Chapter 1

Overview

1.1 Introduction

This book reviews Bangladesh's past water development experience, assesses the present situation, and evaluates the future alternatives. The goal is to suggest ways in which policies need to be changed to make water development in Bangladesh sustainable. There have been some reviews of Bangladesh's past water development experience. However, these have been generally either partial or superficial. Evaluations of the recent government initiatives for future water development are almost non-existent. A comprehensive, objective, and in-depth review of the past and present and evaluation of the future water development options for Bangladesh therefore have become urgent.

The water resources of Bangladesh, in general, and its rivers, in particular, face threats from three origins: domestic, regional, and global. Often, they work in combination and reinforce each other.[1] The domestic threats take different forms, including encroachment and pollution. However, the most important domestic threat is posed by the *Cordon approach* to rivers that Bangladesh has been following for many decades now. This approach is based on the belief that floodplains need to be cordoned off from river channels (through construction of embankments) so that river overflows cannot spread over them. In the context of deltaic Bangladesh, this approach is harmful for both river channels and floodplains. The regional threats are rooted in the fact that about 93 percent of the catchment basins of Bangladesh's major rivers lies outside its borders, and the upper riparian countries are using this geographical advantage to impound, divert, and control their flows. Transboundary water pollution is also another regional threat. The most important global threat to Bangladesh's rivers is posed by climate change, which is causing sea level to rise, due to various reasons, including melting of glaciers. While the sea level rise is causing submergence and salinity intrusion, the receding glaciers are causing the winter flow to decline. Meanwhile, climate change is also increasing the summer precipitation, exacerbating further the seasonality of Bangladesh's river flows.

Unfortunately, the Cordon approach is making it more difficult for Bangladesh to cope with the rising regional and global threats. For example, it is reducing Bangladesh's capacity to handle the increased summer flow of rivers and also to mitigate the further reduction of the winter flow.

The Cordon approach is aggravating the problems of encroachment and pollution, which are in turn made worse by the regional threats. To extricate itself from the vicious entanglement of domestic, regional, and global threats, Bangladesh needs to adopt the *Open approach* to rivers. This approach advocates keeping floodplains open to river channels, so that summer overflows can spread wider over them and keep the depth of inundation low. The stored water in the floodplains can flow back to the rivers to augment their winter flows. The Open approach therefore benefits both river channels and floodplains and helps to achieve optimal distribution of water across both space and time.

This book analyzes Bangladesh's seventy years of water development experience to establish the above propositions. It also reviews the government's recent initiatives regarding future water development of the country. Finally, it offers a guideline for implementation of the Open approach and discusses how the social forces necessary for adoption and implementation of this approach can be mobilized. Accomplishing the multiple goals above has made this book long. This Overview is provided to help the reader get a synopsis of the book and see the connections among its chapters. It can also help the reader to decide which chapter(s) to focus on.

The organization of this Overview is straightforward and basically follows the order of the chapters. Section 2 provides a brief discussion of Bangladesh's water resources, both surface and underground, and acquaints the reader with the main issues of water development. Sections 3 and 4 informs the reader about the alternative approaches to rivers, contrasting the Commercial and Cordon approaches, on the one hand, with the Ecological and Open approaches, on the other. The next five sections summarize Bangladesh's experience with the Cordon approach, including its introduction (Section 5) and the experience of different types of cordons: rural partial cordons (Section 6), rural full cordons (Section 7), coastal cordons (Section 8), and urban cordons (Section 9). Section 10 summarizes the experience of utilization of groundwater. Next, the chapter turns to the Open approach, with Section 11 discussing the rise of this approach in Bangladesh, and Section 12 presenting several flood control and irrigation projects that conform, to a certain degree, with the Open approach.

Having discussed the main domestic threat to rivers, the chapter then turns to the external threats to Bangladesh's rivers, with regional threats discussed in Section 13 and global threats in Section 14.

The chapter next pivots to the future, offering a review of several important recent initiatives of the government regarding the future water development of the country. Section 15 reviews several riverbank improvement projects that are either in progress or about to be taken up. Section 16 reviews the *Bangladesh Delta Plan 2100* that was approved

in 2017, while Section 17 offers an analysis of the proposed Teesta River Comprehensive Restoration and Management Project (TRCRMP) and also the Sustainable River Management Plan (SRMP), which apparently has been prepared by the Chinese Power Corporation (PowerChina) as the new Master Plan for water development of Bangladesh.

The chapter finally turns to Bangladesh's future water development from the viewpoint of the Open approach. Section 18 offers a scenario and guidelines for implementation of this approach in Bangladesh. Section 19 discusses the political economy of water policy making, understanding of which is necessary to identify the obstacles to the adoption of the Open approach. The concluding, Section 20 discusses the prospects of adoption and implementation of the Open approach in Bangladesh.

1.2 Land and water of Bangladesh

Land and water of Bangladesh are intertwined, because the sediment that created Bangladesh was carried by river water and it continues to be so.[2] The history of this intertwined geological process goes back to about 65 million years B. C., when the Indo-Australian plate started moving towards the Eurasian plate, creating a convergence boundary, involving both subduction and collision, lifting the Tethys Ocean floor into the Himalayan mountains. The process also created a transform boundary in the east where the Indian plate rubbed against the Burmese extension of the Eurasian plate to create the parallel folds of the Arakan Mountains. Pressed by the Indian plate from the south-west and the resistance of the Burmese extension of the Eurasian plate on the east, the northeastern tip of the Indian plate downwarped to create the Bengal basin, which began to be filled up by sediments carried by the rivers flowing from the Himalayan mountains on the north and the Arakan mountains on the east. Being a young mountain range composed of sedimentary rock, the Himalayas serves as a rich source of sediments, leading to the formation of the largest delta on the earth, with the undersea fan reaching as far south as Sri Lanka.[3] The thickness of sediment layers across Bangladesh however is not uniform, being shallow to the northwest of the (Bogra) Hinge Line and much deeper to the east and south. Also, subsequent neo-tectonic events further modified the rock structure, uplifting some parts while causing subsidence of others. Consequently, despite the general flat terrain, Bangladesh has a complex geology, with concrete geologic and physiographic characteristics differing across the country.

A distinctive physiographic part of Bangladesh comprises the Barind and Madhupur Tracts, which represent uplifted sediment deposits of the

earlier Pleistocene or Plio-Pleistocene epoch and hence also called the "Old Alluvium Tracts." The Tippera Tract (Lalmai Hills), which represents uplifted sediment of lower Holocene epoch, is also often included in this physiographic part of Bangladesh.[4] The rest of deltaic Bangladesh comprises sediment deposits of the more recent (middle and upper) Holocene epoch. This part may in turn be divided into the (i) Teesta fan; (ii) floodplains of major rivers, and (iii) tidal plains. In addition, there is the Sylhet Basin, caused, in part, by the continued subduction below the Meghalaya (Shillong) Massif. Finally, there are local depressions, such as the Gopalganj depression caused by local geological processes.

The rivers of Bangladesh, particularly the Ganges and the Brahmaputra, are one of the mightiest in the world in terms of water and sediment flow. Though thought to have declined from about two billion tons to about one billion tons, the huge amount of annual sediment is causing the Bengal delta to prograde, particularly in the Meghna estuary, through which the combined flow of the Ganges, Brahmaputra, and Meghna Rivers now reaches the Bay of Bengal. Despite most of the river flow of Bangladesh being transboundary, a part of it is of local origin, resulting from the rain – about 80 inches per year – falling within its borders.

The Quaternary sediments that underlie Bangladesh are generally rich in water. For a long time, the groundwater tables were classified as shallow, medium, and deep, using depth as the criterion. In view of the arsenic contamination, there were efforts to classify them in terms of isotopic (chemical) characteristics. Because of the differences in sediment thickness across the country and the local modifications caused by neo-tectonic events, water tables belonging to particular geological periods may be found at different depths. The structure of groundwater tables of Bangladesh is therefore complex, and classification according to the geological age may be more appropriate. Generally, water tables lying near the surface are more rechargeable, whereas the deeper ones are not. Policies regarding the use of groundwater need to be cognizant of these complexities.

Apart from the high annual volume, the other fundamental feature of the water situation of Bangladesh is the extreme seasonality. About 80 percent of the annual rainfall and river flow is concentrated in just four summer months (June-September) of the year. As a result, rivers overflow their banks in summer, inundating about one-fourth of the country in normal years. By contrast, there is little flow during the winter months. In addition to that of floods, the extreme seasonality of river flow is also at the root of the river bank erosion problem of Bangladesh. Geological events, climate change, behavior of the upstream countries, and Bangladesh's own incorrect policies have aggravated the latter problem and led to undesirable morphological changes in the country's rivers in recent decades.

How to deal with the seasonality in a way that can optimize availability and use of water across seasons is the main question of water development of Bangladesh. More concretely, the question is whether to allow rivers to overflow to the floodplains during the summer so as to keep flood depth low and store water for use during winter or to confine river flows always within their channels by constructing embankments. The answer to this question depends on the approach that is adopted towards rivers, as discussed in the next two Sections.

