Chapter

Coastal Water: Wisdom, Destruction, Conflicts and Contestation – A Case of Southwest Coastal Region of Bangladesh

Hamidul Huq and Tahmid Huq Easher

Abstract

The coastal zone of Bangladesh is full of opportunities and vulnerabilities. Water is the central source of these opportunities and vulnerabilities. Seawater, river water, canal water, floodplain water, wetlands water, pond water is the dominant source of livelihoods of coastal people. The propel of the coastal economy is dependent on this water. But salinity alone creates vulnerability of the economy and people dependent on this water. Tidal surge, storm surge, drainage congestion, waterlogging, saline water aquaculture are the driving forces of water crises. Water crises are the unsolved issues ever despite large scale interventions. A shortage of freshwater suffers coastal people ever in regards to crop production, drinking water, health, aquaculture, and so on. Uncertainties driven by cyclones, river erosion, outsiders' interventions-led consequences are the big challenges of the coastal zone in managing water. Coastal people are challenging, resilient, adaptive, and strong in contestations in managing water resources for their livelihoods. They exploit the opportunities using their ability of reconstruction.

Keywords: salinity, tidal surge, storm surge, water crisis, water logging, uncertainties, adaptive management, water rights, water management, contestation

1. Introduction

Coastal zones refer to areas where land and sea meet. The coastal zone of Bangladesh is delineated in various ways. Drawing upon a five years long empirical research (2001–2006), the three basic natural system processes and events that govern opportunities and vulnerabilities of the coastal zone of Bangladesh are tidal fluctuations; salinities; and cyclone and storm surge risk [1]. Based on these criteria, the boundary of the coastal zone of Bangladesh consists of 19 districts, where around 42 million people of 158.9 total population of Bangladesh [2] live, with a density of 743 people per sq.km, in a land area of 47,201 sq.km, which is 32% of total land area (147,570 sq.km) of Bangladesh [3]. The projected population of the coastal zone in 2050 is 58 million [1]. There is around 34,775 sq.km area of agriculture land, which is 28% of the total agriculture land area (122,954 sq.km) of Bangladesh [2].

It is widely argued that water scarcity throughout the world will put mounting pressure on one of the most abundant freshwater ecosystems on earth. Like many large water basins, the Great Lakes water tension has already begun [4], and water tension in the Southwest Coastal Region of Bangladesh has been on escalating trend. As long as coastal water used to be managed by the local people using their wisdom, ecosystems of all forms were functioning naturally. Until the introduction of hard civil engineering designed plans (since 1961), the ecosystems of both freshwater and tidal saline water were as active as is it naturally possible in the southwest coastal region of Bangladesh. These structures are popularly known as 'Polder' under the Coastal Embankment Project. Their purpose was to protect the wetlands from saline water intrusion towards allowing farmers to grow rice at least two seasons a year. But these poorly planned water projects inherited issues like water scarcity, crisis, tension and conflicts in the coastal region. To address the issues generated by the immediate previous projects, one after another structural engineered projects were implemented under the policy arguments of the government, which nothing but magnified the issues.

However, water has always been an emotional issue in the region for thousands of years, but the structural engineered-dominant projects have been creating confusion among the different stakeholders – farmers, fishers, environmentalists, sociologists, and many others. Now the question is, are the millions of people living in this region can be freed from these confusions? It is argued (Ibid), though water issues often vexing, the public is obligated to understand them because water is the foundation of the ecosystem that keeps humans alive. But the abundance of freshwater in the region has been converted into scarcity and uncertainties by the influences of engineering structural water projects over the decades. It is important to help the general public bring the water into focus. Attempts are needed to engage the citizen and the young scientists, academics, professionals in this most important challenge/effort to protect the globally significant waters of the respective region for the next century and beyond.

2. Methodology

This article is written using data of the author's fieldwork mostly focused on the southwest coastal region of Bangladeshduring the 1991's post-cyclone period, ICZMP project during 2002–2005, post-cyclone Sidr in 2007, IWRM research project in 2007–2012, peri-urban water security research project in 2013–2015, ESPA-Delta research project in 2014–2017, women in aquaculture research project in 2014, and the author's post-doctoral research project in 2013–2014 in the coastal zone. The author has interviewed nine key informants among academics, NGO leaders, environmental activists, government officials, and journalists. Rigorous consultations of literature were done to complement the findings from the field research.

3. Coastal water resources system

The Coastal Water Resources System is defined as an integrated system, which performs various functions that refer to the capacity to support and control either natural systems such as storage of floods, facilitation of fish migration or assimilation of wastes; or human and economic activities, e.g., supplying water for domestic purposes, or providing navigable conditions in rivers. The coastal water resources system is naturally a productive system that produces goods and services for meeting up human needs as well as for the maintenance of ecosystems.

It has got an extensive range of water bodies including water resources sub-systems, which are an interlinked system of tidal rivers and channels; riverine flood plains including wetlands; intertidal lands along the coast and estuary branches; lakes and man-made ponds; the groundwater aquifer; and the sea [1]. The Bay of Bengal is the reservoir of seawater (saline water) along the Bangladesh coast. It is a northern extended arm of the Indian Ocean. The total area of the Bay of Bengal is about 510,000 sq.km.

