Environmental Security in Relation to Trans-boundary Water Regime: A Situation Analysis of GBM Basin

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DRAFT FOR DISCUSSION

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Environmental Security in Relation to Trans-boundary Water Regime: A Situation Analysis of GBM Basin

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1. Introduction

With the increased demand of fresh water for agriculture and other human needs, water resource management experiences challenges both at local and international level from distribution and use. Even though different natural factors such as origin, gradient and flow influence water distribution, but the degree and perception of up and down stream interests, and hence rights and duties, are also influenced by human intervention in the form of dams, reservoirs etc. (Farooque, 2004).The situation is even more critical when a river is trans-boundary, where political definition of *'natural geography'* overwhelms the hydrological needs (Wolf et al., 2001).Thus, coupled complexity of natural in-equilibria and political interest creates tension in 'power base' for a geo-politics and that is evidently reflected in hydro-diplomacy (Farooque, 2004).

Having 4,096.7 km land boarders (SATP, 2008), Bangladesh and India shares fifty four rivers, most of those are originated in the Himalayan range (Haque, 2008). Being situated in the down-stream, Bangladesh receives many of these common rivers at a mature state—when the velocity drops, sedimentation rates increase, and the river changes its course, braiding into multiple channels (Faisal, 2002). Bangladesh topography, therefore, formed with alluvial deposits by these rivers, where the Ganges, the Brahmaputra and the Meghna river system constitutes the major part. The Ganges–Brahmaputra–Meghna river systems, collectively known as GBM river basin (Figure 1), drain a total area of about 1.72 million km^2 (Ahmad et al., 2001) and finally the combined flow discharged into the Bay of Bengal through Bangladesh. Constituting the second largest hydrologic region in the World after the river Amazon, the GBM region stretches across five countries: Bangladesh, Bhutan, China, India (16 states in the north, east and northeast, in part or fully), and Nepal, but Bangladesh and India share all the three river systems; China shares only the Brahmaputra and the Ganges, Nepal only the Ganges, and Bhutan only the Brahmaputra (Faisal, 2002). These rivers discharge 1.5 million m^3 of water per second during the peak period, whereas the runoff is only about 61,000 m^3 per second in lean period (Hasan & Mulamoottil, 1994). The ratio of peak to low season flow is approximately 25:1 (World Bank, 2000). In terms of water availability, March is a critical month. The Brahmaputra and the Ganges account for 80% of the flow measured within the country, but the Meghna contributes only 2% of the total measured discharge in Bangladesh during March (World Bank, 2000).

Bangladesh is a country of rivers having a total of 230 rivers, tributaries and distributaries, two thirds of these are part of GBM basin. Thus, it is not surprising to have the country's large base of livelihood dependency on rivers. Despite overwhelming dependency on these rivers, Bangladesh cannot manage the rivers on its own, since 92 percent of the GBM basin is situated outside the country (Faisal, 2002). Accordingly, any intervention in the upstream ultimately affects socio-ecological systems of Bangladesh.

Since Bangladesh and India share all three rivers of the GBM basin -The Ganges, The Brahmaputra and the Meghna, therefore water sharing remains as priority area for both countries' bilateral diplomacy. Even though the region as a whole receives many times more water than is necessary over the year, but the spatial and temporal distribution of water availability is very uneven. Thus, the dwindling supply of water in the dry season has become one of the key contended issues between India and Bangladesh (Nishat & Faisal, 2000). Water sharing problem between India and Bangladesh is not unique in the sense that many countries sharing common rivers have been going through similar problem. Examining the management systems of 12 trans-boundary river basins: The Mekong, Indus, Ganges–Brahmaputra, the Nile, Jordan, Danube, Elbe, Rio Grande and Colorado, Rio de la Plata, Senegal and Niger, Kliot et al., (2001a) have found a direct linkage between water scarcity and mal-distribution, where the 'powerful' countries are identified at attempting to control the maximum flow for their use. Commonly, uses are often in conflict as the satisfaction of one obstructs the fulfillment of the others (Kliot et al., 2001a). Falkenmark and Rockstom (2000) have argued that conflict on water resource is not only resulting of physical scarcity, but very relevant socio-political dimensions such as distribution, rational use and equity need to be considered. Therefore, obstacles to collective action over trans-boundary water issues (such as physical or constructed water scarcity) are requiring in-depth context-specific understanding (Ostrom, 1990; Savenije Hubert, 2000).

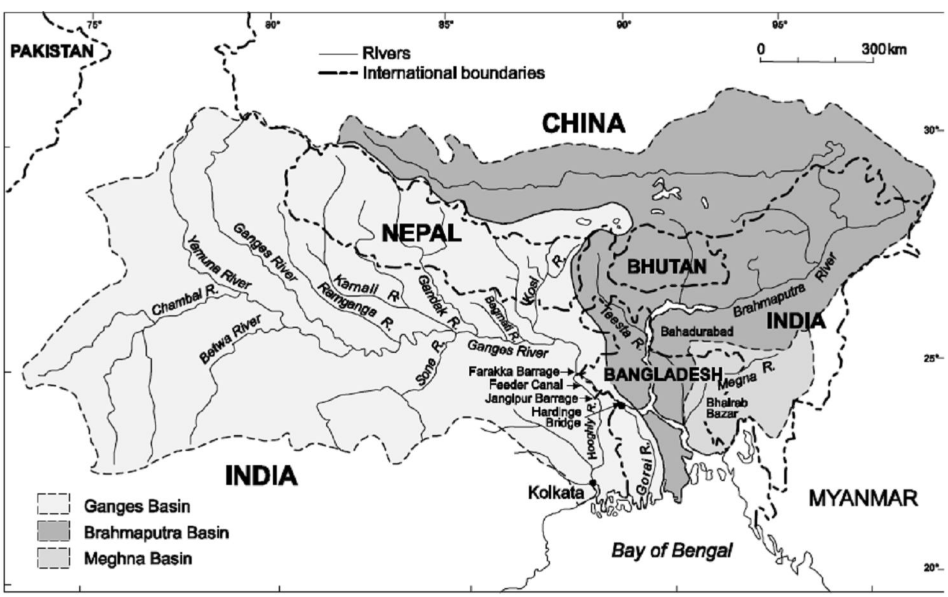

Figure 1: The Ganges- Brahmaputra- Meghna (GBM) Basin (Source: Mirza, 2004)

Upper riparian countries have been capitalizing their geographic advantages and building dams and barrages for irrigation, transportation and other purposes, but the environmental consequences mostly have to be borne by the lower riparian countries (Kliot et al., 2001b). GBM basin is no exception, where natural flows have been obstructed through dams and barrages by the upper riparian country, here India, and consequently Bangladesh experiences low flow condition of its rivers in dry season. The situation is very critical for Bangladesh as 80% of its annual fresh water supply comes from these trans-boundary rivers and obstructions in water flow result into serious environmental degradation in this river dominated delta. Focusing trans-boundary water regime of GBM basin, this situation analysis paper discusses the core issues related to environmental security through analyzing various environmental impacts and its significance at the national and regional level. Specifically, the scope of this paper pertains to trans-boundary water relations between Bangladesh and India, since these two neighbouring countries' environment and livelihood depend heavily on the rivers of the GBM basin and any unilateral or asymmetrical management practice or decision will bring catastrophic damages to the whole region.

2. Environmental Security and Trans-boundary Resources Management

A gradual shift has been observed over the years in the definition of 'environmental security', from an early focus on incorporating environmental and related concerns to a new focus on searching the cause of conflict due to environmental change. It is assumed that this shift is influenced by recent technological development in identifying inherent causes of problem vis-a vis growing list of environmental problems and their associated risks to the human beings (Dabelko et al., 2000; Elliott, 2001). Richard Ullman and his followers' concept of security could be use in this purpose, *"a threat to security includes [any] action or sequence of events that (1) threatens drastically and over a relatively brief span of time to degrade the quality of life for the inhabitants of a state, or (2) threatens significantly to narrow the policy choices available to the government of a state or to private, nongovernmental entities (persons, groups, corporations) within the state."(* Ullman, 1983; Brunnee & Toope, 1997). However, contemporary human security analysis does not oppose the trends of redefining security or of mapping the environmental roots of violent conflict (Najam, 2003). Norman Myers also supported extended definition of human security and argued that human and environmental security are interrelated. Accordingly he defines Ultimate security: … *security applies most at the level of the individual citizen. It amounts to human well- that amounts to human well-being: not only protection from harm and injury but access to water, food, shelter, health, employment, and other basic requisites that are the due of every person on Earth. It is the collectivity of these citizen needs— overall safety and quality of life—that should figure prominently in the nation's view of security* (Myers, 1993).