1.3 Commercial and Cordon approaches to rivers

During the pre-industrial era, human societies did not make major interventions in large rivers. This was mostly because they did not have the necessary technology. They therefore tried to make the best use of rivers, while leaving them, by and large, in a natural state. This was the pre-industrial Ecological approach to rivers. The Industrial Revolution however changed the situation entirely and led to the emergence of the *Commercial approach*. It did so by furnishing both the commercial motive and the machine power that can be used to pursue this motive. Under this approach, rivers are seen primarily as a commercial resource that needs to be exploited fully, ignoring the vital hydrological and ecological functions they perform. The basic premise of the Commercial approach is aptly expressed by the saying, "Any river water that passes to the sea is a waste!" Proceeding from this premise, industrial technologies are used to intervene in rivers to exploit their commercial potential. These interventions are generally of two types, namely frontal and lateral.[5] Dams, barrages, and weirs are examples of frontal interventions, constructed to divert, impound, and regulate river flows to be used for irrigation, generation of electricity, industrial and municipal use, etc. Examples of lateral interventions include embankments, flood walls, channelization, and canalization. While the frontal interventions are more prevalent in upper reaches of rivers, the lateral interventions are more prevalent in middle and lower reaches of rivers. The lateral interventions are generally geared to prevent rivers from overflowing to floodplains in order to enhance their commercial value and use. Depending on the type of intervention used, the Commercial approach can therefore have two versions, namely frontal and lateral. To distinguish the latter from the former, and to express its essence more clearly, the lateral version of the Commercial approach is called the Cordon approach, because its essential purpose is to cordon off floodplains from adjoining rivers.

The Commercial approach spread across the world for about two centuries since the Industrial Revolution. Beginning in Europe in the nineteenth

century, it gained momentum in the early twentieth century and spread to north America and Oceania. The dam and barrage construction spree spread to developing countries after many of them gained independence following the Second World War. Soon, developing countries surpassed developed countries in terms of the total number of dams and barrages, with China alone accounting for more than 20,000 large dams and barrages, and India accounting for another about 10,000. Altogether more than 50,000 large dams and barrages have been constructed across the world. These dams and barrages did deliver, partially, on their intended goals, such as power generation and irrigation.

Along with the frontal version of the Commercial approach, its lateral version, i.e., the Cordon approach also spread across the world, beginning with the early industrializing countries. The Mississippi levee system of the USA is a prominent example of this approach. The embankments of China's Huang He are another. Developing countries also embarked on embankment construction with considerable gusto, with India alone constructing tens of thousands of miles of river embankments.

1.4 Ecological and Open approaches to rivers

However, soon it became clear that the apparent benefits of the Commercial approach were gained at great economic, human, and environmental costs. Aggressive application of the approach led to the complete exhaustion of many important rivers, disrupting the earth's hydrological cycle and damaging the ecology of river basins, including the deltas. Meanwhile, embankments could not solve the flood problem. In fact, in many cases flood damages increased with the construction of embankments.

These experiences, together with a greater awareness about the necessity for protection of environment in general, gave rise to the (post-industrial) *Ecological approach* to rivers. According to this approach, primacy should be given to the rivers' hydrological and ecological functions, which are necessary for the long-term viability of the earth's ecological balance and the survival of the civilizations. Proceeding from this realization, the Ecological approach calls for minimization of interventions in rivers. As in the case with the Commercial approach, the Ecological approach also has two versions, namely the frontal and lateral, depending on whether it is discouraging frontal or lateral interventions. To express its essence more clearly, the lateral version of the Ecological approach is called the Open approach, because its essential purpose is to keep floodplains open to overflows of rivers. Clearly, the Open approach is more relevant for middle and lower reaches of rivers, and in particular for deltas.

The rise of the Ecological and Open approaches has been a part of the overall increase in the awareness about the adverse effects of human economic activities on the environment and the necessity for protection of the earth's ecology and natural resources. The post-industrial Ecological and Open approaches arose first in developed countries, where hundreds of old and small dams and barrages have been decommissioned and demolished and a process of restoration of rivers has unfolded. In the European Union, a process of restoration of floodplains has also begun, reflecting the Open approach. The Ecological and Open approaches are gradually spreading to developing countries too. In fact, some developing countries, reflecting their relatively recent pre-industrial culture and the presence of large indigenous populations, have taken such advanced steps as enshrining the rights of the Nature in their constitutions and offering legal protection to these rights. In some countries, rivers have been declared as living entities with juridical standing. Despite these advanced steps and initiatives, the official circles of most developing countries are yet to adopt the Ecological and Open approaches.

1.5 Introduction of the Cordon approach to Bangladesh

The Cordon approach was introduced in Bangladesh in the 1950s and the 1960s, when it was still a part of Pakistan, following the end of the British colonial rule. During the pre-colonial times, there was not much intervention in the river system of Bangladesh. Other than the Grand Trunk Road, constructed during the reign of the Mughal Emperor Sher Shah, there was almost no major road construction. During the two centuries of the British colonial rule, the main intervention in the river system of Bengal was an unintended one, taking the form of the railway lines, which obstructed the free flow of water across floodplains. After the partition in 1947, increasing food production became a priority for Bangladesh (East Pakistan), which witnessed the Great Famine only a few years ago (in 1943). Several international organizations, including the Food and Agricultural Organization (FAO) and the International Bank for Reconstruction and Development (IBRD), came forward with, what we call, the Cordon approach, aimed at increasing food production. Supported by these foreign agencies, several cordon projects were initiated in the early 1950s.

The water development efforts in Bangladesh however received a big boost when the government – following the floods of 1954, 1955, 1956 – approached the United Nations Technical Assistance Administration (UNTAA) for help. A UN mission, led by J. A. Krug, came to Bangladesh, studied the problem and submitted its report in 1957, recommending formation of a separate agency, entrusted with the task of water and power

development, and hiring of an international firm for formulating a water and power development plan. Accordingly, Water and Power Development Authority (WAPDA) was established in 1959 and the International Engineering Company (IECO) was hired as the consulting firm. The IECO prepared the *Master Plan* in 1964, based on the Cordon approach, identifying 47 projects for implementation. Though review and suggestions from the World Bank led to some modifications of the plan, water development in Bangladesh has since followed, by and large, the *Master Plan*. The implementation of this plan led to the construction of cordons all across the country, saturating its landscape. These cordons may be classified into the following four types: (i) rural partial cordons; (ii) rural full cordons; (iii) coastal cordons; and (iv) urban cordons. Any consideration of future water development strategy of Bangladesh has to begin with a comprehensive, in-depth, and objective review of the experience of these cordons.

1.6 Review of rural partial cordons

Rural partial cordons are among the largest cordon projects of Bangladesh and they include such prominent projects as the Ganges-Kobadak (G-K) project, the Brahmaputra Right Hand Embankment (BRHE) project, and the Pabna Irrigation Project (PIP), later renamed as Pabna Irrigation and Rural Development Project (PIRDP).

The G-K project has been the largest surface water irrigation project, aimed at irrigation of a large tract of the greater Kushtia, Jessore, and Khulna districts, using water pumped from the Ganges River and distributed to the fields by gravity flow through a network of newly excavated canals. Embankments were constructed along the eastern edge of the project area to prevent flooding from the Garai-Modhumati River.

The project was however beset with problems from the very beginning. The construction of the embankment was not timed well with irrigation provision, causing resentment among farmers of the project area. Distribution of irrigation water through gravity flow did not work well, due to both technical and institutional problems. Meanwhile, the commissioning of the Farakka Barrage by India in 1974 reduced drastically the dry season Ganges flow that could be pumped into the G-K irrigation canals. The Jessore and Khulna parts of the project therefore had to be cancelled, limiting the project to two phases of greater Kushtia district only. However, sufficient water was not available even for this part. At the end, the general switch by farmers from surface water to groundwater irrigation (using shallow tubewells) undercut the rationale of the project, with the increase in crop output in areas outside the project being similar to that within the project.

While the G-K project was focused on irrigation, the BRHE was geared more toward protection from flooding by the Brahmaputra-Jamuna and Teesta Rivers. The 216-km long embankment – starting from Kaunia Bridge on the Teesta River and ending at Shirajganj town, located on the bank of the Jamuna River, is the most important embankment of the country. It stopped the overflow of the Jamuna River to the west, including the Chalan *Beel* area, which used to serve as a vast retention pond, equilibrating the stages of the Ganges and Jamuna Rivers and mitigating downstream flooding. On the other hand, the BRHE became a source of transfer flooding to the eastern side, aggravating floods in the districts of Jamalpur and Tangail districts, despite the one-meter higher elevation of the eastern bank. Even on the western side, though the embankment prevented regular overflow, it couldn't do so in unusual years, when flooding in the project area became catastrophic, because of the below-flood-level-settlement that the embankment had encouraged. Also, the goal of the embankment to augment food production by creating flood-free conditions was subverted when the project area, the like rest of the country, switched to *boro* rice as the main crop, grown with groundwater irrigation in winter, when flood protection was not necessary. The BRHE might also have contributed to undesirable morphological changes of the Jamuna River, which has become wider and shallower and shifted to the west.

The PIRDP, located below the BRHE project area, is directed at both flood protection and irrigation. About 200 km long embankments along the Jamuna, Ganges, and Baral-Hoorsagar Rivers were constructed to prevent overflow from these rivers. The irrigation component, based on pump-cum-gravity flow, faced similar design problems as witnessed in the G-K project. The PIRDP embankments were fitted with regulators allowing some river water to get in. However, it has been the general experience in Bangladesh that the partial cordons transmuted into full cordons due to either design-inadequacy of the regulators or their malfunctioning. The same happened to PIRDP. However, the elimination of flooding caused more disruption in the economy and life of the people of this project area, which, being located in the Chalan *Beel* area, was used to and dependent on deep flooding. The dissatisfaction with the PIRDP became more acute as this project area too switched to *boro* rice as the main crop, based on groundwater irrigation in winter, undercutting the necessity of both the irrigation and flood protection components of PIRDP. The project also led to transfer flooding.

