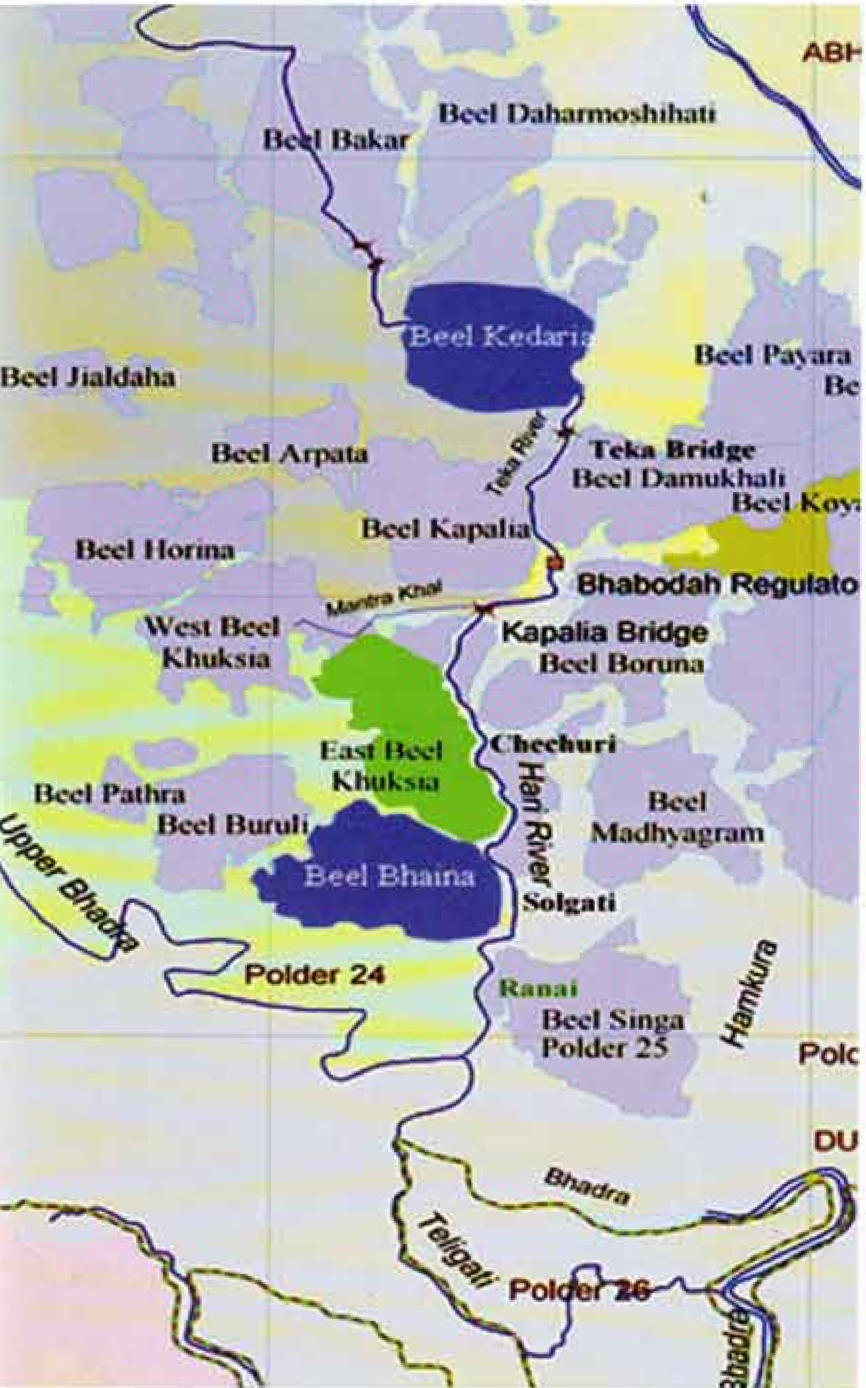
Policy Recommendations

Tidal River Management (TRM)

Climate Change Adaptation and Community Based River Basin Management in Southwest Coastal Region of Bangladesh



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Forward

The attention for participative water management in relation to adaptation to climate change is of great importance: even if the Kyoto objectives for reducing emissions of greenhouse gasses are accomplished, there still will be climate change that is going to have major effects on daily life.