Many factors shape environmental security; the elements that need to be taken into consideration are the dynamics in the natural environment, population change, degree of access to the environmental resources and so on. Interaction between and among the determinants of environmental security sets the stage for addressing the environmental security challenges. Generally, environmental insecurity has two dimensions in spatial and causal senses, i.e. national and transnational (Farooque, 2004). Moreover, the transnational insecurities can be global and regional in terms of cause and effect perspectives, but may or are capable of disrupting national, regional and global environmental orders (Farooque, 2004).

Basically, every rivers system is naturally an indivisible physical unit, and as such, its management should consider the maximum welfare of the whole community irrespective of political jurisdictions (Farooque, 2004). In case of trans-boundary river, the physical unity of the water makes it a *'shared natural resource'*, which creates an opportunity of cooperation between states (Farooque, 2004). The UN General Assembly adopted resolution 3129 (XXVIII) accepting the 'shared natural resources' concept. The resolution declares *"of the importance and urgency of safeguarding the conservation and exploitation of natural resources shared by two or more states, by means of an effective system of co-operation*". It is the duty of the state of origin to its neighbours, who are likely to be affected, regarding environmental consequences that may rise due to any of their intervention (Farooque, 2004).

Having similarity in histories, geographies, and politics, the South Asia is the home of more than one fourth of global population. Even though politically all seven countries of South Asia have their independent territory, but many of the natural resources are shared by two or more political boundaries. Such situation is extremely delicate for flow resources like rivers where demarcation is difficult. Therefore, political concept of security and environmental resource management are best conceptualized in the context of South Asia. The issue becomes important when it comes between Bangladesh and India since they have been sharing 54 common rivers. Unfortunately, Water sharing of the Ganges, the Brahmaputra, and the Meghna could not come to a stable point between Bangladesh and India , despite having a long history of negotiation.

3. Key Issues Related to Trans-boundary Water Regime between Bangladesh and India

Since the GBM region is the home of hundreds of millions of people, any major shift in the flows of the rivers would profoundly affect the peoples' social, economic, and cultural lives along with disrupting the ecological integrity (Faisal, 2002). However, history of GBM river system is characterized by human interventions both at up and down streams (Farooque, 2004). Moreover, water sharing of these rivers has given rise to dissatisfaction, disbelief and dispute among the four stakeholders: Bangladesh, Bhutan, India and Nepal (Khalid, 2004). Having 54 shared rivers including the Ganges, the Brahmaputra and the Meghna, the water sharing issue is attributed with various contentions at temporal and spatial scale between Bangladesh and India. The water sharing dispute between the two riparian countries first came to public domain in 1951, when Bangladesh was a part of Paksitan [Bangladesh became Independent in 1971 from Pakistan] (Nishat and Faisal, 2000). But, the issue received momentum when India built The Farakka Barrage on the Ganges in 1975 just 18 km from the Bangladesh border (Abbas, 1982; Sharma and Sharma, 2008). In justification, India argued that Bangladesh would need a small part of the historic flow of the Ganges and most of it being wasted in the Bay of Bengal (Nishat and Faisal, 2000); in contrast, this barrage would benefit India by allowing them to divert Ganges water into the Bhagirati-Hoogly River through a 1,133 m^3 per second capacity feeder canal, which flushes the accumulated silts from the riverbed and improves navigability at the port of Calcutta (now Kolkata) (Faisal, 2002). However, analyzing pre-Farkka (1949-1970) and post-Farakka (1975-1995) water flow data at Hardinge point (Bangladesh part), Tanzeema and Faisal (2001) found 51 percent decline in the average dry season flow of the Ganges. Such drastic drop in Ganges water flow in dry season has resulted in significant ecological and economic damages in Bangladesh (Crow et al.,1995; Faisal, 2002; Mirza, 2004; Bharati & Jayakody, 2011).Despite having a water sharing dispute resolving mechanism- the Joint Rivers Commission (JRC)[1], there have been disagreements over how to allocate and share the waters of the Ganges and the Teesta, including several other common rivers as well as how to augment the flow of the depleted rivers (Faisal, 2002).

3.1: Ganges Water Sharing

After commissioning the Farakka Barrage, the flow of the Ganges has drastically reduced at lower basin, although plenteous in the upper basin (Haftendorn, 2000). Even though the barrage creates opportunity for upper riparians to use the water abundantly, but the needs of the lower-lying states are not being satisfactorily met (Haftendorn, 2000). Regular and adequate water supply is particularly needed during the dry season (November to May) in the Ganges basin in Bangladesh for maintaining its agriculture production, continuing domestic and industrial purposes, regulating flows of its tributaries and distributaries, maintaining river depths, sustaining fisheries and forestry, and keeping salinity level under admissible limit which otherwise would penetrate to landward (Mirza, 2004). However, there is huge contrast between pre and post Farakka water supply, where the situation was much better in pre-Farakka period even in dry season in the downstream, more particularly in the Bangladesh part (Crow et al., 1995, Mirza & Hasan, 2004). Moreover, climate change has attributed another challenge in Ganges water flow, as glacial melting proceeds, water flows in the Ganges river would increase in the short term and likely to cause severe floods, but in the long-term could drop by two-thirds (Sharma and Sharma, 2008).

The Ganges water dispute is attributed with political opposition and asymmetries, as well as extreme poverty and ecological degradation (Haftendorn, 2000). Even though several attempts have been pushed forward, mostly from Bangladesh side, in response to the problems, but the collaboration always found in political pondering that overlooked the ecological needs. While looking at the diplomatic relation including water sharing negotiation between these two countries, it is commonly observed that Indian Congress Government shows a positive attitude when Bangladesh Awami League is in power (Nishat and Faisal, 2000; Faisal, 2002; Imtiaz, 2009). It is not surprising since India actively helped and supported Bangladesh's independence against Pakistan in 1971 after Awami League's lead. But, the Indo-Bangladesh relation went through an upheaval in

[1] The Joint Rivers Commission (JRC) established on 24 November 1972 to deal with water sharing of the common rivers between Bangladesh and India

1975 when India built the Farakka barrage, on the other hand, brutal murder of Bangladesh's liberation leader Seikh Mujibur Rahman, he was also Head of the Government then. After two years deadlock, water sharing negotiation again revived in 1977 with a five-year agreement and both parties agreed to furthering the talks on dry season flow augmentation of the Ganges (Haftendorn, 2000; Faisal, 2002; Haque, 2008). Accordingly, both countries exchanged proposals in 1978, however none of those were finally accepted by its counterpart. In one hand, India proposed to transfer water from the Brahmaputra through a gigantic canal, which would run from Jogighopa, in Assam, across northern Bangladesh, to just above Farakka. On the other hand, Bangladesh proposed diverting water from the Gandak and Kosi (Faisal, 2002). While in an opposing position with flow augmentation process, Ganges water sharing agreement was extended for another five years in1982. Later in 1983, both the countries submitted their updated proposal, where Bangladesh proposed to build seven dams in Nepal and Bhutan (these were being considered by India and Nepal under various project proposals) in the upper flow of the Bramaputra and Ganges in order to make fulfilling the water requirements of the region easier (Haftendorn, 2000; Faisal, 2002). Conversely, India slightly revised the earlier proposal and expressed their intention to build a barrage at Jogighopa and three dams at Dihang, Subansiri, and Tipaimukh along with earlier proposal of diverting Brahmaputra water through 324-kilometer- long link canal crossing northern Bangladesh reaching the Ganges (Faisal, 2002).Both the countries, again, did not agree to each other's proposal by arguing that counterpart's proposal would hamper their social, ecological and economic condition. Meanwhile, the 1st Ganges water sharing agreement (1977-1982; 1983-1988) between Bangladesh and India reached it culmination and expired in 1988. Practically, there was no agreement effective on Ganges water sharing between these two countries from 1989 to 1996. During this period, water release through Farakka Barrage to its down was only India's mercy and Bangladesh received very low flow by that time (Haque, 2008). Bangladesh experienced lots of problems due to water scarcity, particularly in lean period and raised the issue in many fora. Finally, after eight years continuous bilateral discussion both at expert and political levels, both countries agreed to sign a new agreement of the Ganges water sharing and finally signed the 2nd Water Sharing Agreement on 12 December 1996, commonly known as the *Ganges Treaty*, which is supposed remain valid for 30 years period (Nishat & Faisal, 2000, Faisal, 2002, Haque, 2008). The 1996 agreement is based on the availability of the Ganges water at Farakka point derived from the flow data between 1949 and 1988 (Haque, 2008). Both sides have committed themselves to a complicated formula, where during the dry season, from 1 January until 31 May, they have to sustain a minimum water level of 35 000 cusecs for its counterpart at every alternate 10-days period (Haftendorn, 2000; Haque, 2008). On the other hand, Bangladesh will get minimum 27633 cusecs and India will get minimum 25992 cusecs respectively in those days. However, if the flow comes down to 60000 to 50000 cusecs at Farakka, the share would be 50:50 basis.