Overall, the partial cordon projects proved to be disappointing. The pump-cum-gravity irrigation did not work well. The switch to winter *boro* made flood protection redundant so far as augmentation of food production was concerned. Also, partial cordons tended to become full cordons, depriving the project area from the floodplain-nurturing effects of regular river inundation.

1.7 Review rural full cordons

Many *Master Plan* projects were full cordons by design. Important among these are the: Dhaka-Narayanganj-Demra (DND) project; Chandpur Irrigation Project (CIP); and Meghna-Dhonagoda (MD) project. The DND project was presented as a showcase of water development in Bangladesh in the 1960s and 1970s. Comprising a triangular area, with Dhaka, Narayanganj, and Demra as the three vertices, the project involved construction of embankments to seal off the area from the neighboring Buriganga and Shitalakhya Rivers and the Dholai *Khal*. Both irrigation and drainage were to be carried out by pumping water across the embankment, and separate sets of canals were constructed for this purpose. However, soon drainage congestion became a serious problem, making waterlogging an almost permanent feature of the project area. Being close to major cities, the project area metamorphosed from a rural to a largely urban area, frustrating the original agriculture development goal of the project. Since embankments encouraged below-flood-level settlement, the danger of catastrophic flooding has now become a perennial problem for the people living in the project area.

Both the CIP and MD projects are located on the left bank of the Meghna River and close to the estuary. In this more active part of the delta, the river channels are still unstable, affecting the sustainability of both these cordons. The CIP originally had two parts, a northern and a southern. For various reasons, the northern part was dropped and only the southern part was implemented. However, following the disappointing experience of the G-K project and the advice from the World Bank, the irrigation mode was changed from "pump-gravity" to "pump-gravity-pump." While this switch made it easier to reach the irrigation target, it did not solve the long-term problem of ecological deterioration and subsidence of the cordoned area, caused by the absence of regular monsoon river overflow and sedimentation that comes with it. Also, during the 1988 flood, the embankment along the Meghna River collapsed, with devouring by the river of a large part of the project area and illustrating the vulnerability noted above.

The experience of the MD project is similar to that of the CIP. Being located near Matlab, a well-known hub of research activity, sponsored by the International Centre for Diarrheal Diseases Research, Bangladesh (ICDDR,B) and other organizations, this project has been subjected to more research, generating more information about the impact. Embankments were constructed to seal off the area completely from the neighboring Meghna and Dhonagoda Rivers, making both irrigation and drainage dependent on pumps transferring water across the embankments. Deprived of the nurturing functions of river overflows, the floodplain ecology of the

project is deteriorating slowly, facing nutrient deficiency of the soil and subsidence. Loss of wetlands, waterways, and open capture fisheries have hurt the poor more, aggravating social disparity. The pump-gravity mode of surface water irrigation suffered from various design and institutional problems and ultimately got subverted by the advent of the STWs and the switch to the groundwater-based winter *boro* as the main crop. Also, the cordons could not save the project area during the years of unusual flooding, and the shifting channel of the Meghna River destabilized the cordon and devoured a large tract of the project area in 1988.

Overall, the experience of the full cordons of Bangladesh was no less disappointing than that of partial cordons. In fact, being more aggressive embodiments of the Cordon approach, the full cordons display the pitfalls of this approach more clearly. They illustrate the inappropriateness of the idea of substituting natural gravity flow by pumps, transferring water across embankments, as the method of irrigation and drainage in deltaic Bangladesh where about 80 inches of rainfall takes place in just four months and rivers rise to their full brim and higher, needing space to overflow.

1.8 Review of coastal cordons

Of the different types of cordons of Bangladesh, the coastal codons are the most numerous (about 130) and required construction of more than 5,000 km of embankments, under the Coastal Embankment Project (CEP), which is considered the largest earthen embankment construction project of the world. Coastal cordons are generally rural, but differ from the inland ones because of their goal of prevention of intrusion of saline water coming from the sea. Construction of some coastal polders had already begun in the 1950s, with help from FAO, but got a big boost when the project was included in the *Master Plan*, and the World Bank became its main financier. Coastal polders were supposed to be partial cordons, allowing flap gates for drainage. However, sedimentation rates in the coast are much higher than in inland areas because of the return flow of sediment during high tides. Consequently, the flap gates soon got clogged, converting most coastal polders into full cordons. Drainage therefore has become a major problem for the coastal polders, with some of these becoming permanently waterlogged. By disrupting the natural process of coastal elevation increase that used to occur through sedimentation resulting from the interaction of the fluvial and tidal flows, the coastal polders are now undercutting Bangladesh's natural ability to withstand the sea-level rise.[6] Meanwhile, lucrative shrimp cultivation has led many shrimp entrepreneurs to cut the polders to let saline water in, thus frustrating the original purpose of

the coastal polders. Overall, many coastal polders are in a crisis that many observers have characterized as a "man-made disaster."

The authorities' response to this crisis has generally taken two forms. One is to rehabilitate and improve the polders by repairing and strengthening the embankments; clearing the drainage channels; and unclogging the flap gates. The Coastal Embankment Improvement Project (CEIP) is an example of this type of effort. Unfortunately, these projects do not address the root cause of the polder crisis, and consequently, they cannot provide its durable solution. The riverbeds again get sedimented, instead of the polders, reclogging the flap gates soon. The other type of solution to the polder crisis is represented by, what is called the Tidal River Management (TRM), under which embankments are cut to allow sediment-laden river water to flow in, during high tide, to the *beels*, located inside the polders; deposit the sediment; and flow out during low tide, engaging in considerable scouring to regain the sediment balance, and in the process, deepening the rivers and mitigating the waterlogging. This is an idea that local people had put forward and was later accepted by the authorities. The problem with TRM (which represents partial opening up of coastal cordons) however is that it is contingent on the availability of the *beels*, which get filled up quickly after several years of the TRM operation. Getting passage ways for river water to the *beels* is another problem. Consequently, no satisfactorily solution to the coastal polder crisis has yet been found, and millions of people living in these polders continue to suffer from their adverse effects.

1.9 Review of urban cordons

There is a view that while cordoning rural areas may be questionable, cordoning cities and towns is a must, because these are "high-value" areas. In reality, in a deltaic Bangladesh, with extremely seasonally concentrated high amounts of rainfall, the Cordon approach is not appropriate even for cities and towns. While offering some protection against regular flooding, the Cordon approach, as noted above fosters below-flood-level settlement, invites the danger of catastrophic flooding, and creates waterlogging, which can be a worse problem for urban areas than for rural areas. These undesirable outcomes are illustrated well by the experience of the Dhaka Integrated Flood Protection Project (DIFPP), which was conceived as part of Flood Action Plan (FAP), adopted in the wake of the 1988 flood and implemented on a fast-track basis using Bangladesh's own money. The basic idea of this project was to seal off the city from the neighboring Buriganga and Turag Rivers (on the west), Tongi *Khal* (on the north), and Balu River (on the east). The southern edge of the project area is already covered by the

northern part of the DND embankment. The project divides the Dhaka city into western and eastern parts, with Tongi-Sayedabad Road as the dividing line. Accordingly, the project was conceived to have two phases, with Phase I focusing on the western part and Phase II focusing on the eastern part. The main physical component of Phase I was the construction of the 30 km long Western Embankment, stretching from Tongi in the north to Kellar *Moar* on the south, disconnecting the city from the Buriganga River. Several pump stations were constructed along this embankment for drainage, such as at Dholai *Khal*, Goranchatbari, and Kallyanpur. However, the combined capacity of these pumps is not adequate for pumping all the rainwater that may fall in the city in summer. The project also envisaged re-excavation of 30 km of *khals* to bring accumulated rainwater to the pump stations and piped outlets. Unfortunately, the recovery of the *khals* did not go well. Instead, the disconnection from the rivers accelerated their decay and obliteration of many of them, so that accumulated rainwater cannot reach the pump stations and piped outlets. All these factors have combined to convert Dhaka city into a "City of waterlogging." The Western Embankment has also encouraged below-flood-level settlement, aggravating the danger of catastrophic flooding.

Instead of learning from the negative experiences of the Phase I, the water establishment is pushing for implementation of Phase II, centered on the proposed Eastern Bypass, which is to be an embankment-cum-road, severing the connection of the city with the Balu River.[7] Needless to say, once this embankment is constructed, the entire Dhaka city will become a bowl for rainwater to accumulate, aggravating the waterlogging problem further. The situation of Dhaka city is likely to be similar to that of the perennially waterlogged DND project, only many times larger.

Instead of learning from the disappointing experience of Dhaka city, the authorities are moving ahead with similar urban cordon projects for other cities and towns of the country.[8] An example is the Secondary Towns Integrated Flood Protection Project (STIFPP), under which another 15 towns and cities of Bangladesh are to be disconnected from neighboring rivers through construction of embankments. Needless to say, this wrongheaded approach will only lead to waterlogging, risk of catastrophic flooding, and the general decay of water bodies and environment within these cities and towns. The severe waterlogging of the Chittagong city already shows what can happen if cities are not kept open and connected with neighboring rivers through adequate canal networks.

The above review of different types of cordons shows that the cordon approach is not appropriate for Bangladesh. Instead, the country requires the Open approach. However, before embarking on the discussion of the latter, it is useful to review the ground water issues of Bangladesh.

