

State and management of wetlands in Bangladesh

Talukder Byomkesh · Nobukazu Nakagoshi ·
Rashid Md. Shahedur

Received: 24 January 2008 / Revised: 21 August 2008 / Accepted: 7 October 2008 / Published online: 16 December 2008
© International Consortium of Landscape and Ecological Engineering and Springer 2008

Abstract Wetlands are a vital link between land and water in Bangladesh. A majority of the people of Bangladesh are critically dependent on wetlands. In this paper, the values of wetlands, causes and effects of wetlands degradation, as well as the present wetlands management approach, are analyzed and recommendations for wetlands management are suggested based on participatory rural appraisal (PRA), field visit, personal experience, and existing literature and information. Wetlands play a crucial role in maintaining the ecological balance of ecosystems, but wetlands habitat of Bangladesh is under constant threat due to increase of population, intensive agriculture, overfishing, siltation, pollution, ill-planned infrastructures, lack of institutional coordination, lack of awareness, etc. As a result biodiversity is reducing, many species of flora and fauna are threatened, wetlands-based ecosystem is degenerating, and the living conditions of local people are deteriorating as livelihoods, socioeconomic institutions, and cultural values are affected. Wetlands management is not addressed separately in water management activities of Bangladesh. In order to balance human needs and wetlands conservation, a mainly community-based wetlands management approach has been taken in Bangladesh, but this is not enough to prevent the degradation of wetlands. Therefore, Bangladesh now needs a comprehensive strategy combining political, economic, social, and technological approaches to stop further degradation of

wetlands. Therefore, wetlands management should be incorporated into a system of integrated land and water use and, indeed, into the socioeconomic system of the country. Policies, strategies, and management plans for sustainable use and conservation of wetlands of Bangladesh must be based on solid knowledge and understanding of their ecological and socioeconomic functions and processes.

Keywords Bangladesh · Wetlands management · Values · Degradation · Management approach · Recommendations

Introduction

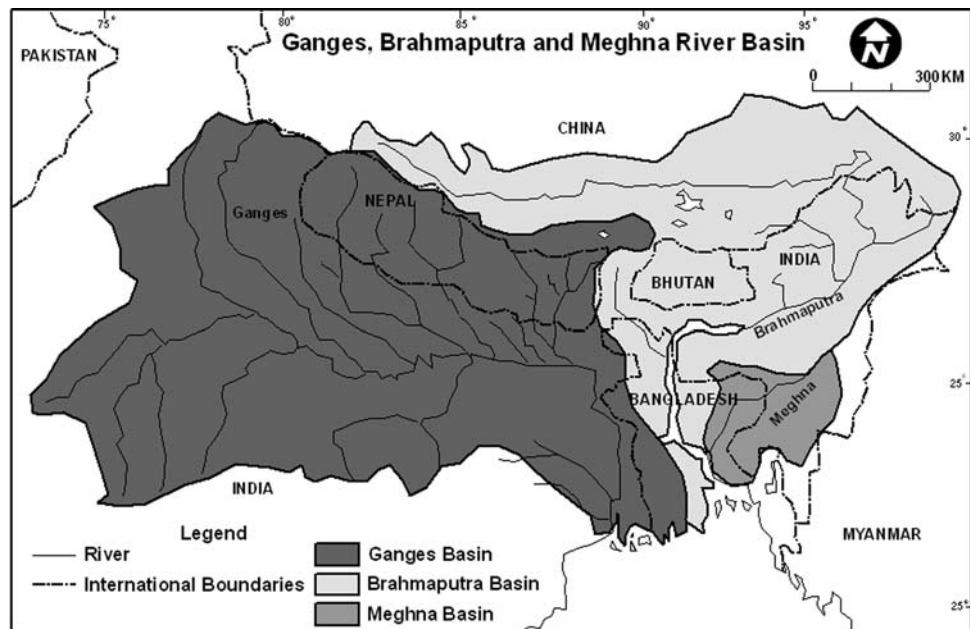
Most of Bangladesh lies in the largest delta in the world, the Bengal Basin, formed by the Ganges, Brahmaputra, and Meghna (GBM) river system (Fig. 1). It comprises only 7% of the total GBM catchment area (Coleman 1969). The Bengal Basin is a vast lowland. It is thought that this lowland basin was once one of the largest wetlands in the world; during the past few thousand years, the wetlands have almost all been converted into rice-growing areas (Chowdhury 1998). The total area of wetlands in Bangladesh is estimated to be 7–8 million hectares, or about 50% of its total land surface (Khan 1993). This includes 5.4 million hectares of open and closed lakes on floodplains that are inundated every year (Ali 1990). Ninety percent of wetlands of Bangladesh are dependent on flow from three major rivers, but are now threatened by diversion of water in India from the Ganga–Padma river (Gopal 1995).