The Ganges Treaty strongly discourages to reduce water below Farakka in Indian side except for *"reasonable use" in a limited amount (Article III)*. The Treaty stressed on principles of ''equity, fairness and no harm to either party'' (Article IX, the Ganges Treaty, 1996), and calls for a desire of the partners for a more equitable use of the

Farakka barrage water (Kliot et al., 2001a). However, many experts assert that proportion of sharing of water between Bangladesh and India is 45:55 and in some cases it will be 30:70, which give rises to dissatisfaction in Bangladesh (Khalid, 2004). Label et al. (2010) found evidence of this claim and showed that Farakka Barrage already diverting as much as 60% of the natural flows for large-scale irrigation in Indian part. Moreover, there is no guarantee clause to release the minimum quantity of water in case of abnormally low flows that is also another concern for Bangladesh. Even the treaty did not say anything regarding the extent and process of water withdrawal from its origin till Farakka (Kliot et al., 2001a). While comparing the 1977 and 1996 water sharing agreement, Nishat and Faisal (2000) argued that neither agreement helped improve the lean season water availability in Bangladesh. Even 1996 treaty performed poorly than 1977 in the most critical10-day periods of March and April. They concluded that these agreements were essentially validated the *status quo* rather than providing Bangladesh its historic share. Ganges water flow data of pre-1975 at Hardinge bridge (inside Bangladesh) supports their statement as it shows during that period Bangladesh received more or less 70000 cusec in dry season (Haque, 2008). Another significant drawback of the treaty is that it is overwhelmingly concerned about lean period water sharing, but the said river is also a major cause of monsoon floods and how excessive monsoon water will be controlled that is completely missing (Khalid, 2004). Even though Bangladesh has raised the issue several times, but India confined to only lean period water sharing and pledged to share flood forecasting information only under SAARC (South Asian Association for Regional Cooperation) umbrella (Haftendorn, 2000; Haque, 2008).

3.2 India River Linking Project:

Despite couple of agreements signed between Bangladesh and India on water sharing, yet the issue completely succeeded to come to a suitable position where both countries can feel comfortable. Conversely, over the years many disputes evolved. One of the outstanding issues that have become a grave concern for Bangladesh is Indian River Linking Project (IRLP) in recent times. Even if the proposal conceived in 1982 by the late Prime Minister Indira Gandhi, based on a policy narrative which argued that the Ganges–Brahmaputra basin has too much water but the south suffers from scarcity. The project plans to divert water from the Ganges- Brahmaputra basin through networks of channels, reservoirs and dams to link all the major rivers in India. At initial stage, the project proposed a total 30 river linkages and 3000 storage structures and 14,900 km of canals to shift water to western and southern India including water from the Ganges and Brahmaputra to the Mahanadi basin (Amarasinghe et al., 2008; Mirza et al., 2008). However, the progress of the project was unnoticed until 2002 when the Supreme Court of India, in response to a public interest petition, ordered the project to revive. Repeatedly the Indian Supreme Court issued an order to the government on 27 February 2012 to implement the rivers-linking scheme in a "time-bound manner." The Court's overarching focus was national interest and in their observation they said, *"This is a matter of national benefit and progress. We see no reason to why any state should lag behind in contributing its bit to bringing the inter-linking river programme to a success, thus saving the people living in drought-prone zones from hunger and people living in flood-prone areas from the destruction caused by floods."*

Under the river linking project, 14 links have been identified under the Himalayan Component where Bangladesh's interest is also included having shared rivers and rest other links designed to peninsular component (Rashid, 2012a). Of these, feasibility reports of 14 links under Peninsular Component and 2 links under Himalayan Component (Indian portion) have been prepared, without any consultation with Bangladesh being sharer of the Ganges- Brahamaputra basin. Bangladesh claims that the plan of linking trans-boundary Himalayan rivers is against the spirit the 2010 Bangladesh-India joint communiqué and the Framework Agreement on Cooperation and Development signed on September 6, 2011. Moreover, the plan also conflicts with the Article 9 of the 1996 Indo-Bangladesh Ganges Water Treaty and the 1992 UN Convention on Biological Diversity (Rashid, 2012a). In addition to policy conflicts, the huge project raises many issues on social and environmental grounds —displacement of people and environmental impacts and trans-boundary impacts with Nepal and Bangladesh (Amarasinghe et al., 2008). Based on previous experiences, the scientists warn that this project would further contribute to imbalance the Ganges flow, where in dry season the flow will decrease drastically that would increase threats of salinity intrusions in South-western part of Bangladesh; on the other hand would cause severe flooding during the monsoon rains (Mirza et al., 2008). The proposed river links even did not satisfy Indian scientists and politicians as a whole. Dr. Manmohan Singh, the present Prime Minister of India has sought to adopt a cautious approach to the interlinking of rivers project; whereas Rahul Gandhi, the Congress General Secretary, and Environment Minister, Mr. Jairam Ramesh are also skeptical about the outcome of the project and regarded this as an 'environmental disaster' (The Hindu, 2009). From environmental point of view the proposed river links may not be as helpful as it is perceived in the plan, more specifically reducing water scarcity problem in drought prone areas seems diificult due to their distance from major rivers and high elevations (Alagh et al., 2006). In these areas, it is better to promote community based adaptation in response to water scarcity and climate change, in the form of rain water harvesting or integrated watershed management (Label et al., 2010). Another significant threat may be observed in the capture fishery. Arresting the natural flow of rivers on a gigantic scale could hamper life cycle of fish community, thus thousands of fishermen would be jobless both in India and Bangladesh (Bandopadhya, 1992). However, both risks and benefits are mostly perceived based on previous experience, since no social and environmental assessment report yet to be shared neither with Bangladesh nor with Indian citizens.

3.3 Teesta Water Sharing:

Both India and Bangladesh have built embankments on a number of major trans-boundary rivers in order to control flood as well as facilitating irrigation. Teesta, an important distributary of the Brahmaputra river system, is one the examples where both the countries have built barrages for irrigation purpose. Although the barrages contributed significantly on increasing agriculture production, but the list of environmental consequences are also exhaustive. In Bangladesh side, water availability of in the dry season has dropped significantly. Bangladesh, therefore, persistently demands equitable water sharing required for agriculture production. Accordingly, after a series of bilateral discussion both countries agreed upon to share Teesta water, where 80% water would be shared at the rate of 42.5% and 37.5% between India and Bangladesh respectively, keeping remaining 20% water for river flow (Rashid, 2012b). The water flow would be measured at the Gazaldoba point, 25 km away from Shiliguri, India. Even though every preparation was done to sign an initial 15-year agreement on Teesta water sharing on the occasion of Indian prime minister's Bangladesh visit in September 2011, but finally it was abandoned due to last-minute opposition from West Bengal Chief Minister Mamata Banerjee on a demand of water sharing ratio as 75:25 between India and Bangladesh (Rashid, 2012b). Nonetheless, Teesta could be cited as first example of cooperation between India and Bangladesh, where both countries reached in an agreement in 1973 to close the gap between embankments separated by boarder (Nishat & Faisal, 2000).

3.4 Tipaimukh Dam project:

Although several agreements were signed for flow augmentation as well as water sharing between Bangladesh and India, but outcomes is under critical scrutiny whether the downstream country is receiving the specified amount? Despite Bangladesh's dissatisfaction for water sharing of Ganges and other shared rivers, India has come up with even larger proposal of constructing a dam on the river Barak near Manipur-Mizoram border , 500 m downstream of the confluence of the river Barak with Tuivai, in Churachandpur district of Manipur (www.nhpcindia.com, accessed on 12 February, 2012). The purpose of the dam is flood control and hydroelectric power generation, as so far known from Indian National Hydroelectric Power Corporation Ltd (NHPC limited), a state owned corporation (www.nhpcindia.com, accessed on 12 February, 2012). The Barak is a trans-boundary river originating at in the Manipur Hills of northeast India and flows west becoming the Surma River and then flows south as the Meghna River, a total of 946 km (669 km within Bangladesh) to the Bay of Bengal. The Barak divides in two parts in the Karimgonj district (India), with the northern branch being called the Surma River and the southern the Kushiyara River. At this point the river enters the Sylhet (North) which forms the Surma Basin. The confluence of Surma and the Kushiyara formed the Meghna inside Bangladesh above Bhairab Bazar. The Meghna joins the Padma (combined flow of the Ganges and Brahmaputra) near Chandpur district and subsequently flows to the Bay of Bengal naming after Meghna. Therefore, the Meghna/Barak basin has unequivocal importance in checking salinity in response to the rise of sea level. Since the proposed Tipaimukh dam will regulate the flow of the Surma and the Kushiara rivers, upon which large wetland ecosystem of North-eastern part lies serving to millions of people including supporting very rich biodiversity; the government of Bangladesh expressed its concern on likely impact of the dam on the flow of water and consequently on the whole basin.