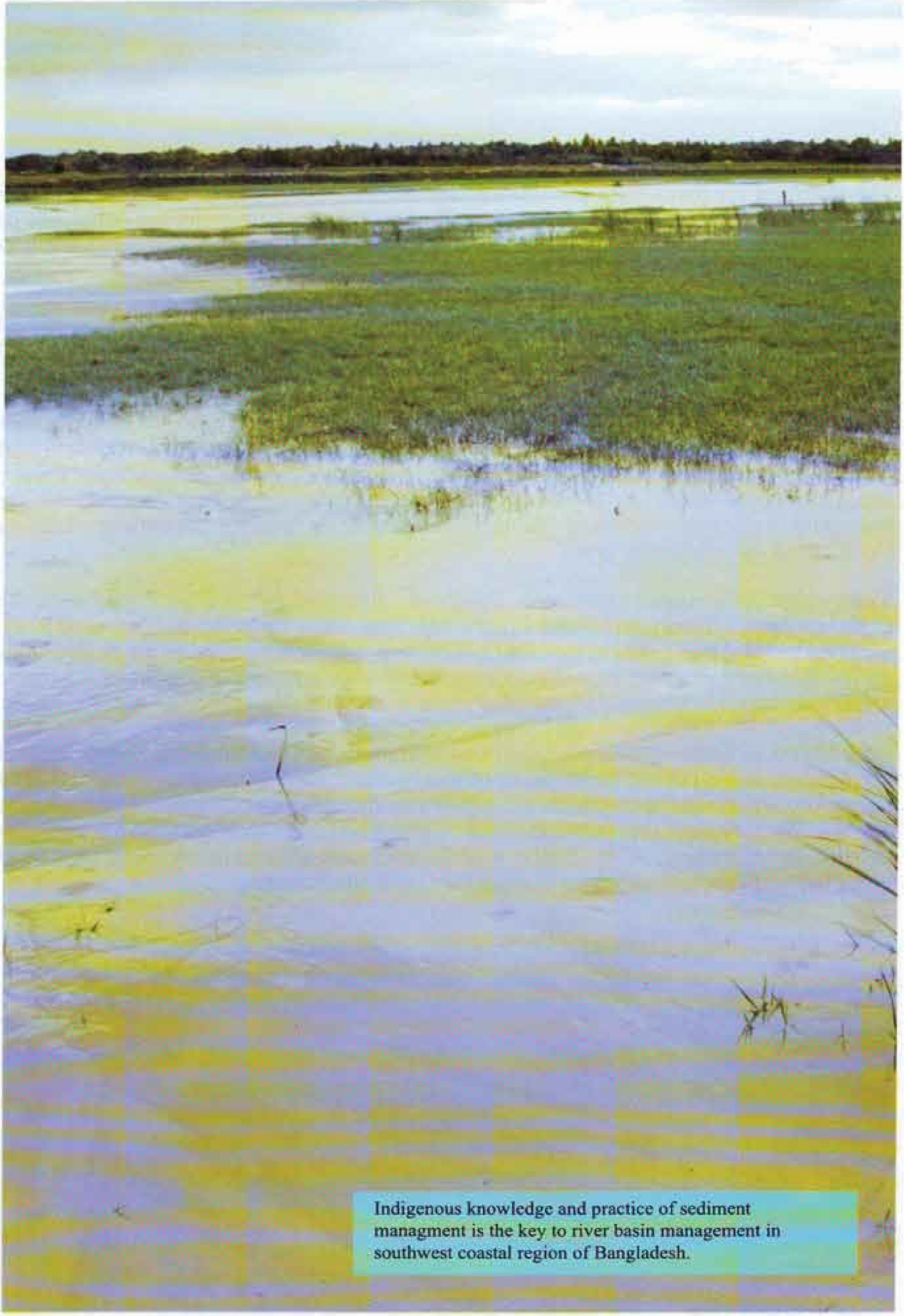
People in Bangladesh are amongst the most vulnerable, especially those living in coastal zones. As a logical consequence, numerous organizations in those areas are developing and implementing measures to reduce vulnerabilities to climate change.

Meanwhile, national and international policy processes related to water management and climate change largely ignore the practical knowledge of local communities and CSOs, despite the fact that their experiences and initiatives can contribute significantly to more sustainable policies and their implementation. They are important actors in reducing vulnerabilities and in making countries such as Bangladesh more 'climate proof'.

The project Negotiated Approach Explored, financed by ICCO, documents the experiences of Uttaran and Paani Committee with Tidal River Management (TRM). By translating these experiences into concrete policy recommendations, it provides policy makers and international donor agencies with a practical insight into generic notions on water management and adaptation to climate change.

Both ENDS is working with organisations in Bangladesh to assure that the vision and knowledge, as well as the experiences of local stakeholders become an integral part of policy processes related to integrated river basin management, adaptation and climate change. We welcome this publication of "Tidal River Management", which provides us with an interesting, scientifically well-founded and successful example of a local initiative on participatory water management and adaptation.

Daniëlle Hirsch
Director Both ENDS
Amsterdam, March 2011



Indigenous knowledge and practice of sediment managment is the key to river basin management in southwest coastal region of Bangladesh.