The main sources of fresh surface water are the Ganges, Brahmaputra and Upper Meghna. These mighty rivers drain a basin of about 16,550,000 sq.km, which provides more than 92% fresh surface water to the coastal zone of Bangladesh [1]. The Coastal Zone has a capillary network of rivers and channels, most of them under a season-dependent tidal regime with twice daily variations of water levels and salinities. Ponds are common features in the coastal zone of Bangladesh as the reservoir of freshwater. Ponds are manmade and of different size and shape and depth and are used for different purposes like fish culture, household purposes, drinking water.

4. Salinity

Salinity is defined as the salt concentration, e.g., sodium and chloride in water, which is measured in the unit of PSU (practical salinity unit. Generally, the average salinity in the global ocean is 35.5 PSU, while freshwater like rivers or inland lakes has salinity close to 0 PSU. Observation of river salinity in the coastal zone of Bangladesh is around 10 PSU to 30+ PSU [5]. Salinity plays a significant role in the processes of the water resources system in the coastal zone. The landward intrusion of saline water determines its usefulness for drinking, household purposes, irrigation, aquaculture and other purposes. Salinity distribution in the estuary is strongly influenced by seasonal changes. During the monsoon (June through mid-October), salinity in the estuary drops and water becomes almost fresh. Salinity increases forthe rest of the time of the year with the effect of low discharges of freshwater from river Meghna, or due to further penetration of tide into the river system [1].

Salinity increases have also been caused by the effects of human interventions, e.g., upstream withdrawal of water and reducing the size of flood plains, dry season flow of the Ganges River has decreased since the Farakka barrage was built in India. Farakka Barrage is across the River Ganges located in Murshidabad district in the Indian state of West Bengal, roughly 18 kilometers from the border with Bangladesh near Shibganj. Construction was started in 1961 and completed in 1975 at a cost of US$22 million. Operations began on 21 April 1975. The barrage is about 2304 meters long. The Feeder Canal (Farakka) from the barrage to the Bhagirathi-Hooghly River is about 42 km long having 109 sluice gates. The purpose of the barrage is to divert 1800 cubic meters per second (64,000 cu ft./s) of water from the Ganges to the Hooghly River for flushing out the sediment deposition from the Kolkata harbor without the need for regular mechanical dredging. Out of 109 gates, 108 are over the river and the 109thone over the low-lying land in Malda, as a precaution. The Barrage serves water to the Farakka Super Thermal Power Station. There are also sixty small canals, which can divert some water to other destinations for drinking and other purposes [6]. It has been observed that this water diversion generated negative impacts in the downstream such as salinity levels raised, contaminated fisheries, hindered navigation, and posed a threat to water quality and public health [6].

Another driving force of the increasing trend of salinity is 'Polderisation' in the coastal zone. After the devastating flood of 1954 and 1955, the United Nations commissioned an international mission (known as 'Krug Mission') to solve the flood problem of the country. Following recommendations of this mission, the government implemented the Coastal Embankment Project (CEP) during the 1960s, which included the construction of 'Polders' to protect coastal flood plans from saline water intrusion and tidal surge. A Polder includes [earthen] embankment, sluice gates, and canals. Polderisation follows a process of first: construction of embankment/dike around a low lying area; then the construction of sluice gates to regulate water in and out; excavation of canals to keep internal drainage system active, and to replace the water in the reclaim area with freshwater. Empoldering can be carried out in coastal and inland areas such as lakes. Polders are enclosed by dikes to keep out the sea. To prevent the polders from being waterlogged, they are managed by drainage canals and pumps. Pumps and drainage canals are used to drain the area.

However, the 'polders' and subsequent flood control and irrigation projects converted the wetlands to dry land to facilitate the introduction of high-yielding variety rice which requires controlled irrigation. These interventions disconnected the wetlands from the rivers and prevented sediment formation inside the wetlands which gradually caused the drainage congestion of the rivers as the sediments deposited on the river bed and the river bed became higher than the wetlands in the surrounding basins. Nature's reaction against the intervention was already building up, siltation started getting deposited at the water entry point of the sluice gates, and rivers and canals' bed height began to increase, which resulted in water logging for huge areas and salinity in soil and water of all sources increased up to a level that they were unusable.

Diversion of the Ganges water at Farakka has caused increased river salinity in the southwest region of Bangladesh to intrude further inland. Both the coastal polders and the Farakka barrage had contributed to the gradual siltation of the coastal rivers and are the principal factors contributing to the tidal water level extremes. The coastal agriculture, forestry, industry, and drinking water sectors have suffered enormously as a result of salinity changes in recent years [7, 8].

Saltwater shrimp farming contributes increasingly higher salinity in the coastal zone, especially the southwest region of Bangladesh, since the 1990s. During this time there was a high demand for shrimp in the export market. The outside businessmen, in collaboration with political power and partnership with local large landowners, initiated shrimp farming displacing rice cultivation. Over the 10 years, almost a hundred percent polderised flood plains/agriculture fields got transformed into saltwater shrimp farms. This practice of shrimp farming is continuing. The permanent existence of saltwater in the flood plains generated extreme salinity in soil and surface and groundwater. However, surface salinity is relatively high across the coastal zone. It is projected that salinity will increase in river channels. This increase is more pronounced in the central and western regions with implications for agriculture, shrimp farming and local well-being [5].