The proposal of Tipaimukh dam was unveiled by India in the first joint river commission meeting in 1972, when the primary purpose envisaged as flood mitigation (Bisht, 2012). Both the countries were then agreed to carry joint study on flood situation in Cachar of India and Sylhet in Bangladesh including its socio-economic impacts. Later in 1978, with addition of hydro-power generation to the original flood control purpose' the Tipaimukh dam entered the lexicon of the Joint Rivers Commission and decision was taken to conduct joint study on engineering feasibility of the dam including mapping the benefits. But the decisions were not translated into action. Over the years, Bangladesh repeatedly raised their concern on the Tipaimukh Dam considering its position in an ecologically sensitive and topographically fragile region, which falls under one of the most seismically volatile regions on the planet (see Wikipedia). Considering the perceived risks, Bangladesh has been asking India to share information on the project design. Bangladesh expressed deep concern on a number of issues related to the adverse downstream impact of the dam in the Joint River Commission Meeting held in September 2005 in Dhaka (Bisht, 2012). In that meeting, India formally promised to share Tipaimukh project design. However, instead of sharing project design to Bangladesh, India made public Environmental Impact Assessment (EIA) Report. Environmentalists and water experts of Assam, Mizoram and Monipur highly crticised the EIA report calling it incomplete and inadequate (Mahmood, 2009). The EIA report indicated to adopt the recommendation of the Shukla Commission Report that recommended to construct a pick-up barrage at Fulertal, 95 km downstream of dam site, which will act as diurnal storage of 1120 cumec inclusive of power release to irrigate subsequently a gross command area of 1,20,337 ha (cited in Mahmood, 2009). However, Bangladeshi experts expressed their concern on such plan of water withdrawal, even if officially India states that no water would be withdrawn under this project in the upstream. Reportedly, Dr Ainun Nishat, eminent water scientist and former member of JRC, argued that such water withdrawn would result in drying rivers and effect on livelihood of the people in Surma Basin (Interview in the Daily Star, cited *in* Mahmood, 2009). While slow pace of data sharing has been contributing to mounting misunderstanding between two neighbouring countries, Bangladesh spontaneously conducted a study in 2005 through Institute of Water Modelling (IWM), an autonomous research organization works under the auspices of Minstry of Water Resources, on the potential hydrological impact of Tipaimukh dam using available rainfall and water flow data of the Barak river. The IWM study (2005) estimated that the Tipaimukh dam might reduce the average annual monsoon inflow from the Barak River at Amalshid point to the Surma-Kushiyara-Meghna River system to around 10 percent in June, 23 percent in July, 16 percent in August and 15 percent in September. Water level would fall by more than 1 m on average during the month July at Amalshid station on the Kushiyara river, while this would be around 0.25 m, 0.15 m and 0.1 m at Fenchuganj, Sherpur and Markuli stations, respectively. On the other hand, at Kanairghat and Sylhet stations on the Surma river, average water level would drop by 0.75 m and 0.25 m, respectively, in the same month. During a relatively drier monsoon year, the dam would have more impact on the availability of monsoon water in the Barak-Surma-Kushiyara river system than the average annual monsoon year. For instance, for July, August and September flow would be reduced as much as 27 percent, 16 percent and 14 percent respectively, 4 percent, 2 percent and 2 percent higher than the volume reduction found for an average monsoon year.

In response to Bangladesh apprehension, upon invitation by Indian Government, a parliamentary delegation of Bangladesh headed by Abdur Razzak (Former Water Resources Minister) travelled Tipaimukh area to see the project activity, but due to bad weather they could not manage visiting the location of Tipaimukh dam. Taking no satisfactory actions, neither sharing information of impacts on downstream nor agreement on benefit sharing with Bangladesh, formally India started implementing the project (An agreement was signed between Government of Manipur with NHPC Ltd. and Sutlej Jal

Vidyut Nigam Ltd (SJVN) on 22 October 2011), something that is a clear breach of The Ganges Water Treaty, more particularly Article IX[2] (Mahmood, 2009).

3.5 Drainage Congestion and Adverse Location

The embankments also create drainage congestion, but the problem is more acute in upstream area. One such problem was observed in Satkhira in Bangladesh, here the Indian side suffered from drainage problem due to construction of a road through a natural wetland (locally called a beel) (Nishat and Faisal, 2000). Likewise, India has built embankments Kodalia and Isamati that have been rendering downstream reaches of these rivers (inside Bangladesh) completely devoid of water in the dry season (Nishat and Faisal, 2000). Other than human intervention, river's spatial location sometime creates diplomatic problems between these two countries. In some cases the border line passes through the middle of the common rivers separating two countries or in some cases river becomes itself boundary line. However, in a natural process river shifts its course quite frequently. Such shifting leaves ownership disputes in newly accreted lands. Adverse location problems exist in the Ganges and the Kusiyara (a branch of Barak in India) rivers (Nishat and Faisal, 2000). The situation can become even more complicated with human intervention in the form of embankment in one side, which in turn causes erosion of the opposite bank. Bank erosion of the Muhuri river is interpreted as falling in this category of dispute (Nishat and Faisal, 2000).

3.6 Modality of Water Negotiation

Another important issue that has been undermining efforts of negotiation is mode of negotiation-whether it would be bilateral or multilateral in case of trans-boundary rivers. Since GBM basin stretches five countries, Bangladesh is interested to include Nepal and Bhutan in the trans-boundary water talks. But, India opted for only bilateral negation by arguing that Nepal could have its own plans and priorities that might not match Bangladesh's requirements (Herdferton, 2000; Faisal, 2002). Another debate on negotiation evolves after different views in river basin management between two countries. Bangladesh is interested to resolve water sharing issues separately within each river basin, but India, on the other hand, argues that all three major rivers form an interconnected system and should therefore be treated as a single, integrated unit (Faisal, 2002). Bangladesh, albeit others, needs immediate solution to water sharing as its northern area has been experiencing acute water crisis in dry season. India's proposal on link all major rivers or dam on Brahmaputra river for flow augmentation based on their view of considering GBM as single unit is not acceptable by Bangladesh either (Faisal, 2002; Biswas, 2008)[3]. But, it is quite difficult or in most cases impossible to consider

[2] Article IX of the Treaty says, "Guided by the principles of equity, fairness and no harm to either party, both the Governments agree to conclude water-sharing Treaties/Agreements with regard to other common rivers".

[3] In the flow augmentation plan, India proposed to divert the equivalent of one hundred thousand cubic meters per second from the Brahmaputra in the dry season (whose flow is estimated at 150,000 cubic meters per second) through the link canal to Farakka. This additional water flow would be divided into two parts: 60 percent would be released toward Bangladesh, the remaining 40 percent being diverted to the Port of Calcutta. This meant that the dry season Ganges flow would be sixty thousand cubic meters per second. Adding to this the remaining fifty thousand cubic meters per second flow of the Brahmaputra would yield a combined Ganges-Brahmaputra flow of 110,000 cubic meters per second. The Indian side asserted that this would be enough to meet the minimum flow requirement at the Meghna estuary, where eighty thousand cubic meters per second are needed to prevent inward movement of the salinity front. Should more water be needed, it could be supplied by building a dam in the Barak basin (e.g., at Tipaimukh)

GBM as one system in planning and management because of its sheer size, complexities and multinational character (Biswas, 2008)

4. Impacts of Water Diversion

4.1 *Hydrological Changes*

River is a dynamic natural object that continuously changes its courses , mostly due to natural causes but few cases attributed with human interventions in the form of dams, embankments etc. However, in most cases the cost of human interventions outweighs the benefits; where interventions' consequences have to be borne by either one of the side (Rosenberg et al., 2000; Baxter, 1977). For instance, the Farakka barrage facilitates navigation in Kolkata port with the cost of reduced water flow in the river system of Bangladesh. There is a sharp contrast of flow of the Ganges in lower riparian side between pre and post Farakka period. It is estimated that the ratio of maximum and minimum discharge at Hardinge bridge stood roughly 70 percent and 27 percent respectively between pre-Farakka and post-Farakka period (Table-1) (FPCO, 1993, Mirza, 2004) .