Tidal River Management (TRM) as Climate Change Adaptation in Southwest Coastal Region

A huge area of land in the southwest coastal region of Bangladesh, a region predicted by experts to be one of the hardest hit by climate change induced sea level rise, is being raised using a unique indigenous ecological knowledge of river management and collective effort of local communities. Around 650 hectares of land in Beel Khukshiya floodplain, on Hari river basin, has been raised by one to one and half metre in the last three years using an indigenous sediment and tidal flow management concept, Tidal River Management, popularly known by the acronym TRM. While in Beel Khukshiya tidal river management is being implemented by the Bangladesh Water Development Board (BWDB), - who learned the concept in 1990s from the local communities and NGOs -, about 31.32 square kilometers of land had been raised by local communities themselves in Beel Bhayna and Beel Dakatiya applying tidal river management. In Beel Jethua, belonging to the Kabodak river basin, local communities raised land by more than one and half meter, in one year, in a beel sized 450 acres, using this sediment management practice (Kibria and Mahmud 2010)[1].

Tidal river management (TRM) is a new terminology bestowed upon by "experts" and water engineers, on an age-old practice in the region perfected by local communities over generations. The unique community practice of "overflow" irrigation and wise use of sediment by the farming communities in the Bengal delta was noted by pioneer colonial researcher Sir William Willcocks. He also noted that the prime of issue of river basin management in Bengal delta is effective management of sediment (Willcocks 1930)[2]. But water resources planners and engineers neglected this illuminating observation. The concept is simple. The estuarine rivers in southwest coastal region witness two cycles of tides in every day. The high tides bring in muddy water flow with a thick concentration of sediments. Local communities cut the embankment, in an appropriate point, to let the river flow enter a floodplain. The natural high tide of river enters the floodplain, leaves a part of the sediment to be deposited on the floodplain and goes back to the ocean. Over time the deposition of sediments raise land level in the floodplain and enriches the soil. Since this process does not allow sediments to be deposited on riverbed, the depth of the riverbed also increases and makes the river congestion free.

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1 Kibria, Zakir and Mahmud, Iftekhar (2010), "Tidal River Management (TRM): Community Struggle for Indigenous River Management and Climate Change Adaptation in Southwest Coastal Region of Bangladesh," in Rivers & Communities, Issue 1, Volume 1, published by Uttaran, Dhaka, Bangladesh

2 Willcocks, Sir William (1930), *Lectures on the Ancient System of Irrigation in Bengal and Its Application to Modern Problems*, University of Calcutta, West Bengal, India

National level scientific and knowledge institutions like Institute of Water Modeling (IWM), Centre for Environmental and Geographical Information Services (CEGIS), and multilateral development finance agency Asian Development Bank (ADB) have acknowledged the concept to be an effective way to mitigate the waterlogging crisis that has been plaguing the region since the 1980s (ADB 2007; CEGIS 1998; IWM 2007, 2008))[3]. Local communities think that planned management of sediment carried by the river is possible through tidal river management. Studies and community consultation has shown that tidal river management can be scaled up and replicated on river basins throughout the southwest coastal region. It is the most effective method to raise land and make it cultivable, mitigate waterlogging crisis, increase navigability of rivers, reduce salinity and is used as the most effective climate change adaptation strategy to protect the region from sea level rise (Uttaran 2011)[4].

[3] Asian Development Bank (2007), Project Performance Evaluation Report on Khulna-Jessore Drainage Rehabilitation Project, Operations Evaluations Department, Manila, The Philippines

EGIS (now known as CEGIS), (1998), Environmental and Social Impact Assessment of Khulna-Jessore Drainage Rehabilitation Project, Dhaka, Bangladesh

Institute of Water Modeling (IWM), (2008), Mathematical Modeling for Planning and Design of Beel Kapalia Tidal River Management (TRM) and Sustainable Drainage Management, Dhaka, Bangladesh

Institute of Water Modeling (IWM), (2007), Monitoring the Effects of Beel Khuksia TRM Basin and Dredging of Hari River for Drainage Improvement of Bhobodah Area, Dhaka, Bangladesh

[4] Uttaran and Paani Committee (2010), Peoples' Plan of Action: Management of Rivers of Southwest Coastal Region in Bangladesh (work in progress, with scientific and technical advice from Institute of Water Modeling and environmental and social advice from Centre for Environmental and Geographical Information Services).

Mujibul Huq, a senior researcher at Centre for Environmental and Geographical Information Services (CEGIS), an autonomous knowledge institution under the auspices of Ministry of Water Resources Management, commented in a recent interview, that, "Tidal river management implemented at the initiatives of local people is such a method which can be used to raise land low cost and keeping the natural process unaffected. TRM can be used to face the challenges of sea level rise and hundreds of kilometers of land in Satkhira, Khulna and Jessore district in southwest coastal region can be raised by using the method"(Kibria and Mahmud 2010)[5].