5. Water ecosystems services

Until the 1960s, there was no 'development intervention' in water resources development in the coastal zone of Bangladesh. Coastal people enjoyed the ecosystem services of water to meet up their needs. Ponds were used as a source of drinking waterand also as the rainwater reservoir that served the villagers around with freshwater round the year. Open water fisheries were highly adequate. Almost every villager caughtenough fish from floodplains, canals, rivers for their consumption. Farmers grew one crop (Rice) a year. They created seasonal earthen dykes to protect their cropland from saline water intrusion and after harvesting, they abolished the dykes. Farmers also grew some other crops like lentil, mastered seeds, etc. in high lands that are free from tidal surge. This environment refers to a statement that the coastal zone is an attractive place to live and work, with more than 500 million people, including 40 million in Bangladesh coastal zone, living in this environment worldwide [9]. The ecosystem services in the coastal zone, until dominant development interventions, provided for and enhanced the well-being of its human populations. Of course, the benefits to society from nature are dependent on biotic and abiotic earth systems and how these systems interact with social-economic and governance structures (ibid).

The following decade of dominant development intervention in the form of polderisation in the coastal zone in the 1960s experienced social-economic and governance structures' interactions with ecosystems services. The central purposes were served – tidal floodplains were protected from tidal surge and saline water intrusion; three crops of rice in a year in polderised flood plains. Food security was ensured. But, the next decades until the present time, the ecosystems, particularly water and land, experienced destructive interactions with social-economic and governance structures by the massive increasing expansions of saline water shrimp aquaculture in the polderised flood plains displacing rice cultivation.

6. Destructions in water ecosystem services

Increasingly massive shrimp aquaculture influenced changes in water and land use - altering agricultural lands into shrimp farms bringing saline water into freshwater fed croplands. Since the 1980s, shrimp aquaculture was started in the *ghers* - *ghers* are shrimp farms surrounded/impounded by earthen dykes, situated by riversides [10]. Two main factors together provided a catalyst to the process of accelerated shrimp farming: strong international market demand and high prices for shrimp product; and it was no longer financially viable to cultivate rice because the polders had become waterlogged due to poor drainage [11, 12].

Changes in government policies made the shrimp business highly lucrative, shrimp took over as the biggest export earner of Bangladesh [12]. The yearly revenue of saltwater shrimp (*Penaeus monodon,* locally known as *Badga*) were high compare to agriculture. The price for 1 kg of shrimp was up to BDT800 ($10), compared to BDT 25 (32 cents) per kg of rice, with much lower labor and input costs for shrimp. Shrimp was widely considered as 'white gold' that would lead to economic growth and the large farmers converted their agricultural land to shrimp aquaculture farms without considering the negative impacts in long run [13, 14]. With this economic incentive, *gher* owners moved their operations inside the polders by taking land on lease from medium and small farmers, applying muscle power and coercion. Against the law, the *gher* owners bring saline water into the polder by breaching the embankment, saltwater (Bagda shrimp) shrimp aquaculture, which was the beginning of the non-reversible loss of ecosystem services other than saltwater shrimp [15].

Although shrimp farming has a significant impact on the economy of Bangladesh, it has high environmental costs, including the destruction of green vegetation, reduction in crop production, especially rice. Shrimp farming has altered the physical, ecological (aquatic and terrestrial), and socio-economic environment.

Over the decades of the 1980s and 1990s and beyond, shrimp farming has emerged as a major industry in Bangladesh, which has impacts on economic, social and environmental dimensions. The increased salinity in water has created good conditions for shrimp cultivation, a practice that is now the main reason for the increasing soil salinity in Bangladesh. The salinity of shrimp cultivating areas is approximately 500% higher than in non-shrimp cultivating areas, which is extremely contradictory to official purposes/objectives of polderisation under the Coastal Embankment project [16].

7. Water crises for agriculture

'*Water, water everywhere, but not usable for agriculture*', pointed by the farmers of Paikgacha of the southwest coastal region dramatically. This is a common situation concerning the availability of freshwater for irrigation. Saltwater aquaculture, waterlogging, storm surge, salinity in groundwater generated water crises for agriculture activities like plowing/tilling the cropland, raising paddy seedlings, etc. Farmers are to use low quality and inadequate water for irrigation, which reduced the crop yield to the extent that the farmers lost interest in cultivating crops because they cannot afford it. It is also a condition that the growth of rice plants decreases with increased salinity in irrigation water. The groundwater is highly affected by salinity and sodium and continuous use of such irrigation water, causes high sodium soils, breaks down the soil structure, and reduces soil aeration and water infiltration [16–19]. Rainwater is the only source for irrigation of *Aman* rice for most farmers. Heavy rain is required to wash out the soil salinity at the beginning of the rainy season. But, in recent years the rainfall pattern has changed. Rainfall has become erratic and there is a decreasing pattern of rain in the early monsoon which is unfriendly to agriculture. The amount of rainfall is decreasing particularly in the pre-monsoon and monsoon periods.