Water diversion by the Farakka barrage and structures has resulted in significant changes in hydrology of the Ganges river system (Mirza & Sarker, 2004; Bharati & Jayakodi, 2011). In Bangladesh part the Ganges river system comprised of the main Ganges River; the Mahananda, an important tributary; and the Mathabanga and Gorai, two distributaries (Mirza, 2004). The average dry season flow of the Ganges in Bangladesh (measured at Hardinge Bridge) has shown a decline of 51 percent compared to the pre-Farakka flow (Tanzeema and Faisal, 2001). Much of these techno-political debates, albeit others, over the impact of the Farakka Barrage on Bangladesh are based on general observations and anecdotal evidences rather than sound analyses of relevant data (Mirza, 2004). Reduction of flow in the Ganges and Gorai might be caused by natural factors such as precipitation, river gradient etc. Since precipitation varies from year-to-year and regulates the river discharge, a decrease in precipitation in the upstream drainage basin in India and Nepal is one possible explanation. Mirza et al. (1998) analyzed precipitation records for 10 meteorological sub-divisions within the Ganges basin in India for the period 1871-1994 and 66 stations in Nepal for 1971-1990 and could not identify any significant increasing or decreasing trend (the only exception is the East Madhaya Pradesh which showed slight decreasing trend). Therefore, decreases in mean discharge in the Ganges and the Gorai Rivers should not be only attributed to precipitation changes (Mirza, 2004). Many studies strongly indicate that water diversion/withdrawal in the upper riparian areas might be the most significant factor of hydrological change in lower riparian countries (Abbas, 1986; Crow et al., 1995; Faisal, 2002; Mirza, 2004; Mirza et al., 2008). The reduced flow in the Ganges system has potentially wide-ranging socio-economic and environmental implications for Bangladesh including increased salinity in the inlands in the south western part of Bangladesh (Figure 2) (Khan, 1993; Crow et al., 1995; Khan, 1996; Mirza, 2004).

Farakka Barrage regulates the normal flow of water and hence velocity decreases. Due to the less velocity of the river current during the lean period the rate of sedimentation is quite high resulting in decrease in river depth / loss of navigability (Nishat and Faisal, 2000). Using stage-discharge relationship and regression analysis Mirza (2004) has shown that siltation in the Gorai river has increased beyond natural limit which is possibly induced by the diversion of water from the Ganges River at Farakka. The reduced supply of water in the Gorai river results in a virtually dries up condition in lean period. Likewise, another 117 rivers are reported dries up due to obstructions and withdrawal of water in their upper reaches (Rashid, 2012b).

Table 1: Mean monthly flows in the Ganges-Padma at Hardinge bridge (in m^3)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Flow													
a	3,090	2,668	2,287	2,031	2,176	4,489	17,290	38,348	36,063	17,870	7,091	4,180	11,685
b	1,932	1,482	1,155	1,063	1,450	3,569	20,111	40,183	39,233	16,685	5,730	2,943	11,295
c	1,436	788	576	712	1,309	5,016	20,269	32,596	32,243	14,798	4,133	2,151	9,663
Minimum Flow													
a	2,055	1,897	1,576	1,260	1,440	2,344	9,704	23,584	20,907	7,714	4,145	2,869	7,817
b	1,249	884	742	263	706	1,512	11,725	26,574	15,360	7,813	2,864	1,930	6,839
c	1,204	551	517	663	1,187	4,547	11,636	26,650	27,035	8,599	3,519	2,064	8,534

Note:
a: 1934-1974, pre-Farakka flows
b: 1974-1988, post-Farakka flows
c: 1989-1992, post-Agreement flows
Source: FPCO, Ministry of Irrigation, Government of Bangladesh, *FAP 25*, 1993

Water diversion in the upstream has affected the aquatic ecosystem in the Ganges including fishes and other aquatic species. The Ganges river system supports a large variety of fishes and prawns which need regular adequate water flow. But due to reduced flow and stagnation of the water in the dry seasons, aquatic organisms have been impeded and the increased water temperature has resulted in decreased oxygen levels creating an unfavorable condition for the riverine fisheries (Swain, 1996). Changes in hydrological regime in the Ganges due to Farakka have affected *Hilsa* (*Tenualosa ilisha*) and other species along with 12 species of prawns (Swain, 1996). Low flows in the dry season hampers its regular migration pattern (Hilsa stays in the river during spawning period, but grows in the sea), closing down the Goalundo Ghat landing station on the Padma River (combined flow of the Ganges and Brahmaputra Rivers) once famous for its large Hilsa landings (Mirza, 2004). In the very first year of the water withdrawal of Ganges, at three landing points in Bangladesh—Khulna, Goalunda and Chandpur—the percentage reduction in the landing of the fish during February to June 1976 compared to the corresponding period of the previous years was 75 percent, 34 percent and 46 percent, respectively (GoB, 1976). A significant decline in fishery in the upper Ganges basin area has also been witnessed in the last three decades (Sinha and Khan, 2001). Moreover, due to the decrease in groundwater and surface water, tremendous pressure has been exerted on wetlands to convert them to agricultural land (Bharati & Jayakodi, 2011), resulting in a serious decline in the numbers of water fowls and reptiles. With the reduction of forest and vegetation cover, a wide variety of insect populations have been severely depleted (Crow,1995)

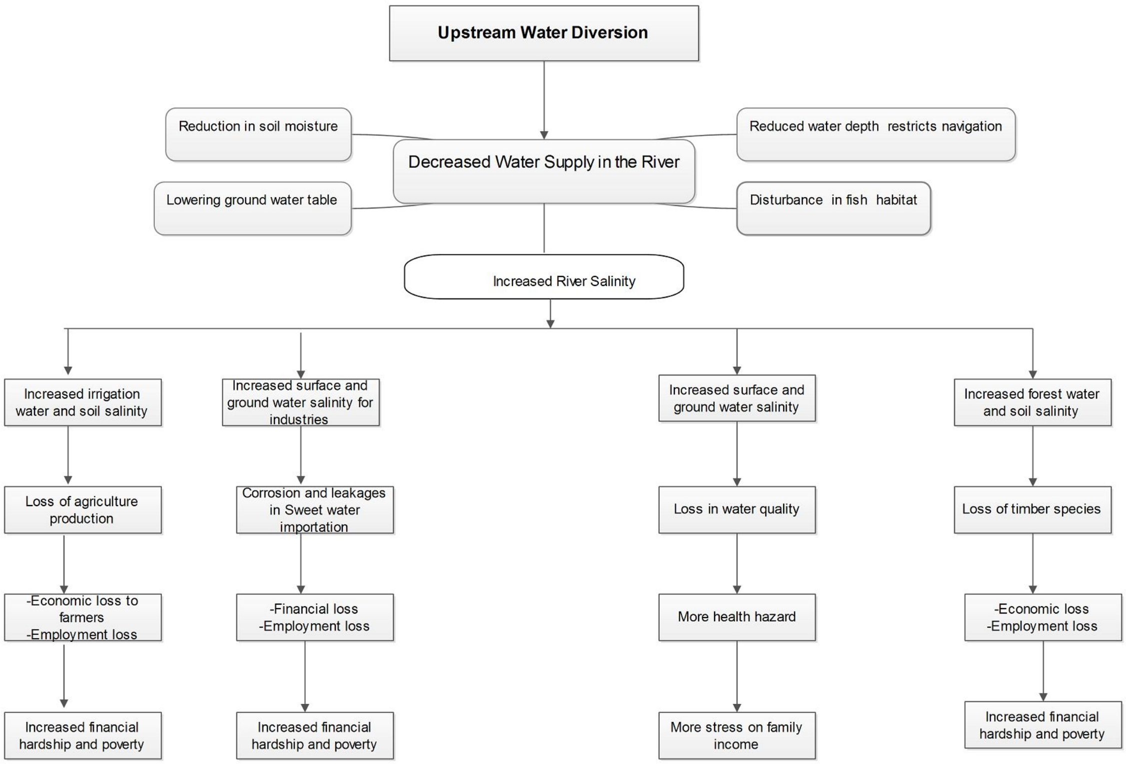

Figure 2: Impacts of water diversion at Upstream (Source: Adapted from Crow et al., 1995; Mirza and Sarker, 2004; Mirza and Hossain, 2004)