During the monsoon season, at least 7–8 million hectares, or about half the country (and sometimes considerably more), may be considered wetlands (Hughes et al. 1994). Wetlands support essential natural resources

T. Byomkesh (✉) · N. Nakagoshi
Graduate School for International Development
and Cooperation, Hiroshima University, Hiroshima, Japan
e-mail: byomkesh.talukder@gmail.com

R. Md. Shahedur
Department of Geography and Environment,
Jahangirnagar University, Dhaka, Bangladesh

Fig. 1 The Ganges, Brahmaputra, and Meghna River Basin, Source: Mirza and Warrick (2001)



and services, and the people of Bangladesh depend on wetlands for fishery and agriculture. The fate of Bangladesh, its people, and its prospects for sustainable development are determined by the association of water and wetlands, and they are the central pillar of the natural resource base. They also sit at the crossroads of two major international shorebird migration flyways, i.e., along the western edge of the East Asian–Australasian flyway and at the eastern edge of the Central Asian–Indian flyway (GOB 2001). The biodiversity of the country reflects this crossroads character. It has a unique mosaic of habitat with extremely rich diversity of flora and fauna. It is observed that communities are most densely settled in and around wetlands, and for centuries society adapted a culture that maintained a close relationship between wetlands nature and human actions.

Wetlands, which are locally called haors, baors, and beels, are vanishing or degraded due to various causes, such as population pressure, demand for wetlands products in markets, ill-planned infrastructures that prevent wetlands, particularly floodplains, from maintaining their ecological and hydrological functions, etc. In addition, government policies and institutions that oversee access to, and management and exploitation of, wetlands have weakened conventional wetlands customs and practice, leading to exhausted ecosystems and poverty. Now, wetlands management has become one of the most important environmental issues in Bangladesh.

Therefore, the objectives of this paper are to (1) identify the detailed values of wetlands for Bangladesh, (2) determine actual causes and effects of wetlands degradation, (3) investigate the present management and conservation

approach for wetlands, and (4) make recommendations for wetlands management.

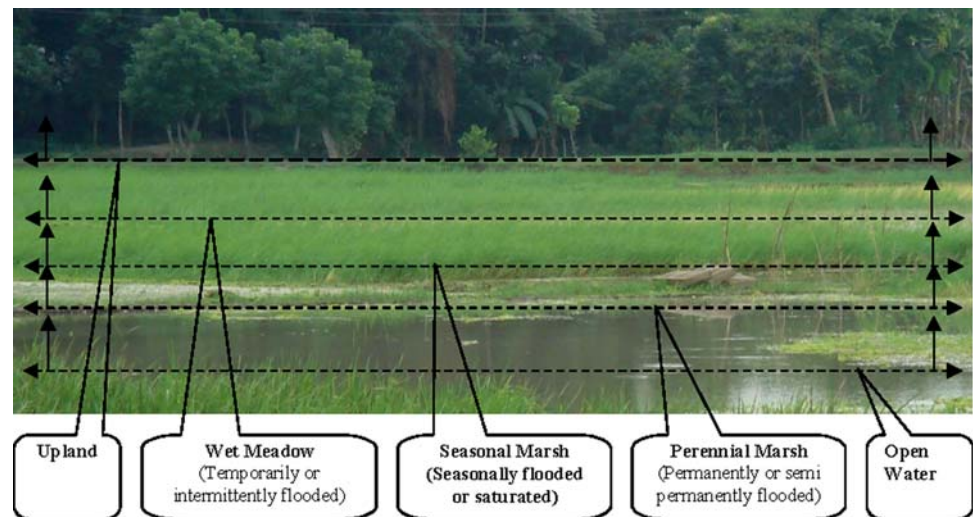
Methods

This paper is mainly based on primary and secondary data. Primary data were collected through participatory rural appraisal (PRA), field survey, observation, and interview with experts. Critical perusals of secondary data included relevant books, articles, reports, unpublished theses, maps, relevant documents, newspaper cuttings, and in situ personal experiences. Collected data were critically reviewed and discussions carried out with experts and local people. It is believed that the management issues of wetlands of Bangladesh have been brought together herein.

Wetlands resources

The main characteristic of the geography of Bangladesh is abundance of water and wetlands. Wetlands are mainly located at the lower edge of the topography and are subject to periodic inundation/flooding. During the wet monsoon they are inundated at shallow to deep levels. Wetlands are defined as low-lying ecosystems where the groundwater table is always at or near the surface, including areas of marsh, fen, bog, floodplain, and shallow coastal areas (Alam and Chowdhury 2003). In other words, wetlands are transitional lands between terrestrial and aquatic ecosystems where the water table is usually at or near the surface or the land is covered by shallow water (Mitsch and

Fig. 2 Transect of a typical wetland of Bangladesh. Source: field visits, PRA, interviews, secondary data, and personal experiences (2007)



Gosselink 1986). According to the definition of wetlands by the Ramsar Convention, more than two-thirds of Bangladesh may be classified as wetlands. Wetlands of Bangladesh have the characteristic of being sensitively influenced by water; wetlands support agriculture, fish, and natural vegetation and maintain soil structure that is distinctive from that of surrounding uplands. Vegetations vary between upland and open water in wetlands. In general, typical wetlands of Bangladesh can be divided into five vegetation belts (Fig. 2), including submerged (macrophyte species), free-floating, rooted floating, sedges/meadows, floodplain grassland (transitional), reed swamp, freshwater swamp forest, crop field vegetation, and homestead vegetation (Bennett et al. 1995).

