building, Jai Singh Road, New Delhi 110001

Oxford University Press is a department of the University of Oxford. It furthers the University's objective of excellence in research, scholarship, and education by publishing worldwide in

Oxford New York

Athens Auckland Bangkok Bogota Buenos Aires Cape Town
Chennai Dar es Salaam Delhi Florence Hong Kong Istanbul Karachi
Kolkata Kuala Lumpur Madrid Melbourne Mexico City Mumbai Nairobi
Paris Sao Paulo Shanghai Singapore Taipei Tokyo Toronto Warsaw

with associated companies in Berlin Ibadan
Oxford is a registered trade mark of Oxford University Press
in the UK and in certain other countries

Published in India
By Oxford University Press, New Delhi

First published by The United Nations University Press 2001
The United Nations University, 53–70, Jingumae 5-chome, Shibuya-ku,
Tokyo 150-8925

ISBN 019 565793 4

Printed in India by Rashtriya Printers, New Delhi 110 032
Published by Manzar Khan, Oxford University Press
YMCA Library Building, Jai Singh Road, New Delhi 110 001

Contents

List of tables and figures

Note on measurements

Both metric and imperial measurements have been used in this book, in accordance with the systems in common usage in the countries concerned.

Preface

Asit K. Biswas and Juha I. Uitto

Water has always been regarded as a key resource and central for economic development in South Asia. A growing population and accelerating economic development activities in the region have made sustainable water management increasingly critical. The Ganges-Brahmaputra-Meghna basin now contains some 550 million people, more than the countries of North America and Western Europe combined. It also contains the largest concentration of the world's poor, more than all of sub-Saharan Africa. The region, however, has considerable development potential, especially if its natural resources could be harnessed sustainably, efficiently, and rationally.

The sharing of the water resources of the Ganges-Brahmaputra-Meghna river system has long been a subject of dispute among the four countries which share the basin: Bangladesh, Bhutan, India, and Nepal. This book presents a unique view of the potential development options for the shared waters as perceived by leading policy-makers and experts from the countries themselves.

The issues related to the sharing of the South Asian waters must be understood against the natural, historical, political, social, and economic backdrop. Low-lying Bangladesh is the last country in line for Ganges water. The river has its beginning in the Himalayas in Nepal, then flows through India before reaching Bangladesh and draining into the Bay of Bengal. The basin of the Brahmaputra is largely in Assam, the Indian state in the far north-east, all but cut off from the rest of the country, and receives much of its waters from the small upstream kingdom of Bhutan.

The Ganges, one of the world's mighty rivers, no longer reaches the sea every year. The upstream diversions and other water demands do not leave enough water for the river to reach its natural outlet in the Bay of Bengal. Since the construction of the Farakka barrage to divert water to Calcutta from the Indian Ganges in the mid-1970s, sharing of water downstream has become a highly contentious political issue between Bangladesh and India. The case highlights the crucial role water plays in the economic development of the region and how it affects all sectors. The rapid growth of the Calcutta mega-city has brought with it heavy demand for water resources. Similarly, the Calcutta harbour requires sufficient water to allow large ships to moor there. The resulting seasonal water deficit poses development constraints on downstream Bangladesh. The lack of fresh water flowing out to the sea has caused a rapid advance of a saline front across the western portion of the river delta, threatening agricultural production.

For more than three decades, the development of the Ganges-Brahmaputra river system has been a hydropolitical bone of contention in the region. Issues arising after the 1971 war that resulted in the creation of Bangladesh still remain unresolved. An agreement between India and Bangladesh to share the dry-season flow from the Ganges expired in 1988. Since then, there has been little progress in the two countries agreeing to a plan to share the water. However, two recent treaties on the Ganges (between Bangladesh and India) and the Mahakali (between India and Nepal) have dramatically changed the political atmosphere in terms of water management.

If the total annual flow is considered, the Ganges has abundant water resources. The main problem is water scarcity during the lean season – from January to April – which affects both India and Bangladesh. Only 5 per cent of the total annual flow of the river would be sufficient to solve the downstream scarcity problems during the lean season. This would, however, require finding new ways to store water in catchments to be used when the flow diminishes. The possibility of flow augmentation should thus receive high priority in management of the water resources of the region.

While the lean-season scarcity problem is easy to resolve conceptually, problems arise when attempting to select a way that would be acceptable to all countries concerned. Historically, Bangladesh has preferred to have reservoirs constructed upstream, in Nepal. India, on the other hand, has supported the construction of a 300-km-long canal – through Bangladesh territory – to transfer water from the relatively water-rich Brahmaputra to the water-scarce Ganges basin. The plan has not met with favour in Bangladesh for a variety of reasons. It would involve resettling a large number of people in the country, and many serious environmental and social problems would probably arise. A canal through Bangladesh which could also be used for navigation from one part of India to another could have serious socio-political implications for both countries.

Against this complex historical and political background, the Untied Nations University (UNU) and the International Water Resources Association (IWRA), supported by the government of the Netherlands, convened a Ganges forum in March 1998. The main purpose of the Ganges-Brahmaputra forum was to provide the countries concerned with an independent platform where senior policy-makers and experts could quietly and objectively explore genuine potential for cooperation in the sustainable development of the water, land, and biotic resources, and come to understand and appreciate each others' resource needs. Groundwork for organizing the forum had been carefully prepared, starting with the joint UNU-IWRA Asian Water Forum organized in January 1995 (Biswas and Hashimoto 1996).

Participation in this very high-level but low-key forum was strictly restricted, by invitation only, to less than 30 senior policy-makers and experts from the basin countries. They were all invited in their personal capacities to allow for free and frank exchange of ideas, opinions, and facts on this complex hydropolitical issue. Because of the position of the participants, the meeting refrained from drawing any formal conclusions or making any specific recommendations, but rather outlined the options available. The role of the UNU and IWRA was to act as impartial facilitators and honest brokers in the process. This book reports on the views of the participants, providing rare insight into the thinking amongst the leading persons concerned with water resources development in these four countries.

Eight background papers were specifically commissioned for the forum. These analysed the historical background of the water-use conflicts, as well as the collaborations among the four basin countries; the future potential for water resources development in the basin; considerations of flow augmentation in the lean season; review of the social, environmental, and political conditions; and discussion of possible legal and institutional frameworks for future collaboration between the countries concerned.

A major problem identified in the forum was the apparent lack of information-sharing. Water experts in one country had surprisingly little access to the information from other basin countries. Even information freely available in one country is often not available in others. The present book also aims to contribute to information sharing. Although preliminary reports on the forum have been published earlier (Biswas, Nakayama, and Uitto 1998), this is the first time the full papers presented at the forum are made available.

The forum also resulted in an agreement to develop a sustainable development framework for the Ganges-Brahmaputra-Meghna region. Two eminent experts each were selected from Bangladesh, India, and Nepal following extensive consultations with the respective governments, water experts, NGOs, and external support agencies. The work of this group is now under way. It is hoped that this work will lead to concrete results for sustainable management of water and natural resources in this important region.

We are most grateful to the Ministry of Foreign Affairs, Government of the Netherlands, and especially to Mr A. J. Diphoorn, for the financial support received which made this book possible.

REFERENCES

Biswas, A. K. and T. Hashimoto, eds. 1996. *Asian International Waters: From Ganges-Brahmaputra to Mekong*. Delhi: Oxford University Press.

Biswas, A. K., M. Nakayama and J. I. Uitto. 1998. "Standing in Line for Water: Cooperation on the Ganges and Brahmaputra", *Work in Progress*, Vol. 15, No. 2, pp. 4–5. Tokyo: United Nations University Press.

1

Management of international waters: Opportunities and constraints

Asit K. Biswas

Introduction

Historically, global water demands have increased steadily with population growth and the subsequent increases in various types of human activities. With a steadily increasing world population, and mankind's eternal quest for higher and higher standards of living, there is no doubt that the demands on our natural resources, both non-renewable and renewable, will continue to increase well into the foreseeable future. Water, a renewable resource, will be no exception to this general trend.

Even when the global population stabilizes, the demands for resources like water are likely to continue to increase because of higher per capita demands from people in the developing world attaining better standards of living, as well as due to the changing lifestyles in both developed and developing countries. These trends are now clearly visible in countries like India, where already some 100 million people have reached a middle-class standard of living. This rapidly emerging class is slowly flexing its new-found political and economic muscles, and, in the area of water, unlike earlier generations, it is unlikely to remain satisfied with the *status quo* of a few hours' intermittent supply of dubious quality every day. The availability of adequate quantity and appropriate quality of water to an increasingly urban population in the developing world is likely to be an important political and social issue in the coming decades in most countries.

Three other factors should also be noted: water requirements for agricultural production and energy generation, and increasing water contamination due to accelerated human activities. Efficient irrigated agriculture is essential for ensuring reliable food production in the twenty-first century. At present nearly 55 per cent of all rice and wheat produced in the world comes from irrigated areas and some 2.4 billion people currently depend on irrigated agriculture for food, income, and employment. Current estimates indicate that 80 per cent of the additional food supplies required to feed the future world population will depend on irrigation (IIMI 1992). Reliable availability of an adequate quantity and quality of water for increasing agricultural production will continue to be an important factor well into the twenty-first century.

While water requirements for increasing total global agricultural production have received considerable attention in recent years (for example at the World Food Summit in Rome in 1996), water needs for energy production have been basically neglected thus far. High development and economic growth rates can be achieved, especially in the developing world, only if adequate energy is available. No large-scale electricity generation is possible without large quantities of water. In addition to hydropower generation, construction and operation of new thermal and nuclear plants would require significant additional quantities of cooling water, a fact that has basically escaped both water and energy planners thus far.

A good example of the implications of massive increases in electricity generation for national and international water resources is the Asian developing countries. These countries had a total generating capacity of 250,000 MW in 1990, nearly 70 per cent of which was thermally generated (mainly coal), with the balance of 30 per cent being accounted for mainly by hydropower. It was estimated that another 240,000 MW would be needed by the year 2000 to fulfil their current development plans. This near doubling of electricity requirements within only one decade means that the water needs of a rapidly expanding energy sector can no longer be ignored, especially as similar growth rates are expected to continue during the early part of the twenty-first century (Biswas and Hashimoto 1996). Similarly, in Turkey electricity demands are now growing by 7–8 per cent annually. It should also be noted that for England and Wales, some 36 per cent of all water abstracted at present is accounted for by the energy generation industry alone. The corresponding figure for France is much higher, and for Mexico it is 69 per cent. The future global water requirements for the energy sector thus need to be carefully considered.

Another important issue is increasing water contamination, especially in the developing world, which means that many sources of water must now receive expensive treatment before they can be used beneficially.

While much rhetoric can be noted in terms of water pollution control and ecosystems' conservation, in reality appropriate remedial actions on the ground are basically missing. Inadequate treatment of domestic and industrial wastewater (for example, in Mexico, only about 6 per cent of the total wastewater produced is properly treated) and complete neglect of non-point sources mean that water quality management urgently needs more attention than the lip service it is receiving at present.

These three issues, as well as other associated factors, mean that sustainable water management in the coming decades will face a challenge the like of which has not been seen before. In spite of the gravity of the situation, unfortunately we currently do no even have reasonably reliable assessments of the global situation in terms of water quantity and quality and associated factors. This fact is a damming indictment of international programmes like UNESCO's International Hydrological Programme, which after spending hundreds of millions of dollars over the decades has been unable to produce even such basic information. Similarly, the United Nations system and the Stockholm Environment Institute (United Nations 1997) recently published a report entitled *Comprehensive Assessments of the Freshwater Resources of the World*. While this report makes some useful points, it is most remarkable for the absence of any serious assessments of the global water quantity and quality conditions. In addition, no major country has prepared realistic estimates of future water demand and availability situations based on expected patterns of development, social and environmental requirements, economic considerations, changes in management techniques, involvement of the private sector, and other related issues. All these would be important considerations in the twenty-first century.

These factors and other related issues, when considered together, indicate the following.

- Water requirements in arid and semi-arid areas will continue to increase steadily in the foreseeable future for a variety of reasons.
- All easily available exclusively national sources of water have already been developed or are in the process of development, which means that the real costs of new projects in terms of per cubic metre of new water available will continue to increase. An analysis of domestic water supply projects supported by the World Bank (1992) indicates that the cost per cubic metre of water for the next generation of projects is often two or three times higher than for the present generation.
- Water needs for ecosystem and habitat preservation will increasingly be considered as a "legitimate" use in the future, probably within a decade, thus putting additional pressure on water available for existing "traditional" uses.
- For environmental and social reasons, the next generation of water

projects will take a significantly longer time to develop than currently anticipated by the planners, which will further intensify the anticipated water shortages in the foreseeable future.
- Water planning and management practices are likely to improve only incrementally in the near to medium term: the radical changes in such practices needed to resolve the water crisis appear to be highly unlikely to take place.

Importance of international waters

All the above factors will probably contribute to tremendous socio-political pressure to develop new sources of water. Since exclusively national and new sources of water which could be efficiently developed techno-economically are generally no longer available, there will be tremendous pressure in many countries to develop international water bodies – that is those rivers, lakes, and aquifers that are shared by two or more countries. This is because international bodies are often the only sources of water that can be developed economically. These water bodies were not considered for development in the past because of the absence of any agreements between the relevant countries on their utilization. The political risks and complexities were considered to be too high for their unilateral development by only one country. However, as water shortages in individual nations become more and more severe, and if and when they create serious internal political and social tensions and unrest, some countries may decide that it is worth the external political risk to develop such resources, even though it could imply a "beggar thy neighbour" attitude.