Southwest Coastal Region on the Frontlines of Climate Change

Bangladesh is one of the most climate vulnerable countries in the world and will become even more so as a result of climate change (BCCSAP 2009 and GermanWatch 2009, 2010, 2011)[6]. This vulnerability is attributed to its disadvantageous geographic

[5] Kibria, Zakir and Mahmud, Iftekhar (2010), "Tidal River Management (TRM): Community Struggle for Indigenous River Management and Climate Change Adaptation in Southwest Coastal Region of Bangladesh," in Rivers & Communities, Issue 1, Volume 1, published by Uttaran, Dhaka, Bangladesh

[6] The Government of the People's Republic of Bangladesh (2009), Bangladesh Climate Change Strategy and Action Plan 2009.

GermanWatch (2011), Global Climate Risk Index 2011: Who Suffers Most from Extreme Weather Events? Weather-Related Loss Events in 2009 and 1990 to 2009

GermanWatch (2010), Global Climate Risk Index 2010: Who is Most Vulnerable? Weather-Related Loss Events Since 1990 and How Copenhagen Needs to Respond

GermanWatch (2009), Global Climate Risk Index 2009: Weather-Related Loss Events and Their Impacts on Countries in 2007 and in a Long-term Comparison

location; flat and low-lying topography; high population density; high level of poverty; reliance of many livelihoods on climate sensitive sectors, particularly agriculture and fisheries. Many of the anticipated adverse affects of climate change, such as sea level rise, higher temperatures, enhanced monsoon precipitation, and an increase in cyclonic intensity, will aggravate the existing stresses that impede development in Bangladesh, particularly by inundating vast tracts of fertile agricultural land in coastal region, reducing freshwater water and food security (Huq and Ayers 2008)[7].

The Inter-governmental Panel on Climate Change (IPCC) predicts that global temperatures will rise between 1.8 C and 4.0 C by the last decade of the 21st century. In South Asia the IPCC Report predicts that monsoon rainfall will increase, resulting in higher flows during the monsoon season in the rivers, which flow into Bangladesh from India and China. These flows are likely to further increase in the medium term due to the melting of Himalayan glaciers. The huge sediment load brought by three Himalayan Rivers, Ganges, Brahmaputra, and Meghna, will cause drainage congestion problems in estuarine rivers. The IPCC also forecasts that global warming will result in sea level rises between 0.18 and 0.79 meters, which could increase

[7] Huq, Saleemul and Ayers, Jessica (2008), Climate Change Impacts and Responses in Bangladesh, Note prepared by IIED for Policy Department Economy and Science, DG Internal Policies, European Parliament (Ref. IP/A/CLIM/NT/2007-09)

coastal flooding and saline water intrusion into rivers and groundwater aquifers across the coastal region reducing freshwater availability. The effects are exacerbated by greater evaporation and evapotranspiration of freshwater as temperatures increase, coupled with greater demand for freshwater in times of water stress (BCCSAP 2009; Huq and Ayers 2008)

Southwest coastal region of Bangladesh is considered to be on the frontline of climate change, directly affected by storm surges, drainage congestion, and sea level rise. If sea level rise up to one meter this century, as estimated by scientists, southwest coastal region in Bangladesh is right on the path of an impending peril. Most of Bangladesh is less than ten meters above sea level with coastal regions below 1 meter, making it extremely vulnerable to increasing high tides and sea level rise. The effect on the coastal region will be severe and including coastal land subsidence, erosion, siltation of river estuaries, waterlogging and saltwater intrusion. Salinity intrusion from the Bay of Bengal already penetrates 100 kilometers inland during the dry season, and climate change is likely to exacerbate this (Huq and Ayers 2008).