Wetlands encompass many different habitats, including ponds, marshes, and swamps, and are ecologically significant areas as they are the meeting place of land and water, and are themselves wet. Plants and animals that are present in wetlands are from both land and water habitats. They are very rich depositories of vegetations, aquatic plants, reeds, and algae, which make them highly productive environments. The flora composition is relatively uniform throughout the haors, beels, jheels, and baors but dominance varies seasonally. Typical wetlands trees are hizal (*Barringtonia acutangula*), tamal (*Diospyros cordifolia*), barun (*Crataeva nurvala*), madar (*Erythrina variegata*), gab (*Diospyros peregrina*), dumur (*Ficus hispida*), chalta (*Dillenia indica*), and dehua (*Artocarpus lacucha*) (Alam and Chowdhury 2003). Wetlands function as ecotones, transitions between different habitats, and have characteristics of both aquatic and terrestrial ecosystems.

The country's wide range of wetlands includes more than 700 rivers and streams, thousands of shallow freshwater lakes and marshes, floodplains, inshore coastal areas, and extensive estuarine systems as haors, baors, and beels, water storage reservoirs, fish ponds, and flooded cultivated

fields. The haors, baors, and beels are of fluvial origin and are commonly identified as freshwater wetlands. Manmade wetlands include lakes, dighis, ponds, etc. (GOB 2001; Alam and Chowdhury 2003). Deepwater paddy fields and ponds are also considered wetlands. About 6.7% of Bangladesh is always under water, 21% is deeply flooded (more than 90 cm), and 35% experiences shallow inundation (FAO 1988). In fact most of Bangladesh may be considered as perennial wetland (Fig. 3). The wetlands can be divided into: (a) the Ganges–Brahmaputra flood basin, and (b) the haor basin of the northeast region (Alam and Chowdhury 2003). Some important freshwater wetlands of the country are (a) Chalan Beel, (b) Atrai Basin, (c) lower Punarbhaba Floodplain, (d) Gopalganj–Khulna Beels, (e) Arial Beel, and (f) Surma–Kushiyara Floodplain (Fig. 3).

Wetlands in Bangladesh encompass a wide variety of dynamic ecosystems, including rivers (7,497 km²), estuaries and mangrove swamps (6,102 km²), beels and haors (1,142 km²), inundable floodplains (45,866 km²), Kaptai Lake (manmade reservoir, 688 km²), ponds (1,469 km²), baors (oxbow lakes, 55 km²), and brackish-water farms (72,899 km²) (Akonda 1989; Khan et al. 1994).

Values of wetlands

Wetlands are the most productive ecosystems, and countless species of plants and animals depend on them for survival. A high concentration of fishes, amphibians, reptiles, birds, mammals, and invertebrate species are supported by them (Khan et al. 1994). Fishes from wetlands provide the main source of protein for the people of Bangladesh. Rice cultivated in wetlands is the main food in Bangladesh. They also provide important ecological functions, socioeconomic services, and products, and are

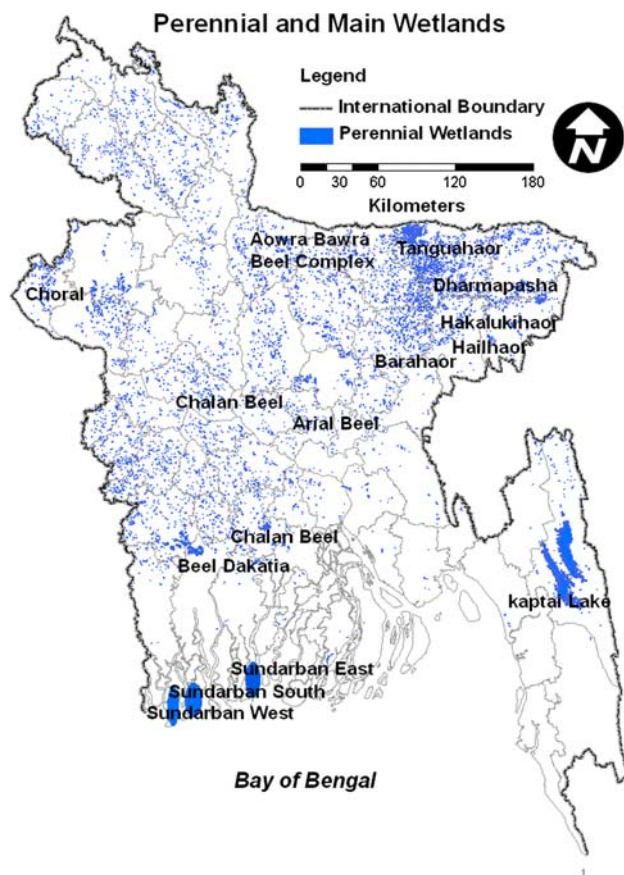


Fig. 3 Perennial and main wetlands in Bangladesh. Source: BWDB (2007)

important for their ecological, socioeconomic, and commercial value.

Wetlands contain very rich components of biodiversity of local, national, and regional significance. Among the estimated 5,000 species of flowering plants and 1,500 species of vertebrates in the country, up to 300 plant species and some 400 vertebrate species are judged to be dependent on wetlands for all or part of their lifespan. Wetlands also provide habitat for a variety of resident and migratory waterfowl, a significant number of endangered species of international interest, and a large number of commercially important species. The inland capture fishery is based on the vast freshwater resources, with some 260 species of finfishes and 25 shellfishes (Khan et al. 1994).

Wetlands are precious for the environment, ecology, and biodiversity. They are an integral part of the local ecosystem and closely related with local cultures, and also support the livelihoods of millions of people based on diverse activities such as fishing and agriculture. Values of wetlands are increasingly receiving attention as they contribute to a healthy environment in many ways.