1.10 Review of groundwater issues

Bangladesh is fortunate to have considerable groundwater resources, in addition to the surface water. These two sources of water are linked in important ways. Proper policies regarding groundwater are therefore important for efficient utilization of not only groundwater but surface water too. As noted earlier, due to the complex geology of Bangladesh, the groundwater tables of a particular geological epoch can be found at different depths, so that policies regarding groundwater need to be more discerning than may appear otherwise.

Several stages may be identified in the process that Bangladesh has already crossed in the utilization of groundwater. At the first stage, several groundwater projects were initiated in the 1950s, i.e. even before the 1964 *Master Plan*. These were based on deep tube wells (DTW), located in the north-western districts of Bangladesh. These were public projects, with government water agencies installing the DTWs and supplying irrigation water to the farmers of the command areas at subsidized prices. However, farmers' group formation and efficient management were a problem from the beginning, and, at a later stage, many of these DTWs were privatized. Also, the DTWs were extracting water from deeper water tables, which were either non-rechargeable or had limited rechargeability, so that over time they faced the problem of receding water tables.

A second stage of groundwater utilization is represented by the explosion in the number of hand tube wells (HTWs) in the 1970s, promoted by UNICEF and aimed at providing safe water for drinking and other household needs. These HTWs could be either privately or communally owned. While bringing about a radical improvement in the potable water supply for the rural population, many of these HTWs were later identified to be extracting arsenic contaminated water and had to be closed down.

The explosion in the number of shallow tube wells (STWs) represents the third stage of groundwater utilization in Bangladesh. Beginning from only 133,844 in 1985, the number of STWs rose exponentially to 1,523,609 by 2013.[9] The area under irrigation by STWs also increased from about 57,000 ha during 1975-1980 to about 3,044,000 ha during 2002-2007.[10] Thus, STWs have become the dominant irrigation technology of the country, taking over the command areas of many of the DTW and gravity-flow surface water projects.[11] The expansion of STWs has dramatically changed the cropping pattern of the country, making winter *boro* as the main crop, thus undercutting flood protection as a necessary condition for increasing agricultural production and thereby undermining the rationale of the FC, FCD, and FCDI projects.

However, the long-term sustainability of groundwater use depends on

the rechargeability of groundwater tables. Since STWs have not always been extracting water from fully rechargeable water tables, the latter have been falling in many areas of intensive STW operation. The long-term viability of groundwater irrigation therefore depends on ensuring rechargeability of the groundwater tables from which the water is extracted. The Cordon approach is not conducive to this goal, because by not allowing river water to spread over floodplains in summer, it lowers the recharge rate of the water tables that lie below the cordoned off areas. By contrast, the Open approach can help to increase the recharge rate by letting river overflows spread on the floodplains. If properly planned spatially and synchronized, ground water utilization can create more space in the groundwater tables in winter for storage of river overflow in summer.

Groundwater is also used heavily in Bangladesh for supply of water for drinking and household purposes in the cities. This is done mostly by DTWs extracting water from deeper water tables which are either non-rechargeable or have limited rechargeability. In recent years, many garment factories and other industries are also extracting groundwater using DTWs to carry out dyeing and other operations. Consequently, water tables are falling in many cities, particularly in Dhaka city, which has been extracting large amounts of water from the geologically scarce water of Dupi Tilla formation. For sustainability, water needs of the cities should be met from renewable surface water sources or groundwater tables that are rechargeable. Finally, the responses to the arsenic threat have so far been patchy, awaiting a more comprehensive strategy. Though the exact cause of the arsenic contamination of groundwater remains disputed, there is no doubt that switching to surface water is the best way out from this problem. Thus, the Open approach can be helpful in dealing with various groundwater issues too.

1.11 Rise of the Open approach in Bangladesh

The disappointing experience of the cordon projects led to the demand for the Open approach. This demand surfaced prominently in the form of the opposition to the Flood Action Plan (FAP) that the government, together with foreign aid agencies, chalked up in the wake of the 1988 flood.

The overall goal of FAP was to double embank all the main rivers and their major tributaries and distributaries, so as to convey the transboundary river flows to the Bay of Bengal without letting them spread to the floodplains. The FAP goal was therefore similar to that of the *Master Plan*, and it was supposed to be implemented in four five-year phases during 1990-2010. In addition to the general idea of double embankment, FAP endorsed the Dutch idea of compartmentalization, entailing construction

of secondary embankments behind the main river embankment so as to ensure different levels of protection, depending on the land-use pattern and other characteristics of particular areas. Compartmentalization was accepted to be the guiding principle of FAP as a whole, and pilot projects of compartmentalization, such as FAP-20, to be implemented in Tangail, were included for the first phase (1990-1995).[12] However, FAP met stiff resistance, led by the civil society, NGOs, and individual scholars, and joined by the common people, who put up physical resistance against FAP-20 in Tangail. In view of this opposition and also disagreements among the donor agencies themselves about its concrete aspects, FAP could not proceed much beyond its Phase I, which was focused on studies, aimed at providing the basis for the construction projects to be implemented in the future phases.

The struggle against FAP also helped to push forward the process of separation between the planning and implementation functions regarding water development. Ever since 1959, both these functions were vested in the BWDB, engendering a conflict of interests. Being the implementing agency, the BWDB was likely to have strong interests in big-budget cordon and other river intervention projects, which may not be beneficial for the country from a broader and longer viewpoint. Apparently, some donor agencies also noticed the problem and prodded the government to embark on a process of moving the planning function away from the BWDB. Accordingly, the Master Plan Organization (MPO) was formed in 1983 to formulate a new Master Plan for water development, and, following FAP's demise, the Flood Plan Coordination Committee (FPCO) – formed under the ministry of water resources to coordinate FAP – was merged with the MPO to form Water Resources Planning Organization (WARPO), entrusted with the function of water planning. This institutional separation of planning and implementation functions created the potential for reconsidering the overall water development strategy of the country and for moving away from the Cordon to the Open approach. However, this potential remains to be fully utilized, and recent developments point to some reversal in this regard.

1.12 Open approach-conforming flood control and irrigation projects

Apart from the opposition to FAP, the Open approach in Bangladesh also found expression – albeit, not a conscious one – in the form of modifications of some the cordon projects and adoption of several irrigation projects that did not require construction of cordons. The PIRDP provides an example of the former. As noted earlier, being located in and close to the Chalan *Beel*, the PIRDP disrupted the ecology of the area and the life of the people

more deeply than in the case of other cordon projects. Consequently, a pressure arose from the local people for modification of the project to restore connections with the neighboring rivers. Yielding to this pressure, the authorities modified the regulators and their operation. As a result, the project area is now more open to the adjoining rivers, though the PIRDP still remains a partial cordon. Another example of local people forcing the authorities to open up cordons (at least partially) is the adoption of the Tidal River Management (TRM) for some coastal polders, as noted in Section 1.8. Despite the limitations on its applicability, the TRM model point to the ways in which the Open approach can provide solutions to waterlogging and other problems that currently inflict many polders.

Among the Open approach-conforming irrigation projects is the Barisal Irrigation Project (BIP), which was inspired by the World Bank's (1972) proposition that local sources of water are sufficient for irrigation in many areas of Bangladesh, so that pumping water (across embankments) from distant rivers and conveying it through long canals are not necessary. Under the BIP, single- or multi-staged low lift pumps (LLPs) were used to lift water to the fields directly from neighboring rivers and rivulets. Not surprisingly, this project was prepared directly by the Planning Commission – instead of the BWDB – and Bangladesh Agriculture Development Corporation (BADC) was assigned an important role in its implementation.

Another example of Open approach-conforming irrigation is provided by the rubber dam projects. These dams are in essence similar to the traditional removable dams – *Ashtomashi bandhs* – which prevent saline water from getting in during eight lean months of the year, and are removed during the four peak months, when river flows are sufficient to thwart the saline tidal flows. The Matamuhuri rubber dam project is an example, implemented to hold the water of the river during the lean season and use it for irrigation through pumps and canals and also to prevent saline water from moving up.

1.13 Regional threats to Bangladesh rivers

The review presented in the sections above shows how the Cordon approach is one of the important domestic threats to Bangladesh's rivers. However, another important thre at is of regional origin, taking the form of diversion, impounding, and control of river flows by upstream countries, misusing their geographical advantage.

Bangladesh has about 58 transboundary rivers, all of which flow from India, except three, which flow from Myanmar. Guided by the Commercial approach, India has constructed, is constructing, or plans to construct

impounding, diversionary, and flow control structures on almost all the important shared rivers. The most prominent among these is the Farakka Barrage, which now diverts most of the dry season flow of the Ganges River, and has thus become the "Sorrow of Bangladesh." Similarly, India is diverting the Teesta flow by using the Gajoldoba Barrage, leaving little dry season water for Bangladesh's Teesta Barrage Project, built for irrigation. The regional threats are getting more serious with India's River Linking Project (IRLP) that aims to divert more water of the Ganges and the Brahmaputra Rivers to the west and south of India. The IRLP is ominous for Bangladesh, because, following the diversion of the Ganges flow by the Farakka Barrage, the Brahmaputra River now serves as the source of about seventy percent of the winter flow of Bangladesh's rivers.

The regional threat is actually graver. While diverting most of the winter flow, India releases the summer flow, often augmented by water stored from the previous season in the reservoirs created by the dams and barrages. This anthropogenic accentuation of the seasonality of river flows is having deleterious effects on the morphology of Bangladesh rivers. With little flow in winter, the river beds get sedimented and compacted and lose their fluvial characteristics to a great extent. Consequently, when large summer flows are released, rivers cannot do as much bed scouring as they did before. Instead, to accommodate the increased flow, they expand sideways, through increased bank erosion and causing immense miseries to the affected people. Thus, upstream interventions are not only reducing the dry season flow, they are destabilizing Bangladesh's rivers.