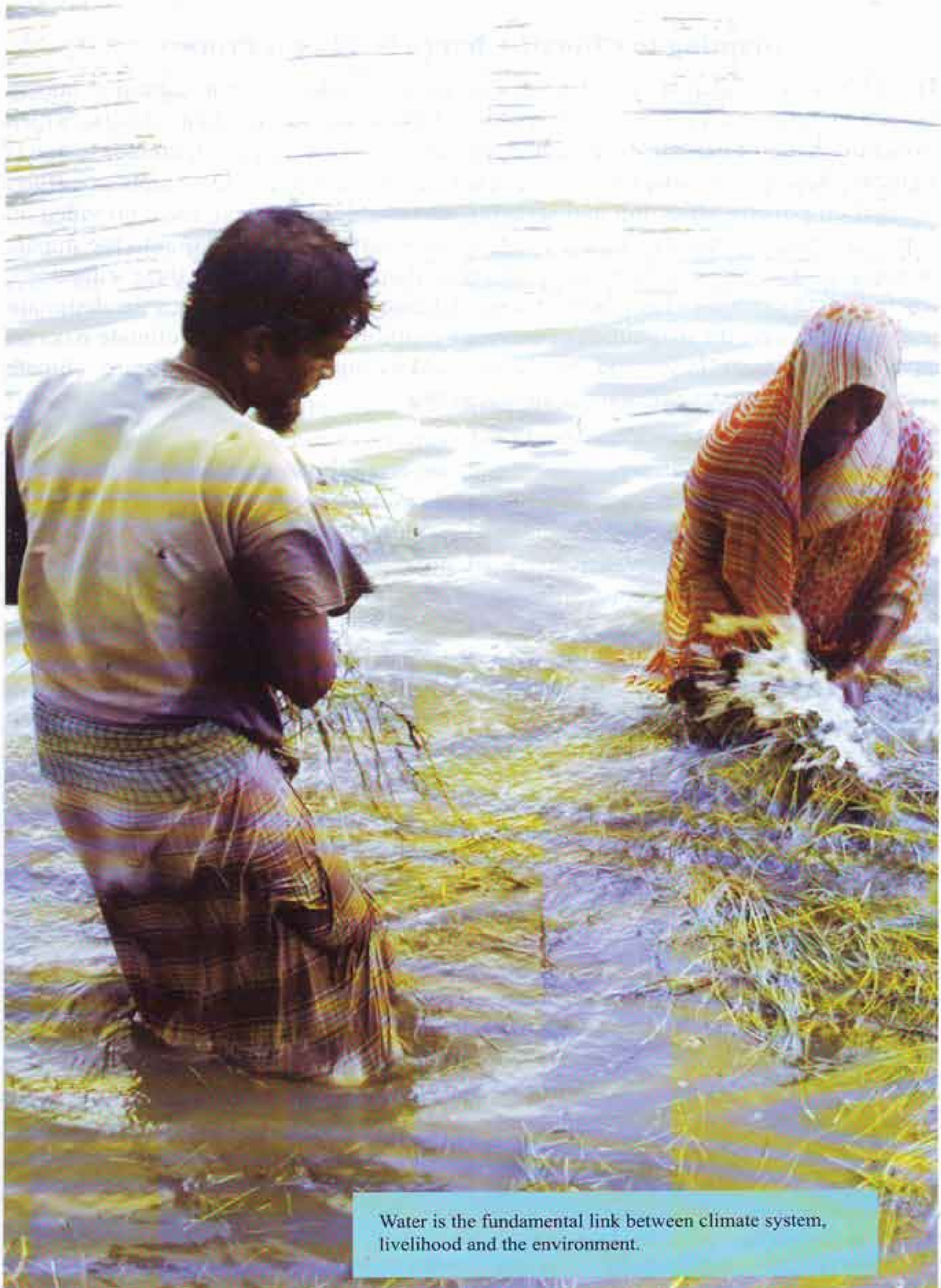
The salinity intrusion experienced by the coastal region is having serious implications for the quality of soil that were traditionally used for growing rice. Increase in water stress will affect the production of major crops, again, particularly rice, which needs significant amounts of water. The fisheries sector will also be affected adversely by

climate change. Many of the fish species in coastal region are sensitive to salt and freshwater conditions. The changes in tidal patterns, as well as increasing saline intrusion into freshwater rivers, associated with climate change, will impact the fish populations. The implications of climate change for agriculture and fisheries are extremely significant, not only because of the livelihoods implications for the majority of the population who depend on agricultural outputs, but also because of the threat to Bangladesh's food security (Agrawala R, et al., 2003)[8].

The Sundarbans mangrove forest, a world heritage site, covers the coastline of the southwest, providing a shield against frequent cyclonic tidal surges, is the single largest mangrove area in the world. Climate change will have detrimental impact of all forest ecosystems in Bangladesh and the Sundarbans are likely to be the worst affected. Saline intrusion is already a major problem in the Sundarbans. It should be noted that the Sundarbans offer subsistence to millions of people who live within and around the forest boundary. Although "opportunities" for shrimp farming have accompanied increasing salinization, shrimp farmers are encouraged to inundate their land with brackish water during times of low salinity, exacerbating damage to forest cover. Depleting forests in waterlogged and salinized areas are putting further pressure on forest resources such as fuel wood and timber, enhancing the rate of forest depletion (Agrawala R, et al., 2003)[9].

[8] Agrawala R, et al., (2003), Development and Climate Change in Bangladesh: Focus on Coastal Flooding and Sundarbans, Organisation for Economic Co-operation and Development (OECD)

[9] Agrawala R, et al., (2003), Development and Climate Change in Bangladesh: Focus on Coastal Flooding and Sundarbans, Organisation for Economic Co-operation and Development (OECD)



Water is the fundamental link between climate system, livelihood and the environment.