Over the past two decades, there has been an increasing number of situations where countries have built dams and barrages on the main stems of international rivers (sometimes even very close to their borders), and/or on major tributaries, which will affect the flow regime in downstream countries. Furthermore, the number of studies that have already been completed, or are under preparation, on the development of the major tributaries of international rivers, especially when they are under exclusive national jurisdictions, is increasing all the time. All such developments on major tributaries would clearly have perceptible impacts on the main international river. A good recent example of this was on the Mekong river. On 5 April 1995, plenipotentiaries from Cambodia, the Lao People's Democratic Republic, Thailand, and Viet Nam signed an agreement on cooperation for the sustainable development of the lower Mekong river basin at Chiang Rai, Thailand. Following the signing ceremony, the VIPs embarked on a boat tour of the Mekong river. The boat, however, was grounded in the river because, unknown to the participants, China was filling up a major new reservoir upstream. China is not a member of the newly constituted Mekong River Commission. Currently several dams are under construction and/or active consideration upstream in the Chinese territory, and China is the most upstream country in the Mekong river system.

International funding agencies have in the past generally declined to provide loans for the development of international waters until and unless the countries concerned have signed a mutually acceptable agreement. Without external financial assistance, developing countries have often been unable to construct capital-intensive water development projects on international rivers unilaterally. An analysis of the latest trends indicates that this situation appears to be changing, for the following reasons.

- Many of the countries concerned are now capable of raising the necessary investment funds from internal national sources.
- Private-sector funds, both international and national, can now be harnessed for such developments.
- International funding agencies appear to be taking a somewhat more liberal approach recently to supporting such development activities. For example, while they are still continuing to decline to finance construction of structures like the dams and hydropower plants, they have began to support associated activities like agricultural development, even though it would use water from a dam or hydropower project.
- In many cases international financing supports only a limited part of the total project cost. Absence of international funds could thus mean a simple extension of the time needed for construction: it may not necessarily stop the project.

Herein lies one of the principal challenges to the water profession in the twenty-first century: how to develop and manage the various international water sources sustainably and efficiently in full agreement and cooperation between the concerned countries so that the result can be a "win-win" situation for all parties. Development considerations will no longer be confined to techno-economical factors alone, as is generally the case for exclusively national projects; other factors will have to be considered, including bi-national or multinational political considerations, the power of the country in which the water development would take place compared to other co-basin countries, the importance of maintaining good relations between the countries concerned, and the general international and media interest in the project. These and other associated issues are likely to complicate water management processes in the future by several orders of magnitude. Hydropolitics is thus likely to become an increasingly important global issue in the future management of international river and lake basins and aquifers (Biswas *et al.* 1999).

Magnitude and distribution of international waters

In this chapter, the various issues associated with international waters will be discussed only in the context of fresh water. Coastal and ocean waters will not be considered, since these sources need to be analysed and discussed in a different context and within wholly different frameworks.

In the area of fresh water, three types of water sources need to be considered: rivers, lakes, and groundwaters, even though these sources are often interconnected. While we now have considerable experience with the management of international rivers, and to a lesser extent international lakes, similar knowledge on groundwater issues is conspicuous by its absence. Because of space and time constraints, the focus of this chapter is exclusively on the management of international rivers and lakes.

The global magnitude and distribution of the problem of international rivers and lakes are basically unknown at present, even though the literature is replete with unscientific and hypothetical "facts and figures". The information base for international aquifers is fundamentally non-existent.

It has generally been assumed in the past two decades that there are 214 international river and lake basins in the world. This number originated from a report completed in 1976 and published in 1978 by the now-defunct Centre for Natural Resources, Energy, and Transport (CNRET) of the Department of Economic and Social Affairs of the United Nations. This number itself was an upward revision of an earlier (1958) CNRET estimate of 166 international river and lake basins.

While the 1976 CNRET study was a useful contribution, its shortcomings are clearly evident more than two decades later. The study defined a river basin as an "area within which waters of natural origin (rain, groundwater flow, melting of snow and ice) feed a given river". It considered only those international river basins which were "separate" (that is not tributary basins), and were connected "directly with the final recipient of the water (oceans, closed inland seas and lakes)". The distribution of the number of international river and lake basins by continents, according to the CNRET study, was as shown in Table 1.1.

The study further indicated that nearly 47 per cent of the world's landmass (excluding Antarctica) falls within international basins. It ranged from a high of nearly 60 per cent of the landmass in Africa and South America to a low of about 40 per cent in North and Central America. Viewed in a different fashion, the report indicated that there

Table 1.1 Distribution of international river and lake basins by continent

Africa	57
Asia	40
Europe	48
North and Central America	33
South America	36
Total	214

are 44 countries where at least 80 per cent of the total landmass is within international basins. Of these 44 countries, 20 are in Africa, seven in Asia, 13 in Europe, and four in Latin America.

The CNRET study can at best be considered a preliminary assessment of the magnitude of the problem, which, incidentally, was also the intention of its originators. It suffered from some serious methodological shortcomings, however, and was based exclusively on maps available at the United Nations map library. It was exclusively a desk study with maps, some of which were on a scale of 1:15,000,000, or even less.

Unfortunately, the results of the CNRET study have been cited often in the past without any technical scrutiny; not surprisingly, these figures are now accepted as facts. This uncritical acceptance of the written word is all the more difficult to justify when one considers the fact that during the intervening two decades many countries, like the Soviet Union, Czechoslovakia, and Yugoslavia, have been split up into new countries, thus creating new international river and lake basins.

In retrospect, the uncritical acceptance of the number of international river and lake basins has had at least one unfortunate side-effect. Since the number is unquestionably an underestimate, it has given the erroneous impression that the overall magnitude and extent of the problem are much less serious than they actually are at present, and are likely to became in the foreseeable future. This issue has now been finally resolved by the work of Wolf *et al.* (1999).

This underestimation has been further compounded by the fact that international organizations, like the various United Nations agencies, the World Bank, and the regional development banks, for the most part have shied away from the issue of the management of international basins, except in non-controversial and non-threatening measures like expert group meetings, which in reality often achieve very little. These organizations have progressively become more and more risk-averse, a subject that will be discussed in the next section. The above two factors, to a significant extent, can explain why the issue of the management of international waters has not been as high up in the international political agenda over the past two decades as it should have been.

Role played by international organizations

During the past two decades, international organizations have played a very limited role in terms of facilitating agreements on international river basins. Unquestionably the most noteworthy and successful case where an international organization played a critical role as a catalyst to get the co-basin countries to agree to a treaty was the Indus river basin between India and Pakistan. Eugene Black, the then president of the World Bank, clearly and unambiguously indicated to the leaders of India and Pakistan at the highest political levels his own personal interest in resolving the conflict over the Indus basin amicably and speedily. He not only made the resources of the World Bank available to both countries for mediation, but also kept himself fully briefed of progress during the almost decade-long negotiations. When there was an impasse, he was not afraid to play a critical role in assisting the countries to overcome it. The World Bank played the role of an "honest broker" properly and impartially. The "carrot" that the World Bank extended in terms of offering to finance new development projects, subject to a mutually acceptable agreement between the two countries on the sharing of the waters of the Indus river system, proved to be a very attractive incentive for both parties conceded. The Indus treaty was formally signed by India and Pakistan on 19 September 1960 (Biswas 1992).

It is interesting to note that although the negotiations between the two countries took less than a decade, the subsequent agreement between the four provinces of Pakistan on the allocation of this water took an additional three-and-a-half decades to negotiate!

The entire negotiating process between the two countries took a remarkably short period for the successful completion of such a complex treaty. The Indus treaty is a major tribute to the astute and dynamic leadership of Eugene Black, who not only accepted the risk of potential failure but was also prepared to get involved personally and had no hesitation in putting his own reputation on the line.

The most unfortunate aspect during the 1960–1996 period was the almost total absence of the courageous and prudent leadership shown by Black, in either the World Bank or any other international organization. In 1976 another World Bank president, Robert McNamara, did discuss the issue of the sharing of the Ganges waters between India and Pakistan (then including Bangladesh), but the topic did not make any progress for many reasons. It was the technical professionals at the World Bank who were interested in the resolution of the problem. By the mid-1970s the Ganges issue had already been highly politicized in the countries concerned. The World Bank career professionals had very little, if any, access the highest levels of political decision-making, especially in India. Without such high-level access, it was impossible to find a solution that would have been politically acceptable to all the countries concerned. What is more, in contrast to the "honest broker" role played by the World Bank for the Indus river treaty, it was no secret that the bank's own idea of the Ganges solution was closer to the one advocated by Bangladesh. Not surprisingly, India did not trust that the bank could play an impartial role in any mediating process, and thus it summarily rejected the bank's overture.

In addition to all these factors, it has to be admitted that the World Bank's credibility with and overall impact on the developing countries were significantly higher in the 1950s as compared to the 1970s and later.

Two other international organizations have attempted to play a role in managing international rivers: the United Nations Environment Programme (UNEP) on the Zambesi river, and the United Nations Development Programme (UNDP) on the Mekong river.

The Zambesi basin covers eight countries: Angola, Botswana, Malawi, Mozambique, Namibia, Tanzania, Zambia, and Zimbabwe. UNEP convened a conference on the environmental management of the common Zambesi river system in Harare, Zimbabwe, in May 1987. The primary objective was to approve the draft Zambesi action plan (ZACPLAN), which was prepared by UNEP in close consultation with most of the countries concerned. The plenipotentiaries of five co-basin countries (Botswana, Mozambique, Tanzania, Zambia, and Zimbabwe) did sign an international agreement on the action plan for the environmentally sound management of the common Zambesi river system (David 1988; Nakayama 1997). While initially considered to be a success for UNEP, real progress in terms of its implementation of the plan in more than a decade has been minuscule.

The UNDP played a role in facilitating the agreement on cooperation for the sustainable development of the Mekong river basin. It is too early to make any judgement on the impact of this agreement. However, the fact remains that the UNDP had played "the roles of godfather, referee, rich uncle and fund-raiser to the Mekong Committee" (Miller 1996), which had already spent hundreds of millions of dollars. The disappearance of the Interim Mekong Committee, which seemed to be a distinct possibility in 1992, would have been a serious moral blow to the UNDP, since all this investment would have been lost. The UNDP subsequently played a very constructive role, which led to an agreement being signed on the lower Mekong by Cambodia, Laos, Thailand, and Viet Nam in 1995. China, the most powerful country in the region and the most upstream one on the river, was not a signatory to the agreement; it is also not a member of the new Mekong River Commission. This is likely to be a major constraint in the future for any basinwide integrated development.

While the agreement on the lower Mekong is a step in the right direction, it is unlikely to contribute significantly to the sustainable development of the Mekong river basin for the following reasons.

First, water requirements for all uses in China are increasing rapidly, and thus it needs to develop its water resources as much as possible and as quickly as possible. Currently several provinces of China have plans to develop the water resources of the upper Mekong. China has steadfastly refused to join either the earlier Interim Mekong Committee or the present Mekong River Commission. Also, the fact that China was one of the three countries which voted on 21 May 1997 against the resolution to establish an international convention on the non-navigational uses of international watercourses at the United Nations may have some negative implications for the future development of the Mekong.

Second, the most difficult part of any international agreement in the developing world is the actual water allocation between the various co-basin countries. The Mekong agreement does not include any specific allocation of water between the countries. It contains terminologies like "reasonable and equitable utilisation", and "prevention and cessation of harmful effects", on which even independent, objective experts may not agree, let alone countries with vested interests. The potential for conflicts between the countries on this issue in the future is therefore very high.

Thus, overall, no matter what criteria are used for analysis, international organizations have played a very marginal role in resolving conflicts on international rivers and lakes in recent decades. Given real leadership in the major international institutions, they could have played a significantly more effective role in this area over the past 35 years. Regrettably, there are no signs that this situation is changing for the better.

Resolution of locational water conflicts

Since water is mobile and does not respect political boundaries, countries on an international river could use its resources sequentially as it moves downstream. When a river forms a boundary between two countries, two political units have simultaneous authority over it, which could contribute to the generation of several types of transboundary water conflicts.

Because of potential conflicts between co-basin countries on international rivers and lakes, historically many nations have negotiated mutually acceptable agreements as to how such water bodies can be used. Over 3,600 treaties can be noted on international water bodies between AD 800 and 1985, the majority of which deal with navigation – water was the primary means of transportation in earlier times. Especially after the Second World War, many treaties were negotiated on international water bodies dealing with non-navigational issues like flood control, hydropower development, water quality management, and water allocation. It should be noted that generally it has been easier to negotiate treaties on the navigational uses of rivers, since these do not require water allocation or use considerations. Historically, it has been most difficult to reach agreement on the actual allocation of water quantities between the relevant co-basins countries.

The first important study on the legal aspects of using the waters of international rivers was carried out by Professor H. A. Smith of London. His book on *The Economic Use of International Rivers* was published in 1931, and reviewed more than 100 treaties and studied several conflicts on the use of international rivers. He emphasized the doctrine of riparian rights, which entitles the lower riparian states to a share of the natural flow of a river. He also noted that some of the treaties considered the concept of equitable utilization.

In 1956, the International Law Association (ILA) produced the Dubrovnik Rules for international rivers. In 1959, Bolivia introduced a resolution in the United Nations General Assembly which requested the Secretary-General to prepare a report on laws related to international rivers. This resolution was passed, although Bolivia's motivation for proposing it this is unknown.

In 1966, the ILA adopted the so-called "Helsinki Rules" for international watercourses. In 1970, Finland introduced a resolution in the UN General Assembly on the laws for international watercourses which suggested that the Helsinki Rules should be considered as a model.

During the ensuing discussions, three reservations concerning the Helsinki Rules surfaced.

- The rules were formulated by a professional organization which did not represent nation-states.
- Since nation-states had not participated in the formulation of the rules, their adoption as a model could preclude new considerations on this complex issue.
- The rules were based on a drainage basin approach, which could be a potential threat to national sovereignty.

An analysis of the ensuing discussions indicates that the most important reservation was use of the drainage basin concept. Belgium, Brazil, China, and France argued that such an approach would be a radical departure from the traditional channel-based international law. In contrast, Finland and the Netherlands felt that the drainage basin framework was the most rational and scientific approach. Certain other countries opined that the problem of international river basins was so diverse that codification may be not possible.

The resolution to refer to the Helsinki Rules as a model was lost.

However, a similar resolution was passed with only one negative vote (Brazil) after the reference to the Helsinki Rules was deleted. This resolution recommended that the International Law Commission (ILC) should "take up the study of the law of the non-navigable uses of international watercourses with a view to progressive development and codification".

