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Issues of Livelihood, Sustainable Development, and Governance: Bay of Bengal

This article is based on the findings of the Global International Waters Assessment (GIWA) Subregion 53, Bay of Bengal. It introduces the Subregion. The wide disparity in development indicators in the Bay of Bengal Subregion (BOBSR) is presented. The large population of poor people living in South Asia is presented as a factor that needs special attention. The article focuses on the 3 geographic sites selected for detailed analysis: *i)* the Ganges-Brahmaputra-Meghna river systems; *ii)* the Merbok Estuary mangroves, Malaysia; and *iii)* the Sunderbans mangroves, Bangladesh. Integrated water management based upon regional cooperation among Bangladesh, India and Nepal holds opportunities for mutual benefit. Policy options are proposed. For mangrove ecosystems, the impacts of urbanization in Malaysia and the unmanaged expansion of shrimp farming in Bangladesh are analyzed. Improved governance was seen to hold promise for enhancing economic benefits from shrimp farming while safeguarding the natural ecological system. However, these measures need to be a part of national efforts to achieve the UN Millennium Development Goals.

GEOGRAPHY AND OCEANOGRAPHY OF THE BAY OF BENGAL WITH DRAINAGE BASINS (GIWA SUBREGION 53).

The Global International Waters Assessment (GIWA) subregion 53, Bay of Bengal (Fig. 1) includes the Bay of Bengal Large Marine Ecosystem (BOBLME) (1), and associated watersheds. The nations of Bangladesh, Bhutan, Maldives, Myanmar, Nepal and Sri Lanka are all in the Bay of Bengal Subregion (BOBSR). The major land area of India, a relatively minor part of Indonesia (eastern Sumatra), western Peninsular Malaysia, and the western part of southern Thailand are included. The Tibetan Plateau of the People's Republic of China occupies the northernmost part of the BOBSR. Three major transboundary river systems significant to the BOBSR originate in the Tibetan Plateau.

The estimated land area of BOBSR is about 4 mill. km^2 must of which is in India (Table 1). In addition to the 2 large islands, Sri Lanka and Sumatra, numerous small islands, some inhabited, but the majority uninhabited, are part of the BOBSR. Some islands are simply coral atolls, while others have significant mangrove ecosystems. The Indonesian island of Sumatra and the Indian Andaman and Nicobar Islands are volcanic.

The physiography of the BOBSR ranges from the high Himalayan peaks to coastal plains, with similar profiles traversing Myanmar. The elevation of Peninsular Malaysia, southern Thailand, eastern Sumatra and Sri Lanka ranges from heights of between 1000–3000 m descending to coastal plains. The Maldives consist entirely of atolls of elevations

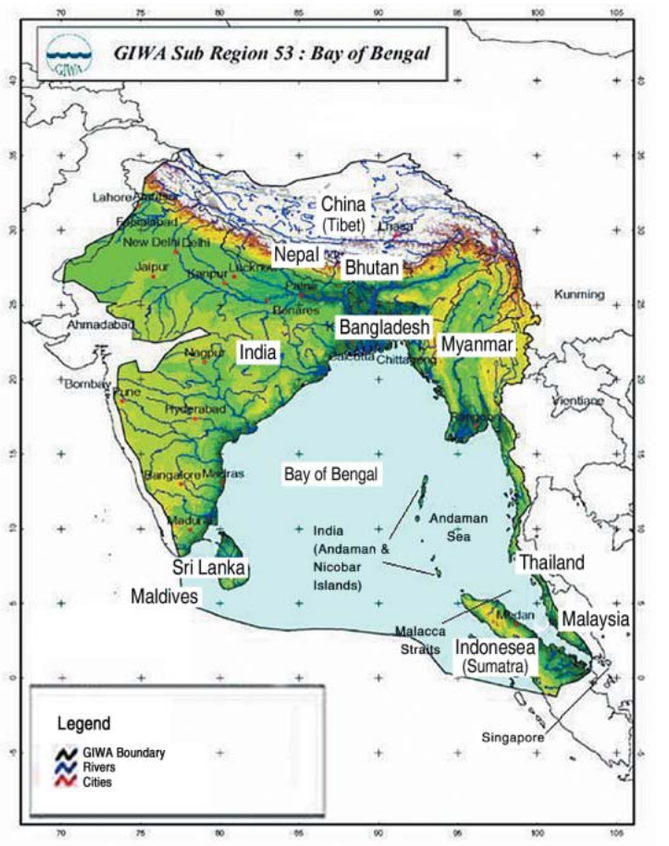


Figure 1. The Global International Waters Assessment (GIWA) Subregion 53, Bay of Bengal including the Maldives.

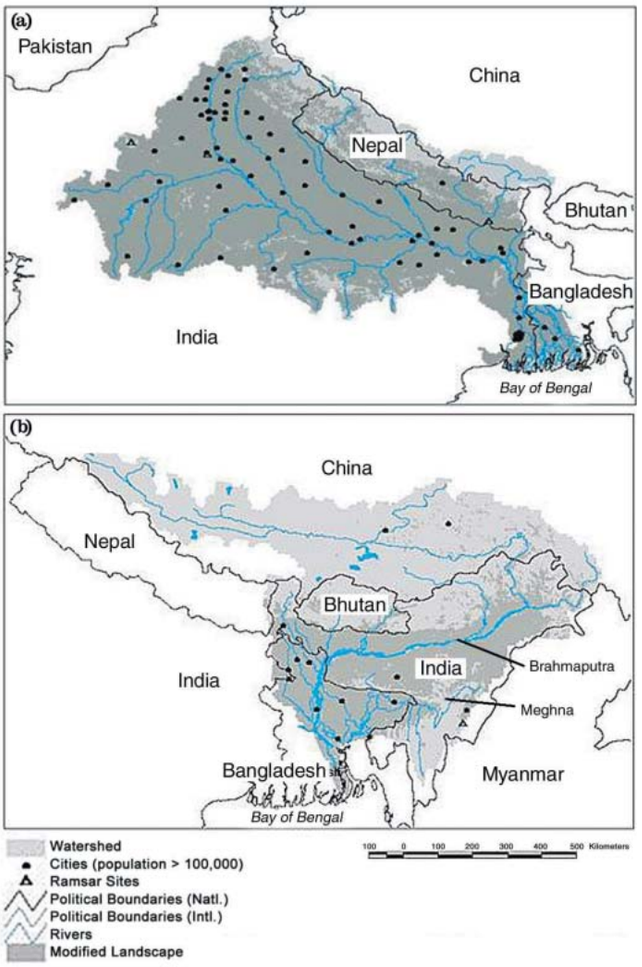
of less than 3 m.