Adapting to Climate Change is a Local Process

The IPCC defines adaptation to climate change as "an adjustment in natural or human system in response to actual or expected climatic stimuli of their effects, which moderates harm or exploits beneficial opportunities (IPCC 2001)[10]. Climate change is a global phenomenon, adapting to its impacts is a local process. Development efforts focused on poverty reduction and securing sustainable livelihood, have provided an important means to reduce vulnerability, but now have to pay attention to the impact of climate extremes and how these changes shape livelihood. In these situations, where coping capacities have been exceeded, humanitarian aid has been the dominant response. Because the magnitude of current variability and additional climate risks on development is so large and pervasive, addressing current and future climate vulnerabilities into development is an urgent task.

The people of Bangladesh have adapted over generations to the risk of floods, cyclones and other climatic extremities. In areas where inundation is a risk, communities raise their houses on mounds, above the normal flood level, and adjust their cropping patterns to take advantage of the flooding water. Farmers adapt to local flooding and changing rainfall patterns by growing a range of indigenous rice and other crop varieties.

Indigenous Ecological Knowledge and Practices in Adaptation

The effects of climate change are highly contextual; they can worsen and intensify existing problems and create new problems, but always within an existing local reality. The ability of communities to adapt to climate change is determined by their access to resources, indigenous ecological knowledge, practices and technical capacity, depending on cultural features, social capital, socioeconomic contexts, and political situations. Over the years, researchers have shown that indigenous knowledge is vast with respect to natural resource management and continuously being produced and maintained through social processes; and that these processes depend on social, cultural and biophysical conditions, as well as on access to natural resources. Indigenous ecological knowledge plays a significant role in protection of large ecosystems, and that it will be difficult to achieve climate change adaptation without taking account to strengthen the necessary conditions for continued use and development of indigenous knowledge.

[10] Intergovernmental Panel on Climate Change (IPCC), 2001. *Impacts, Adaptations, and Vulnerability – Contribution of Working Group II to Third Assessment Report of the Intergovernmental Panel on Climate Change.*

Autonomous adaptation has been occurring for centuries, in response to all manner of external stimuli, including climate related conditions, changes and events. Local knowledge, experience and practices in coping with climate change in the past and present have much to contribute to the design of planned adaptation. Local level planned adaptations, on the other hand, have to focus on enabling communities to enhance their own adaptive capacity, make effective use their knowledge of local ecosystem, and empowering the communities to increase their own resilience to the impacts of climate change. However, "expert knowledge" continues to dominate climate change discourse and policy space, and while ground-up approaches that prioritize local knowledge are gaining momentum, they meet with difficulty in terms of scaling up and mainstreaming (Kronik and Dorte, 2010)[11].

Genealogy of Emergence of Tidal River Management (TRM)

Hydrodynamics of river flow and sediment in estuarine rivers of southwest

Tidal deltas have large areas of low-lying lands that, in the case of Bangladesh, extends throughout much of the country. Much of the country's low-lying landmass is the result of millions of years of sediment deposition brought by the major rivers rising

[11] Kronik, Jakob and Verner, Dorte, (2010) "The Role of Indigenous Knowledge in Crafting Adaptation and Mitigation Strategies for Climate Change in Latin America", in *Social Dimensions of Climate Change: Equity and Vulnerability in Warming World*, Edited by Robin Mearns and Andrew Norton, The World Bank

from the Himalayan Ranges. The process continues to this day. Natural processes degrade the material that make up the mountain ranges, and the rivers carry the product of degradation down with their flow. The cross section of the river itself and the slope of the riverbed usually determine river flow. The steeper the slope of the riverbed, the faster the river flows; conversely, the flatter the slope of the riverbed, the more sluggish the river flow becomes.