In 1974, the ILC sent out a questionnaire to all members of the General Assembly soliciting their view on nine key questions. The responses, however, were not encouraging. By 1975, only 21 of the 147 UN members had bothered to reply. Four additional countries replied by 1978, one in 1979, four in 1980, and two more by 1982. Not surprisingly, on the critical issue of the appropriateness of the drainage basin concept, the countries were sharply divided. Approximately half supported the concept (Argentina, Finland, and the Netherlands) and the other half were either strongly negative (Austria, Brazil, and Spain) or ambivalent. Because of such sharp differences, the ILC decided to begin with the formulation of general principles, and then determine the scope of the term "international watercourses" later. This issue was finally addressed in 1991, when the ILC produced a draft report on the law of the non-navigational uses of international watercourses.

Considerable discussion took place on the ILC draft between 1991 and 1997. Finally, on 8 July 1997, the UN General Assembly approved the resolution on non-navigational uses of international watercourses. It is interesting to review the voting pattern on this resolution, especially in terms of existing disputes on international basins. Bangladesh, Brazil, Cambodia, Jordan, Laos, Nepal, South Africa, Sudan, Syria, Thailand, and Viet Nam were in favour; Burundi, China, and Turkey were against; and Argentina, Egypt, Ethiopia, France, India, Israel, and Pakistan abstained.

The General Assembly resolution adopted the Convention on the Non-Navigational Uses of International Watercourses, and it is now open for signature by the states. Even though some 106 countries voted for the convention, it is unlikely to be ratified in the foreseeable future because of the complexity and sensitivity of the issue.

The future

If and when a convention on non-navigational uses of international watercourses is ratified, a major issue will be its potential impact in terms of resolving existing and future disputes. In all probability it will have very marginal impact on the resolution of the conflicts, for several reasons.

Table 1.2 Current water conflicts and voting patterns on UN Convention on Non-Navigational Uses of International Watercourses

Euphrates/Tigris	Syria in favour, Turkey against, and Iraq not involved
Ganges	Bangladesh and Nepal in favour, but India abstained
Jordan	Jordan in favour but Israel abstained
Mekong	Cambodia, Laos, Thailand, and Viet Nam in favour, but China against
Nile	Sudan in favour, Egypt and Ethiopia abstained, and Burundi against
Plata	Brazil in favour but Argentina abstained

First, not all countries that are currently parties to disputes on international watercourses are likely to sign the convention. Table 1.2 shows some of the current conflicts and the voting patterns on the proposed convention in the UN General Assembly of the countries concerned.

This probably means that if and when the convention is ratified, some parties to specific conflicts are unlikely to be signatories. As past experience with the nuclear non-proliferation treaty has shown, moral pressures are likely to be of little value when faced with strong, entrenched, vested national interests; experience with this new convention is unlikely to be any different.

Second, while the 1997 convention could be considered to be an important benchmark, its two basic principles are similar to what had generally been accepted much earlier: equitable and reasonable utilization and an obligation not to cause appreciable harm. Thus the proposed convention did not break any new ground, at least conceptually.

One of the main problems with the proposed convention is that it is full of vague, broad, and general terms (Waterbury 1997) which can be defined, and in certain cases quantified, in a variety of different ways. Accordingly, expert advice can be easily "tailored" to legitimize each country's political views and demands. Technical analyses can be produced to justify and support appropriate national positions. Such situations, however, are not new: they have happened in the past and will no doubt continue to occur in the future. Furthermore, the convention does not give any practical guidance to the negotiators, nor any operational assistance to the technical experts. It simply outlines a very broad, general framework, within which everything is considered to be relevant and important. It is likely to contribute to the generation of significant differences of opinion among the negotiators and technical experts as to how each general article should be interpreted in operational terms.

One can argue that the convention outlines certain factors which could determine one of the fundamental principles, that of "equitable and reasonable use". According to the convention, such a process should take "into account all relevant factors, and circumstances", including:

- geographic, hydrographic, climatic, ecological, and other factors of a natural character;
- social and economic needs of co-basin countries;
- effect of the uses of the watercourse on other co-basin states;
- existing and potential uses of the watercourse;
- conservation, protection, development, and economy of use of the watercourse resources and the cost of measures taken to that effect;
- availability of alternatives, of corresponding value, to a particular planned or existing use.

None of these factors can be defined uniquely or precisely, since they are general and broad in character. Accordingly, when all the factors are integrated to define "equitable and reasonable use", the countries in conflict would find it a very difficult task to arrive at mutually acceptable estimates, and estimates are likely to differ significantly even when groups of truly independent and objective experts make such attempts separately.

Third, the prevailing national political sentiments in each negotiating riparian country, as well as the incentives to negotiate in good faith, are likely to be important factors in the resolution of all such conflicts. In addition, as the number of riparians increase to four or more in any international basin, the importance and relevance of any proposed settlement could range from exceedingly important for one country to total indifference or even downright hostility from another. For a basin like the Nile, which has 10 riparians countries, the incentives for all parties to arrive at any specific settlement are likely to range from very high to of no discernible interest. Equally, the types of settlements preferred by the different countries are likely to vary significantly. The new convention can at best be of limited help in such cases.

Finally, ratification of the convention is an important requirement. The convention can enter into force on the "ninetieth day following the date of deposit of the thirty-fifth instrument of ratification, acceptance, approval or accession with the Secretary-General of the United Nations". The convention is open for signature until 20 May 2000.

Nearly two years after the approval of the convention by the General Assembly, only four states (Finland, Norway, South Africa, and the Syrian Arab Republic) have so far ratified it. Whether another 31 states will ratify it before the closing date is an open question. Accordingly, the potential impacts of the convention on the resolution of disputes over international rivers and lakes cannot be surmised at present.

The above considerations and other related factors mean that agreements in individual international basins will continue to occur only through protracted negotiations between the riparians concerned. The convention, even if it is ratified, is unlikely to speed up the time needed to reach mutually acceptable agreements in the vast majority of disputes on international river basins.

Conclusion

As the twenty-first century dawns, it is becoming evident that, like oil some two decades ago, the era when water could be considered to be a cheap and plentiful resource is now virtually over. Increasing water demands, limited availability of this resource, and higher levels of contamination mean that the water management profession will face a problem of a magnitude and complexity which no earlier generation has had to face. The water profession really has two fundamental choices: to carry on as before with only incremental changes and a "business-as-usual" attitude, and thus endow future generations with a legacy of inefficient water management practices and potential serious conflicts on international water bodies; or to continue in earnest with an accelerated effort to plan, manage, and use international watercourses sustainably and fairly.

The root for the English word "*rival*" is from the Latin term *rivals*, which originally meant using the same river (*rives*). But as the world becomes increasingly more and more interconnected, countries sharing the same river should no longer consider each other as rivals. With properly conceived frameworks, management and use of international water bodies should result in "win-win" situation for all the parties concerned. Contrary to popular belief, these are not zero-sum games.

REFERENCES

Biswas, Asit K. 1992. "Indus Water Treaty: The Negotiating Process", *Water International*, Vol. 17, pp. 201–209.

Biswas, Asit K., N. V. Cordeiro, B. P. F. Braga, and C. Tortajada-Quiroz. 1999. *Management of Major Latin American Rivers: Amazon, La Plata and Sao Francisco*. Tokyo: United Nations University Press.

Biswas, Asit K. and T. Hashimoto, eds. 1996. *Asian International Waters: From Ganges-Brahmaputra to Mekong*. New Delhi: Oxford University Press.

Centre for Natural Resources, Energy and Transport. 1978. *Register of International Rivers*. Oxford: Pergamon Press.

David, L. J. 1988. "Environmentally Sound Management of the Zambesi River Basin", *International Journal of Water Resources Development*, Vol. 4, No. 2, pp. 80–102.

International Irrigation Management Institute (IIMI). 1992. *Developing Envi-*

ronmentally Sound and Lasting Improvements in Irrigation Management: The Role of International Research. Colombo: IIMI.

Miller, M. 1996. "Transformation of a River Basin Authority: The Case Study of Mekong Committee", in *Asian International Waters: From Ganges-Brahmaputra to Mekong*, eds A. K. Biswas and T. Hashimoto. New Delhi: Oxford University Press, pp. 226–244.

Nakayama, M. 1997. "Successes and Failures of International Organisations Dealing with International Waters", *International Journal of Water Resources Development*, Vol. 13, No. 3, pp. 367–382.

United Nations, Report of the Secretary-General. 1997. *Comprehensive Assessments of the Freshwater Resources of the World*. Committee on Sustainable Development, Fifth Session, E/CN. 17/1997/9. New York: United Nations.

Waterbury, J. 1997. "Between Unilateralism and Comprehensive Accords: Modest Steps toward Cooperation in International River Basin", *International Journal of Water Resources Development*, Vol. 13, No. 3, pp 279–290.

Wolf, A. T. *et al.* 1999. "International River Basins of the World", *International Journal of Water Resources Development*, Vol. 15, No. 4, pp. 387–428.

World Bank. 1992. *World Development Report*. New York: Oxford University Press.

2

Ganges-Brahmaputra: The outlook for the twenty-first century

R. B. Shah

Introduction

The Ganges-Brahmaputra-Meghna (GBM) river basins, encompassing Nepal, India, Bangladesh, the autonomous Tibet region of China, and Bhutan, have considerable water resources potential which can be harnessed for multipurpose beneficial uses – like irrigation, hydropower generation, flood control, navigation, fishery development, etc. – in the countries forming a part of these mighty river basins through cooperation among those countries in order to make optimal use of this potential for common good. Incidentally, this region constitutes one of the poorest regions in the world. Global experience clearly shows that development of water resources ushers in an era of all-round prosperity by increasing agricultural production through irrigation, by industrial development with the increased availability of electric power, and by preventing/mitigating the recurring damage caused by frequent floods. These trigger a chain of economic activities with forward and backward linkages, which increase employment potential considerably and result in an improvement in the standard of living of the people, and in turn of the nations involved.

However, so far very little of this precious natural gift has been utilized in these river basins. Consequently, year after year, the waters of these river systems continue to flow unused to the seas, causing flood damage en route in most years.

Meanwhile, with ever-increasing population growth and increasing demands on water for various competing uses, available water is becoming scarce, the cost of development is escalating, misconceived opposition to the conservation and development of water resources is growing, and, at the same time, the degradation of not only the environment but also the quality of life of the people of this region is continuing at a faster rate.

At the end of the twentieth century, one gets an inescapable feeling of sadness in having lost/wasted the century as far as the development of water resources and their utilization in this region are concerned.

This chapter, therefore, is a modest effort to highlight the enormous potential, make an honest assessment of the efforts and limited achievements so far, and summarize the outlook needed and the tasks ahead for the twenty-first century.

Basic facts

To have a proper appreciation of the problem and the perspective, it is necessary to note the basic indisputable facts which constitute the parameters for any growth model. While the Ganges-Brahmaputra and the Meghna are three distinct river basins, these merge into one as far as Bangladesh is concerned. As they are adjoining basins with some degrees of commonality as well as disparity, it is desirable to study them together as one entity, as there is a scope of complementality. Therefore, this chapter covers the region traversed by the Ganges, Brahmaputra, and the Meghna. In dealing with details, the Tibet region is left out, as many facts and figures concerning it are not available and the impact of developments there may not be significant in other parts of the region. Some of the basic facts in the region pertaining to these river systems are given in the following sections.

Geographical area

The total area traversed by these rivers is around 1.65 million square kilometres. Distribution of geographical area in the countries of the basins is given in Table 2.1. The percentage of the total geographical area of the GBM region contributed by various countries (Char 1997a) is as given in Table 2.2.

Population

The total population in the GBM region is about 536 million. The breakdown by country is given in Table 2.3. The GBM region constitutes about 0.12 per cent of the world's total geographical area, but it has to

Table 2.1 Geographical area of the GBM region by country

	Basins (million ha)				
	Ganges	Brahmaputra	Meghna	Minor rivers	Total
India	86.14	19.44	4.17	3.63	113.38
Nepal	14.70	–	–	–	14.70
Bhutan	–	4.50	–	–	4.50
Bangladesh	3.90	4.70	3.62	–	12.22
Total	104.74	28.64	7.79	3.63	144.80

Table 2.2 Percentage of GBM geographical area by country

Country	Ganges %	Brahmaputra %	Meghna and minor rivers %	GBM %
India	82.24	67.88	68.30	78.30
Nepal	14.03	–	–	10.15
Bhutan	–	15.71	–	3.11
Bangladesh	3.73	16.41	31.70	8.44
Total	100.00	100.00	100.00	100.00

Table 2.3 Regional population

Country	Population (millions)	% of total GBM population	Population density/ha
India	405.4	75.66	3.57
Nepal	18.9	3.53	1.28
Bhutan	1.5	0.28	0.33
Bangladesh	110.0	20.53	9.00
Total	535.8	100.00	3.70

support about 10 per cent of the world's total population. Most of the population, varying from about 70 per cent in India to 90 per cent in Nepal, works in agricultural-based employment.

Poverty

According to an assessment by the World Bank, about half of the world's poor live in South Asia. Within the South Asian region, the Ganges-Brahmaputra-Meghna region contains the largest concentration of the poorest in the world, representing about 40 per cent of the total number of the poor in the developing world.

Table 2.4 Human deprivation parameters in the GBM region

Parameter	India %	Nepal %	Bangladesh %	Bhutan %
Population in absolute poverty	46	40	52	N/A
Population without access to safe water	25	55	22	66
Population without access to sanitation	71	79	66	87
Human development index	0.436	0.332	0.365	0.307
GNP per capita (US$)	300	190	220	170

Table 2.5 Average annual rainfall in GBM countries

Country	mm
Nepal	1,520
India (whole country)	1,300
Bangladesh	2,400
Bhutan (higher altitudes)	500
Bhutan (southern plains)	2,000
Bhutan (foothills)	5,000

There are various parameters/indicators of poverty. Prasad (1997) states that the UNDP estimated poverty index for Bangladesh is 86.5 per cent, for Nepal 60 per cent, and for India 55 per cent. In 1993, some of the human deprivation profile parameters were as given in Table 2.4 (Rangachari 1997).