Added to the regional threats emerging from India are now threats from China. According to press reports, China has already built several and is planning to build more impounding and diversionary structures on the Upper Brahmaputra River (Yarlung Zangbo), thus controlling and reducing the flow of the river for lower riparian countries. India has reportedly approached Bangladesh to jointly oppose China's interventions, forgetting that it has been doing the same, harming Bangladesh for about fifty years.

Bangladesh's efforts to deal with transboundary river issues with India in a bilateral framework have not yielded desired results so far. The Bangladesh-India agreement on the Ganges, signed in 1996, failed to increase the dry season flow of the Ganges in Bangladesh in any significant way. Though efforts are underway for a Teesta sharing agreement, there is little future for a meaningful agreement, because, with about fifteen more structures being built by India on upstream reaches of the Teesta River and its tributaries, there will be hardly any water left to be shared. Thus, for all practical purposes, the Teesta agreement is dead even before it was born. Pollution carried from India is another regional threat to Bangladesh's rivers.

Though Bangladesh, being a lower riparian country, is constrained in

terms of its response to the upstream interventions, it has a few strategic options. One of these is to sign – and ask all co-riparian countries to sign – the 1997 UN Convention on Non-navigational Uses of International Watercourses, which upholds many rights of co-riparian countries. Though signing this Convention by itself will not solve the problem, unless upper riparian countries also sign and agree to abide by it, Bangladesh will be able to refer to the protections offered by this Convention to argue for its rights on the shared rivers in both bilateral and international forums.[14] Another strategic option for Bangladesh is to advocate the "Transit in exchange for rivers" formula, under which India will restore the natural flows of the rivers, while Bangladesh will provide India transit and transshipment facilities through its territory to its (India's) seven north-eastern states. Such an exchange will help India to overcome the access bottleneck that is widely believed to be a major cause for the lack of development of its north-eastern states. The restoration of natural flows of rivers is also necessary to sustain the water navigation that provides the cheapest means of transportation of goods across Bangladesh to these north-eastern states of India. It can also help india to avoid the pressure of potential climate refugees. The adoption of the "Transit in exchange of rivers" formula can therefore boost mutually beneficial cooperation between the two countries in many other areas, and prove to be a win-win formula for both India and Bangladesh.[15]

1.14 Global threats to Bangladesh rivers

In addition to the regional threats, Bangladesh's rivers face global threats, arising mainly from climate change, which is affecting the county in at least five main ways, namely (i) submergence; (ii) salinity intrusion; (iii) aggravation of seasonality of river flows; (iv) increased frequency, scope, and intensity of extreme weather events; and (v) increased risk of diseases.

The sea level is rising along Bangladesh's coast at a rate higher than that of the global mean sea level and is causing submergence and erosion. The problem is going to get only worse with time.[16] The sea level rise is also pushing salinity deeper inside, affecting adversely the agriculture and life of people even in areas that are not yet submerged. Climate change is leading to greater precipitation in the summer, thus accentuating the seasonality of river flows. Sitting at the apex of the Bay of Bengal, Bangladesh is already a frequent destination of cyclones and accompanying storm surges, which are going to be more frequent, larger in scope, and greater in intensity with time. The waterlogging in the coastal polders that result from these events increase the risk for water-borne and other diseases for the coastal population. The extreme weather events are taking many other forms, such untimely and unusual amounts of rainfall.

The Cordon approach, coupled with the frontal version of the Commercial approach practiced by upstream countries, is aggravating the above adverse climate effects. Decrease in the volume of sediment due to upstream interventions and its maldistribution due to the Cordon approach are depriving Bangladesh of a natural shield that it has against the sea level rise. By making Bangladesh more vulnerable to the sea level rise, the Cordon approach is also worsening the salinity intrusion problem. It is also making more difficult for Bangladesh to accommodate the increased summer flows caused by climate change. The polderization of coastal Bangladesh has made the coastal people more vulnerable to the increase in extreme weather events, because, first, the artificial dryness offered by the polders has made their inhabitants less prepared for these events. Second, the subsidence caused by the polders make these more prone to waterlogging following cyclones and storm surges and face more risk of water borne and other diseases.

The Open approach, accompanied by the adoption of the Ecological approach by upstream countries, can help Bangladesh to withstand the climate effects. The combination of the two can restore the original volume of sediment reaching Bangladesh's coast and ensure its proper distribution, allowing the coastal elevation to increase and counteract the sea level rise. By doing so, the Open approach can help to mitigate salinity intrusion too. Similarly, by keeping floodplains open for river overflows, the Open approach can help to accommodate the increased summer flows resulting from climate change. By opening up the polders and restoring the natural conditions, the Open approach can prod the coastal people to build on higher grounds, use sturdier materials, ensure safe drinking water and hygienic facilities, and keep water transportation available to face the cyclones and storm surges. Finally, by opening up the polders, the Open approach can help to end perennial waterlogging suffered by many polders and the waterlogging that currently follows the cyclones and storm surges, and thus reduce the risk of water-borne and other diseases. In short, switching to the Open approach can be an important way in which Bangladesh can cope with the rising threat of climate change.

1.15 Riverbank improvement projects

The review of the past water development experience and recognition of the regional and global threats provide the necessary backdrop for considering the future of water development in Bangladesh. In this regard, it may be noted that the Government is now moving ahead with several projects that can have far reaching effect on future water development of the country. Some of these focus on the issue of river bank erosion, which has become

more serious in recent decades. The past efforts at protection of riverbank – mostly based on construction of hard structures, such as groynes, spurs, hardpoints, and revetments – have not proved that successful. A promising development in this regard is the emergence of the geo-bag technology, which has many attractive features as compared with those of the hard structures. Unfortunately, authorities in Bangladesh have so far considered the use of this new technology within the framework of the Cordon approach. Yet, the realization of the full potential of the geo-bag technology requires the Open approach.

The first of the recent riverbank protection projects is the Jamuna-Meghna River Erosion Mitigation Project (JMREMP), which became effective in 2003 and was completed in 2011. It was aimed at protection of the Jamuna side embankment of the PIRDP and the Meghna side embankment of the M-D project, both of which were and remain threatened by river erosion. The main distinction of this project lay in the use of geo-bag technology to construct long revetments which prove to be more effective in protection of riverbanks from erosion than the hard structures.

Partly encouraged by the success of JMREMP, the Government undertook Flood and Riverbank Erosion Risk Management Investment Program (FRERMIP), aimed at extending the use of geo-bag technology to a wider scale, including the 60 km lower segment of the Jamuna River (from BJMB to Goalondo); 20 km lower segment of the Ganges River (from the proposed site of the Ganges Barrage, near Sujanagar, to Goalondo); the entire 100 km Padma River (from Goalondo to Chandpur); and part of the Meghna River bordering the Meghna-Dhonagoda Project and the Chandpur Irrigation Project. The investment program was originally divided into three projects, the last two of which were later combined into one. Project 1 of FRERMIP became effective in September 2014, and the Project 2 is expected to be complete in June 2024. An important way in which FRERMIP differs from JMREMP is that, while the use of geo-bag technology in the latter was entirely directed to the protection of embankments from river erosion, this is not so in the former, though there are many segments in it where riverbank protection is combined with embankment protection, demonstrating that, even in FRERIMP, the use of the geo-bag technology is considered within the framework of the Cordon approach. The evaluation of the FRERMIP has to await its completion.

Meanwhile, another project that is working its way through the government decision making process is the River Bank Improvement Project (RBIP) that focuses on rehabilitation of the BRHE and its conversion into a highway. While both the JMREMP and FRERMIP are financed mainly by the Asian Development Bank (ADB), the RBIP is financed mainly by the World Bank. Though the BRHE was constructed with an average set-back distance of 1.5 km, high rates of bank erosion and westward movement of

the Jamuna River have undermined the integrity of this embankment. In many parts, the embankment had to be retired multiple times (in some cases, nine times!), so that only 41 km of the original about 180 km of the BRHE remains in place, and in many places it no longer exists. Instead of seeing the above as a failure of the Cordon approach and switching to the Open approach, the RBIP proposes to double down along the former and envisions to be implemented in three phases, spanning over 2015-2023. The idea of protecting and rebuilding the BRHE is not new. It was put forward in FAP 1 and apparently a master plan was prepared in 1994 for protection of the BRHE through construction of a series of hardpoints and other hard structures. Many of these were indeed constructed but evidently did not prove that successful. Reflecting the appeal of the geo-bag technology, the RBIP also proposes to use this technology. However, it does not answer the question why the expensive highway it wants to build will not meet the same fate as the BRHE did. In fact, before conceiving a project for protection of the Jamuna bank, it is first necessary to know the reasons for the accelerated erosion by this river and its westward shift and the role the BRHE itself might have played in this process. It is quite likely that, by not allowing the Jamuna River to overflow to its right-hand side floodplains, the BRHE increased pressure on the right bank, conducing to more erosion. That being the case, the geo-bag technology is likely to be more successful in protecting riverbanks in open conditions than when riverbanks are embanked. The merit of the RBIP therefore needs to be rethought, particularly in view of the fact that the proposed highway will be reducing the travel distance, as compared to the existing highway, by only 13 km.