The values of the wetlands of Bangladesh can be classified into three major groups: environmental, economic,

and social. Storage and recycling of nutrients and organic waste, recharge and discharge of groundwater and storage of surface water, natural drainage, flood control and flow regulation, fish breeding ground, and maintaining ecological balance are some examples of the environmental value of wetlands. Wetlands agriculture, freshwater, fish, wild foods, forest resources, agricultural land, and biomass are some examples of the economic value of wetlands. Transportation, human habitat and settlement, research, education, and aesthetic are some examples of the social value of wetlands in Bangladesh. Table 1 summarizes the overall values of wetlands of Bangladesh.

Causes and effects of wetlands degradation

Wetlands and their habitats are under constant threat due to various causes. Wetlands productivity and biodiversity are declining all over the country. The overall cause and effect relationships of the wetlands degradation of Bangladesh is shown in Figs. 4, 5.

Present wetlands management approach

In Bangladesh the most important part of every natural resources policy is agriculture for achieving food self-sufficiency. This is also true for water management in the country. In the water management of Bangladesh only the crop sector is strongly addressed. Here, crops mean cereals, which focus on high-yielding varieties (HYV). Emphasis has been placed on crop production, as the growing population demands more food (Nishat 2003). Wetlands management is not addressed separately in the water management policy of Bangladesh. The National Water Policy (NWP, 1999) basically controls the present wetlands management of Bangladesh. The NWP is the main base for water management activities in Bangladesh. In this policy the main goal is stated as follows:

to ensure progress towards fulfilling national goals of economic development, poverty alleviation, food security, public health and safety, a decent standard of living for the people and protection of the natural environment (GOB 1999).

In the NWP (1999) under section 4.9 the main objectives for water, fishers, and wildlife are that (1) fisheries and wildlife will receive due emphasis in water resource planning in areas where their social impact is high, (2) measures will be taken to minimize disruption to natural aquatic and water channels, (3) drainage schemes, to the extent possible, will avoid state-owned swamps and marshes that have primary value for waterfowl or other

Table 1 Values of wetlands in Bangladesh

Category	Values
Environmental	Storage and recycling of nutrients and organic waste, storage and discharge of surface water, recharge and discharge of groundwater, natural drainage, control of flooding and regulation of water flow and water regimes, reduction of water logging and storage of flood water, transport of sediments and sediment/toxicant retention, storage and recycling of human waste, control of erosion and salinity, purification of water and maintaining the water table high and relatively stable, relief of drought and stabilization of climate and control of microclimate, stabilization of shoreline and reduction of erosion, reduction of sediment and pollutant load, maintenance of soil structure and helping soil formation, protection against river bank erosion, helping nutrient retention/removal, protection against storm surges, helping carbon sequestration, maintaining ecosystem stability and the integrity of other ecosystems, fish breeding grounds, maintaining biological and genetic diversity, supporting food chains and habitat for wildlife and protecting wildlife, helping pollination, work as ecotones (vital links between land and water), habitats for a variety of resident waterfowl and a significant number of endangered species of international interest and as internationally important wintering areas for migratory waterfowl, principally ducks and shorebirds
Economic	Agricultural activities, crop production, freshwater fish production, provision of forage resources, production of wild food, production of vegetables, as agricultural land, providing forest resources, supply of irrigation water, helping stock farming, grazing places for domestic livestock, helping water duckery, supply of wildlife, supply of fuel wood, as a place of primary activities, provision of medicinal plants and genetic resources, provision of subsistence-oriented economy and livelihoods, supply of raw materials for building, construction, and industrial use, provision of places for industrial and pharmaceuticals plants, as places of primary economic activities, as pasture, and as storehouses of plant genetic material
Social	For transportation, tourism and recreation, provision of settlement places, help in research and education, uniqueness, cultural heritage, cultural value, aesthetic value, heritage value, spiritual and inspirational values, bequest value, ecotourism, as leisure or recreational place, place of education and amusement, fostering of beneficial rural-urban links, and transformation and empowerment of poor user groups as resource managers

Source: field visits, PRA, interviews, secondary data, and personal experiences (2007)