The figures in Table 2.4 are more-or-less representative in respect of Nepal, Bhutan, and Bangladesh. However, in the case of India, national averages are not valid for the GBM region. States of India like Assam, Bihar, Madhya Pradesh, Rajasthan, Uttar Pradesh, and West Bengal, which form a part of this region, are below the national parameters and constitute a major poverty subregion in India.

Rainfall

The average annual rainfall in some countries of this region is given in Table 2.5.

Most of the annual rainfall (75–80 per cent) occurs in the three to four months of the south-west monsoon. Even in this period, the bulk of the rainfall comes in three to five spells of a few days each. Thus, most of the water is received in a period of 30–40 days, but it has to last for the entire year. There are also variations in the quantum of rainfall from year to

Table 2.6 Average annual surface water flows in GBM countries

	Million ha-m			
Country	Ganges	Brahmaputra	Meghna	Total
India	52.50	53.72	7.93	114.15
Nepal	20.00	–	–	20.00
Bangladesh	3.40	10.25	5.10	18.75
Bhutan	–	N/A	–	–
Total	75.90	63.97	13.03	152.90

Table 2.7 Available groundwater resources

	Million ha-m			
Country	Ganges	Brahmaputra	Meghna	Total
India	17.17	2.78	0.18	20.13
Nepal	1.20			1.20
Bangladesh	N/A	N/A	N/A	3.22
Bhutan	–	N/A	–	N/A
Total	–	–	–	24.55

year, apart from spatial and temporal variations. Bangladesh is subject to frequent cyclonic storms bringing intense spells of rainfall.

Available water resources

Surface water

On the basis of available published figures, average annual surface flows in various river basins in different countries are given in Table 2.6. In terms of water resources availability, the GBM is the second largest river basin in the world, after the Amazon river basin.

It will be seen from Table 2.6 that India contributes about 75 per cent of the water resources of the entire GBM region – comprising 69 per cent of the Ganges basin, 84 per cent of the Brahmaputra basin, and about 61 per cent of the Meghna and minor rivers. In fact, out of the total surface water resources in India, about 63 per cent are in these river basins.

Groundwater

The available groundwater resources are roughly as given in Table 2.7. Groundwater resources as per present estimates are about 16 per cent of the available surface water resources.

Utilizable water resources

Surface water

On account of the fact that bulk of the surface water resources are derived from south-west monsoon rainfall, falling over a total period of 30–40 days per year in short spells spread over the monsoon season, unless these waters are stored in minor, medium-sized, and large reservoirs for subsequent multipurpose use throughout the year, they cannot be utilized.

Therefore, ultimate utilizable surface water resources in India have been estimated as 32 per cent of the available resources of the Ganges with dams in India, or 47 per cent of the Ganges with dams in India and Nepal, and 4 per cent of the Brahmaputra and Meghna.

Thus, the maximum utilizable surface water resources in India in the GBM region will be about 19 million ha-m, which may rise to about 27 million ha-m with the construction of dams in Nepal. Since all the possible dams may not materialize, the utilizable surface water resources can be considered as about 20–24 million ha-m.

In the case of the Ganges basin, with the limited availability of suitable sites for construction of storage dams in India, utilizable water in India is about 32 per cent. Since most of the important tributaries of the Ganges rise in Nepal before flowing down to India, and storage sites on these tributaries are available in Nepal, the utilizable quantum of Ganges water in India will increase to the extent that storage dams are built in Nepal. Even so, more than 50 per cent of Ganges water from India will continue to flow unused to the sea, mainly in the monsoons.

Similarly, it is quite evident that only 4 per cent of available water in the Brahmaputra-Meghna basin can be utilized in India, and the balance will continue to flow unused to the sea through Bangladesh; even this minimal utilization will only be realized provided a few dams which are feasible within Indian territory are actually constructed.

Similar estimates for other countries are not available. Since the consumption requirements for water in Nepal are not likely to be very high, and since there is no possibility of constructing dams in Bangladesh, total utilizable surface water resources can be estimated as about 20–24 million ha-m, which is only about 13–15 per cent of available water resources. This constitutes one of the major constraints in development of water resources in this region.

Groundwater

As far as groundwater is concerned, the entire available potential again cannot be utilized. Normally, 80 per cent of the annual recharge is utilized so as not to affect the groundwater dynamic equilibrium adversely.

In India, in some states, adverse effects of overexploitation of groundwater in terms of continuous decline in water levels, appearance of harmful chemicals like nitrates, arsenic, etc., and intrusion of salinity in coastal areas are already being experienced. Thus, about 20 million ha-m of groundwater may be considered available for utilization. Most of the rural water supply for drinking and domestic use is from groundwater. In addition, in the Ganges basin in India, groundwater is being extensively used for irrigation.

Therefore, for future development, groundwater will not be a major source, and future planning for development and utilization of water resources has to take into account these facts/constraints.

Hydropower

The GBM region, with its rivers originating in Himalayan and sub-Himalayan ranges with steep topographical slopes and almost year-round availability of flows, has a tremendous hydropower potential. Although there are varying estimates of the potential, generally accepted figures are that India has 45,635 MW (economically exploitable), Nepal has 83,000 MW (estimated) and 42,000 MW (economically exploitable), and Bhutan has 21,000 MW.

The potential developed so far and under creation is indeed meagre, as may be seen from the figures of installed capacity in India of 3,525 MW, Nepal 244 MW, Bhutan 336 MW, and Bangladesh 230 MW. Thus, the hydropower potential developed/under development in the entire GBM region is only 4,335 MW, which is about 5 per cent of economically exploitable potential.

This brings out the tremendous scope for future development, which will not only help in boosting agricultural and industrial development in the region as a whole, but will particularly help in considerable economic development of Nepal and Bhutan, as hydropower is the most precious natural resource and asset for these countries and perhaps the only major resource for their economic growth. For both of these countries, India, where the supply-demand gap is ever increasing, will be the market.

Flood control

While about 60 per cent of India's flood-affected area lies in the Ganges-Brahmaputra-Meghna basins, almost 80 per cent of the entire area of Bangladesh is prone to floods. The areas subjected to floods are the least in Bhutan, as the rivers flow in deep incised channels. The problem of floods in Nepal is also comparatively limited for the same reason, although areas in the inner terai and terai regions are prone to flooding. The floods are caused by incessant rains, which also contribute to landslides.

It is universally recognized that the only method of really controlling the floods is the detention of flood waters in storage reservoirs and subsequently releasing the water in a regulated fashion. There are no storage reservoirs constructed so far in India in the Brahmaputra and Meghna basins. On the northern tributaries of the Ganges there are hardly any adequate storage sites available in India, although a number of sites exist in Nepal. However, so far no major dams have been constructed in Nepal. In India, some dams on the southern tributaries of the Ganga have been constructed, but, except for a dam on the Ramganga, no major dam on the northern tributaries has been completed. Another major dam, Tehri, is under construction. There is no scope for constructing any dams in Bangladesh, which is essentially a deltaic region.

Because of this, major portions of the GBM region in India and Bangladesh are subjected to recurring flood damage, and will continue to be so to an appreciable extent.

A brief review of past cooperation

India-Nepal cooperation

The earliest attempt at Indo-Nepal cooperation in the field of water resources dates back to 1920–21, when, under the British rule, an agreement was reached on the Sarada barrage on the river Mahakali in India. This envisaged the diversion of 460 cusecs (flow of cubic feet per second) of water during the wet season and 150 cusecs during the dry season to Nepal through an independent canal; meanwhile, the Sarada barrage has provided irrigation over a large area in the Indian state of Uttar Pradesh.

In the post-independence period, cooperation between India and Nepal began with the implementation of the Kosi barrage at Bhimnagar and the Gandak barrage at Baisaltan, both financed by India under agreements signed for the two projects in April 1954 and December 1955 respectively; both the agreements were subsequently revised in 1966. The barrages provide benefits of irrigation, hydropower, and flood control (to some extent) to both countries. Under these two projects, some irrigation benefits are extended to Nepal as well as the supply of hydro-electric power. Since no storage dams have been constructed on these rivers upstream, the existing irrigation benefits are basically from run-of-the-river operation.

India has also assisted Nepal with both technical and financial assistance in building hydro-electric projects, such as Trisuli (21 MW), Kataiya (20 MW), Gandak (15 MW), and Devighat (14 MW). In addition, India provided assistance for the modernization of Chatra and Chandra canals for stabilizing and extending irrigation benefits in Nepal.

Although a number of other major multipurpose water resources projects on the important tributaries of the Ganges like the Kosi, Rapti, Sarada, Gandak, Bagmati, etc. have been under formulation and discussion for a number of years, no tangible results have been achieved so far.

However, on 12 February 1996 a treaty between the governments of India and Nepal was signed concerning the integrated development of the Mahakali river, including the Sarada barrage, Tanakpur barrage, and the Pancheswar project. This was a significant benchmark in cooperation after the unfruitful results of discussions at various levels over the preceding 30 to 40 years. This treaty was ratified by both the countries and instruments of ratification exchanged during the visit of the Indian prime minister to Nepal in June 1997. The multipurpose Pancheswar project is envisaged as having an installed capacity of 2,000 MW/6,480 MW of hydropower and irrigation and flood control benefits to both countries; the agreed detailed project report, including the installed capacity for hydropower, is yet to be finalized.

During the Indian prime minister's visit in June 1997, a power trade agreement was also signed.

India-Bangladesh cooperation

Following the visit of the prime minister of India to Bangladesh in March 1972, the Indo-Bangladesh Joint Rivers Commission (JRC) was set up in November 1972 for harnessing the rivers of the two countries for the benefit of both. Initially, the commission was entrusted with matters related to flood management and the resolution of common border river problems. Subsequently, in 1974, the JRC was entrusted with the additional task of resolving the issue of sharing flows of all the common rivers, and the formulation of agreed proposals for augmenting the flows of the Ganges at Farakka.

Interim arrangements for sharing lean flows of the Ganges at Farakka were formulated for short periods during 1977, 1982, and 1985. The last interim sharing arrangement expired on 31 May 1988; because of the failure of both the countries to arrive at any amicable solution for augmenting the flows at Farakka, there was no agreement for sharing lean flows of the Ganges after 1988. However, on 12 December 1996 a new treaty for sharing Ganges waters at Farakka for the lean season was signed. In this treaty, the issue of augmentation of lean-season flows at

Farakka has not been made contingent to the sharing arrangement. However, the treaty does stipulate the need to cooperate with each other in finding a solution to the long-term problem of augmenting the flows of the Ganges during the dry season. This treaty will remain valid for a period of 30 years and shall be renewable by mutual consent. This has been a significant landmark in Indo-Bangladesh cooperation, as it removes one of the major irritants.

The issue of lean-season sharing of the waters of the Teesta river and 54 other small rivers common to both countries is still under consideration.

In the meantime, the government of Bangladesh has revived its proposal to construct a barrage on the Ganges at Pangsha, about 60 kilometres downstream of the Hardinge bridge in Bangladesh. This project will be multipurpose in character; India has welcomed the proposal and has offered technical assistance for preparation of detailed feasibility reports. It is understood that the government of Japan is likely to provide financial assistance for investigations and the preparation of a feasibility report for this project.

India-Bhutan cooperation

Bhutan has a hydropower potential in the order of 20,000 MW. India has been giving both technical and financial assistance to Bhutan for about the last 40 years for various development activities, including development of hydropower. Since the commissioning of the first micro-hydro-electric project in Thimpu (400 kW) in 1966, a number of other micro-hydro-electric stations have been planned and built in various parts of Bhutan, with a total installed capacity of about 10.5 MW. The first major hydro-electric project, Chukha, with 336 MW installed capacity, was constructed under an agreement signed in 1975 with financial assistance from India (60 per cent grant and 40 per cent soft loan), and was commissioned in 1987. Since the requirements for power in Bhutan are extremely small, the bulk of the power from this project is exported to India under an agreed tariff which is revised at fixed intervals. With the encouraging experience of this project in terms of the economic development of Bhutan, another project, Kurichu in western Bhutan, with an installed capacity of 45 MW, is also under implementation. Another major project, Tala, second in the cascade development of the Wangchu river, with an installed capacity of 1,020 MW, has also been taken up for implementation from 1997 with financial assistance from India (60 per cent grant and 40 per cent loan). Both the Chukha and Tala projects are being implemented through project authorities specially set up; these are autonomous, with high-level representation from both India and Bhutan, and are chaired by a representative of the king of Bhutan.

There are several other major hydro-electric projects in various stages of planning, investigation, and preparation of project reports, such as Wangchu Stage II (900 MW), Sankosh (4,060 MW), and Bunakha (180 MW) (Char 1997).

Indo-Bhutan cooperation is very significant in terms of economic development in Bhutan, where the revenue earned from hydropower development will be the main source of income for the country to help in its overall economic development and raising standards of living. At the same time, it will enable India to meet its increasing demand for power.

Future areas of cooperation

Against the background of the basic indisputable facts mentioned earlier, as well as in view of the large potential for development of water resources for the overall benefit of the region, it will be obvious that there are many areas of mutual cooperation. These can be briefly summarized as:

- hydropower generation and inter-country transfer of power;
- flood control and forecasting;
- technical assistance in formulation of water resources projects;
- joint implementation and operation of major multipurpose projects;
- management and equitable sharing of lean flows;
- inland navigation;
- augmentation of flows.

While these are general, broad areas of cooperation, the forms and modalities of cooperation in each specific area will differ from one country to another. However, it needs to be emphasized that past mindsets have to be changed, and flexible rather than rigid approaches need to be adopted, with the sole aim of mutual cooperation for the benefit of the countries of the region. The old maxim "where there is a will, there is a way" is all the more applicable now. The last few years have witnessed the rapid demolition of political, mental, and attitudinal barriers the world over. Interdependence among nations is an inevitable fact of the new world order. Regional cooperation in countries geographically close to each other with many bonds of past history and similarities in culture and way of life should provide a favourable platform to foster cooperation for the common good of the poorest people inhabiting this region. Gradually, enlightened public opinion in all the countries of this region is veering round to this approach. This now needs to be crystallized in specific cooperative ventures. A broad delineation of some areas of this cooperation has been attempted in the following sections.