In the past, farmers used canal water for irrigation, which was fresh. But, since the recent past, the canal water cannot be used for irrigation purpose anymore because of its salinity, which is the contribution of saline water shrimp farms. The condition of pond water is also the same. Besides, the ponds and the canals are occupied by the shrimp farm owners through the means of manipulations and merged with shrimp farming. This practice refers to the absence of good governance and practices of *mal-governance* of water resources management and denial of rights to use of water resources for many purposes of the local people.

One alternative source of freshwater is groundwater, which is not easily available in the coastal zone of Bangladesh. The freshwater table is so deep (250–350 meters, is mostly unavailable) [20]; installation costs of a deep tube well are costly, most farmers cannot afford it. Large farmers privately install deep tube well and supply irrigation water to others on payment, which is also expensive for the medium and small farmers and sharecroppers. The consequences of the excessive amount of water pumped up from the ground/aquifer with the amount recharging it increases the entry of saltwater into freshwater aquifers [16, 19, 21].

8. Water and livelihoods

Water is Life. No one can disagree with this discourse, as long as we are respectful of 'water wisdom'. Wisdom here refers to responsibility that uses in multiple senses: responsible use of water resources; reasonableness towards other uses of water; awareness of what our actions and interventions mean to others, particularly the poor and disadvantaged; and responsibility towards future generations, other forms of life and nature [22].

Livelihoods refer to 'poor' people's living. For them, earning bread is a livelihood. Earning to meet up the basic needs (food, cloth, shelter, health care, and

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education) is livelihoods. The term livelihood is associated or relevant or applicable only for the 'poor people'. It is applicable only in addressing 'needs'. If it is beyond that, meaning fulfilling 'wants', then it refers to economic growth, which in other words 'economic development'. Economic growth and development refers to meeting up 'wants', which are unlimited, endless, and known as man's greed.

The Coastal zone of Bangladesh was once prosperous fisheries and agricultural hub. Freshwater was available; saline water was beneficial because it flows naturally; the forest was full of resources to serve local people: and the villages were rich in having trees of fruits, timbers; households had have cows, chicken and duck. Overall, the ecosystem services were available at a level that served local people's livelihoods. This inspired me to recall Mahatma Gandhi, "Earth provides enough to satisfy every man's needs, but not every man's greed". Water ecosystem services were available in ample quantity – fishers could catch fish from open water enough for their consumption and to sell for earning cash income; other villagers could catch fish enough for their consumption; villagers could collect vegetables of many types from the crop fields for their consumption. Due to sufficient natural siltation, there were enough crops; there were practices of shared cropping, which provided the landless and small farmers to grow rice that was enough for their annual food stock. Rich bio-diversity and natural environment supported livestock. Farmers were depended on each other for their agriculture work, which kept them tightened in collective initiatives. Thus they lived in harmony; there was little space for inequality and limited power exercise between themselves or by external forces; rich bio-diversity and open access to the natural food sources allowed the poor and disadvantaged people to avoid conflicts with landlords or big farmers [23]. The family structure was simple, joint family – everyone worked and earned for the joint family, work between men and women were segregated; the females looked after the household and in addition to that grew vegetables, fruits and took care of livestock adjacent to their household (ibid).

Today, communities face a regional depletion of natural resources including safe drinking water, and struggle to maintain livelihoods. Both natural and polderisation-induced disasters and the effects of climate change place increasing pressure on the region, hindering livelihoods. Over the past 40 years, development interventions made modifications to the natural environment by controlling the tidal water/rivers. But they failed to control storm surge which is a driving force of ecosystems destructions. On top of that, sponsoring shrimp farming displacing rice production, sponsoring aquaculture in rice fields that centralized the controlling of natural resources in hands of the rich and powerful elites; constructions of engineering infrastructures (roads, bridges that improved transportations to do marketing of industrial products to coastal zone), created huge drainage congestions of rivers, canals, channels. The introduction of tube wells and PSF (pond-sand-filter) technology for drinking water supply by displacing the thousands of years of practice of using [protected] ponds as a dependable (sustainable) source of drinking water. These modifications have caused extensive environmental damage to the point where we are today. Livelihoods are under big threats and the natural environment is extremely fragileand under increasing pressure.

Livestock makes vital contributions in the rural livelihoods in respect to both diet (milk and meat) and generation of income. Livestock faces mainly two types of vulnerabilities due to increased shrimp farming: reduced sources of fodder, and increased mortality rates because of salinity. Saltwater shrimp farming occupied state-owned lands where the people grazed their cattle and also reduced the quantity of fodder and other cattle feed. The current number of cattle had decreased significantly compared with the number of cattle before the period of shrimp farming. The poor farmers either sold their livestock or took them outside of shrimp farming areas [24].

The people's practice of conflicting livelihoods that the contestation between saline water and freshwater in the southwest coastal zone in Bangladesh, can be traced in history in the way water has been managed and the way political-economic forces influenced water systems [25].