The Bay of Bengal is a relatively shallow embayment of the northeastern Indian Ocean, occupying an area of 2 173 000 km^2 (2). The Andaman Sea is a subsection of the Bay of Bengal. The Malacca Straits, extending from the Andaman Sea until but excluding Singapore, is also a part of the BOBSR (Fig. 1).

The tropical climate of the BOBSR is strongly influenced by the monsoons. A highly complex, seasonally reversing current system, linked to the Arabian Sea and influenced by the Southwest- and Northeast Monsoons, exists in the Bay of Bengal (3). However, a contrary view holds that the Bay of Bengal differs from the Arabian Sea in maintaining a clockwise circulation of major currents during both monsoons (4). The coastline of the Bay of Bengal is influenced mainly by the Southwest Monsoon which brings heavy rain. The inflow of freshwater from the major subcontinental rivers coupled with monsoonal rainfall depresses salinity in the coastal waters. This is compensated for by water with higher salinity from the Indian Ocean, which is driven northward during the Southwest Monsoons. The primary

Table 1. The land area and length of coastlines of the countries in the Bay of Bengal drainage basins including the Maldives (6, 12–14, 30). The land extents of India, Peninsular Malaysia, southern Thailand, and Sumatra are approximations based on discussions with members of the Subregional Task Team.

Country	Land extent in subregion (km^2)	Population in subregion (millions)	Length of coastline (km)	Remarks
Bangladesh	147 000	133	580	Entire country
Bhutan	44 000	2	Landlocked	Entire country
China	326 000	3	Landlocked	Tibet
India	2 800 000	800	7000 (east coast)	Approximation
Indonesia (Sumatra)	200 000	10.9	1200 (west coast of Sumatra)	Population of watersheds associated with Malacca Straits
Malaysia (western)	70 000	13	1100 (east coast of Peninsular Malaysia)	Coastal population associated with watersheds of western Peninsular Malaysia
Maldives	300	0.25	Not available	Total of atoll coastlines
Myanmar	678 500	49	1900	Entire country
Nepal	140 800	24	Landlocked	Entire country
Sri Lanka	65 610	19	1340	Entire country
Thailand (southwestern)	30 000	2	600 (west coast of Southern Thailand)	Approximation
Total	4 522 210	1 456 548 000	Not relevant	
Total (World)	577 800 000	6 201 000 000	Not relevant	



productivity of the Bay of Bengal is increased by nutrients from land drainage and fluctuates inversely with salinity. Tropical storms also have a severe impact. Each year, on average, about 3 storms of cyclonic severity affect Bangladesh, India, and Myanmar (5).

Malacca Straits, situated between Sumatra Island and Peninsular Malaysia, merges with the Straits of Singapore at its southeastern end. The Malacca Straits is about 1200 km long with the widest section of about 400 km, near the northwest entrance, narrowing to about 16 km near the Singapore Straits. About 270 vessels pass through daily making the straits the second busiest shipping lane in the world after the English Channel (6).

River Systems

Several large rivers drain into the Bay of Bengal. Seven of these are transboundary and traverse at least 2 countries (7). However, a major focus of this article is the Ganges-Brahmaputra-Meghna (GBM) river systems since these were chosen for detailed analysis during the final phase of the BOBSR Assessment. The GBM river systems are important in determining the life and livelihood of a large transboundary population as well as the structure and functioning of the BOBLME. The entire flow, water and sediment, of the GBM river systems (except for some tributaries of the River Ganges in India) pass into the Bay of Bengal through one country, Bangladesh, sometimes causing serious environmental impacts (Figs 2a, 2b); (8).

Figure 2. (a) The Ganges watershed and (b) the Brahmaputra and Meghna watersheds which together form the Ganges-Brahmaputra-Meghna river systems. The confluence is in Bangladesh. The intensity of urbanization is shown by the dispersion of cities (8, http://www.wri.org/wri/).

Coastal Ecosystems

The mangroves are the dominant coastal ecosystem in terms of geographic spread in the BOBSR. A range of other coastal ecosystems also occurs in the BOBSR (6, 9, 10). The only exception is the Maldives where the dominant coral reefs ecosystem has associated seagrass beds and sandy beaches. The focus in this article is on mangrove ecosystems since they were chosen for detailed analysis in the final phase of the BOBSR assessment.

The Sunderbans mangrove forest shared by Bangladesh and India is the largest continuous mangrove ecosystem in the world, spread over 12 000 km^2. About 60% of this area is situated in the deltaic coastal region of Bangladesh and ranks third in the Indo-Pacific region (4). The Bangladesh Sunderbans are now designated as a Unesco World Heritage Site. About 500 000 ha of mangroves occur in the deltas of the Irrawaddy and the Salween in Myanmar, and an estimated 250 000 ha are associated with the western Peninsular Malaysia, eastern Sumatra and southern Thailand. Smaller mangrove areas occur in Sri Lanka, the deltaic reaches of the rivers Mahanadi (in Orissa, India) and Godavari (in Andhra Pradesh, India) and the Andaman and Nicobar Islands (India). These mangroves are affected by a wide range of human activity, and in some areas are degraded (9). Mangroves also sequester atmospheric carbon dioxide and thereby contribute toward mitigating global change problems (11).

Socioeconomic Issues of Livelihood and Poverty

Living standards in the BOBSR differ widely. The per capita GDP of Malaysia, the richest country in the BOBSR, is about 15-fold greater than that of Nepal. Sri Lanka's per capita GDP, highest in South Asia, is less than a fourth of Malaysia's. The size of the South Asian population is about 50-fold greater than that of Malaysia (Table 2). The poor population, about 250 million living on less than USD 1 day^{-1}, is the most significant demographic characteristic of the BOBSR. Close to half the world's poor live in the South Asian region of BOBSR, and what happens to them will go far toward determining the success or failure of efforts to reduce global poverty (15).