4.2 Water Salinity in South-Western Region of Bangladesh

The Farakka Barrage was commissioned in April 1975 and India unilaterally withdrew water from June 1975 to November 1977 until signing first Ganges treaty (Mirza and Sarker, 2004). In dry season the water level reduced drastically in the Gorai, the main distributary of the Ganges in Bangladesh, and the minimum level of water recorded was about 5.5 feet (Khalid, 2010). The discharge of Ganges at Hardinge Bridge reached a record low level, 23,200 Cusec (Haq, 1993; Khalid, 2010). As a result the river system of the Southwest region of Bangladesh starts to be affected by coastal saline water inflow in November, and reaches to a maximum in April and May (Mirza and Sarker, 2004). It is true that natural causes also have significant influence on the inter-annual variations of salinity, but fluctuations of the Ganges water flow, as controlled by the Farakka Barrage, might be the most important factor as salinity data of pre and post Farakka depicts (Table-2) (Mirza, 1996; Mirza and Sarker, 2004). The salinity situation started to improve after the signing of the 1977 Ganges Water Sharing Agreement, albeit, the situation again deteriorated after 1988 When the Second MOU expired. The 500 m-micro-mhos/cm (hereinafter referred to as m-mhos/cm) front moved 241 km from the coast in 1986 (MPO, 1986) to 280 km in 1992 (Khan, 1993). The highest salinity ever recorded was in 1992 for February, March and April when the flow in the Gorai River was zero. The April salinity rose to 29,500 m-mhos/cm, 1,800% higher than the pre-Farakka average (Mirza and Sarker, 2004). As a whole, salinity situation has aggravated in southwestern coastal region of Bangladesh during post- Farakka period. By analysisng salinity data of 20 years (1977 to 1997) in south-western coastal region, EGIS (2001a) study concluded that absolute salinity in south western region of Bangladesh has increased many folds over the years (Table-1). It would be partial if just Farakka barrage could be blamed for such salinity increase, but many studies indicate for a strong co-relation between Farakka barrage and salinity increase (Crow et al., 1995; EGIS 2001a; Mirza and Sarker, 2004) . For example, at the Khulna station, the average monthly maximum salinity for April in the pre-Farakka period was 1,626 During 1976, when the Gorai discharge declined to 0.5 m3/sec from its pre-Farakka average of 190 m3/sec, maximum salinity in April increased to 13,000 m-mhos/cm (Table-1) (Mirza & Sarker, 2004) . Since 1996, signing of second Ganges treaty, the situation has improved a bit, but still salinity increase in rampant due to sea level rise and increased tidal surge (Agarwal et al., 2003; Mirza et al., 2008). Nonetheless, Tanzeema and Faisal (2001) argued that first Ganges Treaty (1977) had been performing better than second Ganges Treaty (1996). Hence, Farakka barrage could be blamed for increasing water salinity in the south-western coastal region of Bangladesh, despite water sharing treaty under operation.

Likewise soil salinity also increased in the south western coastal region of Bangladesh since construction of Farakka Barrage (Khalid, 2010; Mirza & Hossain, 2004). Both sea water penetration and capillary rise of saline water from the underground water table are believed to be responsible for increased soil salinity in the greater Khulna and Jessore Districts. The use of saline water for irrigation makes areas more saline by the accumulation of salts in the soil profiles[4]. BWDB (1993) and EGIS (2001) reported increased soil salinity level in nine districts including both interior and exterior coast such as Khustia, Meherpur, Jhenidah, Faridpur, Gopalgonj, Narail, Magura, Satkhira and Bagerhat from the pre-Farakka period (Table 3 & 4).

Salinity intrusion is a cause of concern for environmental security, particularly for the lower riparian regions of the Ganges (Rashid and Kabir, 1998). Bangladesh, therefore, is more concerned about the increased salinity in the southwestern part of the country, caused by the decline in the Ganges flow. Despite the Indian claim that "withdrawal of 40,000 cubic meters per second at Farakka would have practically no effect at all," scientific investigations have clearly established that the dry season salinity level has significantly increased in the greater Khulna area since 1976 (Karim et al., 1982). Water diversion affects the dynamic balance of fresh and salt water aquifers, more particularly in the deep coastal zone where the recharge zone is located far from the coast along the Ganges. Any change in the quantity, timing, or direction of flows in inland areas can affect surface and sub-surface salinity in the coastal zone. Increased salinity has adversely affected agriculture, industry, and ecosystems in the entire region[5] (Begum, 1987; Karim et al., 1982)

4 Two salinity thresholds are considered in estimating the discharge requirements in the Gorai and Ganges Rivers. FAO (1976) recommended a 750 m-mhos/cm salinity level for irrigation. However, MPO (1987) accepted a level of 2,000 m-mhos/cm for the worst case scenario.

Table 2: Pre- and post-Farakka average monthly maximum salinity* at four stations in southwest Bangladesh

Station	January		February		March		April		May	
	Pre-Farakka	Post-Farakka	Pre-Farakka	Post-Farakka	Pre-Farakka	Post-Farakka	Pre-Farakka	Post-Farakka	Pre-Farakka	Post-Farakka
Khulna	293	1,254	371	3,396	467	8,305	1,626	12,149	1,508	11,208
Goalpara Power Station	340	515	397	1,303	750	4,422	1,320	7,422	786	5,456
Chalna	2,600	6,280	2,625	11,510	8,950	17,310	8,675	21,927	12,000	19,009
Mongla	2,300	5,200	3,900	7,880	7,500	11,075	11,800	17,150	13,500	17,100

** Salinity expressed in micro-mhos/cm (m-mhos/cm) and measured at 25°C* (Source: Mirza, 1996; Mirza and Sarker, 2004)

Table 3: Changes in areas (sq km) under different soil salinity classes between 1973 and 1997

Year	Slightly Saline (Km^2)	Slightly to Moderately Saline (Km^2)	Moderately to Highly Saline (Km^2)	Highly Saline (Km^2)
1973	2,676	2,675	2,596	2,934
1997	3,377	3,176	5,105	4,529
Change (+/-)	+701	+501	+2,509	+1,594
% increase	26.2	18.7	96.6	54.0

Source: EGIS (2001a)

Table 4: Soil salinity in selected districts at 15 cm depth (m-mhos/cm at 25^{o}C)

District Village/Thana	Year	January	February	March	April	May
MEHERPUR						
Gangni	1992	2,000	2,100	2,400	2,600	-
	1978	<1,500	1,800	2,000	2,200	2,300
Meherpur	1992	2,100	2,200	2,400	2,800	-
	1978	<1,500	1,600	1,700	1,800	1,600
NARAIL						
Laxmipasha	1993	2,000	3,600	-	4,100	4,200
Lohagara	1992	2,000	3,500	4,000	4,500	-
	1978	1,500	1,500	1,800	3,000	3,800
SATKHIRA						
Mirzapur	1993	2,500	3,500	-	5,600	5,500
Kalaroa	1992	2,800	4,000	6,000	5,500	-

Source: BWDB (1993).

4.2.1 *Impacts of increased salinity on the Sundarbans*

The Sundarbans, world's largest single tract of mangroves, stretching between Bangladesh and India, is complexly dissected and watered by the older distributaries of the Ganges, interconnected through a great web of meandering tidal rivers and creeks. Having positioned in the estuary, salinity plays a vital role in the physiological ecology of the brackish riparian components of the Sundarbans community. Each mangrove plant requires certain amount of salinity for growth and survival. Any fluctuation in salinity hampers natural ecological process. Increased salinity causes substantial harms to young plants, which are less resistant to salt. The adverse effects of increased salinity on the ecosystem of the Sundarbans is displayed by, among others, the dying tops of Sundari (*Heriteria fomes*) trees, retrogression of forest types, slowing of growth of forest, and reduced productivity of forest sites (MPO, 1986). Even though scientists are yet to come to a consensus over the causes of 'Top dying' of Sundari, but many studies indicate salinity increase as the most pressing cause (Swain, 1996; Agarwal et al., 2003, Mirza and Hossain, 2004, Potkin, 2004). Alteration of the hydrological regime due to anthropogenic and natural causes results in sedimentation, salinity increase and ultimately hampers aquatic ecosystems. Many studies found an increase in salinity and sedimentation in the rivers and creeks of south-western coastal region in the post-Farakka period (Crow et al.,1995; Swain, 1996; EGIS, 2001b; Mirza and Sarker 2004; Potkin, 2004; Bharati & Jayakodi, 2011) that ultimately affects both the floral and faunal community of the Sundarbans. Indian side of Sundarbans also has been encountering same problem. Experts suggesting augmenting flows in the Ganges to check salinity and stopping further intrusion (Bandyopadhyay, 1992; Potkin, 2004). India, therefore, proposed for inter basin transfer of water and completed a survey and investigation in interlinking of the Ganges river with the Sundarbans and taken up the same work for the Manas-Sankosh-Teesta-Ganges project (The Daily Star, 2012). However, many experts are skeptical about the idea. They reject the idea by arguing that such interlinking could increase dry land salinity further as majority of the rivers of the Ganges Plain and Northeast India originates from the Himalayan mountain ranges where the concentration of total dissolved solid is low and most of the rivers flow through arid or semiarid regions of the Ganga Plain (Misra et al., 2007). In such situations especially in the downstream, the concentration of salts will rise steadily with distance due to evaporation. The diversion of water through interlinking will aggravate the situation further as the salt concentration could be escalated by evapo-transpiration and will increase the dryland salinity (Misra et al., 2007).