The unique tidal wetlands of the southwest have always maintained some level of salinity yet the soil remained fertile and rice production was high. It was not until the introduction of the embankment system and subsequent, promotion and proliferation of shrimp farming that salinity became such a serious problem. Today, the southwest faces a development-induced disaster as salinity infiltrates soil and watertablesthreatens crops andkills vegetation. Shrimpfarming perpetuates and increases salinity levels in the region, reducing options for livelihood diversification and day-laboring opportunities. People are now often forced to migrate to cities for work [26].

9. Drinking water

It was in 1987. I went to Patharghata, an offshore island, under the Borguna district located on the southwest border of the Southwest Coastal Region of Bangladesh for a study purpose. I was having a meeting with a youth club. There was a tube-well (suction pump) in front of the club office. I asked for water to drink. The youth leader asked one member to go to his house and bring water for me. He brought water in a jug and offered me a glass of water. I was surprised to see that they did not offer me the tube-well water. I asked them, why not tube-well water? They said it is not drinkable, because it is too salty. I went to the tube well and tested its water and I was extremely shocked by the taste of water, which was too salty. I drank water that they offered me and found a bit different taste that we do find in tap water in the cities. I asked them the source of that water. That was pond water. They told me, people of this island use pond water as drinking water for thousands of years. After the meeting, they brought me to the pond side. A big pond, full of green with coconut trees on the banks, no other trees, and water was looking so clean. This pond is used only as a source of drinking water, no other purpose. Everyone is abided by this unwritten rule, the youth told me.

My second visit to this island was in 2005 for another study purpose. I met the same person, the then youth club leader, and asked him (after we discussed water and sanitation on the island) about that pond which they used to use as a source of drinking water. He answered me, we were just standing on the bank of that pond, where I saw, at that moment, 10 to15 men were taking bath in the pond, few were washing clothes, one man was cleaning his cow on another side, the water looks unclean, and the *ghat* is with concrete steps and platform for villagers convenient for bathing and washing. He showed me some more concrete work, which is the structure of PSF (pond-sand-filter), constructed by a local NGO with funding and technical supports of an international NGO around three years back. Since then the pond is open to all for uses. But the PSF is not working anymore (after working for about two years). So, the pond water is no longer usable for drinking. The only source of drinking water is few Deep Tube Wells, which is far away from many and saline too.

Historically, people in the coastal zone of Bangladesh, especially the Southwest region, all along used to use pond water for drinking. The community collectively excavated the pond deep as the reservoir of rainwater, constructed earthen banks strong and high to protect the pond from saline water intrusion, planted coconut trees on the blinks for shade on the water to keep the water cool. One pond did serve neighboring two-three villages, even more. Zamindars also excavated ponds to supply drinking water for their citizens/people. But with the influences of 'development interventions' of public health programs on the government using ADB/WB loan, since the mid-1980s, a massive shift from surface water to groundwater sources for domestic water supply. Sadly, in around two decades, the situation turned to reverse: availability of safe drinking water reduced because of arsenic poisoning in tube well water, resulted in the dealing with saline groundwater by the people of coastal areas. The availability of safe drinking water is poor for the coastal communities, as fresh groundwater is only available at great depths, if at all [1].

Department of Public Health Engineering (DPHE) of Bangladesh Government, spending loan fund supports from multilateral organizations, especially the Asian Development Bank, the World Bank, IDBand funding supports of DANIDA, UNICEFimplementeda number of water supply projects include installation of Deep Tubewells, 'Pond-Sand-Filter' (PSF) system since the late 1990s. NGOs have been implementing their PSF projects since 2000.

Despite all these initiatives of development interventions in drinking water supply during the last more than four decades, the coastal people are not ensured with safe drinking water supply. Study [27] shows, at least two-third of coastal rural households fell into the water scarcity and the root causes are saline water intrusion, reduction of upstream flow, sea-level rise, disasters, polder, arsenic contamination, shrimp cultivation in brackish water, excessive use of underground water and lack of appropriate aquifer were highly influential for the disturbance of potable water supply. Water scientists [28] argue that uses of deep tube-wells render the aquifers to overdrawing, which is a potential cause for upcoming. The overdrawing of groundwater is also contributing to declining the capacity of freshwater in flushing out the saline water from the aquifers. This is becoming a great concern in this region [28]. It is argued that recharge to deep aquifers is extremely low in southwest coastal Bangladesh. Water at a depth between 100 and 300 m in this area is a few thousand to >10 thousand years old, suggesting that these aquifers are not receiving any current recharge [28–32]. It is so unfortunate, this scientific knowledge of groundwater dynamics is often ignored in the development interventions in the water supply sector in the southwest coastal region of Bangladesh leading to high risks of water shortage and water crises.

Currently, the coastal rural households are dependent on tube well water, which is not saline and arsenic-free; PSF water, which is available only for monsoon months and only where PSF projects were implemented; rainwater that villagers harvest; and open pond water. One study shows, in some cases, 97% of local people collect their drinking water directly from ponds [33]. Ministry of Water Resources of Bangladesh Government has recently initiated a new project of excavation *deeghi* (big pond) in the southwest coastal region to ensure safe drinking water supply for the local people.