The majority of the poor in the BOBSR lives in rural areas and depends upon agriculture and harvesting of natural products from forests, and fish and shellfish from accessible waters. The rural agricultural population is more than a 100-fold larger than the small-scale traditional coastal fishers. About 2 million poor fisher families depend upon coastal and marine resources that can be exploited using their artisanal craft and gear (16). Overexploitation of shrimp juveniles and brood shrimp which are in demand for aquaculture is an increasingly serious problem in Bangladesh (17) A similar situation exists in the northeastern coastal areas of India (18) and elsewhere in South Asia. Coastal fishery productivity is inextricably linked to mangroves which serve as nurseries of many commercially important species (19). A strong link appears to exist between the complete loss of mangroves to shrimp farming in the Chakaria Sunderbans in

Table 2. Socioeconomic and selected environmental indicators for countries in the BOBSR (12–14, 20). Dashes (--) indicate where particular information is irrelevant or not available (NA).

Country	Population (millions)	Population density (people km^{-2})	Gross national income per capita (USD)	Access to improved water source (%)	Access to improved sanitation (%)	Poverty: population below USD 1 a day (%)	Rural population (%)	Adult literacy (% Male/ Female)	Under 5 mortality rate per 1000	Maternal mortality rate per 100 000 live births modeled estimates	Average annual decline in forest area 1990–2000 (%)
Bangladesh	136	1042	360	97	48	29.1	76	40.8: 51.7/29.3	77	600	-1.3
Bhutan	1.7	36	590	58	70	--	--	42.0: 58.0/30.0	127	1600 (1993)	--
India	1048	353	480	84	28	44.2	72	56.5: 67.8/44.5	93	440	-0.1
Indonesia	212	117	710	78	55	7.7	60	94.5: 98.0/92.0	45	470	1.2
Malaysia	24	74	3540	--	--	--	43	87.0: 97.0/83.0	8	39	1.2
Maldives	0.29	--	2090	51	76	--	--	96.2: 96.2/96.2	77	202	--
Myanmar	49	74	NA	72	64	NA	73	84.5: 91.0/80.0	108	170	1.4
Nepal	24	169	230	88	28	37.7	88	40.4: 58.0/22.8	91	830	1.8
Sri Lanka	19	283	840	72	9	6.6	77	91.4: 94.3/88.6	19	60	1.6
Thailand	62	121	1980	84	96	<2.0	79	95.0: 97.0/93.0	28	44	0.7
World: Low and Middle income countries	5237	53	1170	79	51	--	--	75.0: 82.0/68.0	88	--	0.3

the Cox's Bazaar area of Bangladesh and loss of livelihood from shrimp seed collectors (20).

Political Culture and Governance

The World Development Report 2004 (21) and Water and Sanitation in the World's Cities (22) cogently place before the global community the causes of the failure to provide essential services that can improve the lives of the poor in developing countries. The existing exclusion of the voice of poor people from the policy-maker-service-provider alliance is shown to be the main contributing factor. This exclusion enables the latter to escape accountability. The seriousness of this exclusion and the manner in which it functions as an impediment to the general social good have been analyzed by many researchers (23–27). Ahmad (28) analyzes water-poverty relationships in the context of Bangladesh. The clear inference is that improved governance is an essential condition for the lives of the poor in the region.

GIWA SUBREGION 53, BAY OF BENGAL ASSESSMENT

The GIWA Subregion 53, Bay of Bengal Assessment, was carried out by the Subregional Task Team (SRTT) which met at 2 workshops. The composition of the SRTT is given in detail in the GIWA Final Report. One outcome of the initial part of the BOBSR assessment was prioritization of the water-related environmental concerns for South Asia (including Myanmar) and the 3 countries associated with the Andaman Sea and the Malacca Straits. For South Asia and Myanmar, Freshwater Shortage became priority 1. For Indonesia, Malaysia and Thailand Ecosystem and Habitat Modification became priority 1. Accordingly, the sites selected for detailed analysis during the last part of the BOBSR Assessment were:

– The transboundary GBM river systems (Figs 2a, 2b).
– The Sungai Merbok mangroves, Malaysia and the Sunderbans mangroves, Bangladesh, which show the multiple and conflicting uses of mangrove ecosystems. These are essentially national issues. However, because of the growing economic importance of shrimp culture and its impact on mangroves, they have shared significance for all maritime countries in the BOBSR except the Maldives.

This article addresses the 2 priority issues stated above in considerable detail. However, these issues and other relevant facts are indicated in the Conclusions section.

THE BOBSR DETAILED ANALYSIS: CAUSES AND POLICY OPTIONS

The GBM River Systems

The GBM river systems constitute the second largest hydrologic region in the world after the Amazon (Figs 2a, 2b). The total drainage basin of about 1.75 million km^2 is shared by 5 countries: Bangladesh, Bhutan, India, Nepal, and the People's Republic of China (Tibet). The estimated population is more than 600 million, larger than the combined total of Mexico, United States and Canada (Table 3). More attention in this article is given to Bangladesh, India, and Nepal. The populations in these 3 countries associated with the GBM river systems are growing at an average rate of about 2% yr^{-1}. It is one of the poorest regions of the world, with about 250 million people surviving on less than USD 2 per day (29, 30). Other social indicators like literacy, infant and child mortality are lower than the world's average. While access to safe water has increased, sanitation remains woefully inadequate. The per capita availability of arable land is very low, about one tenth of a ha (29–31). The existing urbanization rates are also low, but likely to rise significantly in India and Bangladesh.

Despite all these indicators of poverty and backwardness, the GBM region is water-rich. The average annual water flow of the region is 1350 billion m^3 (BCM), while the replenishable reserve of groundwater is 230 BCM. However, water abundant during the Southwest Monsoon, is scarce during the remaining parts of the year; of the average rainfall, 80% occurs during June-October; of the total flow of water in the GBM river systems, an average 1160 BCM (85%), after losses, due to evaporation, evapotranspiration and deep percolation, is available for use in Bangladesh or passes into the Bay of Bengal (31). Excess water causes catastrophic floods in Bangladesh with increasing frequency. Floods are also a serious concern in the foothills of Nepal and lower Gangetic plains of India. Many studies and syntheses of information have demonstrated that transboundary cooperation in integrated water management in the GBM system can offer these countries benefits far beyond those that can be achieved through isolated national efforts (29–32).