4.3 *Declining Groundwater Level*

The availability of usable groundwater in the southwest region is 1,958 million cubic meters (mcm), which is only 4 percent of the national usable groundwater resources of 45,738 mcm (MPO, 1986; Mirza, 1996). It seems the region is not blessed with adequate ground water. Moreover, low rainfall and inadequate water flow in the rivers in the lean period do not effectively contribute to recharge the ground water aquifers. As relatively low rainfall and high evapo-transpiration create a high irrigation water demand, excessive withdrawal of groundwater for irrigation, limited recharge and flow from the groundwater table to the river as a 'base flow' have resulted in the lowering of groundwater and the upcoming of saline water in different parts of the Khulna division (Mirza, 2005). The decline of groundwater table became more evident in the Khustia and Jessore districts during the dry season, where in many areas the water_table dropped below 7 m from the pre-diversion period (Swain, 1996; Rashid and Kabir, 2004; Mirza, 2005). Excessive ground water withdrawal through hand tubewells and deep tubewells is the primary cause of ground water table declination, but surface and sub-surface flow reduction due to obstructions created by dams and barrages slow down the ground water recharge process (Crow et al., 1995).

Arsenic contamination is a matter of concern for both Bangladesh and West Bengal (India), and in many areas ground water found with arsenic beyond admissible limit as recommended by WHO (Rashid and Kabir, 1998). The arsenic problem becomes severe with the over extraction of ground water to meet the increased demand of drinking and irrigation water due to unavailability of surface water in dry season. The building of the barrages/dams and the drilling of tube wells resulted in repeated wetting and drying of arsenic bearing sulfides in organic rich sediments. Due to a lowering the water table oxidation of arsenic bearing minerals accelerates and cause arsenic to be released to the ground water (Bridge and Husain, 2002).

4.4 Flood, Sedimentation and Riverbank erosion

Bangladesh is one of the most vulnerable countries to flood having 80% of the land area being flood prone. Even in a normal year up to 30% land area of the country become flooded (Biswas, 2004, Mirza et al., 2005). Having a sandwiched location, in one side the Himalayas where most the rivers originated and in the other side the Bay of Bengal where the rivers fall into the Bay of Bengal crossing all the way land area, Bangladesh bears the brunt of flooding in the GBM region (Mirza et al., 2005). A variety of factors like flash floods from neighbouring hills, inflow of water from upstream catchments, overbank spilling of rivers from in-country rainfall, and drainage congestion are responsible for flooding in Bangladesh. The situation becomes disastrous when flood-peaks synchronize in all the three rivers (Biswas & Uitto, 2001; Mirza et al., 2005). Sedimentation that is being carried by the GBM rivers from the mountains to the plains contribute to furthering the situation through raising river beds that significantly reduces water holding capacity of the rivers. Any water diversion/withdrawal structure, therefore, decreases the velocity of current and increase sedimentation rate that aggravate the flood situation (Biswas, 2008). Activities in the upper reaches of the drainage basin obviously affect the sediment characteristics in the lower basin (Hasan and Mulamoottil 1994). Moreover, a negative balance may develop because of the water and land management practices upstream (Datta and Subramanian, 1996).

The sedimentation, on the other hand, is regarded as the blessings for this region forming the vast Indo- Gangetic alluvial plains. The sedimentation on the flood plain forms the natural soil, increases the fertility of the soil, and makes raising land. The proposed interlinking of rivers may cause large reduction in the sediment deposition, which could affect the natural land up-gradation process on the flood plains for cultivation carried out by river. Moreover, it could retard the formation rate of emerging islands along the southern coast of Bangladesh (Misra et al., 2007).

Flood is also a problem in the GBM plains of India. About 68% of total flood prone area in India lies in the GBM states, mostly in Assam, West Bengal, Bihar and Uttar Pradesh (Biswas & Seetharam 2008). The Ganges in northern India, which receives waters from its northern tributaries originating in the Himalayas, has a high flood damage potential, especially in Uttar Pradesh and Bihar. Likewise, the Brahmaputra and the Barak (headwaters of the Meghna) drain regions of very heavy rainfall and produce floods from overbank spilling and drainage congestion in northeastern India. Bangladesh and India built many dams and embankments in the GBM region to control flood and facilitate irrigation. But their contribution to flood control is minimum as observed by many studies (Faisal, 2002; Aylward et al., 2005). The Farakka water sharing treaty focuses only on dry period water sharing leaving any responsibility for monsoon heavy flow regulation, therefore in case of heavy rain in up-streams Bangladesh become the most victim as a downstream country. Conversely, flood occurrence has increased in Indian side due to drainage congestion.

River bank erosion, on the other hand, could be a by-product of flood or a natural phenomenon occurred when a river changes its course. Every year Bangladesh experiences riverbank erosion, especially in the Brahmaputra river system. Large seasonal variations in river flows and the gradual loss of channel depth cause banks to erode and river courses to change (Mirza et al., 2005; Biswas, 2008). However, the situation becomes more complicated when the river courses change are attributed by human intervention. If one country builds flow diversion structures to protect a border town from erosion, which in turn causes erosion of the opposite bank, the community living on the eroded side may interpret this as a deliberate act of territorial expansion (Faisal, 2002). For example, the Muhuri river is under such dispute where India has built dam which causes bank erosion in Bangladesh side.

4.5 Agriculture and Irrigation

Introduction of High Yielding Variety (HYV), mostly in the boro season, has significantly increased irrigation demand in the mid seventies and onwards. People living in the Ganges basin area used to irrigate the crop field by Low Lift Pumps (LLPs) and low gravity irrigation from Ganges-Kabadak (G-K) canals in Bangladesh. However, the scenario started changing in the post-Farakka period with increased water demands and decreased surface water availability in the Ganges and its distributaries and tributaries (Bharati & Jayakodi, 2011). BWDB (1993) reported that irrigation by DTWs, STWs and indigenous methods was increased while irrigation by LLPs and G-K Canal has decreased considerably compared with 1991-1992. Due to water withdrawal at Farakka during the dry season, the water level in the Ganges drops abruptly and most of its distributaries become dry (Mirza and Hossain, 2004). BWDB (1993) further reported that due to less rainfall and reduced water shortage in G-K canals a considerable amount of crop was damaged.

The northwest and southwest regions of Bangladesh, where the Ganges basin is located, are naturally drought-prone areas. Inadequate rainfall and excessive water demands creates this situation (Linseley et al., 1975). Local agriculture used to cope with this situation by irrigation from the surface water sources that include the Ganges and its distributaries, ponds, and other water bodies (Mirza, 2004; Bharati & Jayakodi, 2011). However, in the post-Farakka period the drought situation has aggravated with combined effect of meteorological and hydrological drought in the Ganges basin (Mirza, 2004). The growing water demand in drought-prone areas is affected by reduced water availability (Table 5) (IWM, 2008), because of upstream uses and regulation, saltwater intrusion, salinization of aquifers and declining ground water tables (EGIS, 2001b).

Table 5: Seasonal fluctuation in surface water availability and overall demand

	Critical dry period (February–April)	Wet season (June–October)
Average water Availability	60 billion m^3	1,030 billion m^3
Demand	90 billion m^3	142 billion m^3

Source: IWM, 2008

Since the surface water scenario has been indicating a conflicting present and worrying future, transfer of so called 'surplus water' to'water deficit areas' through river linking project would definitely attribute another conflicting dimension . The concept of 'surplus water' is itself faulty, as a reduction of surplus/flood water will affect the surface water supply in terms of quantity and quality as well. India has an average annual flow of 1,869 billion cubic meters (bcm) of which 1,122 bcm is useable, distributed seasonally during the monsoon period (Bandyopadhyay, 2004). In India per capita availability of water has reduced from 6008 CuM to 2266 CuM since 1947 to 1997 (Bandyopadhyay, 2004).
Reduction in surface water will also cause reduction in ground water, i.e., lowering of ground water in one area, hampering the irrigation, and in other areas causing the problem of water logging again affecting the crop yields. Under the circumstances, either cost of production will be high or productivity will be reduced. Farmers will be directly suffered (Misra et al., 2007).Another significant cause of yield reduction might be change in agro-climatic patterns, as reported by many farmers (Titumir and Basak, 2011; Mirza & Hossain, 2004). Adel (2002) argued that with the diversion of water for about three decades, land features in the Ganges basin in Bangladesh have changed, and consequently, the thermal properties of the surfaces and climates have also changed.