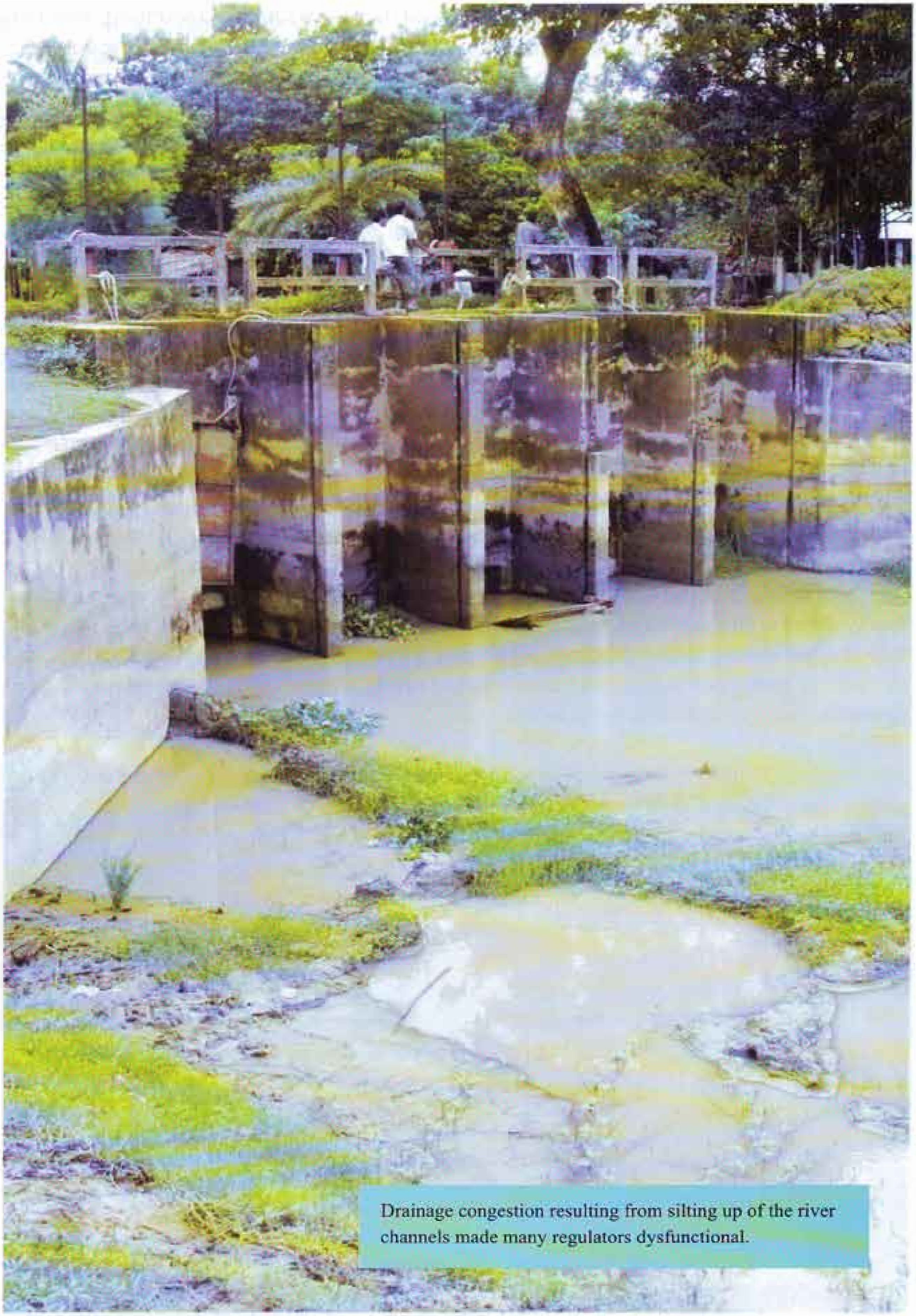
One significant hydraulic fact is that the faster the river flow is, the more sediment it can carry with it, as its sediment-carrying capacity is a function of velocity. The significant point relating to the deposition of silt and sediment brought in with the incoming tide is that much of this is in suspension and is thus carried when the tidal flows are fast. When the flow slows down, which happens in less steep slopes, the flow will lose its ability to move much of this sediment. In the extreme case where the slope is almost flat as in the lower southwest coastal region of Bangladesh, the rivers tend to drop most of their sediment load on the riverbed itself. This becomes a problem as the affected river length will soon accumulate the sediment dropped by the river itself and will become choked and will eventually generate congestion which in turn generates waterlogging problem as the runoff from catchment areas can not release through the river. Local communities in southwest coastal region of Bangladesh over generations of experience learned how to use the sediments and harness the benefits in their favour by allowing the sediments to enter floodplain and raise the land, a process later christened by the water "experts" as tidal river management.

There are two complete tidal cycles every 24 hours, with two incoming and two outgoing tides at sea and occurring in the river and tributary networks. As the southern part of the country is very low-lying, during the rainy season the rivers carry extremely large flows that need to be discharged to the sea. If there are impediments on the way, the rivers flow over their banks, causing extensive flooding as seen repeatedly in Bangladesh. Impediments include silted up river sections, channels blocked with sediment deposits as well as structures built across the river section that constrict the river flow. The runoff during the dry season (with water quality varying between fresh and brackish) from the river catchments and the resulting river and channel flows is low but still needs to be discharged to the sea. The sediment load in the incoming tides is very high, and is primarily in the form of suspended sediment, which is a particular feature of the tidal river system in the project areas.

As the incoming tidal flows are seawater to brackish in salinity, they cannot be used for raising traditional crops. Salinity is minimal in the wet season and starts to rise in November at the end of the wet season. Maximum salinity is reached in late March to early April. The values are highest near the Bay of Bengal (from 25 to 30 grams (g)/l and decrease further inland from the Bay. In the lower Sholmari or the Ghangrail, they vary from 15 g/l to 20 g/l. The installation of regulators with automatic and controlled lift gates is one method of controlling the inflow of saline water into the upper parts of the system on the incoming tide. These flap gates will close automatically when the tide reaches the regulator structure. The gates are designed to open automatically when the tide is going out to sea, and also when there is a buildup of drainage water from upstream, which will then drain to the sea.