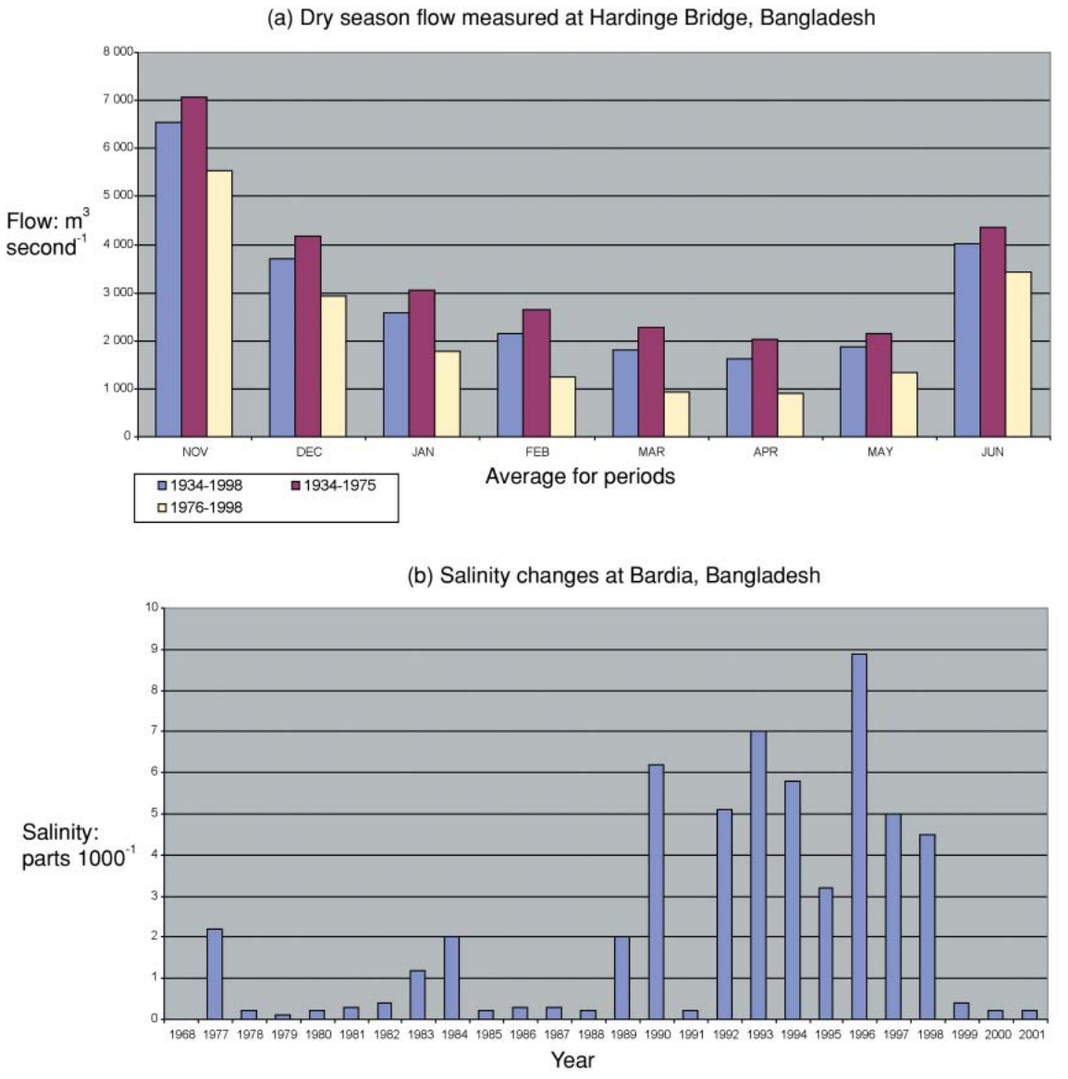
The Issues

Unilateral decisions: The existing problems in the GBM river systems are attributable to the lack of cooperation and to decisions taken by one co-riparian country without fully considering the upstream and downstream transboundary consequences in the other countries (29, 30, 33, 34). Thereby, the opportunity missed was eloquently stated by Rangachari and Verghese (33) "That a region so richly endowed (with water) should remain so poorly developed is a painful paradox. The logic of optimum development and management of vast natural resources for national and regional benefit has been obscured by political boundaries, perceptional differences and a legacy of mistrust". Following discussions between governments of co-riparian countries (Track-1 efforts) of the GBM river systems and parallel discussion at other non-official forums (Track-2 efforts), a new spirit of cooperation and co-management has emerged. India has

Table 3. Development indicators for the population in Bangladesh, India, and Nepal in the watersheds of the Ganges-Brahmaputra-Meghna river systems (29).

Item	Bangladesh	India	Nepal
Estimated population (1998) millions	128	987	24
Annual growth rate (%)	2.2	1.8	2.5
Life expectancy at birth (yrs), 1997	58	62	57
Infant mortality rate (1997)	81	71	75
Population without access to safe water (millions)	25	178	11
Population without access to sanitation (1995; millions)	91	665	18
Population below poverty line (%), (1989-1994), below USD 1 per day	29	53	53

Figure 3. Some adverse effects of construction of the Farakka Barrage 1975.



signed 2 treaties in 1996, the Ganges Treaty with Bangladesh and the Mahakali Treaty with Nepal. The BOBSR analyses were conducted in the context of the emerging spirit of regional cooperation, but with the recognition that lasting solutions would only be possible if the co-riparian governments make the necessary commitment.

The construction of the Farakka Barrage in 1975 across the Ganges River at Farakka in India diverted some 1000 million m^3 of water into Bhagirathi, a tributary of the Ganges. The objectives of the Government of India were met; including improvement of drafts for navigation below Kolkata (Calcutta) and checking salinity intrusion. However, it resulted in some adverse consequences for Bangladesh, including reduced water availability for dry season cultivation, salinity intrusion, loss of fishery, loss of navigation, loss of coastal mangroves, possible premature death of tributaries and increased floods during the wet season (29, 30, 32, 34, 35) (Figs 3a, b).