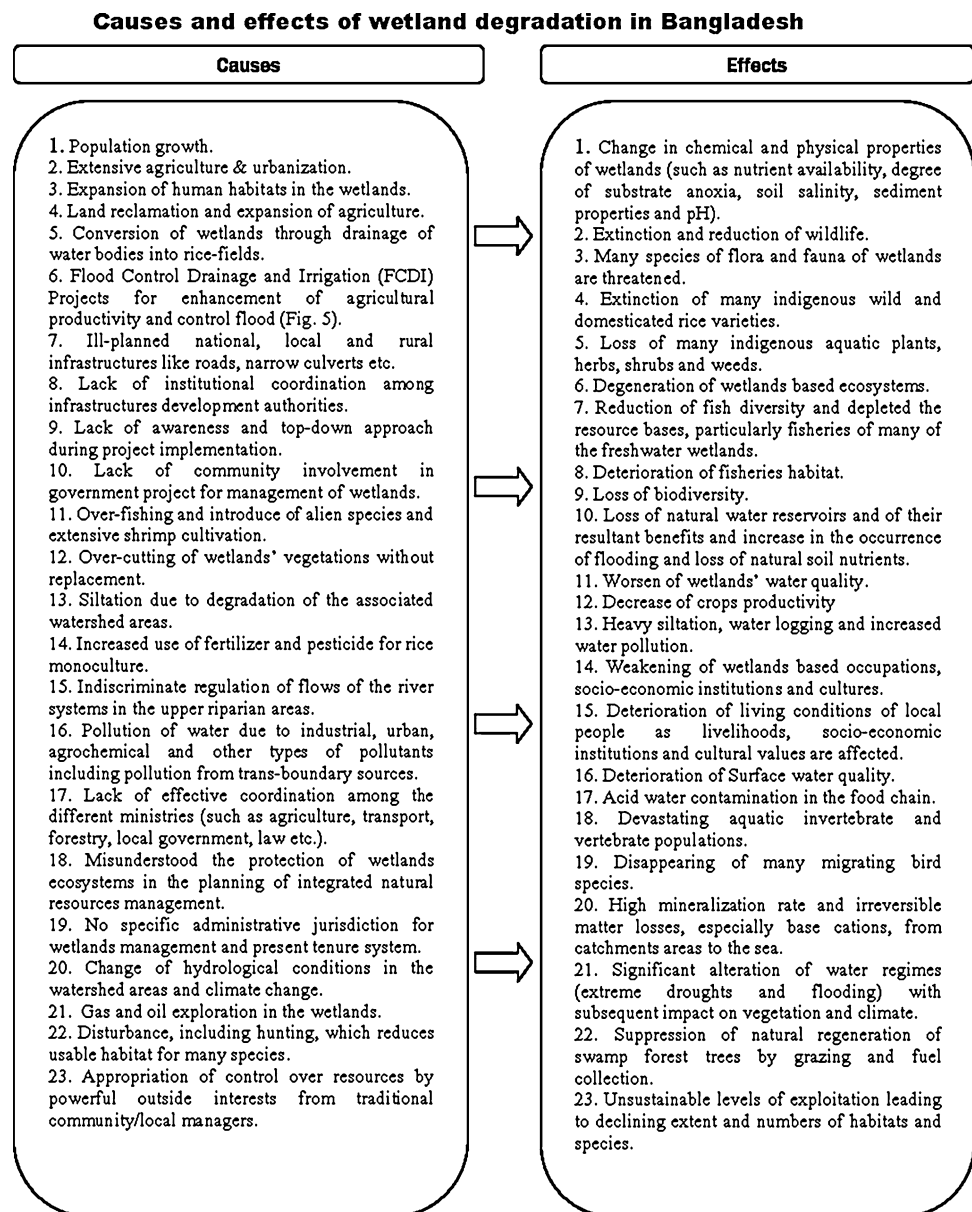
wildlife, (4) water bodies such as haors, baors, beels, roadside burrow pits, etc. will, as far as possible, be reserved for fish production and development; perennial links of water with rivers will also be properly maintained, (5) water development plans will not interrupt fish movement and will make adequate provisions for control structures for allowing fish migration and breeding, (6) brackish aquatic culture will be confined to specific zones designated by the government for this purpose.

In section 4.13 for preservation of haors, baors, and beels the main objectives are that: (1) natural water bodies such as beels, haors, and baors will be preserved for maintaining the aquatic environment and facilitating drainage, (2) only those water-related projects that will not interface with the aquatic characteristics of those water bodies will be adopted, (3) haors that naturally dry up during the winter will be developed for dry season agriculture, (4) integrated projects in those water bodies will be adopted for increased fish production, (5) natural water bodies will be developed, where possible, for recreational use in support of tourism. So far, this is the main basis of wetlands management from the national water policy point of view.

However, on the basis of the widely held view in development that management of natural resources can be improved if it is devolved to the resource users themselves, a participatory approach has been adopted for management of some wetlands in Bangladesh. The objectives of this approach are (1) to select wetland sites in the haor basin and floodplains, and to characterize the

biophysical and socioeconomic status of the selected haor and floodplain sites; (2) to organize community groups, which will act as the local management committee; to develop a management plan with the local community; to provide training to groups on conservation and sustainable uses; (3) to collect baseline environmental data; assess socioeconomic development needs and flood/erosion vulnerability of the groups; (4) to identify afforestation sites and establish local plant nurseries; plant the selected wetland with swamp forest trees; carry out plantation in beneficiary households; (5) undertake habitat rehabilitation measures in haor and floodplain areas; (6) carry out and demonstrate vegetable farming in wetland sites; (7) conduct environmental awareness programs (primary schools, high schools, college, villages, fishermen groups, UP chairman/members); (8) conduct training programs on wetland and floodplain resource management for local committee groups, fisher-folks, farmers, and teachers; (9) undertake pilot flood/erosion proofing measures in the haor area; (10) establish small conservation areas managed by local communities with at least 50% women participation; (11) establish wetland management training centers (WMTC); (12) establish a participatory monitoring and evaluation system with the involvement of local government representatives and provide quarterly reports on the performance of project activities; (13) produce a terminal report documenting the findings of the project at the end of the project period; (14) disseminate the success of the project through workshops and through the media; and (15) document the

Fig. 4 Causes and effects of wetlands degradations in Bangladesh. Source: field visits, PRA, interviews, secondary data, and personal experiences (2007)



implementation process, results, impacts, lessons learnt, and case studies (IUCN 2007).