1.16 Bangladesh Delta Plan 2100

While Bangladesh's Ministry of Water Resources (MoWR) was proceeding with specific projects, such as the JMREMP, FRERIMP, and RBIP, the Ministry of Planning engaged itself in the formulation of a comprehensive plan, called the *Bangladesh Delta Plan 2100* (BDP or Delta Plan, in short). Prepared with financial and technical assistance of the Government of the Netherlands (GoN), this plan, approved by the Government of Bangladesh (GoB) in September 2017, aims to spend about 2.5 percent of Bangladesh GDP on its projects each year, making it more ambitious than even the *Master Plan* of 1964.

Being led by the General Economics Division (GED) of the Planning Commission of Bangladesh, the formulation of the BDP represented a continuation of the process of separation of the water planning and implementation functions. Accordingly, it created an opportunity for an objective review of Bangladesh's past water development experience and to

chart a new course for the future. The BDP was prepared with considerable sincerity and transparency, for which all those involved with the project, in particular, its leader, Shamsul Alam, deserve commendation. The twenty-six baseline studies that were compiled for this plan represent a significant repository of knowledge about the state of land and rivers of the country and can serve as a useful source of information for future researchers. However, the opportunity that the BDP had created for rethinking Bangladesh's water policies remained largely unutilized.

The problem began when the BDP proceeded with a confused understanding of the relationship between the Delta Plan and the national development plans, creating the impression that the former subsumes the latter, when in fact the Delta Plan is expected to deal – albeit from a longer-term perspective – with a subset of the issues that the national development plans deal with. Because of the above conflation of its scope, the BDP fails to conduct original research on the important long-term issues regarding Bangladesh's land and water and come up with findings that could provide an actionable agenda.[17] The BDP's tendency to overreach also finds manifestation in the fact that it considered as "hotspots" 93.2 percent of Bangladesh's area, including the Chittagong Hill Tracts, defying the general understanding that the latter does not constitute a part of the delta. The BDP also indulges in too much of jargons, terminologies, and circuitous reasonings, instead of getting at the points directly and quickly.

The second major problem of the BDP is that it does not carry out an objective and in-depth analysis of Bangladesh's past water development experience, relying instead on the misleading and self-serving assessments of the implementing agencies themselves.[18] Consequently, the Delta Plan cannot benefit from the rich set of lessons that Bangladesh's past water development experience offers. Instead, it appears to be inspired more by the Dutch experience, even though the latter's applicability to Bangladesh is limited due to the fundamental differences in the physical conditions between the Bengal and Dutch Deltas.[19] The BDP also does not offer a proper analysis of the transboundary water issues, including the experience and consequences of the Farakka and Gajoldoba Barrages.

The third major problem of the BDP is that it lacks an overall consistent philosophy. Though it puts forward Optimum Water Control (OWC) and Adaptation by Design (ABD) as two alternative philosophies, its characterization of these philosophies remains confusing, and, in the end, it proves reluctant to uphold consistently one or the other. Instead, it falls for a confusing eclecticism, rendering the Delta Plan effectively rudderless.

Because of the above weaknesses, in particular, its inability to come up with an actionable agenda based on original research, the BDP in the end fails to produce a project portfolio that could be regarded as an organic outcome of the plan. Lacking such a portfolio, the BDP managers in the

end turned, for submission of project proposals, to implementing agencies, who were only eager to do so. A committee scrutinized these proposals, using a set of criteria, and selected 80 projects, out of a total of 123 submissions. Many of the selection committee members were not involved with the preparation of the Delta Plan, and the criteria used for selection of projects did not require a big plan to be developed. The project portfolio was therefore largely the outcome of an extraneous exercise, and ended up being a smorgasbord of projects which were already in the making and went in different, often opposite, directions. The very purpose of the BDP was thereby defeated, and the Delta Plan remained mostly a missed opportunity. The trajectory of Bangladesh's water development, remained basically the same as it was before the formulation of this plan.

1.17 Teesta River Comprehensive Management and Restoration Project (TRCMRP) and Sustainable River Management Program (SRMP)

The progress in separating water planning and implementation functions that was achieved under the BDP now appears to be lost to some degree, with both these functions reverting back to the BWDB. This regress can be seen in the TRCMRP, conceived now to be the first project under the SRMP, which is to cover all the major rivers of Bangladesh. Also, while the Delta Plan was formulated with considerable transparency and stakeholder consultation, the TRCMRP and SRMP appear to be proceeding with considerable secrecy, with little, if any, information sharing and consultation with the public.

The SRMP and TRCMRP appear to be the result of two processes. The first is Bangladesh's increasing frustrations with the proposed Teesta treaty, the hope for which dies hard, even though this treaty has become more a chimera than a meaningful goal. The second is the Chinese proposal to help Bangladesh build large infrastructure projects, by providing necessary technical expertise and finance, as made concrete by the $17 billion package offered by the Chinese President Xi Jinping during his visit to Bangladesh in 2017.[20] It seems that the BWDB and the China Power Company (ChinaPower, in short), which is already engaged in the construction of several infrastructure projects in Bangladesh, got together to propel a process under which PowerChina formulated a new master plan, called the SRMP, whose goal is to channelize all major rivers of Bangladesh. There are four main components of this channelization plan, namely (i) drastic reduction of the width of rivers; (ii) increasing the depth of river channels through capital dredging; (iii) building embankments on both sides of the

rivers, and (iv) land reclamation, using the dredged materials to raise the elevation of the river bed that will remain outside the embankments and the use of the reclaimed land for various commercial purposes. It appears that the SRMP was originally supposed to begin with the Jamuna River. However, the priority later changed and, since the Prime Minister Sheikh Hasina's visit to China in 2019, the Teesta River became the first candidate for implementation of the SRMP, leading to the TRCMRP.

According to the TRCMRP, almost the entire stretch of the Teesta River in Bangladesh – from the Teesta Barrage at Dalia to Chilmari, where the Teesta River joins the Brahmaputra-Jamuna River – will be channelized. The river currently has an average width of about 3 km, but it increases in some places to about 7 km. The TRCMRP aims at reducing this width to 700 meters between Dalia and Kaunia and to one kilometer between Kaunia and Chilmari. For this purpose, the river will be embanked on both sides and its depth will be increased to 10 meters through dredging. The excavated soil will be used to raise the elevation of the river bed that will remain outside the embankments, allowing reclamation of about 170 sq. km, which will be used for setting up townships, industries, solar parks, etc. The total price tag of the project is about $1 billion.

The TRCMRP raises many questions, both procedural and technical. From the procedural viewpoint, it is somewhat surprising and anomalous that the GoB would propel formulation of another master plan (SRMP) when it was already engaged with the formulation of the Delta Plan, supposed to serve as the overarching framework for water development effort for the next 100 years. Second, though the Delta Plan mentions the idea of channelization, and a few projects of its portfolio may be characterized as channelization projects, these are not central for the Delta Plan as a whole. By contrast, the entire SRMP seems to be focused on channelization. Third, the suggested channelization projects of the Delta Plan do not include the Teesta River, whereas the SRMP has now prioritised the Teesta River. Fourth, the channelization projects of the Delta Plan were made conditional on independent feasibility studies. By contrast, PowerChina, the contractor of the SRMP and TRCMRP, itself is allowed to conduct the feasibility studies of this program and plan, engendering clear conflicts of interests.[21] The procedure followed for the SRMP and TRCMRP is therefore quite problematic.

Questions regarding the technical soundness of the TRCMRP are also numerous. The main problem with the Teesta River – as is the case with other rivers of Bangladesh – is the seasonality of its flow, exacerbated by upstream interventions by India. As noted earlier, due to diversions in the dry season, river beds in Bangladesh dry up and get compacted, limiting the rivers' bed-scouring capacity to hold the summer flow, forcing them to expand sideways and increase their width. It is not clear how channelization,

as proposed by the TRCMRP, can solve this underlying problem. Analysis shows that the drastic reduction of the width – despite the increase in depth through dredging – will reduce the river's cross-section, leading to aggravation of bank erosion and siltation of the river bed. This will lead to the "From low to higher embankment!" vicious cycle and subject the people of the Teesta Basin to the perennial risk of catastrophic flooding. Ironically, China itself provides the classic example of this vicious cycle, as seen in the case of its Huang He (see Islam 2020, Chapter 9). Second, the TRCMRP seems to face a catch22 regarding holding of summer water for use in the winter. On the one hand, to hold water, another barrage needs to be constructed at Chilmari; otherwise, all the Teesta water above the Jamuna River stage will drain off to the latter. On the other hand, a barrage at Chilmari will trap the sediments – about 49 million tons per year – and nullify the increase in depth achieved through initial dredging. Third, it is not clear what the TRCMRP will do to about a dozen tributaries and distributaries of the Teesta River within Bangladesh. If the embankments do have openings for them, the embankments will fail to perform their water holding role. On the other hand, if no openings are left, the distributaries will dry up and the tributaries will lose their natural destinations. In both cases, the ecology of the Teesta Basin will be disrupted.

Thus, the TRCMRP does not seem to be a technically sound project. It does not offer a durable solution to the problem of extreme seasonality of the Teesta flow, aggravated further by upstream diversion and control by India. Instead of artificial channelization, the solution to this problem has to be sought in the Open approach, i.e. in the rejuvenation of the entire Teesta River system in Bangladesh.[22] Earlier, the embankment on the right-hand side of the Teesta River (constructed as part of the BRHE) and the artificial systems of irrigation and drainage canals (constructed as part of Bangladesh's Teesta Barrage Project) have already done much harm to the pre-existing rivers, rivulets, and other surface water bodies of the Teesta Basin. These need to revived and the connections of the Teesta River with its tributaries and distributaries need to be strengthened so as to create the capacity to hold and store the rainy season flows and allow the stored water to augment the dry season flow. The analysis of the TRCMRP casts doubt on the proposed SRMP as a whole.