Salinity intrusion: The greatly diminished flow in the dry season allows salinity to penetrate inland through the estuarine river systems. Salinity limits opportunities for supplemental irrigation and fresh groundwater availability for human and industrial consumption. Water wells in the coastal areas must penetrate 250 m or more to reach water of acceptable quality. A clear reduction in freshwater flow from the Ganges River into Bangladesh during the dry season months occurred following construction of the Farakka Barrage in India (Fig. 3a) (35). During the dry season the decreased freshwater flow into the south-western coastal area through the Gorai River, a tributary of the Ganges River, enabled salinity to penetrate more than 180 km to the north of the Bay of Bengal. The penetration of the 1 part 1000^{-1} (the tolerable limit for agriculture) has increased by more than 180 km as shown by measurements at Bardia (Fig. 3b, 36). Apparently the situation has improved since the Ganges Water Treaty was signed by Bangladesh and India in 1996.

Table 4. Water chemistry and heavy metals as indicators of surface water quality in Bangladesh (41).

Sampling location: rivers	Chemical indicator (mg L^{-1})						
	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	Cl^{-}	SO_4^{2-}	HCO^{3-}
World average	14.70	3.70	7.20	1.40	8.30	11.50	53.0
Ganges near Rajshahi	35.00	3.00	3.12	2.30	7.10	6.99	110.00
Brahmaputra near Kurigram	25.00	3.60	2.34	3.50	14.20	3.40	79.00
Meghna near Bairab Bazaar	20.00	3.00	3.90	1.53	7.10	4.09	49.00
	Heavy metals (mg L^{-1})						
	Al	Cd	Cr	Pb	Hg	Se	Zn
Recommended value*	0.200	0.005	0.05	0.05	0.001	0.01	5.00
Buriganga, Hazaribagh	3.26	0.008	0.23	0.47	0.003	0.0006	0.402
Buriganga, Chandnighat	5.4	0.006	0.006	0.25	0.0016	ND**	0.984
Buriganga, Friendship Bridge	3.27	0.014	0.036	ND	0.0021	0.01	0.56
Turag, Amin Bazaar	11.88	0.018	0.11	0.394	0.0058	0.0002	1.002
Lakhya, Demra intake	2.95	0.006	0.028	0.074	0.0032	0.0005	0.246
Balu, Ziram Khal	2.17	0.006	0.0224	ND	0.001	ND	1.122

* Environmental Quality Standards for Bangladesh, Department of Environment July 1991.
** ND: not detected.

Conservation of the Sunderbans: The major part of the Sunderbans, shared by Bangladesh and India can be conserved and protected only by augmenting freshwater flows into the channels of the southwest flowing rivers and their tributaries (30).

Maintenance and restoration of wetlands: Flows will be required to restore and maintain the wetlands throughout both Bangladesh and in the Gangetic Plains in India. The loss of coastal wetlands has been conspicuous since they have been replaced mainly by shrimp farms. The loss of freshwater floodplain wetlands is more insidious. It can be assessed indirectly by the impact on fishing communities and the extent of fragmentation of river basins. Between 1991 and 1995 about 50 000 ha of coastal wetlands were lost to shrimp farming along the East Coast of India (37). Comparable extents were lost to shrimp farming in Bangladesh (17, 20). The impact of river fragmentation on freshwater fisheries particularly in the Ganges River basin serves as an indicator of the extent of damage to biodiversity. About 98% of the fishery in Bihar State, associated with the Ganges River and contiguous wetlands, collapsed after construction of the Farakka Barrage (38). Similarly, damming of the Mahanadi River which discharges to the Bay of Bengal reduced fish species diversity. The 183 fish species recorded in 1955 diminished to 43 in 1992 following dam construction (38). The integrity of wetlands is necessary for freshwater fisheries on which many poor families depend for income and food security (39). Many of the engineering changes in river morphology that have been carried out in India aimed at minimizing flood damage. However, statistics suggest that the benefits of flood control measures are dubious whereas the floodplains wetlands that have served both in flood impact mitigation and in rural livelihoods have been seriously damaged (40).

Dilution of pollution and effluents: Pollution loads that are of concern to Bangladesh as well as to the entire region include sediment load, industrial effluents, agrochemicals, and domestic wastes. These rise to alarming proportions in the low flow season, especially in densely populated areas. Various studies conducted on pollution loads suggest levels that are unacceptable (41) (Table 4). Industries and large urban centers that discharge untreated wastes are responsible for pollution not only within the country but also for trans-boundary water-quality problems (30, 41). The poor quality of surface water led to increasing extraction of groundwater for agricultural and domestic consumption. This has resulted in higher than safe levels of mineral arsenic being mobilized into groundwater in GBM areas with alluvial soil, a problem which was neither foreseen nor detected until the 1980s (42) (Box 1).

Maintenance of channel morphology: When abstractions are made for various human uses, a reasonable quantity of water must remain in the rivers to sustain channel equilibrium including movement of sediments (30, 34, 35).

Floods: Floods are a recurring phenomenon in Bangladesh where 80% of land area lies within the floodplains of the GBM river systems. Catastrophic floods undermine development of the country while the interval among catastrophic floods has been declining in recent years. Floods are also serious concerns in Bihar State, India, situated on the Gangetic plains and in Nepal (32). Since 93% of the catchments of the GBM river systems are situated outside Bangladesh, regional cooperation among the co-riparian in flood forecasting would contribute to reducing damage to life and property in the short-term until structural measures are implemented (31).

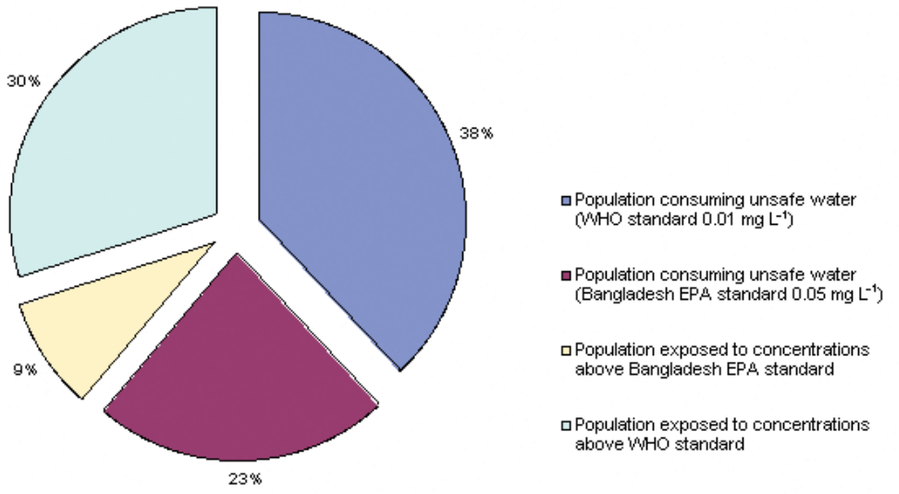
Root Causes

Technology and knowledge: A purely technical solution to the loss of navigability in Kolkata Port was provided by the building the Farakka Barrage. An Environmental Impact Assessment (EIA) combined with a transboundary impact assessment was not seen as needed in the context of existing knowledge in the mid-1970s.