The whole experience of development interventions inthe 'coastal water supply' sector of Bangladesh can be denoted as capillary chaos of projects and programs initiated by the outsiders, which generated permanent water crises in the coastal zone. Water crises refer to 'grossly inequitable distribution of the available water; the decline of traditional water management and conservation systems; the disappearance of once-numerous water bodies; the damage to ecological systems from the interventions in nature in the form water resources development projects; the infliction of hardship, inequity and injustice on poor, disadvantaged communities particularly the ethnic groups, and on women; and uncontrollable, unmanageable generation of waste of all kinds, and the consequent reduction in the availability of water' [22].

Drinking water in the southwest region, both surface and groundwater, has become unfit for human consumption since the salinity has exceeded the recommended level of 960 μmho/cm for potable water since 1987 [7, 34]. Drinking water from natural sources in coastal Bangladesh has become contaminated by varying degrees of salinity due to saltwater intrusion from rising sea levels, cyclone and storm surges, and upstream withdrawal of freshwater [13].

In the pre-shrimp farming period, pond water could be used for drinking purposes even in the dry season, but after the introduction of shrimp cultivation, the pond water becomes too salty to use even for bathing in summer. There are deep tube wells, which are privately owned by the large and the middle farmers. The poorer households depend on these deep tube wells for drinking water. In the previous time, the scarcity of drinking water was not as much as it is at present [25]. As per the opinions of the specialists, the main causes of drinking water scarcity are salinity, arsenic, and the shortage of groundwater. The sea level of this region is rising 3–4 ml per year and it creates new salinity affected areas, which creates further scarcity of drinking water [35]. The average estimated sodium intakes from drinking water ranged from 5 to 16 g/day in the dry season, compared with 0.6–1.2 g/day in the rainy season. The average daily sodium excretion in urine was 3.4 g/day (range, 0.4–7.7 g/day). Women who drank shallow tube-well water were more likely to have urine sodium >100 mmol/day than women who drank rainwater [odds ratio (OR) = 2.05; 95% confidence interval (CI), 1.11–3.80]. The annual hospital prevalence of hypertension in pregnancy was higher in the dry season (OR = 12.2%; 95% CI, 9.5–14.8) than in the rainy season (OR = 5.1%; 95% CI, 2.91–7.26). The estimated salt intake from drinking water in this population exceeded recommended limits. The problem of saline intrusion into drinking water has multiple causes and is likely to be exacerbated by climate change-induced sea-level rise [13]. This study finding suggests that the mean sodium intake in pregnant women is well above WHO/FAO–recommended levels and above those of many other countries. Hypertension in pregnancy is associated with increased rates of adverse maternal and fetal outcomes, both acute and long term, including impaired liver function, low platelet count, intrauterine growth retardation, preterm birth, and maternal and prenatal deaths. The adverse outcomes are substantially increased in women who develop superimposed (pre)eclampsia. It further suggestshypertension in pregnancy is associated with increased rates of adverse maternal and fetal outcomes, both acute and long term, including impaired liver function, low platelet count, intrauterine growth retardation, preterm birth, and maternal and prenatal deaths. The adverse outcomes are substantially increased in women who develop superimposed (pre) eclampsia [36].

10. Discussions

Coastal people are naturally resilient to natural hazards. They are educated by nature. They are knowledgeable about the coastal context up to a higher level. Their knowledge is rooted in 'learn by doing'. They are born to win over the challenges of exploiting the opportunities of livelihoods. Their day-to-day life-world is full of risks, threats, pressure along withthrills, joys, and happiness. Philosophy and Forms of their initiatives of exploiting natural resources – ecosystem services of all forms are embedded in fulfilling needs, not wants. They have followed this discourse for thousands of years until the 'development interventions' were introduced on the coast in the recent past (the 1960s). I have discussed these interventions in the previous sections.

Local people, from their full understandings of possible consequences of the proposed development projects, opposed, protested, and non-cooperated the implementations of the projects. For example, while implementing the Coastal Embankment Project (CEP) local people registered their protest against the project identifyingthe wrong design and irrelevance of the project. Violent protests were also there. But the CEP was implemented and contributed dramatic increases in rice production in the embanked/polderised area. Farmers were able to harvest two or even three bumper crops per year. But nature's reaction against the intervention was already building up. Within 15 years of the construction of embankments, siltation started at the water entry point of the sluice gates and rivers and canals' bed height began to increase. As a result, the polderised flood plains started getting water-logged one after another.

The local people first contested one of the projects of the Coastal Embankment Project (CEP): one five-vent sluice gate became nonfunctioning because the link canal got silted up, in six years of its construction in 1967, resulting in waterlogged areas in 1973. People demanded a solution, but no response was there from the government side. People waited for three years but no action was taken. Then local people (in 1976), especially the farmers were organized and excavated an alternative canal (because people have no access to government built structure to do any repairing work) and connect it directly to the link river (*Bhadra* river), which released the waterlogging of 65,000 hectares land and 54 villages. In this case, water-logging is referred by FAO technically to a situation when the level of groundwater meets the plants' root zone [37]. This may last for at least three months and may prolong up to 8–9 months or even become perennial. The depth of flooding varies, according to the topography of the area, and can reach up to 3 m. This study grouped the effects of water-logging into two categories: (a) immediate loss of life, property, and access to essential services such, e.g., potable water and food, humanitarian assistance, and (b) damage to infrastructure and other assets which underpin livelihoods, health, and sanitation, shelters, etc. They further assessed, at the homestead level, the direct impacts of water-logging is the loss of shelter/house, loss of animals, plants, trees, and access to safe food and water. The affected communities are deprived of basic services such as health, children's education. Over the longer term, as water stands and stagnates, health risks go higher. This study suggests that during waterlogged periods both the poverty and nutrition situation quickly worsens, negative coping strategies, e.g., sale of assets, are adopted, that insecurity due to waterlogging may be a factor in early child marriage, and that spread of disease and social breakdown combine to aggravate underlying vulnerability.