Hydropower generation and interconnection

Potential and market

As already mentioned, Nepal has an economically exploitable hydropower potential of 42,000 MW and Bhutan has about 20,000 MW. The market for absorption of this power is basically in India, as the requirements of Nepal and Bhutan, even on a long-term basis, will be quite small. However, transmission and absorption of the power generated in Nepal and Bhutan will have to be through an interconnected integrated power system between the various countries.

International experience

Interconnection of power systems of contiguously located countries and their coordinated operation provide immense technical and economic benefits (Sambamurty 1997). In Europe, such integrated power systems have been in existence and operation for over 70 years, covering most of the European countries like Germany, France, Italy, Belgium, the Netherlands, and Switzerland as well as the former Yugoslavia, Greece, Spain, and Portugal. Similarly, there is another integrated system between Norway, Sweden, and Finland. The USA and Canada are also sharing hydropower in the St Lawrence and Columbia river basins.

Recently, development of interconnected power systems has also commenced in the countries of Egypt, Libya, Tunisia, Syria, Morocco, Jordan, Lebanon, Iraq, and Turkey. Similarly, in Central America, Mexico, Columbia, and Venezuela have started development of interconnections between their systems. There is thus plentiful international experience available in the successful interconnection and operation of inter-country power systems. This can usefully be extended to the GBM region, where the present status is as follows.

India-Bhutan

The power generated at the 336 MW Chukha project in Bhutan is transmitted thorough 220 kV lines to Birpara in India; this provides the link between the Bhutanese power system and the eastern regional power grid of India, and enables transmission of the surplus Chukha power to India. The operation of the Chukha plant is coordinated in the eastern regional grid by the eastern regional load despatch centre in Calcutta. Similar arrangements between India and Bhutan will be extended for transmission of surplus power from the proposed 1,000 MW Tala project downstream of Chukha.

The power to be generated from other hydro-electric projects in Bhutan, like Kurichu, Chukha Stage II, etc., will be similarly interconnected to the Indian system.

India-Bangladesh

Studies of the interconnection of the Bangladeshi and Indian power systems were initiated by the Power Grid Corporation of India in 1994. Studies carried out by the two countries, discussions between them, and the interest shown by the Asian Development Bank led to the formulation of an ADB regional technical assistance project known as the India-Bangladesh Electricity Exchange Project. Under this project, the techno-economics of two 132 kV double-circuit lines to interconnect the Indian and Bangladeshi systems will be examined to gauge the feasibility of the import and export of power from India to Bangladesh and vice versa.

India-Nepal

At present, India supplies power from the Kosi and Gandak projects to the border towns and villages in Nepal. However, there is no major system of significant interconnections between the Nepalese and Indian power systems.

Nepal has already started construction of some hydropower projects, like Kali-Gandaki (144 MW). In addition, some projects are also being taken up in the private sector, like Bhote Koshi (36 MW). Nepal's electricity demand by the year 2025 is projected to be about 1,700 MW, thus the power to be generated from major hydro projects like Pancheswar will be surplus to its requirements. Such surplus power will have to be transferred to India thorough an interconnecting system. In future, major multipurpose projects having a predominant hydropower component, like Chisapani on the Karnali (10,800 MW) and Kosi (7,000 MW), are likely to come up – recently it was reported that some private foreign enterpreneurs have already shown interest in developing the Chisapani project.

A programme for promoting interconnections between the Nepalese and Indian power systems will therefore have to be planned and implemented. It may begin with interconnections across the border at 132 kV level, which will later need to be extended and strengthened when the other hydro projects in Nepal are developed.

Necessity of interconnection studies

In India, the bulk of the power potential lies in the northern and north-eastern portions of the Himalayas; even at present, the north-eastern and eastern regions are somewhat surplus in power (Sambamurty 1997).

Therefore, planning of an all-India grid is already under way. The long-term national power plan prepared by the Central Electricity Authority (CEA) in March 1997 indicated the core transmission system required to transfer power from the north-eastern to the eastern and northern regions, considering both EHV AC and HV DC alternatives. These studies will have to be supplemented as and when the possibilities of power exchanges between the GBM countries materialize. The transmission lines envisaged by the CEA, considering only the projects to be developed in India, will have several nodal substations and it may be possible to use them for interconnections.

Therefore, on the lines of the study already undertaken with ADB assistance for interconnection between India and Bangladesh, similar studies for interconnection between India and Nepal need to be undertaken to decide various techno-economic details. This will involve the compatibility of the system sizes and parameters in different countries, as well as setting up of load despatch centres and system control facilities which at present are not available. This area of cooperation, which is more or less non-controversial, needs to be pursued vigorously to plan the feasibility of interconnecting systems and work out broad techo-economic details.

Tariffs

So far, there are no problems of any type between India and Bhutan. However, in the case of Nepal the question of tariffs will have to be amicably settled. At present, it is understood that there are some basic differences over even the tariff to be charged for the surplus power from the proposed Pancheswar project – this is understood to be one of the main reasons for the non-finalization of a mutually acceptable project report. However, it will be in the interest of both the countries to resolve this issue amicably as early as possible and to lay down agreed principles for the fixing of tariffs, as the actual tariff may vary slightly from project to project.

Flood control

Extent of problem

In India, the Ganges and Brahmaputra basins are subject to recurring floods of varying intensities. It is estimated that about 55 per cent of the total flood damage in India takes place in this region. Even within the region, the intensity and recurrence of floods is higher in the Brahmaputra basin, where flooding is almost annual, compared to the Ganges basin.

Floods in Bangladesh are also a recurring phenomenon, with about 80 per cent of the country's geographical area being prone to floods. Every year, almost one-third of the area gets flooded. In the recent past, the floods experienced in 1988 were the worst in living memory: over 60 per cent of the total land area was flooded and about 50 per cent of the population was directly affected.

Floods in Nepal are comparatively less severe and restricted mainly to inner terai and terai areas.

Flood control measures so far

As already pointed out, one of the recognized methods of direct control of floods is to construct storage reservoirs for flood waters. These are more effective if located near the damage centres. In the Brahmaputra-Meghna basins in India, so far no storage reservoir has been constructed. Even in the Ganges basin, where the flood problem is more severe on its northern tributaries, no storage reservoir has been constructed excepting on the Ramganga river, a tributary of the Ganges where the flood problem is not serious.

In Bangladesh, on account of its deltaic region, there is no possibility of constructing any storage reservoirs. In Nepal there are adequate storage sites on the main tributaries of the Ganges, but no storage reservoir has yet been constructed.

Therefore, so far recourse has been taken to reduce the flood damage, particularly in urban and agricultural areas, by construction of flood embankments. In India, in the Ganges basin, about 5,800 km of embankments have been constructed, and in the Brahmaputra basin about 4,800 km of embankments, giving a total of more than 10,500 km. Similarly, it is reported that about 8,300 km of embankments have been constructed in Bangladesh.

Although the embankments have afforded some degree of protection, particularly in less severe floods, they are subject to breaches during high floods and some of the embankments also get overtopped. This is mainly on account of the fact that embankments for protection of agricultural areas are generally designed for a flood of 25-year frequency. Because of poor maintenance, the embankments are subject to severe damage during floods, and damage through breaching and overtopping is much more serious than that caused by normal floods. Embankments also adversely affect the natural drainage of the protected areas. Besides, in the case of long embankments on both banks, there is an appreciable rise in flood levels for the same magnitude of floods. In many cases, the heights of the embankments have to be increased, or they have to be protected by costly anti-erosion measures.

Due to these problems, embankments along with river training works are now generally restricted to protection of urban areas. In India, many towns and cities, including Delhi, are protected by embankments.

Prospects of storage reservoirs

On the basis of the study of all available topographical sites in India, it has been estimated that the total storage capacity which can be constructed in the Ganges basin is only 5.44 million ha-m; while in the Brahmaputra-Meghna basins it is 4.76 million ha-m. Thus, together, these reservoirs will constitute only one-third of the total storage capacity that is proposed to be created in India. The storage capacity already created in the Ganges basin is 3.22 million ha-m. On the Brahmaputra, no storage capacity has so far been created. On the Barak river in India, the Tipaimukh multipurpose project envisages a 163-m-high dam with a specific flood control storage capacity. This will control the floods in the Barak valley as well as affording some relief in Bangladesh. The project will also have a hydro-electric generating capacity of 1,500 MW, and will irrigate almost 100,000 hectares of land in India, besides augmenting lean flows which will also be beneficial to Bangladesh.

On the Brahmaputra, two major storage facilities were planned at Dehang and the Subansiri. Apart from the proposed installed hydropower capacity of 20,000 MW at Dehang and 4,800 MW at Subansiri, these two reservoirs were expected to reduce the flood levels in the main Brahmaputra downstream by about one metre. However, strong reservations due to the proposed submergence of important townships mean that three dams instead of one dam on each of these rivers are now under investigation. It is not definite whether ultimately these dams will materialize, and to what extent they will afford flood protection. In any case, since the dams will take many years to construct, the problem of floods in the Brahmaputra basin will continue as before. The same situation will more or less hold good for the Ganges basin unless some major storage dams on the important tributaries like the Kosi, the Rapti, and the Bagmati are constructed in Nepal. However, these also appear to be a distant prospect.

Thus, there is no possibility of any reliable flood control in the Ganges and Brahmaputra basins, even on a long-term basis. The focus for flood management, both in India and Bangladesh, will therefore have to be shifted to "living with floods" by reducing the loss of human lives and misery to the people and livestock. The measures to be taken to achieve this purpose are flood-plain regulation, scientific and extensive flood forecasting and flood warning systems, raising of houses, important communications and tubewells above the flood levels, and storage of adequate food and fodder on raised platforms, etc.

Table 2.8 Analysis of annual rainfall

Decade	Average mm	Maximum mm	Minimum mm
1871–1880	1,059	1,230	914
1881–1890	903	1,158	1,060
1891–1900	1,094	1,336	811
1901–1910	1,040	1,156	920
1911–1920	1,077	1,349	858
1921–1930	1,074	1,125	1,032
1931–1940	1,123	1,280	998
1941–1950	1,140	1,216	957
1951–1960	1,123	1,334	972
1961–1970	1,069	1,314	872
1971–1980	1,091	1,199	848
1981–1990	1,070	1,244	965

Source: *Theoretical and Applied Climatology*, 1994

Are floods on the increase?

There is a misconception in the public mind that the floods in this region have been on the increase in recent years due to changes in the rainfall pattern and deforestation. An exhaustive study carried out by the author (Shah 1996) indicates that the floods are not on the increase, nor are the causes attributed to the floods scientifically valid.

Analysis of the annual rainfall in India carried out for a period of 120 years from 1871 to 1990 clearly indicates that there is no trend whatsoever in the rainfall pattern. The position in respect of average, maximum, and minimum annual rainfall for each decade indicates that it has been more or less the same over the last 120 years; an analysis is given in Table 2.8.

Similarly, data on heavy storms from 1901 to 1990 were collected and analysed, as the floods occur basically from the intense rainfall during heavy storms. This analysis also indicates that over the years there has been no change in the intensity and magnitude of rainfall in heavy storms. An analysis of the most severe storms published by the India Meteorological Department also indicates that there has been no change in the one-day or three-day intensities of rainfall over a period of about 90 years.

It is expected that the same position should be valid for the rainfall pattern and intensities in Nepal and Bangladesh.

Therefore, while it can be concluded that there has been no increase in the physical magnitude of floods, there has been an increase in the resulting damage, mainly on account of the encroachment in the flood plains of various rivers, as well as an increase in economic activities in the flood plains due to the increasing pressure of population.

A popular misconception that forests reduce the magnitude of floods by absorbing a portion of the heavy rainfall is also incorrect. The studies carried out indicate that while the interception for small storms with rainfall of 1–2 mm is 80 per cent, it reduces to only 4 per cent for storms where rainfall is more than 60 mm. The major storms in India which cause floods have an intensity of 360 mm and above in one day, and interception by the forests or vegetal cover is almost negligible. Major floods are also almost invariably associated with long periods of intense rainfall, during which the soil becomes nearly saturated.

Leopold and Maddock (1961) clearly state that:

> No unequivocal or unqualified statement can be made that floods are more severe and larger in number in the present generation than those which occurred prior to settlement.

Agarwal, the reputed environmental crusader in India, states (Agarwal 1991) that:

> The Indus, Ganga and Brahmaputra valleys have always been flood prone. Even when the Himalayan mountains were uninhabited and the forest cover intact, major floods visited these valleys and disrupted human civilisation. Ancient Indian literature is full of references to devastating floods ... Environmentalists should not enter into a game of one-upmanship with water engineers. There is no evidence to believe that ecological solutions like afforestation will control floods any more than engineering solutions like dams and embankments have been able to.

Flood forecasting

Flood forecasting and warning plays a very significant role in saving human lives and livestock as well as in reducing the damage to portable property by informing the affected population in advance of the likely flood levels and their duration at specific places. It also helps in organizing timely rescue and flood-fighting measures in order to prevent/minimize the damage to flood protection works like embankments. It is thus the recognized non-structural method of minimizing flood damage, although it cannot prevent or alter the occurrence of floods. In the GBM region, it is all the more significant in view of the facts mentioned earlier.

Effectiveness of flood forecasting increases with the increase in lead time, and forecasts should be given as much in advance as possible. This can be achieved by getting real-time information about rainfall as well as flows in upstream reaches of the rivers. Inter-country cooperation, therefore, is extremely useful in improving the efficacy and utility of flood forecasting. The present status in various countries is briefly summarized below.