Neglect of environmental value of water: The allocation of water in the basin for various uses such as agriculture,

Box 1. Bangladesh: estimated population exposed to arsenic contaminated groundwater: 125 million

The first case of arsenic poisoning, arsenicosis, was detected in West Bengal, India in 1982 and in Bangladesh in the mid-1990s. Recent research and surveys have revealed the enormity of the problem in Bangladesh. An estimated 125 million people living in the alluvial plains in Bangladesh are exposed to arsenic. Of this number about 87 million are exposed to levels greater than the WHO standard. The poor and malnourished are more vulnerable. Prolonged exposure causes debilitating, skin lesions, and cancer. (42, 43). The United Nations University provides information for West Bengal and Nepal. The solution to the transboundary arsenic problem in the GBM river systems would require a combination of awareness, remediation, research and medical treatment (44).



industry, domestic, navigation, etc. has not included ecosystem function. It is important to keep the rivers alive to support aquatic ecosystems and the coastal mangroves, which are dependent on the balance between fresh and saltwater. This goal requires adequate basinwide environmental and social impact assessment (EIA) and monitoring. Generally, it is the case in most developing countries that EIAs are inadequate or side-stepped (32, 45).

Improper pricing policies: Investment costs in the irrigation sector in both India and Bangladesh are rarely recovered. This may be responsible for the overuse of water by the farmers, and for the shift to water-intensive crops (46).

Lack of good governance at the national level: Water-resources management in all the co-riparian countries is fragmented among many agencies and needs to be integrated. Water Resources Councils have been established in all 3 countries but they appear not to function, except in Bangladesh. Environmental laws and dependence on large engineering interventions have delayed solutions to pressing problems. There is a need for more transparency, inclusion, and sharing of information among stakeholders. Focus can shift to small impoundments like ponds and tanks so that the major impacts of large diversions can be avoided (40).

Lack of good governance at the international level: There is no mechanism for monitoring hydrological information and ensuring the use of accurate data by all the co-riparian states. The Indo-Nepal Treaty (1996) has not progressed much because of differences in perspective about the respective water rights and also about the area to be submerged if a dam is built. Until 1996, the Farakka project was a subject of contention between India and Bangladesh. The 1996 treaty attempts to apportion the water resources at Farakka in an equitable manner but also refers to best utilization of the resource. Since the GBM region encompasses many rivers, the treaty provides a good example for considering the sharing of the waters of the other rivers.

Policy Options

Short-term options

Pricing policies for water: The 3 co-riparian states need to revise irrigation and power prices for groundwater extraction where they exist (Nepal and some Indian states) or introduce them (Bangladesh). Urban and industrial supply is generally metered and priced in all the 3 countries. However, households may not be charged the full resource price. The price should ensure the financial viability of the service provider. In the case of irrigation, participatory approaches may enable

recovery of at least the operation and maintenance costs. Pricing should adequately consider equity issues to prevent adverse impacts on those who are already poor.

Reuse of wastewater: South Asian societies have traditionally reused wastewater. However, official recognition is required for the large quantities of wastewater available for reuse. If wastewater is not treated it aggravates the pollution problem. Given the problems of freshwater shortage in the region, reuse of wastewater for agriculture, aquaculture, etc. could strengthen freshwater conservation in the region.

Water harvesting: Construction and rehabilitation of traditional tanks/ponds is an alternative to construction of large reservoirs in the Ganges basin in India. Decentralized institutions at the local level could maintain these. These small tanks/ponds help to recharge wells and springs and insure against severe drought (47). Restoration of the floodplain lakes in the Ganges (lower reaches in India) and the Brahmaputra basins (in Assam in India) could also assist in increased storage of water during the periods of higher precipitation and subsequent recharging of the ground aquifers (39).

Long-term option

Augmentation appears to be the only long-term policy to deal with the problem of freshwater shortage in the dry season. Medium-sized storage in Nepal for releasing the water during the dry season is an option. This requires a regional treaty between Nepal, India and Bangladesh. Such a project should take into account the environmental value of water downstream with the objective to keep the river alive. Possibly, navigability of the Ganges could also be considered. A regional project such as the above would require participation by all the governments (including Bhutan and China). Bangladesh may have to invest in the project if it is to receive dry weather flows. However, there would be problems with submergence in Nepal and displacement of about 100 000 persons. Gyawali (32) presents reasons for incisive technical analysis before water storage tanks/ponds are built in Nepal based on the long-standing assumption that water is abundantly available. Goldsmith and Hildyard (40) present a strong case for careful examination of costs and benefits of large dams.

Analysis of Options

Conservation options like pricing, water reuse, and water harvesting are "efficient" in the sense that they make the best use of available resources without large-scale structures. However, a strict application of pricing as a method to achieve better use of the water may be impossible for political and social reasons. Issues related to equity must be central elements when pricing is used in the region. Nepal and India are moving towards a pragmatic pricing policy in the drinking water sector and tariffs for pumping groundwater. While water markets exist in pockets in India, "tradable water rights" may not be possible at the international level. If hydropower is produced in Nepal it has to be exported to India for the project to be viable. The controversy often lies in the proper price. Bhutan has benefited greatly from selling power to India from a joint hydroelectric project at Chukha. As a consequence, the per capita income of Bhutan has increased to USD 545, higher than that of Nepal or India (33). Bhutan has ensured that India pays the "opportunity cost" for the power. Nepal needs to ensure that a good price is paid for its power if storage is to be built on the river Kosi. A trilateral treaty among the co-riparians would be required if the storage is to augment the river Ganges at Farakka. However, the process can move forward under the auspices of the South Asian Association for Regional Cooperation (SAARC) to build an institutional arrangement such as the 'Mekong Commission'. The Helsinki Rules of water sharing could be used as a model in any long-term regional arrangement (48).