Some other studies showed that within 10 years of implementation, the ill effects of the polder surfaced in massive areas such as many drainage canals became inoperative due to siltation, rendering vast tracts of lands waterlogged all year round [38]. The civil engineering structures impeded vast volumes of sediment-laden monsoon flood flows. The floodwaters caused consequently deposited silt and sediment in the riverbeds and channels. The effect caused a reduction in the bulk-carrying capacity of the water by the rivers and channels, leading to further flooding due to severe congestion of drainage, which progressively led to water-logging. It is classed as a man-made disaster. The cumulative impacts were increased salinity, loss of soil fertility, a decrease in income, worsening of sanitation conditions, loss of livelihoods, and problems in gaining access to residents' homes, agricultural land, and infrastructure facilities. Many people were compelled to move onto embankments and roadsides. Educational institutions were severely damaged and remained closed; children were forced to discontinue schooling. Biodiversity and livestock were adversely affected. Safe drinking water became scarce. Waterborne diseases like diarrhea and scabies became epidemic. Moreover, unemployment forced many people to migrate to cities. Strong competition for the rapidly diminishing resource base heightened tensions and conflicts between sectors of society and created a volatile social situation.

However, collective initiatives and actions of local people to address the issues like waterlogging continued. One of the other experiences of contestations occurred in 1986. After 15 years of construction of two parallel large sluice gates on a deep river (Hari river in 1965), the river was silted up and resulted in waterlogging, which flooded 139 villages and croplands around. Local people of all strata demanded the removal of waterlogging but got no response from the govt. side. So, thousands of villagers collectively cut the embankment at an appropriate point that resulted in releasing waterlogging from this area.

Immediate and continuous consequences of the engineering structure dominant 'flood control' projects over water systems in the southwest coastal region of Bangladesh compelled the local people contesting the interventions that work against interests of naturally grown natural systems of ecosystems of all forms, which provide local people with services to meet up their needs. But these outsiders' designed projects, ignoring and undermining the science and wisdom of ecological systems, embrace explicit notions of befitting the outside professionals, businessmen, politicians, and civil bureaucrats both immediately and in long run. These contestations exist since the project's interventions until now for the survival of the local people. These include organized protests, collective actions to solve the issues, and local initiatives of managing ecosystem services for local people's livelihoods and reducing disaster risks. For example, among many collective actions, one action took place in July 1988. More than 20 thousand people were organized and made a 'public cut' of an embankment, released a big shrimp farm from logged saline water, and brought the land back to rice cultivation. The govt. parties engaged hired terrorists and police against the mob, one farmer and policeman were killed. Govt party sued 300 farmers. Another historical people's movement against a system rehabilitation project, which took place in 1990. Knowing the project design/plan, the local people were convinced that this project would not help in releasing waterlogging in large wetlands, locally known as *BeelDakatia*. The govt. line agency Bangladesh Water Development Board (BWDB) started the project into action on people's protests. At one point the project river dredger got trap by siltation in the river (Solmari river). Mass agitation inoculated against the project, which was eventually withdrawn after completing only 11% of the required construction. Then in September 1990, a large number of people gathered and cut the embankment to release waterloggedBeelDakatiathrough connecting regular tide with the link river (Hamkura river in the area). Through regular tidal actions and the accumulation of alluvium, the land formation process of the *Beel*resumed [39].

Conflicts of disciplinary boundaries, as well as professional knowledge versus local knowledge and people's wisdom, exist in the polderisation processes all along with the project life. Repeated failure of the 'system rehabilitation' approach throughout the 1980s, 1990s, and beyond invoked public protests and collective actions. In cases of implementation of Drainage Rehabilitation Projects, defying army deployment, local people took civil actions that included road blockades, burning cars of the project officials and government high officials visiting project sites; public cut of the embankment to release the stagnant floodwaters and at the same time, to allow tidal inflows to let the natural circulation of water. These contestations worked up to a certain level protecting local interests and popularized in the whole coastal zone and the knowledge world. Following lessons learned and experiences, the local people demanded that their knowledge of 'Tidal River Management' - to allow tidal flow in the basin to increase tidal volume, to store floodwater during flood current and to trap sediment during the long storage