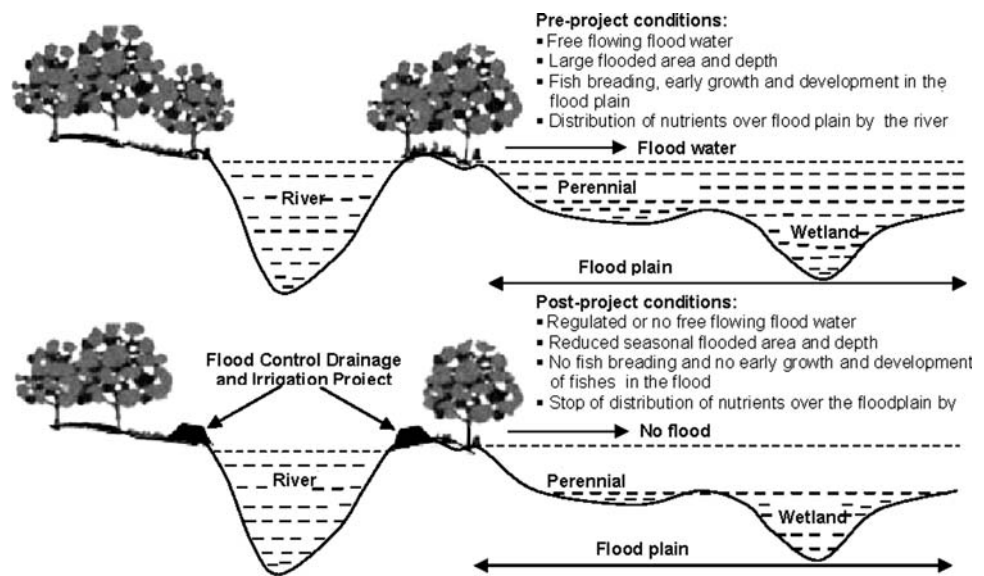
Towards proper management of wetlands

Management of wetlands in a sustainable manner is a key for keeping a sound environment and livelihoods of rural people of Bangladesh in the future. The rural economy of Bangladesh depends on production from and hydrological functions of wetlands. Causes and effects of wetlands degradation are numerous and the present approach is not sufficient to manage the wetlands of the country in a sound environmental way. Conservation and management of the wetlands have to be considered in a broader

context for sustainable natural resources planning and management. There is an urgent need to protect against wetlands degradation, and maintain and manage them through sound environmental management. Hence, the following steps are recommended for proper management of the wetlands of Bangladesh along with the present approaches.

1. Control of the ever-growing population of Bangladesh is very important for proper management of wetlands in Bangladesh. Growth of population is one of the main causes of wetlands degradation; for example, increasing population is expanding settlement into wetlands and converting them to agricultural land. Hence, control of population must be ensured.

Fig. 5 Illustration of how the Flood Control Drainage and Irrigation Project (FCDI) impacts on wetlands. Here, scenarios of both pre- and post-project conditions of wetlands are represented diagrammatically. From this figure it is evident that, after the project implementation, the ecological conditions are deteriorating. Source: field visit, PRA, interviews, secondary data, and personal experiences (2007)



2. The root cause of wetlands degradation is information breakdown during project implementation processes. Decision-makers often have insufficient understanding of the economic values of wetlands, so protection of wetlands does not appear to be a serious enough alternative during project planning. Wetlands are often perceived to have little or no economic value compared with alternative use of its lands and water. There is therefore a real need to better and more widely estimate the economic benefits of wetlands and to further highlight the economic and other values of wetlands to decision-makers. Hence, the identification and definition of economic value, goods, and services of wetlands of Bangladesh are necessary.
3. To identify the economic values of wetlands of Bangladesh, detailed studies on wetlands economic value should be carried out to improve knowledge and awareness.
4. In order to understand the range of values of wetlands and include the values in decision-making processes, efforts must be directed at inventories of values of wetlands in Bangladesh. There should be dialogue among development policy-makers, project teams, and local community-based user groups to understand the values of wetlands and improve the information base for wetlands management.
5. Significance of wetlands in national-, zonal-, and local-level planning processes should be recognized, as well as at the transboundary level also.
6. Studies should be carried out on comparative assessment of the cost of degrading and restoring wetlands ecosystems and their natural functions (Millennium Ecosystem Assessment 2005).
7. Identification of the problems of wetlands management through an intensive participatory rural appraisal exercise is crucial for proper management of wetlands.
8. Implementation of a comprehensive wetlands inventory, expedited scientific enquiry, and more research and study on all aspects of wetlands of Bangladesh should be accelerated. In this assessment, hydrodynamic and morphodynamic analysis of wetlands must be included. Hence, wetlands mapping and managing, monitoring and protecting through geographical information system (GIS), remote sensing along with other sciences are very important. GIS and remote sensing database should be created for study of present conditions and transformation of wetlands.
9. Modeling of the physical effects on wetlands due to changes in management and use is also necessary (Nishat 2003).
10. Wetlands of Bangladesh must be classified on the basis of hydrology, hydrophytes, hydric soil, topography, shape, size, landscape, biota, dominant vegetation communities, pollutant source, land-use pattern, etc. This must be done because it allows the characteristics, functions, and values of wetlands to be understood. These classifications will be used in conserving and managing wetlands (Kim et al. 2006).
11. Technical knowledge, planning, and management capabilities should be enhanced for wetlands management. This will be integrated with landscape ecology, wetland ecology, ecological network planning, shape of the wetland, hydrology, geomorphology, information system, human resources, institutional capacity, etc.