In Nepal, at present during the monsoon, data from 12 rainfall and seven river-gauge stations are transmitted to Patna in India (Baweja and Rangachari 1997), although as far back as in 1987–88, a joint Indo-Nepal project for flood forecasting was envisaged, comprising the setting up of 45 rain-gauge stations and 20 river-gauge stations. All of these were to be equipped with automatic water-level recorders and self-recording rain-gauges. The observed data were to be transmitted to India on a real-time basis. However, this project has yet to become fully operational. It is reported (Yogacharya 1997) that the infrastructure at 43 stations has been completed and the balance were likely to be completed by the middle of 1998.

Bhutan is collecting and transmitting rainfall and river-flow data from selected sites on some of the tributaries of the Brahmaputra originating in Bhutan, like the Puthimari, Pagladiya, Manas, and Sankosh. At present, data from five stations are transmitted to Cooch Bihar in West Bengal and further data are transmitted to Barpeta/Nalbari in Assam from seven civil wireless and hydromet stations in Bhutan (Gyalshen 1997). The Bhutan Department of Power has also set up 70 Class C meteorological stations, four snow-gauging stations and 16 hydrological stations, mainly for planning purposes. There is considerable scope for improvement of observations, analysis, and transmission. Upgrading and strengthening of the present observation network in a phased manner is planned.

In India, flood forecasting has been done at 109 stations in the GBM region for a considerable time (Baweja and Rangachari 1997). Although upgrading and modernization of the system in a phased manner is under way, the track record so far of the timeliness and accuracy of forecasts has been very good. Under a bilateral arrangement, India is also transmitting actual and forecast river-level data to Bangladesh from five stations: Farakka on the Ganges, Goalpara and Dhubri on the Brahmaputra, Domohani on the Teesta, and Silchar on the Barak. In addition, rainfall data from Goalpara, Dhubri, Tura, Cooch-Behar, Siliguri, Jalpaiguri, and Agartala are also transmitted from India to Bangladesh.

Both India and Bangladesh at present are using similar technology for processing the data, statistical correlations, formulation of forecasts, and transmission. Both the countries have also sought assistance from DHI Denmark for setting up forecasting models like MIKE II and making them operational in a few forecasting systems.

In view of the large extent of the flood problem, for which there is no visible long-term solution, flood-forecasting networks in all the countries needs to be extended and strengthened considerably, including increasing the density and coverage of observation stations. While the upgrading and modernization will be a continuous long-term process to increase the accuracy and advance time (lead time) of forecasts, Indian experience indicates that it is always useful first to set up an observation and communication network to start forecasts with statistical co-relations, and later to upgrade the observation network and use forecasting models to incorporate other parameters.

Flood forecasting is again a non-controversial area of mutual cooperation not needing a heavy financial investment, but which will benefit the large population in this region by reducing their recurrent loss and misery. However, the progress so far is limited, and flood forecasting should now be taken up as a priority programme in regional cooperation. An international seminar held in Dhaka on 5–6 December 1997 was a good step forward, and the need for cooperation was agreed by all the countries.

Technical assistance in formulation of projects

As is well known, with the exception of Bhakra dam, where foreign technical assistance was sought, over the last 50 years India has planned, designed, constructed, and operated a number of water resources projects – irrigation, hydropower, and multipurpose – without external assistance. These projects include dams of various heights, barrages, weirs, and canal systems, as well as flood control works. On account of the wide topographical and hydrological variations in India, Indian engineers have gained considerable expertise in successfully tackling complex problems in different rivers. Their expertise and capability in development and management of water resources has also been recognized by international financial agencies like the World Bank, the ADB, the UNDP, etc. The track record of the safety of structures in India has also been extremely good as compared to other countries around the world.

The neighbouring countries in the region can, therefore, easily take advantage of the technical expertise available in India. Bhutan has already taken advantage of this for hydropower projects; similarly, Bangladesh has accepted in principle an Indian offer of technical assistance in the design of the proposed Ganges barrage in Bangladesh.

There has, however, been so far some reservation in Nepal about utilization of Indian technical assistance. In the 1970s and early 1980s, although it was decided that the entire survey, investigation, planning, and design of the Pancheswar project would be carried out jointly by

Indian and Nepali engineers, with the cost being borne by India, the proposal did not materialize, as Nepal wanted to use international consultants. In fact, the Pancheswar project is a simple project with no major geotechnical or other issues compared to many more difficult projects tackled by India.

The cost of international consultants is high – varying between eight and 10 times the cost of Indian consultants. In addition, a full knowledge of Himalayan geology, which in itself is highly complicated, is not available to the international experts. Indian experience for the last 20 years indicates that at times international experts did not take into account fully the local conditions or the economics as relevant to developing countries with limitations of financial resources, and tried to transplant ideas and methodologies adopted in developed countries, which are not necessarily useful and cost-effective for Asian conditions. This was one of the reasons why there was a considerable difference of opinion between the Indian engineers and the international consultants appointed by the government of Nepal for the preparation of a feasibility report on the Karnali (Chisapani) project. This also resulted in considerable delay in finalization of that report.

There was a similar example in Bangladesh, where, after the unprecedented floods of September 1988, a flood action plan was formulated by 11 donor countries and four multilateral agencies coordinated by the World Bank. The plan basically proposed the construction of a number of embankments with drainage sluices, etc., with a total estimated cost of about US$10 billion. The cost of the first study phase itself was US$150 million (Rs. 500 crores), 60 per cent of which was for the fees of foreign consultants. The plan provoked considerable reaction and resentment, not only among the flood-affected people but also in the scientific community in Bangladesh (Bangladesh Centre for Advanced Studies 1994). After a review of existing flood protection works and innumerable interviews with the affected people and a number of experts/scientists in Bangladesh, the Bangladesh Centre for Advanced Studies book clearly brought out that even the existing embankments had not resulted in an increase in agricultural production in the protected areas. It also revealed that almost 80 per cent of the embankments had maintenance problems and almost 66 per cent were subject to frequent breaches. On the other hand, the embankments had resulted in a permanent loss of annual fish production of 45,000 tonnes by preventing migration of fish and natural restocking. Fish production is one of the main means of subsistence in Bangladesh. The book clearly highlights considerable opposition to a plan prepared by foreign experts from all concerned; according to Bangladesh, the plan will cause great potential damage to the Bangladeshi economy by importing the views of foreign experts without fully understanding the local problems and without the involvement of the people to be benefited.

In India also, in some of the projects assisted by the World Bank, there were similar problems, although there were no major changes in the planning and designs which were produced by the Indian engineers.

Taking all these factors into account, it will be in the interest of the region to avail itself of the technical expertise already developed in the region, which will also be economically cost-effective. At the most, since some programmes and projects will be financed by other countries/ international agencies which insist on the use of foreign consultants, a broad review of the project formulation can be carried out by international consultants and their suggestions considered in finalizing the project reports.

Since the sizing of a project may create differences of opinion, leading to delays in finalization, it will be desirable to work out different scenarios of development along with their economics, so that after discussions and mutual agreement the exact scope of the project and techno-economics can be expeditiously finalized without resorting to further investigations and studies.

Joint implementation and operation

As already indicated, the existing Chukha hydro-electric project in Bhutan was jointly implemented and is now being successfully operated. A similar arrangement of having a specific project authority for implementation and operation of each of the proposed major hydro projects in Bhutan, with equal representation of both India and Bhutan, has been agreed to. In the case of the proposed Pancheswar project, a similar joint Pancheswar authority is envisaged. Since projects in Nepal and Bhutan will have varied and appreciable repercussions in India, apart from the fact that India will be the major purchaser of the hydropower to be produced, it will be essential to have joint control for implementation and operation of these projects, although they will be located within the sovereign territories of Nepal and Bhutan. This aspect will assume particular significance in respect of projects in Nepal, as most of these will be multipurpose – having irrigation benefits in both India and Nepal, generation of hydropower to be consumed in India, and flood control benefits, again in both Nepal and India. It is also likely that apart from purchasing the power at mutually agreed tariffs, India may have to share a portion of the cost of projects which will have specific and identifiable irrigation and flood control benefits in India, depending on the quantum of benefits. In such cases, joint planning, implementation, and operation will create confidence in India that the planned benefits will be available on a sustainable basis in the future. The exact functions and type of composition of the joint machinery can, however, vary with each project; but agreement on this should not delay the formulation of detailed project reports. After the successful experience of Pancheswar when it is implemented, it will be easier to have such joint arrangements for other projects in Nepal.

Management and equitable sharing of lean flows

India-Bangladesh

A long-term (30 years) treaty on sharing of the lean flows of the Ganges between India and Bangladesh has recently been concluded. Similar arrangements need to be evolved for the Teesta and some of the common small rivers flowing from India into Bangladesh (tentatively the number is 54). It has been recognized that the available flows in the Teesta during the lean season are not sufficient to meet the reasonable needs of both India and Bangladesh. A number of studies carried out earlier in India indicated that it is not feasible to construct a major dam on the Teesta river in India, because it would have a very limited life thanks to the tremendous silt load carried by the Teesta all year round. Therefore, the development in the Teesta region in both India and Bangladesh has to be mainly "run of the river". Already two barrages, one in India and the other in Bangladesh, have been constructed for diverting the available flow to provide irrigation facilities in both countries. A treaty similar to the Ganges treaty on sharing the lean flows, after taking into account the realistic needs of both countries, will have to be evolved; the governing principle will be that during periods of flow inadequate to the requirements of both, the shortages will have to be equitably shared by both the countries.

On the smaller common rivers, again, the possibility of constructing storage dams in India will be very limited, and full utilization of available surface waters may not be possible. Here again, sharing of flows with run-of-the-river development will have to be resorted to. So far, no significant studies have been carried out in either India or Bangladesh for determining the actual requirements of optimal use of the waters of these rivers. Therefore, it will be desirable that instead of tackling the problem of all the common rivers, initially detailed studies should be made in respect of a few identified rivers; meanwhile the broad studies of requirements of other rivers can continue.

India-Nepal

As regards sharing of flows between Nepal and India, since in the past there was no significant irrigation development in Nepal, the flows in the lean season coming to India from various rivers in Nepal have been utilized for irrigation in India for a number of years by constructing barrages and canal systems – particularly on various tributaries of the Ganges like the Kamla, Bagmati, Gandak, etc. Nepal has now been developing projects on some of the smaller tributaries – the Rapti, Ghagra, Kamla, etc. – for providing irrigation in Nepal. As strictly such a use by Nepal cannot be totally opposed on the basis of the recognized principle of disturbance in the established riparian rights, it should be possible to evolve some arrangements where equitable sharing of lean flows can be agreed. Besides, in most of the tributaries there is scope for constructing medium to large storage dams in Nepal which will store the flood waters and thus make more waters available for utilization in both Nepal and India. Such projects, which may not have a very long gestation period as well as not requiring substantial investment, can be implemented early; again, sharing of costs by both countries will not only sustain the existing benefits being derived by India but also enhance these. Since the overall requirements of consumption in Nepal will be comparatively much smaller, as a principle, in any such storage projects the full requirements of Nepal should be met. Thereafter, the unutilized portion of water from Nepal, which naturally has to flow through India, can be developed and utilized by India in the best manner possible. In some cases, apart from irrigation it may also be possible to develop navigation, through either the rivers or the canal systems; this again can be studied while detailed planning of the projects is carried out.

Once the genuine desire for and determination of mutual cooperation is established, it should be possible to evolve satisfactory solutions on the basis of a flexible "give-and-take" attitude. Continuous dialogue and interaction at both technical and political levels will, however, be necessary.

Augmentation of flows

Demand scenario

The irrigation potential of the Ganges basin in India is estimated to be of the order of 61 million ha. The potential already created is about 20 million ha. As pointed out earlier, the present irrigation is essentially based on river diversions (run-of-the-river development), as there are no storage dams possible on the tributaries of the Ganges in India. The low flows at present available in the various tributaries and the main river are totally inadequate to meet the requirements of the balance of irrigation potential of about 41 million ha. On the other hand, with progressive utilization of lean flows in Nepal, there will be some reduction in the existing low flows in the Indian territory. The present population in the Ganges basin portion of India is about 400 million, and this is expected to increase to about 550 million by the year 2010. Consequently, the demand of water for various purposes, including domestic, municipal, livestock, and agriculture, will be progressively increasing every year.

In Nepal, it is estimated that the present irrigation is of the order of about 1 million ha and the total population is about 20 million. According to a master plan prepared in Nepal, it may be possible to provide irrigation to an area of about 2.8 million ha in Nepal and in addition about 4.2 million ha in India by constructing 13 dams with a total cumulative storage of around 7.7 million ha-m.

In Bangladesh, the potential area requiring irrigation depending on the waters of the Ganges is estimated to be about 1.31 million ha. The area actually irrigated at present is not known.

In the Brahmaputra and Meghna river basins in India, the in-basin utilization is estimated to be only about 4 per cent of the available waters. Similarly, the requirement for consumption in Bangladesh is also comparatively very limited.

Thus while there is a shortage of flows in the Ganges basin to meet the future requirements of Nepal, India, and Bangladesh, there is surplus water available in the Brahmaputra river.

Ways of augmentation

The term "augmentation" connotes augmentation of flows during the lean season. It does not imply overall augmentation of water resources, as these are fixed. There are three different possible means of augmentation:

- creation of major storage facilities by dams and releasing the stored waters during the lean season;
- utilizing a portion of the stored waters behind the dams for trans-basin diversion to adjoining river basins;
- constructing diversion structures across the river (without any storage) for transfer of the surplus flow of one river system to another by canals and river structures like barrages en route.

Within the Ganges basin

As already discussed, there are no possibilities of constructing dams on the main Ganges river or its tributaries in India – particularly northern tributaries. Storage facilities on the southern tributaries have already been built, and these waters are being almost fully utilized within the Ganges basin in India. However, there are great possibilities for constructing major storage facilities on the northern tributaries of the Ganges in Nepal. According to the master plan prepared by Nepal, 13 dam sites on various tributaries are possible, with a total storage capacity of about 7.7 million ha-m. Of these, the major storage dams are Pancheswar, Karnali, and on the Kosi, which together will provide a live storage capacity of about 5.5 million ha-m. With the construction of these facilities, it will be possible to augment the lean-season flows in various tributaries to provide irrigation benefits both in Nepal and in India. However, excepting the proposed high dam on the main Kosi, construction of other dams is not likely appreciably to augment the lean flows in the main Ganges at Farakka, as most of the stored waters will be utilized in Nepal and India. The Kosi is one of the largest tributaries of the Ganges and the consumption requirements in the Kosi sub-basin in both Nepal and India are limited. As such, the stored waters in the Kosi dam could be utilized for augmentation of lean flows in the Ganges upstream of Farakka, simultaneously using the conveyance of waters for navigation between Nepal and India. Thus the only reliable source of augmentation of the Ganges flows will be the Kosi dam if and when implemented, although Bangladesh has been pleading for construction of dams on various tributaries of the Ganges in Nepal. Such dams will no doubt be beneficial to both Nepal and India for multipurpose use, but are not likely to augment the main Ganges flows at Farakka in any sizeable way.