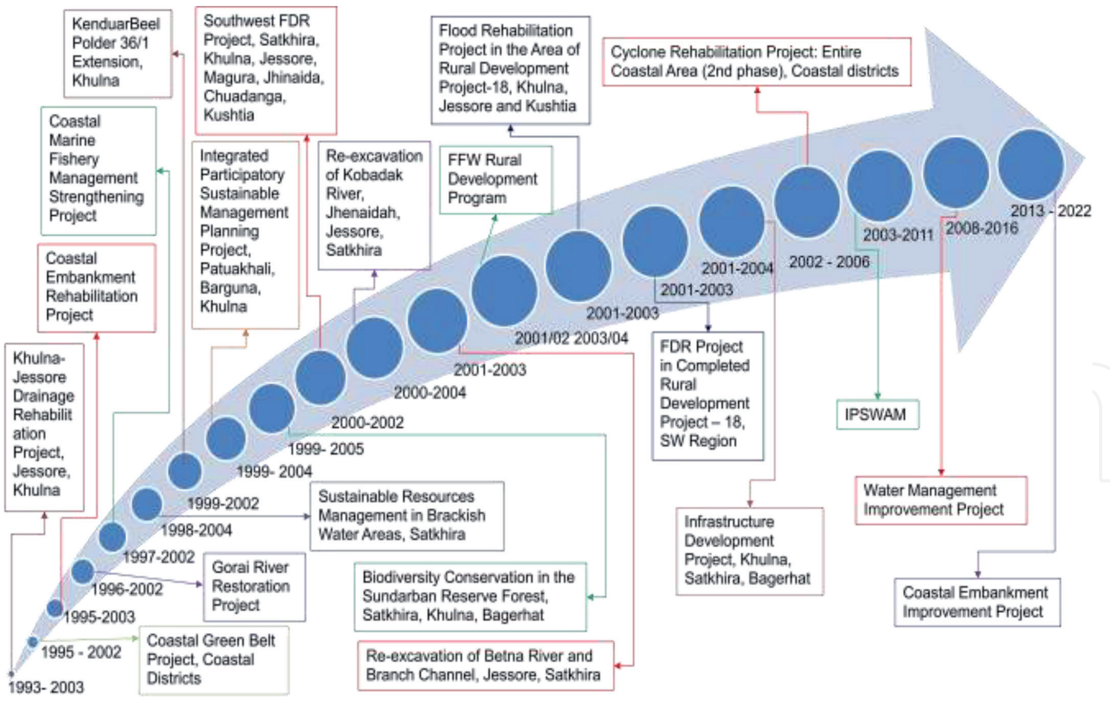

Figure 1.
Structural engineered water projects over the years in the southwest coastal regions of Bangladesh.

period of sedimentation–must be taken into account of project processes, particularly in coastal drainage improvement project design. But the government line agencies keep denying it. Rather the government line agencies and their development partners together have been undertaking projects one after another showing justifications of addressing issues generated by the previous projects. One may easily argue, next projects are taken up by the government to deal with the problems caused by the previous projects but very project generates new problems and escalate the water-related complexities to a further higher level (See the **Figure 1**). The processes of coastal water projects and funding are complex and not easy to understand. Many seek to profit from it and would wish it to continue [37]. But it is expected that the local people's demand together withthe pressure of intellectual work from home and abroad, and negotiations of the civil society remain continued for the interests of protecting coastal zone ecosystems.

11. Conclusion

Historically, the management of coastal water resources was in hands of local people for thousands of years. Water is life, water for life – for humans, animals, trees, fish, biomass, and so on are naturally relevant to coastal overall life-world. Coastal nature is grown naturally and water is the life of this nature. Coastal life-worldis rooted in water systems. Water is the dominant system of overall biophysical systems that embraces major opportunities and vulnerabilities of the coastal people.

Water means to coastal people is surface water – sea, river, canal, pond, *beel*/floodplains, and rainwater. Other than rainwater, all the systems are guided by a unique natural system which is called 'Tidal System'. If any external intervention is designed in technical/engineering science or even social science or multidisciplinary approach, it is essential to understand this tidal water system. Otherwise, you are absolutely wrong, and if you implement any project, which is designed ignoring and undermining the deeply rooted complexities of the tidal water system, you generate water-related problems of all forms in the coastal zone permanently. And it happened to the coastal zone, particularly in the southwest region of Bangladesh.

Water was a natural resource, which required no economic investment for its management for thousands of years in the case of Bangladesh's coastal zone until the 1960s. Heavy interventions by development projects began in the 1960s, which resulted in problems of so many kinds for the insiders that required more projects to address those problems, and implementations of new projects generated further problems, which required further projects. The coastal water has been using as a commodity of development projects business of outsiders- the politicians, businessmen, professionals, multilateral moneylenders, international and national NGOs, consultancy firms, water industries, and so on.

Coastal water is made a 'commodity' from 'natural resource' with the influences of water sector projects. 'Water Resources Management', which was in hands of local people for thousands of years, has been shifted to the 'Water Development' paradigm, which ensured the protection of outsiders' interests at the costs of continued and sustained sufferings of the insiders. Costal water is no longer within the control of insiders, but a central control of outsiders has been already established, which will remain established unless the government draws a hard-line of "Tradeoff".

Author details

Hamidul Huq[1]* and Tahmid Huq Easher[2]

1 Institute of Development Studies and Sustainability (IDSS), United International University (UIU), Dhaka, Bangladesh

2 Department of Environmental Science and Management, North South University, Dhaka, Bangladesh

*Address all correspondence to: hamidulhuq@idss.uiu.ac.bd

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