12. Methods for sustainable and comprehensive agricultural practices and ecoland management need to be devised for the use of wetlands areas. Econetworking and ecoengineering should be introduced and followed during construction of infrastructure (roads, bridges, etc.) in wetlands areas of Bangladesh. Ecological networking in agriculture should also be introduced. Environmental impact assessment (EIA) should be strictly followed both in project implementation and maintenance periods to ensure sustainable management practices at all levels.
 13. Functions of selected wetlands should be rehabilitated, and critical wetlands should be declared protected areas. Mapping of community resource-use zones in the protected area should also be introduced.
 14. Wildlife conservation, fisheries development, wildlife enhancement, and maintenance of a diverse community of wetland plants and a diverse genetic pool are necessary (Nishat 2003). Fish sanctuaries should be set up within the wetlands and also in some locations in rivers to create a safe haven for spawning of various fish species. Sanctuaries should also protect birds and other animals in the area.
 15. Heavy penalties for the introduction alien invasive species (AIS) should be imposed to avoid their harmful impacts. In this regard, aquaculture activities should be monitored by the Department of Fisheries to avoid possible escape of AISs to neighboring open water bodies. Leasing of wetlands for commercial fishing should be linked to a quota on maximum allowable catch and maintaining appropriate quality of water as a fish habit (CPD 2001).
 16. Attention should be given to awareness and motivation, education, and research of wetlands of Bangladesh. Awareness should be created at the local level of politicians and people. Topics on wetlands management should be incorporated into textbooks for junior to high school and students and the general public should be motivated to participate in wetland management. Documentary films on wetlands management should be produced and broadcasted on television and wetlands news coverage should be given emphasis
 17. Political commitments for management of wetlands should be ensured.
 18. To ensure wetlands health, water quality should be enhanced and erosion should be reduced. Processes of water and airborne pollution control, and conservation and protection measures including eutrophication abatement are needed. For this, flood control and groundwater recharge and discharge in wetlands areas and wetlands management in a changing climate are also necessary.
 19. A coordinated approach, building environmental awareness and organization and the development of institutional funding arrangements through integrated mechanisms at national, regional, and international levels together with legislation to regulate all activities that impact upon wetlands are also needed (Nishat 2003).
 20. Indigenous resource management practices should be identified and tenure arrangements should be included in legislation dealing with resource tenure, ensuring these issues are kept on the agenda of policy-makers.
 21. An indigenous knowledge database for wetland management should be created.
 22. Efforts should be made for the conservation and wise use of wetlands by designating wetlands sites under the Ramsar Convention and improving the sustainable management of wetlands (including as an increasingly important means of poverty reduction) according to Ramsar objectives.
 23. Provide a buffer zone between wetlands and adjacent urban or industrial uses and provide aesthetic and psychological support.
 24. Shrimp farms in wetlands in coastal areas must be monitored in terms of their impact on the environment.
 25. All types of hunting should be banned immediately in the wetlands.
 26. Use of wetlands for gas and oil exploration increases the risk of destruction of wetlands ecology. Consequently, exploration companies must ensure that appropriate and effective precautionary and preventive measures are taken while searching for oil and gas in wetlands (CPD 2001).
 27. A wetland research institute should be set up and international cooperation among wetlands management institutes to exchange management experience should be established. Experts from social sciences, ecology, engineer, the local community, and politicians and administration should be included in wetlands management. Transboundary and international cooperation should be enhanced in wetlands research and management.
 28. National wetland management policies should be introduced.
- Integrated wetlands management involves many issues and methods. On the basis of the above discussion it is clear that, to reach the objectives of integrated wetlands management in Bangladesh, a systematic approach is needed. For the management of wetlands of Bangladesh the

Social Environmental Management System (SEMS) in Wetlands Management in Bangladesh

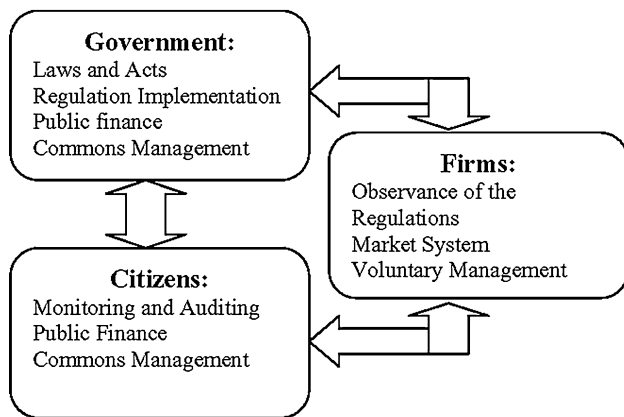


Fig. 6 Social environmental management system (SEMS) in wetlands management in Bangladesh. Source: Graduate School for International Development and Cooperation (IDEC), Hiroshima University, Japan, 2007

roles of three groups are very important: government (administration), citizens (communities, NGOs, research institutes, etc.), and firms (market). Therefore, the social environmental management system (SEMS) concept can be applied to the management of wetlands of Bangladesh. SEMS is a new concept for environmental management that has been introduced by the Graduate School For International Development and Cooperation (IDEC), Hiroshima University, Japan. The social capacity for environmental management is the main concept of SEMS. Social capacity is defined as the capacity to self-manage environmental issues, and is also expressed as the ability to conduct the social environmental management system based on the relationship between the national and local levels, as well as the separate abilities of the government, various corporations, and citizens, and how these abilities interact. SEMS consists of three social actors: the government, firms, and citizens, and interactive relations between and among these actors. National and local relations are also important in this system. Each actor's behaviors are defined under intra- and interactor, formal and informal institutions, which form a bundle of institutions, that is, a system. In SEMS there are three stages. First is the setup stage, during which the fundamentals of the capacity (law, administration, etc.) are developed. The second stage is the operating stage, and the third is the self-management stage.