The above does not mean that efforts should not be made to stop and reverse the unwarranted changes in the river morphology. However, such efforts need to work "with the nature," instead of working "against it." To reverse the widening, it is necessary first to establish the causes of the widening and then address these causes, and not just the symptoms. A natural process has to be initiated that can stop the rivers from expanding sideways and instead lead them to recede to narrower channels.[23] Also, the strategy has to be river-specific, instead of a "one size fits all" strategy that

seems to be championed by the SRMP. For example, if the 1950 Assam earthquake has been the main driver of the widening of the Jamuna and Padma Rivers since the 1970s, then these rivers are expected naturally to recede to a narrower course, as the debris produced by that earthquake are all washed away to the Bay of Bengal. Attempts to narrow these rivers can then piggy back on this natural process and proceed gradually, stage by stage, with efficient use of the geo-bag technology to reach durable and desirable river regimes. The 1950 Assam earthquake however cannot be the reason for the widening of the Teesta River. Hence more efforts have to be made to determine the specific causes for the widening of the Teesta River and then devise a strategy for reversing this trend that can work "with the nature" for this river. However, no matter which particular river is considered, keeping the floodplains open to its overflow will be a precondition for durable success in avoiding and reversing the unwarranted morphological changes.

1.18 Open approach implementation scenario

The review above shows that the future water development plans, programs, and projects following the Cordon approach are not that promising, reinforcing the conclusion derived earlier from the review of the past water development experience that the future of water development in Bangladesh has to be sought along the Open approach. A scenario of implementation of the Open approach is therefore warranted.

Contrary to what it may appear to be, the Open approach is an active approach and will require a wide-ranging and sustained effort. An overarching determinant of the process is that the implementation of the Open approach will not be like writing on a clean slete, because the country is already saturated with cordon structures. Due to this path dependence, the implementation of the Open approach in Bangladesh will largely take the form of modifications of the existing cordons, and it will aim at opening them up to river overflows while preserving the useful roles that the cordons have come to play. As noticed earlier, the World Bank characterized the 1964 *Master Plan* as a "massive program of empolderization of Bangladesh." Paraphrasing, it may be said that the Open approach will entail a massive program of de-polderization of Bangladesh. However, this objective will be achieved largely through modification of the embankments, not through their demolition.

In view of the above, the implementation of the Open approach has to follow a *case-by-case* strategy, because each cordon is unique regarding both its physical parameters and the institutions and awareness level of its

inhabitants. The specific modalities of opening up will have to be determined in the light of these specific conditions. It also has to be a *stage-by-stage* strategy, allowing people to adjust to the changed conditions. In addition, the implementation of the Open approach has to be a bottom-up process of *people's enterprise*, requiring revival of indigenous, grass roots level institutions, such as Village Councils (*Gram Parishads*). It will also involve revival of indigenous technologies of river and flood plain management, such as *kata khal* and *ashtamashi bandhs*.

In more concrete terms, the implementation of the Open approach will entail a broad range of activities, including (i) modification of settlement pattern; (ii) modification of infrastructure to ensure free passage of water; (iii) consolidation of settlement; (iv) land leveling and terracing; (v) re-excavation and dredging; (vi) restoration of water ways; (vii) revival of capture or open fisheries; (viii) re-direction of crop research program; (ix) riverbank protection; and (x) use of discontinuous embankments.

Of the above, riverbank protection will have to be a priority task for the Open approach. It will begin with the determination of the specific causes of increased bank erosion and other unwarranted morphological changes in a particular river and formulation a strategy for halting and then for reversing these changes. The strategy will be geared to work with nature than against it, and will follow a gradual, stage-by-stage progression, giving full scope for the realization of the potential that the geo-bag technology has in this regard.

At a broader level, the challenge of opening up will vary depending on the type of cordons. It will be easier for the partial cordons, particularly the ones whose partial feature has indeed been upheld due to popular pressure, such as the PIRDP. The opening up will be relatively more difficult for full cordons, particularly the ones that have been around for a long time and has witnessed significant expansion of below-flood-level settlement, as such the DND project.

Opening up of the coastal polders poses a particular challenge because, in many cases, these serve as a protection against saline tidal flows, and, for sea-facing polders, as a protection, to a limited extent, against storm surges. However, the restoration of sedimentation is of overriding importance for the survival of the coastal area against sea level rise caused by climate change, and hence ways have to be found about how this can be achieved while protecting and improving the life and livelihood of the people living in these polders. The process has to be such that it can prove to be a win-win solution, being beneficial in the short-run as well as in the long-run. The principle of following a stage-by-stage and case-by-case strategy will be particularly helpful in dealing with the coastal polders. Different ideas

regarding how the short- and long-run interests may be combined have to be first tested out as pilot projects in the case of a few polders before considering their applicability for a larger number of polders.

The waterlogged polders can provide the starting point for the process of modification of coastal polders. Showing how the Open approach can help to relieve the people of the waterlogged polders from their miseries can build the popular support for the approach and convince the people of other polders to embrace the Open approach. Similarly, demonstration of the fact that better protection of life and livelihood can be achieved under open conditions of the sea-facing polders can help to make the approach acceptable to others. The process of experimentation may also lead to solutions that are currently escaping the scholars and policymakers. However, the imperative is clear: sedimentation of the coastal region has to be restored in order to prevent the gradual sinking of the region under the sea – a process that sea level rise caused by climate change has now accelerated.

To mitigate the regional and global threats to Bangladesh's river, the implementation of the Open approach needs to proceed with signing and ratifying the 1997 UN Convention on Non-navigational Uses of International Watercourses and leveraging it, to the extent possible, in all forums of discussion and negotiations – bilateral, multi-lateral, and international. In the bilateral negotiations with India, the implementation of the Open approach will entail advocacy and pursuit of the "Transit for rivers" formula as the basis for win-win cooperation between the two countries.

A big and complex change such as the switch from the Cordon approach – which held sway form more than seven decades – to the Open approach cannot be spelt out in all its details *ex-ante*. What is necessary is to make the rationale of the change and its main directions clear, leaving the rest to the creative energy of the people of Bangladesh.

1.19 Political economy of water development policies

Despite its evident greater suitability for Bangladesh, the Open approach remains yet to be adopted whole-heartedly by the authorities of the country. The reason for this paradox lies in the political economy of water policy making. Policies are not random occurrences and instead depend on the relative strength of social forces that rally behind different policy options. Generally, there are two factors that determine why particular social groups or individuals advocate particular policies. One of these is "knowledge." People may advocate a policy because, according to their knowledge, it is the

best policy. The other and often more powerful factor is "material interests." Thus people may advocate a policy because it is in their material interests. Sometimes, these two factors work in the same direction. However, they may work in opposite directions too. Thus, some people may favor a policy because it serves their material interests, even when they know that it may not be in the best interest of the society.

It so happens that the Ecological and Open approaches are generally at a disadvantage on account of both these factors, as compared with the Commercial and Cordon approaches. So far as knowledge is concerned, understanding the merits of the Ecological and Open approaches generally requires more information and a broader outlook than that for the latter. To understand the influence of material interests, it is useful to distinguish between "immediate beneficiaries," whose material interests are served by the very process of implementation of the policy, and "end–beneficiaries," whose interests are served by the outcome of the implementation. In the case of an embankment project, for example, the contractors, consultants, bureaucrats, politicians, etc. are the immediate-beneficiaries; while farmers, expecting to get protection against untimely flooding, are among the end-beneficiaries. The theory of policy choice shows that it is easier for beneficiaries who are small in number but whose potential per capita benefit is large to get organized and mount pressure for adoption of the policy they favor. By contrast, beneficiaries who are large in number but whose per capita benefit is small find it difficult to do so. It so happens that projects of the Commercial and Cordon projects generally involve immediate-beneficiaries with large per-capita benefits, while Ecological and Open approach sack such large immediate-or end-beneficiaries. Consequently, it is easier for beneficiaries of the Cordon projects to lobby for these projects than it is the case for the beneficiaries of the Open approach to lobby for measures that follow from the latter. It is these asymmetries regarding both knowledge and material interests that make the switch to the Ecological and Open approaches difficult. In a developing country such as Bangladesh, the difficulty is compounded by foreign influence – which generally takes the form of both knowledge (technical advice) and material interests (financing) – and still favor more the Commercial and Cordon approaches.

One way to overcome both the knowledge and material interest-related barriers is to move the discussion of river policies to the public arena. As Amartya Sen (1999) points out, public discussion has both the instrumental value of helping to reach better policy choices and also the intrinsic value as a way of popular participation in decision making and hence of democracy. Public discussion can inform the people about the pros and cons of the alternative policy choices and thus overcome the knowledge barrier. At the

same time, more knowledge about the policy options may help people to make more informed decisions about which policy to support. In particular, it may prompt the end-beneficiaries of the Open approach to get organized and resist the vested interests advocating the Cordon projects, vindicating the saying that "Knowledge is Power!"

1.20 Prospects of the Open approach in Bangladesh (In lieu of conclusions)

In view of the political economy of water policy formulation, it is clear that the adoption of the Open approach requires overcoming both the knowledge-deficit and the mobilization-deficit. The last chapter of the book considers ways and prospects of overcoming these twin deficits.