Transfer from the Brahmaputra

There are surplus waters in the Brahmaputra, and the flows even during the lean season at Jogigopa in India vary from 126,000 cusecs in January to 200,000 cusecs in April. Further, there is a lag in this lean-season flow compared to the lean-season flow in the Ganges, which occurs during the months of March and April. Because of these facts, various possibilities of diverting the flows of the Brahmaputra into the Ganges upstream of Farakka have been under consideration.

One of the earliest proposals suggested by India was to construct a barrage on the Brahmaputra at Jogigopa in Assam (India), diverting about 100,000 cusecs of water through a 324-km-long link canal crossing Bangladesh territory and then reentering India and outfalling upstream of Farakka. However, such a proposal was not found acceptable by Bangladesh, for technical and other reasons.

Another proposal was broadly studied, wherein the link canal instead of passing through Bangladesh would traverse entirely within Indian territory from the Jogigopa barrage and connect the Ganges through the Teesta and Mahananda rivers in India. This would also provide large irrigation benefits in Assam and West Bengal. However, such a proposal involves considerable pumping, as the waters have to be lifted in different stages from Jogigopa up to the Teesta river, whence it flows by gravity through the Mahananda to the Ganges. It was considered that consumption of such a large quantum of power, apart from the dim prospects of its availability, along with very heavy annual operation costs may not render the proposal techno-economically viable.

The third alternative (Char 1997b) is a diversion channel from the proposed dam to be constructed on the Sankosh river in Bhutan, where apart from generating 4,000 MW of power, the channel will enable a discharge of about 12,000 cusecs to be diverted through a link canal falling into the Teesta barrage in India and later augmenting the flows of the Ganges at Farakka. This proposal is yet to be studied and fully investigated in India by the Central Water Commission and the Ministry of Environment and Forests.

While trans-basin diversions of water have been attempted in other countries, and even a proposal for linking some of the major rivers in peninsular and southern India are under study, there is considerable opposition to such proposals from the environmentalists, apart from the heavy capital investment. It is thus not clear whether such mass water transfer proposals, although technically feasible, will be implemented at all.

Interconnection within Bangladesh

There is a possible alternative of diverting the Brahmaputra through a link canal within Bangladesh itself. Such a proposal would be the shortest link and would give substantial irrigation benefits even in the Teesta region in Bangladesh. In the past Bangladesh did not favour such a proposal on the grounds that there is no surplus water in the Brahmaputra. However, it is now understood that a Brahmaputra barrage within Bangladesh territory is likely to be investigated and studied by Bangladesh. This barrage, coupled with the proposed Ganges barrage now being planned in Bangladesh, could substantially improve the surface irrigation facilities in that country.

In view of these various facts, while the studies on possible alternatives can continue, the viable solution in the near future appears to be the construction of barrages on both the Ganges and the Brahmaputra in Bangladesh itself. In this connection it also needs to be noted that the investment required in the construction of major dams in Nepal will be very high and will be beyond the financial capabilities of both India and Nepal. Even with some international financial assistance, realistically, these appear to be projects in a very distant future. It is therefore necessary to take a pragmatic view of the most feasible proposal of augmentation, and that which is likely to give benefits in the near future.

Conclusions and recommendations

Project reports

After necessary investigations and studies, the project reports of major storage dams in Nepal should be formulated for different scenarios of development and finalized in consultation with India. A start has already been made with the Mahakali treaty. For implementation of this treaty, the Pancheswar project needs to be finalized expeditiously. This should be followed by the Karnali and Kosi projects, apart from other smaller projects.

The project reports on the Ganges and the Brahmaputra barrages in Bangladesh need to be finalized early with the technical assistance already offered by India.

Flood forecasting

It is absolutely necessary to extend, strengthen, and modernize the flood forecasting system and the network covering Nepal, Bhutan, India, and Bangladesh for the benefit of all countries. This proposal is non-controversial and will need comparatively little investment – it should be given top priority.

Interconnection of power systems

Studies of interconnection of power systems in India and Nepal and their techno-economics need to be carried out to enable implementation of the necessary transmission network for transfer of power first from Pancheswar and then from other future projects in Nepal.

Barrages in Bangladesh

In view of the fact that no other augmentation proposal is likely to materialize in the near future, it would be in the interest of Bangladesh to undertake the construction of barrages on both the Ganges and the Brahmaputra in their territory as early as possible.

Sharing of lean flows

Earnest efforts for an amicable settlement between India and Bangladesh should continue for sharing of the lean flows of the Teesta and other small common rivers.

REFERENCES

Agarwal, A. 1991. *State of India's Environment: A Citizens' Report*. New Delhi: Centre for Science and Environment.

Bangladesh Centre for Advanced Studies. 1994. *Rivers of Life*.

Baweja, M. L. and R. Rangachari. 1997. *Indo-Bangladesh-Nepal Cooperation in Flood Disaster Management*. New Delhi, Centre for Policy Research.

Char, N. V. V. 1997a. *Integrated Water Resources Development of Ganga, Brahmaputra and Meghna River Systems – International Dimensions*. New Delhi: Ministry of Water Resources.

Char, N. V. V. 1997b. *Augmentation of Water Resources in the Ganga Basin*. New Delhi: Ministry of Water Resources.

Gyalshen, Wangdi. 1997. *Country Report on Flood Forecasting and Warning Status in Bhutan*. Thimphu: Ministry of Planning.

Leopold, L. and T. Maddock. 1961. *Flood Control Controversy*. Washington, DC: US Geological Society.

Prasad, T. 1997. *Integrated Water-Based Development of the GBM Region – Indo-Nepal Aspects*. New Delhi: Centre for Policy Research.

Rangachari, R. 1997. *Water-based Integrated Development of the GBM Region*. New Delhi: Centre for Policy Research.

Sambamurty, M. K. 1997. *The Eastern Power/Energy Grid*. New Delhi: Centre for Policy Research.

Shah, R. B. 1996. "Water Resources – Myths and Realities", Dr Kanwar Sain memorial lecture, New Delhi.

Yogacharya, Kiran Shankar. 1997. *Status Paper on Flood Forecasting and Warning System in Nepal*. Kathmandu: Ministry of Irrigation.

3

Constraints and opportunities for cooperation towards development of water resources in the Ganges basin

A. T. M. Shamsul Huda

Introduction

River systems constitute distinctive hydrological units and nature wants them to be treated as such. Unfortunately, there are very few major river systems that flow through one single country; most are transboundary rivers. In such a situation, basinwide planning for water resources' development and management would be the most logical approach by the co-riparian countries. However, the political, social, and cultural dispositions of these countries, supported by the current political doctrines, have not been very conducive to the expected level of cooperation.

The Ganges basin: The physical conditions in Bangladesh

The lack of cooperation has been particularly acute in the case of South Asia, and nowhere has this been more acute than in the Ganges basin. The mighty river Ganges is about 2,550 km long. After taking off from the Gangotri glacier near the Indo-Chinese border, it passes through Nepal, India, and Bangladesh before merging with the Bay of Bengal. The basin accounts for 104.74 million ha, of which 86.14 million ha fall within India, 14 million ha in Nepal and 4.60 million ha in Bangladesh. Like any major river system, the significance of the Ganges lies in its very extensive network. The Ganges receives large volumes of water from Nepal through its three left-bank tributaries – the Karnali, the Gandaki, and the Kosi. It distributes water to large parts of Uttar Pradesh, Bihar, Assam, and West Bengal, and through a network of distributaries to north-west and south-west parts of Bangladesh.

The tributaries of the Ganges in Nepal are snow and glacier fed. A large part of their drainage area is covered by snow and glaciers throughout the year. The major floods experienced in the Himalayas are mainly due to glacier lake outbursts or cloud outbursts. Rockslides and landslides, which are common in Nepal, also aggravate flooding problems by reducing river capacity or even by temporarily damming the rivers. Moreover, there have been a number of instances of extraordinary floods due to outbursts of temporary dams erected by rockslides and landslides in the rivers (Bangladesh-Nepal Joint Study Team 1989).

The Ganges basin is experiencing intensive erosion due to natural geomorphologic conditions, intense rainfall, frequent seismic activity, and inappropriate land-use practices. The Ganges river system carries a large quantity of sediment and delivers this each year into the Bay of Bengal.

Geography has destined Bangladesh to face the unenviable situation of too much water during the monsoon and too little during the dry season. The fact that Bangladesh occupies only 7 per cent of the Ganges basin shows the country's lack of control over the inflow of water that determines the geophysical conditions. The various manifestations of these conditions are enumerated in the following sections

Flood and drought

The country's unique physical setting makes it extremely vulnerable to both flood and drought. The annual minimum flow of rivers near the Bay of Bengal is only 5 per cent of their peak monsoon discharge. The high-water levels in the major rivers during monsoon cause drainage congestion and over-bank spillage of their tributaries, which is often exacerbated by runoff from coincident high local rainfall.

Bangladesh generally enjoys a subtropical monsoon climate. It receives a normal annual rainfall ranging from 1,200 mm in the extreme west to as high as 5,800 mm. About 81 per cent of Bangladeshi rainfall occurs in the summer humid period – May to October.

The country, being the lowest riparian, offers an outlet for the entire volume of flow of all upstream major rivers. The magnitude of flood damage is of catastrophic proportions when the flood waves from the Ganges, Brahmaputra, and Meghna combine with rainfall all over the country. Rainfall of long duration in the monsoon season often generates water volume in excess of the local drainage capacity, causing localized floods.

Certain parts of the basin are also subjected to drought during the monsoon season, which adversely affects the cultivation of summer *kharif* crops. The upstream withdrawal of water during the dry season has further aggravated the situation, giving rise to the need for supplementary irrigation.

Siltation

Each year, some 2.5 million imperial tons of sediment are brought down by the Ganges and transported through the area to the Bay of Bengal (Bangladesh Ministry of Water Resources 1998). A part of this sediment load is deposited on the floodplains during the flood season, gradually changing their topography and drainage conditions. Continued siltation has reduced the efficiency of Mongla port. Low flows in the Ganges have seriously affected navigation on the rivers in the Ganges-dependent areas, with 160 km of the Ganges, 70 km of the Gorai, and the Modhumati and Passur rivers suffering from reduced flows and siltation.

River-bank erosion

The floodplains and coastal delta are in a constant state of slow morphological change. The large seasonal variation in river flow results in a varying sediment transportation capacity and causes river-bank erosion, migration of river banks, and meandering river channels. Recent satellite-image studies of the Ganges-Brahmaputra-middle Meghna rivers under the Flood Action Plan show that 106,300 ha were lost to erosion, while only 19,300 ha accreted, over the period 1982–92. The net area of 87,000 ha lost to erosion is equivalent to an annual erosion rate of 8,700 ha, most of it agricultural land. Erosion of border river banks has the serious implication of losing lands to a neighbouring country. River-bank erosion has significant economic and social impact. The loss of land, crops, and property has led to landlessness and impoverishment for thousands of households (World Bank 1996).

Salinity intrusion

After commissioning of the Farakka barrage in West Bengal, the net availability of surface water to Bangladesh via the Ganges during the dry season has been reduced beyond critical levels. The impact of this reduction is demonstrated by a marked increase in salinity in south-western Bangladesh. The southern part of this affected region is subject to tidal action from the Bay of Bengal, and saline intrusion from the tides is normally pushed back by upland flows of fresh water from the Ganges through its tributaries, among which the Gorai plays a vital role. Due to flow reduction since 1975, tidal limits and the salinity front have moved northward. Around Khulna, some 146 km upstream from the Bay of Bengal, the salinity (in terms of electric conductivity) has increased from 380 micro-mhos/cm in the pre-barrage diversion period to 29,000 micro-mhos/cm. This is a major problem in over 25,900 km^2 of Ganges-dependent area (GDA) and is causing both short- and long-term problems in crop production, fisheries, forestry, power generation, industrial development, health care, and domestic water supply (Bangladesh Ministry of Water Resources 1997).

Arsenic contamination

Recently, arsenic contamination in groundwater, far in excess of the World Health Organization's drinking water provisional guideline value of 0.01 mg/l, has been detected in several districts of Bangladesh. Of these, Rajshahi, Jessore, Meherpur, Kushtia, Khulna, Bagerhat, and Faridpur have been identified as the highly affected districts. This development has posed a serious threat to the health of people already affected and the people at risk.

The cost and consequences of lack of cooperation

The Ganges basin is one of the most densely populated and poverty-stricken areas in South Asia. It is also one of the most richly endowed in the world, but its potential is the least exploited. The cost and consequences of lack of cooperation so far as these relate to Bangladesh have not been systematically explored. However, by looking at a few key sectors like agriculture, forestry, and health we can have some idea of the extent of damage being caused to the economy of Bangladesh.

Agriculture

The south-west region situated in the Ganges basin is deficit in food production. Of the total area of 40,500 km^2, only 62 per cent is cultivable and 10 per cent is covered by mangrove forest, the Sundarbans, an area of immense environmental importance. The area is predominantly low lying with a maximum elevation in the north of about 14 metres above sea level. The eastern half tends to be flood prone, while the west suffers an acute shortfall of water in the dry season. Groundwater is available in limited quantity in the northern half, but there is hardly any of usable quality in the south. Saline water intrudes from the southern coast as deep as 185 km upland, and the salinity itself has increased over the years as inflows from the Ganges have reduced.