Sungai Merbok Mangroves, Malaysia, and the Sunderbans Mangroves, Bangladesh

Sungai Merbok mangroves in Kedah state of Peninsular Malaysia are situated at the northwestern entrance to the Malacca Straits. These mangroves, which contain one of the highest recorded levels of species biodiversity in the world, are unique and require both global and regional attention because land-use changes accompanying economic growth, urban settlement expansion in coastal areas particularly, occurring in Merbok, can recur at other locations along the coastlines of southern Thailand and Sumatra (6).

Sunderbans mangroves shared by India and Bangladesh are situated on the deltas of the GBM river systems. The Bangladesh Sunderbans are the main focus in this article. They are significant as one of the largest mangrove ecosystems in the world and as a Unesco World Heritage Site. Shrimp culture as presently practiced adversely impacts the Sunderban mangrove and rural livelihoods. Conversely, if properly managed, equitable economic benefits may be created on a substantial scale. Hence implications exist for many other sites along the coastlines of South Asia, where poverty and livelihoods are major issues.

The Merbok mangroves (49–51) presently cover an area of about 2800 ha. They are surrounded mainly by rice, rubber and oil palm cultivation. A fast growing town, Sungai Petani lies contiguous with the Merbok estuary. There were some 8000 ha of mangroves a half a century back. Initially, about 2800 ha were converted to rice fields, in keeping with the national policy of food self-sufficiency. This policy has since changed. The Department of Agriculture recognizes that the acid sulfate in mangrove soils makes it unsuitable for commercial rice growing. The rice fields belonging to private individuals now remain semifallow. Another 2400 ha of mangroves were lost to shrimp farming from the early 1970s to the end of the last century (50). Now, significant areas (hundreds of ha over the past 5 years) are being converted into housing estates. If this trend continues there will be little or no mangroves left in Merbok by 2020 when Malaysia is projected to achieve developed country status (52).

The scale and nature of habitat change in the Sunderbans are different from Merbok. Driving forces are both natural and anthropogenic. River flow, with the highest sediment load in the world from the GBM river system (53), in interaction with the coastal dynamics of the Bay of Bengal, and low-level seismic activity results in stabilization of deposited sediment. Consequently, mangroves naturally expand in some areas and shrink in others. Although the extent has not been measured, estimations are available on the conversion of mangroves for shrimp farming. In Cox's Bazaar several thousand ha of mangroves in the Chakaria Sunderbans were lost by 1986 (Fig. 4) (54). Parallel expansion of shrimp

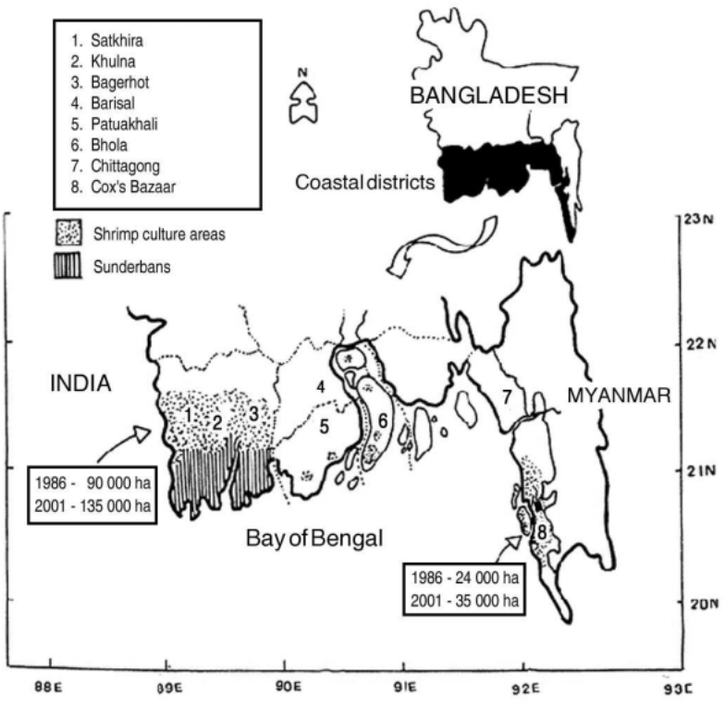


Figure 4. Shrimp cultivation areas in Bangladesh have aleady replaced the Chakaria Sunderbans mangroves in the Cox's Bazaar area and now lie contiguous with the Sunderbans forest reserve (17, 54).

farming has since occurred, contiguous with that of the Sunderbans, in the Khulna area in the southwest (Fig. 4), (17, 20, 54, 55)

Since the 1960s, flood prone settlement areas in the coastal area of Bangladesh, several thousand ha in extent, have been protected from flood hazards by embankments. This land was gradually flushed of soil salinity and made cultivable. These enclosed areas, polders, were developed with infrastructure for settlement expansion. Some parts of the polders later became uncultivable due to waterlogging. Shrimp farming expanded on these lands causing displacement of the poor, landless sharecroppers who were compelled to encroach into state land or to migrate into cities, thus adding to the burgeoning urban labor force. The adverse impact on mangroves is visible in the Sunderbans Unesco Heritage Site in the southwest coastal area (Fig. 4) (17).

Shrimp farming in Bangladesh supplies about 2.5% of global production and is the second largest export industry. Some 600 000 to 800 000 persons are employed in shrimp farming (17, 55). Nevertheless, This practice creates social and environmental impacts, including expansion into rice growing land, depleting livelihood options for the poor and forcing encroachment into state land (55). Shrimp farming provides an opportunity for addressing poverty and gender issues while increasing national income since aquaculture is predicted to grow over the next 20 years in developing countries (56). Positive results have been recorded in situations where poor, landless families have been enabled to become partners in shrimp farming (20).

The Issues

Governance: Increasing affluence in Malaysia during the past half century has been accompanied by a shift in the utilization of mangroves from agriculture (food self-sufficiency) to aquaculture (self sufficiency and export) to real estate development (housing demand and exploitation of 'cheap' land). Without encouraging the use of semifallow, unprofitable rice fields perhaps at a slightly higher price, the State authorities have given grossly undervalued mangrove land to real estate developers (57). Equity was ignored since the losers were the poor and politically less influential small-scale fishers who depend upon the natural productivity of mangrove ecosystems for their income.