So far as the knowledge-deficit is concerned, it notes that, first, more technical research needs to be done on many issues that require more definitive answers. For example, while the morphological changes of the rivers are now better documented, their causes are yet to be sufficiently established, so as to devise effective strategies for reversing them. Second, for public discussion to be fruitful in influencing policies, it has to be properly informed. Hence the information, arguments and research findings regarding river and water policies need to be presented in a way that is accessible to the public.

So far as mobilization-deficit is concerned, generation and dissemination of knowledge can themselves help to overcome this deficit, as noted earlier. However, additional mobilization efforts are necessary. In this regard, it is encouraging that, since the late 1990s, a broader environment movement has developed in the country through the joint efforts of resident Bangladeshis (RBs) and non-resident Bangladeshis (NRBs). The latter formed *The Bangladesh Environment Network (BEN)* in 1998 to work together with pro-environment RBs for the protection of environment. The joint effort led to the formation of *Bangladesh Poribesh Andolon (BAPA)* in 2020, as a united platform of pro-environment forces of Bangladesh. Reflecting the central role of rivers in Bangladesh environment, BAPA initiated and promoted river protection movements across the country and formed *the Jatiyo Nodi Rokkha Andolon (JNRA)* at the National Conference on Rivers in 2006. The Convention also adopted the comprehensive *Resolution on Rivers*, based on the Open approach.

The river movement has achieved many successes too. For example, responding to the demands of this movement and the High Court ruling of 2009 (noted below), the government formed the River Task Force in 2010. Though initially focused on the four rivers of the Dhaka City, BAPA and

other river activists persuaded the Task Force to extend its attention to other rivers, including the Baral River of North Bengal, for the protection of which BAPA had built up a strong movement of the local people. As a result, the Task Force took some steps that led to partial opening up of the river. At the same time, the government took some steps to free up rivers from encroachments, and formed the National River Conservation Commission (NRCC) in 2013, also in response to the High Court directive of 2009. However, the government's measures generally remain half-hearted and half-done, so that stronger mobilization of the public is necessary.

Fortunately, the movement for protection of rivers is receiving commendable support from many quarters of the society. One of these is the media, both print and electronic. Exposure of the deplorable state of the rivers by the media has played an important role in sensitizing the public and prompting the authorities to actions. These exposures have also helped to seek and obtain relief from the upper-level judiciary (High Court and Supreme Court), which is playing a particularly active role in protecting rivers both through hearing of petitions submitted to it and sometimes through *suo moto* initiatives. The series of pro-river rulings have culminated in the landmark High Court ruling of 2019 (upheld by the Supreme Court in 2020, with minor modifications) that declared rivers as "living entities" and "juridical persons," and appointed the NRCC as the guardian (*locos parentis*) of the rivers with the responsibility of protecting their rights. This verdict puts Bangladesh at the forefront of countries of the world in terms of recognizing the rights of rivers.

It is instructive that the county's top political leadership, represented by the Prime Minister Sheikh Hasina, also seems to be on the side of the Open approach. She has been calling frequently for cohabitation with rivers and floods and has asked engineers to refrain from indiscriminate construction of river - intervening structures. In a sense, this is not surprising, because, unlike many current ministers, bureaucrats, and technocrats, she spent a considerable part of her childhood in a deltaic village in close proximity with rivers. She therefore has the direct knowledge and a deeper understanding of the role of rivers and river overflows in the ecology and economy of floodplains. Unfortunately, many in her administration do not understand and appreciate her position well and, often, motivated by material interests, push the country's water development policies and projects in harmful directions. In view of the above, there seems to be the potential to leverage the Prime Minister's position to move the country away from the Cordon approach and to the Open approach.

Finally, unlike the 1950s and 1960s, when the external influence on Bangladesh's water development was almost entirely in favor of the Cordon approach, that is not the case now. With growing awareness at the international level about the necessity of protection of environment and

rivers and of the merit of working with nature rather than against it, external influence in favor of the Open approach is also now reaching Bangladesh. This was already evident during the FAP debate, and this trend is growing with time. Hence, going forward, external influence can also be a favorable factor for the adoption and implementation of the Open approach.

Overall, a strong constellation of forces is now arrayed in favor of the Open approach in Bangladesh. What is necessary is to harness these forces and raise people's mobilization to a higher level. The mobilization is necessary not only to overcome the obstacles to the adoption of the Open approach but also for its implementation as a people's enterprise. Dissemination of necessary knowledge is a precondition for such mobilization. This book meant to be a contribution to the generation and dissemination of that knowledge, and it is hoped that it will help to strengthen the mobilization of the people in favor of the Ecological and Open approaches and thereby to ensure sustainable water development in Bangladesh.

Endnotes

1. For example, encroachment of rivers within Bangladesh is facilitated by the upstream withdrawal, which causes rivers to dry up, making them an easy target for acquisition. Similarly, domestic pollution adds to the transboundary pollution.
2. Land and water issues are therefore more intricately connected in Bangladesh than anywhere else in the world.
3. The above sea-level area of the Bengal Delta is estimated to have an area of about 100,000 sq km, and the sub-aquatic sediment layer is estimated to extend more than 3,000 miles south into the Indian Ocean.
4. In fact, according to some authors, the Lalmai Tract is also considered to be of Pleistocene epoch (see Sarker 2018a, p. 7).
5. Frontal interventions may also be called cross-sectional.
6. Geologists have shown that the elevation of coastal Bangladesh in certain areas used to increase by about 2 cm per year through the natural process of sedimentation (Auerbach et al. 2015 and Bhattacharya 2009). By disrupting this natural process, the polders are making Bangladesh more vulnerable to submergence. See Chapter 14 for more details.
7. In fact, the project is called Eastern Bypass to emphasize its role as a road and to deflect people's attention from the more important fact that it is an embankment.
8. One can see a parallel between the lack of appetite for learning from the experience of Phase I of DIFPP in thinking about its Phase II and the lack of enthusiasm for learning from Dhaka city's experience in thinking about flood and drainage issues of other cities and towns of the country.
9. See Zahid (2018, p. 335).
10. Ibid. (p. 334).

11. STWs proved to be a particularly suitable technology for Bangladesh and has brought about revolutionary changes in the rural economy and life in many directions. First, being small in scale, they are much more suitable than DTWs for the small and fragmented landholding pattern of Bangladesh agriculture. Accordingly, they can be privately owned and avoid difficult problems of farmers' group formation and management. Second, they also allowed the emergence of an irrigation water market and a class of irrigation entrepreneurs who owned STWs and offered (excess) irrigation water to neighboring farmers, who did not own STWs. Third, the installation and operation technology of STWs were very much within the scope of common rural people, so that no government patronage and role were necessary for their wide expansion. Fourth, the STW engines are easily transportable and versatile in their uses. Accordingly, the same engine can be used at different spots of agricultural fields, as necessary. More importantly, these engines can be taken out from the fields once irrigation season is over and used for other purposes, such as in transportation vehicles, including boats, post-harvest operations, such as threshing, etc. Thus STWs are serving as the main engine for raising the rural technology from the pre-industrial level – based on human and animal muscle power – to the industrial level – based on machines.
12. Most construction projects of FAP were planned to be undertaken in its future phases.
13. As noted earlier, the Ganges River in India is one of the most polluted rivers in the world. Rivers flowing from the Indian state of Meghalaya are also bringing to Bangladesh waste generated by mining operations taking place in that state. Bilateral cooperation is needed to mitigate the problem.
14. The signing of this Convention by itself will not enable Bangladesh to seek international arbitration, which will require India's consent. However, signing this Convention will allow Bangladesh to refer to the rights that it confers to it as a lower riparian country and leverage it in other ways possible. Also, Bangladesh can urge India and other co-riparian countries to sign this Convention too.
15. These include trade, investment, culture, and security.
16. In the long run, sea level rise is the most serious threat to Bangladesh caused by climate change. According to the Intergovernmental Panel on Climate Change (IPCC)'s *Climate Change 2007: Synthesis Report* (IPCC 2007, p. 47), the sea level has risen at an alarming average rate of 3.1 mm per year during 1993-2003 and may rise in future by several meters as a result of complete melting of the Greenland and Antarctica Ice sheets and the North Pole ice cap. This would submerge a significant part of Bangladesh, much of which is within 10 meters from the sea level. Given the extremely high density of population of the country, this will result in displacement of a huge number of people. For more details, see Chapter 14.
17. The Baseline Studies are actually a compilation of pre-existing research and do not represent research based on newly collected data and information.
18. The BDP also fails to pay enough attention to the critical assessments that were available, including those conducted by some of the foreign lending agencies.
19. The BDP also does not pay much attention to the changes that have taken place in the Dutch thinking and practice regarding river management, as reflected by the

recent "Room for Rivers" project, adopted and implemented by the Government of the Netherlands. See Chapter 16 for more discussion.

20. It was thought to be part of the Belt and Road Initiative (BRI) that the Chinese President Xi Jinping declared and launched earlier in 2013. Though originally focused on transport and communications, the scope of BRI was later expanded to include water projects too. Most of the latter focused on building dams and barrages.
21. The MoU signed between the BWDB and Power China effectively grant the latter the exclusive right to be the contractor of this project. Apparently it was also been given the task of conducting the feasibility study. Though fraught with conflict of interests, it has become common for Bangladesh to entrust the task of conducting feasibility study of a project to the company that has been awarded the contract. The same happened earlier regarding the Rooppur Nuclear Power Plant. The Russian company AtromStroi was given the task of conducting the feasibility study.
22. The Teesta is not only a river, it is the backbone of a river-system, connected with other tributaries and distributaries.
23. In this regard, Bangladesh can make use of the experience it has acquired through the river training work done for the construction of the Jamuna and Padma bridges.