The Ganges-Kobadak project, a major gravity system irrigation project, was built to irrigate 125,000 ha, but actual coverage for Kharif II could not be raised above 80,000 ha.

Bangladesh has set a target for production of 25 million imperial tons of food grain per annum by the year 2010 to keep pace with the growth of population. To contribute to this national effort, the GDA has to raise production through expanded irrigation. In the absence of a sizeable surface irrigation programme, groundwater irrigation has grown very rapidly in the GDA. However, this growth may not be sustainable in the long run. The following developments have raised concern about the unfettered growth of groundwater irrigation:

- expansion of groundwater use entails the lowering of groundwater tables, which affects domestic supply wells, the sustainability of ponds, and, in the long term, equity and social equilibrium amongst user groups;
- too much extraction of groundwater may have something to do with the release of arsenic into water supplies;
- studies have shown that at the current rate of expansion, groundwater exploitation would reach its upper limits in another five to 10 years' time (Master Plan Organization 1991).

The fundamental issue for agricultural development in the GDA that emerges from the above is the need for ensuring fresh water availability and balanced use of groundwater and surface water. The key to doing all that is the management of the Ganges water in a manner that will supply fresh water through its distributaries. Preliminary studies have indicated that this can be done by diversion of Ganges water during the dry season by constructing a barrage on the Ganges. Undertaking such a large project needs the active support and cooperation of India as an upper riparian. This has not been possible in the absence of a long-term water-sharing arrangement.

The delay in arriving at some long-term understanding on water sharing has very adversely impacted the agriculture of the GDA in a number of ways. Soil moisture depletion, lowering of the groundwater table, increase in salinity content in water, and, above all, reduction of acreage for cultivation due to the shortfall in surface water irrigation have all contributed to stagnation in agricultural growth. One study estimated the direct loss to agriculture due to these reasons at about Taka 2,000 million per annum (US$1 = Taka 44) at 1991 prices (Nishat 1996).

Forestry

The GDA is rich in forest resources and is home to the Sundarbans, the largest mangrove forest in the world. The forest is spread over an area of about 58,000 ha, interlaced with 170,000 ha of tidal channels and rivers. With a vast range of plants and animals, including the Royal Bengal tiger, it is a rich source of biodiversity. In recognition to its value, UNESCO in 1997 designated 140,000 ha of the forest as a World Heritage site.

In recent years, the phenomenon of "top dying", which afflicts the sundari trees and affected 17 per cent of the forest in 1985, is thought to be caused by a synergistic reaction to flows characterized by increased salinity and higher levels of industrial pollution. Damage to the sundari forests threatens the integrity of this important habitat and the species dependent on it as well as its economic potential.

The Sundarbans act as a buffer against tidal waves. Substituting the forest with artificial defences may cost around Taka 16,000 million with Taka 320 million as annual maintenance costs (Bangladesh Ministry of Water Resources 1998). Moreover, about 90,000 people depend on the area for their livelihood. The Sundarbans can only be saved by reversing the process of degradation caused by excessive salinity and other human-induced changes. If fresh water flow and the flood regime are restored, the mangrove forests and the ecosystem can be revitalized.

Health

Over the last three decades, environmental decadence in the GDA has adversely affected the health of the people of the area. The fall in groundwater levels and reduction in dry-season flow of the Ganges have adversely affected the quality of water. Scarcity of pure drinking water has caused a rise in the incidence of various enteric diseases in the region.

Acute arsenicosis has been detected in the far west of the south-west and the Paksi region in particular, and research is now being conducted into the viability of alternative drinking water sources, both from groundwater and surface water sources.

As has already been pointed out, there is no systematic study of the losses sustained by Bangladesh due to failure to take action to reverse the environmental degradation set in motion in the GDA. However, by even a rough estimate, the damages done to the economy of Bangladesh by not taking any action to mitigate the physical conditions in the south-west are enormous. One recent attempt to calculate that put it at about Taka 108,500 million (Nishat 1996). The figure must be taken to be tentative, but it gives an idea of the cost of not taking appropriate decisions at the right time.

Opportunities for cooperation in the Ganges basin

In absolute terms, the total quantum of water available in the catchment area of the Ganges-Brahmaputra-Meghna basins is enough to meet the requirements of all the co-basin countries. Though there is wide seasonal and spatial variation in availability of water, this can be overcome through proper planning and management of the waters in the region.

Lacking this much-needed cooperation and out of desperation, Bangladesh has ventured in the past to manage waters within its own boundaries. One such major effort was the launching of the Flood Action Plan in 1990, aimed at controlling the adverse effects of devastating floods in Bangladesh. The country was driven to such a desperate action following the floods of 1988. On completion of a number of studies by 1996, the idea of total control of floods was abandoned, due largely to the fact that for any effective flood control measure cooperation from the upper riparians was considered essential (Bangladesh Ministry of Water Resources 1997).

The Ganges water-sharing treaty of 1996 signed between Bangladesh and India is indeed a landmark treaty, and has resolved a long-standing irritant between the two countries. However, the fact remains that the dry-season flow of the Ganges at Farakka is insufficient to meet the demands of Bangladesh and India. The demand for water from the tributaries of the Ganges in Nepal is also increasing. There is thus an urgent need to augment the flows of the Ganges.

The characteristics of water resources in the Ganges basin in terms of spatial and temporal distribution are such that these can be used to the mutual benefit of the co-basin countries. Flooding and reduction of flow during the dry season that bedevil south-western Bangladesh can be taken care of by Nepal by regulation of flows upstream.

The concept of storage reservoirs in the upper reaches of the Ganges has engaged the attention of concerned experts for a long time. Preliminary studies conducted in 1978 by Bangladesh and updated in 1983 revealed the possibility of constructing seven storage reservoirs in Nepal along with a number of storage dams in India. Studies conducted by Nepal at different levels (master plan, pre-feasibility, and feasibility) have identified about 30 reservoir sites. The total storage capacity of high-dam projects identified so far in Nepal is of the order of 82 billion cubic metres of live storage that would regulate over 95 per cent of the total annual flow (Bangladesh-Nepal Joint Study Team 1989).

The storage reservoirs can hold the vast monsoon runoff within Nepal and, since all this volume of water has to pass along the Ganges into the Bay of Bengal, they will play a very significant role in mitigating the adverse affects of severe floods in India and Bangladesh. Besides flood mitigation, the stored water would go a long way towards augmenting the dry-season flow of the Ganges. Augmentation potential in Nepal during the dry season can range from 2,400 to 4,950 cumecs. These incremental flows alone are over four times the present lean-season flows in the Ganges at Farakka. A single storage facility such as the Karnali project alone has the augmentation potential to more than double the existing low flow of the Ganges.

Flow regulation has the further potential of expanding dry-season irrigation and the possibility of river navigation. When fully developed, regulated flow can be used to irrigate 27 million hectares of land. Since the availability of agricultural land is very limited in Nepal, most of this surplus water can be used by water-hungry co-basin countries like India and Bangladesh.

Water control in the upper reaches also opens up the opportunity for inland river navigation throughout the entire channel. Nepal is a land-locked country, and the north-eastern states of India also lack direct access to other parts of India. All of them need transit facilities through Bangladesh for access to the sea, or to other parts of their own country. Development of reservoirs help these possibilities in at least two ways. First, flow augmentation can ensure round-the-year navigation by improving the barrage for inland water transportation. Secondly, the Ganges could provide a riverine transit from Nepal to a seaport. Similar transit opportunities may be available to the north-eastern states of India.

The Mahakali treaty and the Ganges water-sharing treaty signed by India with Nepal and Bangladesh respectively are bilateral in nature. These have been signed after many years of patient negotiations. At this stage, the concept of basinwide planning may not be immediately attainable, though that should be the goal to be achieved by all the co-riparian countries. The transition from enlightened bilateralism to commercially oriented multilateralism may not be too far away: but the distance needs to be traversed carefully by overcoming the obstacles on the way one by one.

Approaches to cooperation

The foregoing discussion has tried to bring into focus the imperatives of cooperation for water resources development among co-riparian countries. The cost of not doing that has also been highlighted by citing the current status of a few important sectors in the GDA in Bangladesh.

The history of interaction between co-riparian countries does not contain many success stories, but efforts at such cooperation must continue. In South Asia, the full implementation of the Indus basin treaty of 1980 between India and Pakistan has been beneficial to both and has removed for good one major source of tension between them.

Mutual distrust, lack of vision, and pure narrow-mindedness appear to be the major constraints for an integrated plan for water resources development. These constraints cannot be removed overnight, nor can they be ignored. In the light of recent experience, there can be a variety of approaches to pursue the long-term goal of substantive cooperation between and among co-riparian countries.

The two bilateral treaties related to the Ganges basin are landmark treaties in the sense of cooperation among two co-riparian countries. A couple of years ago, this framework did not exist. The relationship created by the treaties is new and is still shrouded by disbelief and mistrust. In both the cases, the political will and statesmanlike vision of the respective leaders clinched the deals. Civil servants and the water experts have to come to terms with these sudden realities by shaking off their long-held rigid technical orthodoxies. In the immediate future, no major achievements in basinwide planning and development of water resources are visualized. However, there are a number of approaches to bilateral cooperation through which, over time, we could achieve a much greater level of cooperation among all co-basin countries.

Confidence-building

The benefits of cooperation are easy to appreciate if they are discussed and projected. The relationship among the co-basin countries has been influenced by history, and their unequal size, resource base, and capacity. India, as the big neighbour, would have to take steps to build confidence in her smaller neighbours. This can be done by scrupulously following the provisions of any treaty. In the case of Bangladesh, for example, the delivery of water during the dry season as per schedule would be a positive measure toward such confidence-building.

Picking the least difficult

In the expansion of bilateral cooperation, there will be a host of issues needing attention. Some of these will be very complex, some a little less so, while a few may be not that difficult. The ones in the last category are those most likely to succeed. It is a good idea to target these activities and set examples of good neighbourly cooperation. After the Ganges treaty, the Joint Rivers Commission charged with the implementation of the treaty decided in its first meeting, held after a lapse of seven years, to start work towards linking the two embankments on the right bank of the Teesta falling within the respective jurisdictions of the two countries. This had been a pending issue for a long time, although its implementation was not likely to harm any side. Rather, when completed this season, it will save the thousands of people living on both sides of the border from the havoc of flash floods.

Supporting activities

Misinformation breeds mistrust. There is a tremendous lack of information as to the potential benefits of cooperation among co-riparians on a commercial basis. Transferring benefits on commercial terms, particularly from a small country like Bangladesh to a big neighbour like India, is viewed by some members of the public with suspicion. There should be regular exchanges of visits by scholars, academics, and officials of the concerned countries and open discussion on the imperatives of cooperation. The recent Track II activities by independent scholars, water experts, and private research foundations have contributed significantly in creating awareness about the problems and prospects of water resources development in the Ganges basin. On their way to the Ganges water-sharing treaty, both the governments concerned received much-needed intellectual and moral support from these organizations. With the signing of the two treaties, their activities should neither diminish nor cease; rather, they should be geared up to maintain the momentum and help implementation. Successful implementation of bilateral treaties shall pave the way for expansion of cooperation with other countries.

Transparency and sharing of information

Even when programmes are discussed and finalized on a bilateral basis, it is important to keep other co-riparians informed of every important step taken. It is always better that the concerned government gets the information from its counterpart rather than getting the news of developments in a common basin from newspaper columns.

An agenda for action

An important area where collaboration between neighboring countries could yield substantial benefit is integrated basin and inter-basin water management. This is an overriding consideration for Bangladesh because, for a greater part, its river basins lie in India and Nepal. Basin management is a complex task and requires extensive study of the hydrological and morphological characteristics of the terrain that underlies the territory of all three countries. The following action plan may show the steps towards the evolution of an effective water resource management system for the entire Ganges plain.

- Each of the three countries, Bangladesh, India, and Nepal, must establish a system for exchange of information and data on relevant aspects of hydrology, morphology, ecology, changing watershed characteristics, cyclone, drought, and flood warning, etc., to help each other understand current and future problems for short-, intermediate, and long-run planning.
- Each of the three countries should designate a technical agency; these could consult each other on matters of water management stretching across national boundaries.
- A set number of planning meetings should be held between the technical agencies each year to discuss matters of mutual interest on water management.
- A joint assessment of international river resources should be made by Bangladesh, India, and Nepal for understanding the overall basins' potential.
- The three countries should work towards establishing joint river basin organizations to act as central clearing houses for planning, water-sharing, and the preparation and execution of jointly owned projects.
- Concerted efforts should be made by all three countries to manage the catchment areas, with the help of afforestation and erosion control for watershed preservation and reduction of land degradation.
- Concerted efforts should be made by the three countries for preventing chemical and biological pollution of the rivers flowing through these countries, by managing the discharge of industrial, agricultural, and other pollutants generated by human action.

REFERENCES

Bangladesh Ministry of Water Resources. 1997. *Bangladesh Water and Flood Management Strategy: An Update Following the Signing of the Ganges Water-Sharing Treaty*. Dhaka: Ministry of Water Resources.

Bangladesh Ministry of Water Resources. 1998. *Socio-Economic and Environmental Status of the Ganges-Dependent Area with Reference to Water Resources Development*. Dhaka: Ministry of Water Resources.

Bangladesh-Nepal Joint Study Team. 1989. *Report on Mitigation Measures and*

Multipurpose Use of Water Resources. Dhaka and Kathmandu: Ministry of Irrigation, Water Development, and Flood Control, Dhaka and Ministry of Water Resources, Kathmandu.

Master Plan Organization. 1991. *National Water Plan*. Dhaka: Ministry of Irrigation, Water Development, and Flood Control.

Nishat, Ainun. 1996. "Impact of Ganges Water Dispute on Bangladesh", in Asit K. Biswas and Tsuyoshi Hashimoto, eds, *Asian International Waters: From Ganges-Brahmaputra to Mekong*. Bombay: Oxford University Press.

World Bank. 1996. *Bangladesh River Bank Protection Project Staff Appraisal Report*. Washington, DC: World Bank.