For integrated management of wetlands through SEMS (Fig. 6) in Bangladesh, the first stage will be the setup stage, during which fundamentals of the capacity such as wetlands law, wetlands administration, and wetlands information systems will be developed. In the second stage, the operating stage, people will experience the effects of

countermeasures of wetlands management and improvement. In the third, self-management stage, comprehensive wetlands management will be undertaken based on strong interactive participation among the government, firms, and citizens.

Conclusion

In the recent history of landscape development, wetlands have been among the most affected ecosystems of Bangladesh, but wetlands play a key role in the country's lifecycle, are highly productive and diverse ecosystems, and also play an irreplaceable role in a sustainable landscape. Hence, special care must be taken to maintain wetlands environment. Wetlands managements need to be incorporated into a system of integrated land and water use and, indeed, into the socioeconomic system of Bangladesh. Appropriate land and water use policies/strategies related to wetlands need to be implemented. Land and water managers must pay attention to issues related to wetlands ecosystems. Mechanism for resolving conflicts among infrastructure, agriculture, fish, and land and water management approaches needs to be evolved. Awareness of the importance of wetlands at all levels from policy level to project level needs to be created. Since Bangladesh is a small part of a larger hydrodynamic system that comprises several countries in the region, mutual understanding and cooperation among the co-riparian countries will be necessary to formulate any long-term and permanent solutions of wetlands management.

References

- Akonda AW (1989) Bangladesh. In: Scott DA (ed) A directory of Asian wetlands. IUCN, Switzerland
- Alam SM, Chowdhury HM (2003) Wetland. *Banglapedia: National Encyclopedia of Bangladesh*, Banglapedia Trust, Asiatic Society of Bangladesh
- Ali MY (1990) Open water fisheries and environmental changes. In: Rahman AA, Huq S, Conway GR (eds) *Environmental aspects of surface water systems of Bangladesh*. University Press Ltd, Dhaka
- Bennett S, Scott D, Karim A, Sobhan I, Khan A, Rashid SMA (1995) Wetland resources specialist study, northeast regional water management plan. *Bangladesh Flood Action Plan (FAP)-6*, Bangladesh
- BWDB (2007) *Perennial and main wetlands of Bangladesh*. Ministry of Water Resources, Bangladesh
- Chowdhury S (1998) Saving our oceans: some thoughts on fisheries conservation. *The Daily Star*, vol 2, No. 100, Dhaka
- Coleman JM (1969) Brahmaputra river: channel processes and sedimentation. *Sedimentary Geology* B129-239
- CPD (2001) Policy brief on environmental policy. Task Force Report, Centre for Policy Dialogue, Dhaka

- FAO (1988) Agro-ecological regions of Bangladesh. FAO, Rome
- GOB (1999) NWP (National Water Policy). Ministry of Water Resources, Bangladesh
- GOB (2001) Coastal and wetland biodiversity management at cox's bazar and hakaluki haor project documents. Ministry of Environment and Forests, Government of Bangladesh
- Gopal B (1995) Limnology in developing countries. vol 1. SIL-International Association for Limnology, New Delhi
- Hughes R, Adnan S, Clayton BD (1994) Floodplains or flood plans? A review of approaches to water management in Bangladesh. Research Advisory Service, Dhaka
- IUCN (2007) Community based haor and floodplain resource management project document. Ministry of Environment and Forests, Bangladesh
- Khan AA (1993) Freshwater wetlands in Bangladesh: opportunities and options. In: Nishat A, Hussain Z, Roy MK, Karim A (eds) Freshwater wetlands in Bangladesh—issues and approaches for management. IUCN, Dhaka
- Khan SM, Haq E, Huq S, Rahman AA, Rashid SMA, Ahmed H (1994) Wetlands of Bangladesh. Bangladesh Centre for Advanced Studies (BCAS) Dhaka
- Kim GK, Park YM, Choi SH (2006) Developing a wetland-type classification system in the Republic of Korea. *Landscape Ecol Eng* 2:93–110. doi:10.1007/s11355-006-0012-x
- Millennium Ecosystem Assessment (2005) Ecosystem and human well-being: wetlands and water synthesis. World Resources Institute, Washington
- Mirza QMM, Warrick AR, Ericksen JN, Kenny JG (2001) Are floods getting worse in the ganges, brahmaputra and meghna basins? *Environmental Hazards* 3:37–48
- Mitsch WI, Gosselink IG (1986) *Wetlands*. Van Nostrand Reinhold, New York
- Nishat A (2003) Management of fresh water wetlands in Bangladesh: issues and strategy at “http://www.doe-bd.org/cwbmp/inception_report/grp3_nishat_wetl_use.ppt” visited on 26 October 2007