4.6 *Migration/ Displacement*

Involuntary or forced migration has received attention of the policy makers now-a-days with the changing climate, more particularly high percentage of the population migration from the Khulna-Sathkhira and Rajshahi regions (western Bangladesh) due to flood, cyclones, salinity intrusion, river bank erosion led one to believe that hydro-meteorological events are more responsible for forced migration than economic or social factors. While analyzing migration data of Rajshahi and Khulna regions, Ahmed (2009) indicates that there might have a strong correlation between migration and Farakka led water scarcity. Swain (1996) makes a link between the diversion of water at Farakka by India and forced migration of Bangladeshi citizens to other parts of the region, including India. Swain pointed out: "*It is true that the Ganges water dispute is an excellent case* *study of an inter-state conflict where two state actors are striving to acquire scarce water resource by rationally calculating their interest in a zero-sum situation. However, the resulting environmental destruction in a vast region of Bangladesh has added another important dimension to it. The loss of agriculture, closure of industries and navigation facilities, drop in fish catching, dying of valuable forest resources, disappearance of land due to river bank erosion and devastating floods, have no doubt, resulted in the loss of source of living of a large number of populace in Khulna and some parts of Rajshahi region of Bangladesh, which seem to necessitate their migration from the homeland in the pursuit of their survival"* (Swain 1996). India's construction of broader wide barbed wire fencing to Bangladesh also supports the truth of involuntary migration.

However, it would be over simplification and rhetoric largely if someone only point Farakka Barrage as the single most causative factor for migration. Ahmed (2009) shows that a considerable number of population also migrated to India from Dhaka, Thakurgaon,and Faridpur districts which are not directly affected by the withdrawal of water at Farakka. There are some other factors are relating to environmental disruptions reproducing environmental refugees, need to be scrutinized carefully. In addition, environmental destruction not only creates resource scarcity conflicts, but these forced migrations further have led to native–migrant conflicts (Swain, 1996).

5. Gaps in Knowledge

It is important for the riparian countries to share hydro-meteorological, physical, environmental and socio-economic data for the integrated management of the river basins and water resources. Information-sharing can usually provide confidence-building measures among riparians. Unfortunately, India and Bangladesh classify river flow data as secret and use the lack of mutually acceptable data as a tactic to promote their own national interests (Beach et al., 2000: 51; Abbas, 1984). The inaccessibility to adequate data and knowledge of the ecological processes associated with the Himalayan rivers has enhanced the ecological complexity of the GBM region (Bandyopadhyay 1992, 2004; Bandyopadhyay et al., 1997). Through the India–Bangladesh Joint River Commission, mutually agreed hydrological data should be made publicly available. Mechanisms for "open information flow" should be included in future treaties.

Feasibility studies on government-led engineering projects in the upper stream were confined to the narrow perspective of economics; very little attention has been paid on the broader social and ecological dimensions. Widespread human interventions have been made in the GBM region in order to satisfy certain myopic economic needs, without really looking into long-term economic, ecological, social and political implications. The inherent economics of water and poverty has not been adequately conceived in the GBM region, whereas the missing fundamental understanding of Himalayan ecology has precluded the importance of applying important instruments provided by the discipline of ecological economics in the planning and policymaking process of the GBM basin (Gosh and Bandyopadhyay, 2009). It is, therefore, imperative to understand and internalise the ecological characteristics of the GBM region, given the knowledge gaps and uncertainties integral to the origin of the rivers (Gosh and Bandyopadhyay, 2009; Bandyopadhyay 1992). Crucial elements of this uncertainty are in the consequences of the great differences in the peak and base flows in the GBM rivers; the generation, transportation, and deposition of high sediment loads; the rapid changes in the river courses in the foothills and flood plains; the relationship of the flow with large biological productivity of the river; the impact of climate change on the hydrological features, estuaries and the coastal areas; and so on (Gosh and Bandyopadhyay, 2009). These issues need to be taken into consideration in any future research agenda.

The intense monsoonal rainfall on the geologically unconsolidated and tectonically active Himalaya makes the associated ecological processes complex. The Himalaya generates very large sediment loads in the rivers. This is particularly true for the rivers emerging from the eastern Himalaya, where the monsoon precipitation is the most intense. Thus, in the eco-hydrological description, rivers emerging from the eastern Himalaya are to be taken as constituting a combined flow of sediment, water, and energy. For example, the Kosi, a Himalayan tributary to the Ganges, carries 8.220 tonnes of sediment annually per sq km of catchment area, while the Teesta, a Himalayan tributary to the Brahmaputra, has recorded annual sediment load of 12,510 tonnes per sq km. Further to the east, tributaries of the Brahmaputra like the Dibang, the Subansiri, the Manas, and many others also carry large amounts of sediment (Hasan and Mulamoottil 1994; Milliman et al., 1995; Faisal, 2002). Integration of the knowledge of the dynamics of the sediments with the flow of water would make engineering more ecological. Further analysis is required to understand the shortcomings of the structural intervention at the upper Ganges in light of ecological point of view.

Little attention has been paid on understanding the emergence of appropriate type of institutional mechanism on regional cooperation, or a detailed comprehensive evaluation of the types of costs and benefits that might evolve, given the hydro-political dynamics of the basin. Thus there is an immense opportunity in the basin, in terms of creating a comprehensive interdisciplinary framework for evaluation and hydro-diplomacy with the discipline of economics being the backbone to the framework (Gosh and Bandyopadhyay, 2009).

6. Future Research Questions

● Continued investments in huge structural interventions is being challenged by those who believe higher priority should be assigned to projects that meet basic and unmet human needs for water (Gleick, 1993). The US, which started the global trend of building large dams, is following "… a new trend to take out or decommission dams that either no longer serve a useful purpose or have caused such egregious ecological impacts so as to warrant removal. Nearly 500 dams in the USA and elsewhere have already been removed and the movement towards river restoration is accelerating" (Gleick et al., 2001). The World Commission on Dams (WCD) has also drawn global attention to the problem of limited vision of the traditional approach of engineering interventions to the rivers. There is a need for a comprehensive assessment of water development projects keeping the integrity of the full hydrological cycle.

● Understanding the trade-offs between ecosystem and economic services in the GBM region through an integrated river basin approach.

● It requires an in-depth study to what extent Sundarbans ecosystem and its associated services have been affected due to structural interventions in upstream and natural causes

● Environmental security necessitates in-depth knowledge of the diverse demands and requirements of water. The present approach to governmental water management in both countries is based on traditional perspective. There is serious need to evolve an ecosystem-based perspective and what benefits this approach can bring.

● The regular monsoon inundations are summarily seen as “flood disasters” with a relief dominated approach to their management. In terms of trans-boundary water relations between Bangladesh and India a holistic understanding of the monsoon flows, and the ecosystem service they offer, is lacking.

7. Conclusion

Analysis of trans-boundary environmental regimes runs the risk of being off-mark if detailed complexity of cooperation is not explicitly considered (Zeitoun & Mirumachi, 2008). A narrow focus on the existence of data-sharing between some Indian and Bangladeshi institutions instead of on the very active political nuances of inter-state relations related to the water conflict on the GBM rivers may not be adequate, the foundational issues that underpin the water conflict (which cannot in any case rationally exclude upstream Nepal) may be overlooked in that case (Zeitoun & Mirumachi, 2008). The value of cooperation over the selected issues should be understood within the political context of riparian interactions. In fact, conceptualizing ‘environmental security’ as primarily concerned with potential conflict over scarce or degraded resources should broaden its scope to consider environmental problems beyond national interests. Thus, understanding of environmental security with particular emphasis on protection of the environment itself is the need to highlight common concerns that can help to counterbalance the preoccupation with competing state interests (Najam, 2003). Indeed, environmental security in relation to trans-boundary resources can only be achieved through an ecosystem orientation of international norms and regimes flows. For a longer term solution, only freshwater regimes built upon ecological criteria can ensure the security of the environment itself (Najam, 2003). The primary concern for GBM region is sustainable human development for peace, stability, and an enhanced quality of life that could be achieved through water-based regional cooperation, i.e., a regime of regional cooperation of which the entry point is water but which then expands and embraces all possible directions as it gathers momentum (Biswas, 2008). It is therefore obvious that both upper and lower riparian countries would collaborate effectively to ensure lasting solutions to the common water-related problems such as flood, drought, erosion, sedimentation, and water quality deterioration. (Faisal, 2002; Label et al., 2010)

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