In Bangladesh, absence of land-use zoning and land-use policy (34) enables law enforcement authorities to become involved in diverse market activities which contribute to large-scale change in the forest structure. The very poor local communities do not have a voice since common interests also exist between politicians and powerful market players. Polders have been converted to shrimp ponds under extensive cultivation by wealthy landowners. Shrimp seed collection now provides an alternative income to some poor, displaced sharecroppers. Some have encroached into mangrove areas to carry out marginally profitable rice-fish cultivation. The high population density combined with poverty and landlessness pushes people to encroach into mangrove areas for habitation and to harvest natural resources. The conditions of law and order are weak, allowing harassment of the poor by agents of vested interests (23).

Technology: Shrimp cultivation and hatchery technology were introduced in Bangladesh in the 1980s (54). High export value accelerated shrimp farming in densely populated coastal areas, including accessible mangroves. This was mainly driven by private investment encouraged by government which placed high priority on foreign exchange earnings. Equity was ignored because of political patronage extended to investors and the absence of political power among the poor and landless. The impact of technology was linked also to governance.

Root Causes

Policy dislocation: Bangladesh and Malaysia are signatories to the international conventions for the protection of biodiversity. It is not mandatory for states in Malaysia to follow national policy since in this case land is under state jurisdiction. In Bangladesh, absence of a land-use policy enables distortions to occur in land acquisition procedure even in biodiversity reserves (9, 34).

Governance: The basic problem is the absence of transparency in the manner of land acquisition (including its valuation) aggravated by the lack of stakeholder participation. The situation is complicated because the major stakeholder, the fishers (in Malaysia), are poor and have relatively little political clout (58) compared to real estate developers. In Bangladesh, absence of accountability from law enforcement authorities and investors coupled with the political weakness of community members militate against balanced decisions. The involvement of political authorities and government officers in various market activities has undermined the authority of the government.

Poverty and demographic pressure: In Bangladesh, absence of broad-based stakeholder participation and equity in the development process drive poorer community members to seek least cost options for livelihood. One such option is encroachment into government land including the mangroves in the Sunderbans Unesco World Heritage Site.

Policy Options

Do nothing: This option does not exist because of the international significance of both Sungai Merbok and Sunderbans mangroves and since Bangladesh and Malaysia are signatories to the UN Biodiversity Convention. The Federal Government needs to ensure that the constituent state governments adhere to national policy.

Strategic land-use zoning: A land-use zoning plan which designates key mangrove ecosystems as protected areas would assist in safeguarding existing mangroves if properly enforced. This would require strict enforcement with adequate legal backing by the government coupled with incentives for refraining from encroaching into mangrove ecosystems.

In Merbok, incentives would have to be provided to investors to carry out housing development in abandoned agricultural areas with the landowners as equity partners. The state needs to realize that mangrove land is grossly undervalued. Shadow valuation dictates that natural mangroves have higher value than mangrove land converted to rice fields (57). The state needs to realize that selling mangrove land below its true value is tantamount to short changing the people of the state and ultimately the whole nation.

In the Sunderbans, incentives need to be provided to involve the poor and landless in shrimp farming as one of the available options. Already they obtain income from shrimp seed collection and from farm labor (20). There is growing official recognition that the solution to poverty is very complex, but progressive participation of the poor in development activities that immediately improve their life contributes substantially to long-lasting results (23). Adequately planned shrimp farming, which involves the poor in long-term partnerships holds potential among the necessary interventions (55), such as enforceable protected areas and ecotourism, in order to safeguard the mangrove ecosystem for their natural goods and services (20). However, increasing income by itself is not the entire solution (21). Freedom from illness and illiteracy are recognized as 2 of the most important ways in which poor people can escape poverty when combined with economic growth (21).

Analysis of Policy Options

An enforceable land-use zoning system, properly implemented, can be efficient in safeguarding mangrove areas in both medium-income (Malaysia) and low-income developing countries (Bangladesh). The need for such policies are recognized in a recent document, the Consortium Publication on Shrimp Farming and the Environment (59), and the ongoing fisheries development plans being implemented jointly between the Government of Bangladesh and the World Bank (55, 60). However implementation would be a challenge. The key would be for governments to address the equity issue. A land-use zoning plan when implemented would be robust only to the extent that all stakeholders are empowered to engage in dialogue such that each party is publicly held accountable for straying from the zoning boundaries.

CONCLUSION

Regional consultation and sharing of technical information would contribute toward the building of transboundary social capital, which could facilitate identification of options for win-win solutions to the existing problems in the GBM river systems. It is imperative that China is brought into regional consultation to ensure that unilateral decisions by China would not undermine integrated management efforts for the GBM river systems by Bangladesh, Bhutan, India, and Nepal (32). However, where water sharing on an equitable basis becomes a reality, its contribution to improvement of the living standard of the rural poor may not occur automatically. Poverty reduction will rest upon fair prices for rural agricultural produce. Governments will need to provide supportive market mechanisms. External factors such as farm policies in the developed countries also will have serious implications for poor farmers in developing countries even when land and water issues are overcome (61). Therefore, joint action at global forums would have to be strengthened through regional consultation and collaboration to ensure that lasting results are obtained from integrated management of the GBM river systems.

Shrimp farming in particular and coastal aquaculture in general provide an opportunity to the countries in the BOBSR to analyze and share experience with regard to optimizing social and environmental benefits while increasing national income. However, lasting social good would result only where equity issues are seriously addressed and community empowerment is recognized as both a necessary and essential condition for sustainable development. The opportunity exists (56, 59). However, these opportunities need to be perceived as a part of the bigger picture (21).

With the exception of Malaysia, all the other countries in the BOBSR are grappling with varying degrees of poverty. Poverty has many dimensions in addition to low income; illiteracy, ill health, gender inequities, and environmental degradation. In parallel with enhancing economic growth, which could contribute to family income, ever more serious attention is required to reach the UN Millennium Development Goals, i.e. the international community's agreement on the targets for reducing poverty. Table 2 reflects the magnitude of the task faced by some countries in the BOBSR with regard to them. The 8 UN Millennium Development Goals (62) include:

- Eradicate extreme poverty and hunger.
- Achieve universal primary education.
- Promote gender equality and empower women.
- Reduce child mortality.
- Improve maternal health.
- Combat HIV/AIDS, malaria, and other diseases.
- Ensure environmental sustainability.
- Develop a global partnership for development.

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