When the incoming tide was stopped at the flap gates, the tide drop its sediment load in the river channel area just downstream of the gates, or just at the face of the gate itself and continued to build up this deposit. This situation causes the rapid buildup of sediment against the face of the gate, and the flap gate could no longer function or operate, defeating its design purpose. These automatic gates remain nonfunctional until the sediment against the downstream face cleared manually, or sometimes when the pressure on the upstream face became very high, which will be the case with monsoon floods. Even manually operated gates could be rendered non-operational if they were not attended to very regularly. The reason for this was that even a small buildup of sediment on the downstream face could become a major impediment to the lifting of the gates. Thus, constant operation and maintenance are required to keep these flap and sluice gates functional, and the sediment must be removed by using flushing releases or by manual clearing/dredging of the built-up sediment. During the wet season when the rainfall runoff was very high, the flap gates could usually be kept open by the flow of fresh water toward the sea.

There are two primary problems: (i) drainage congestion, and (ii) entry of salty/brackish water onto agricultural lands from tidal inflows. Drainage congestion



Drainage congestion resulting from silting up of the river channels made many regulators dysfunctional.

resulting from silting up of the river channels has seriously reduced their ability to discharge the runoff flows to the Bay of Bengal and leads to widespread flooding. Salty/brackish water from the Bay gaining entry to agricultural lands has serious negative effects primarily on rice growing and other agricultural activities that require salt-free water and soils. The two problems are seemingly mutually exclusive, but both use the same network of river channels. Drainage congestion and consequent widespread flooding have regularly caused untold hardship to numerous residents and need to be addressed as the major primary issue. Communities who have agriculture as their primary livelihood need to see that their lands are not over-inundated and that the water on their lands is fresh and not saline, as rice is sensitive to salt. Communities who are primarily in fish farming and raising brackish water shrimp need to have low-lying lands that need to be flooded at all times and which require brackish water inputs from the incoming tides. These two groups have diametrically opposing sets of requirements.

Development interventions on the river system in southwest in 1960s and 1970s

In the 1960s and early 1970s, flood control and drainage provisions were two key interventions in the Government's strategy for increasing monsoon season rice crops, particularly wet season (*aman*) rice. In 1957 The Krug Mission was set up in by the United Nations after the severe floods in 1954, 1955 and 1956. Following the recommendations of the report the East Pakistan Water and Power Development Board (EPWAPDA) was established and the irrigation department was merged with it. It was the heyday of "green revolution" and there was a flood control and river management initiatives were driven by the thrust to increase food production by introducing high yielding variety (HYV) crops in dry land with controlled irrigation (Kibria 2005; Adnan 2006)[12].

The Coastal Embankment Project (CEP) was conceived in the mid-1960s with finance from international donor agencies. The initial phases of the CEP were financed by the USAID. The CEP constructed what are essentially high earthen embankments along much of the southern coastline to protect the land from daily tidal inundation by saline water as well as to protect it from monsoon rains and storm floods. This was one of the classic solutions, known as polder that the Dutch have employed very successfully along their coastline. In addition to the embankments, CEP constructed a number of different types of drainage structures across river sections to protect the land within from flooding and also from tidal influx. The areas upstream of the polders were further subdivided into smaller polders with smaller earthen embankments.

The polder system performed well for 10–15 years, primarily by denying entry of salty or brackish water to the land within the polders, as the land was developed intensively and gave significant increases in agricultural production until the mid-1980s.

[12] Kibria, Zakir (2005), "Development Interventions on the Rivers of Bangladesh", A backgrounder note prepared for Policy Literacy Circle (PLC), Dhaka, Bangladesh

Adnan, Shapan (2006), 'Wetlands vs. Drylands': The Retreat from Flood Control in the Ganges-Brahmaputra-Meghna Delta in Bangladesh

Subsequently, the polders and gated structures, such as regulators constructed during the CEP, over this same period of time became devices that throttled and restricted tidal flow and de-linked the rivers from the catchments. The polder system disrupted the indigenous river and sediment management. In pre-polder days, local communities used to construct seasonal embankments, known as *doser badh (*embankment constructed collectively by community) or *osthomasi badh* (embankment constructed for eight months) allowing the tidal flow to raise the floodplains. The local communities developed an indigenous knowledge system of water and river basin management uniquely adapted to this natural process. They used to construct low dikes and wooden sluice gates around the areas to protect the arable land from saline water intrusion. In the rainy season farming communities exchanged saline water of their fields with river water when it became almost sweet. Sweet water normally minimizes the salinity of the land. Thus they got good harvest and variety of fish. It was a unique system of land-water interface developed over hundred of years of experience and practice (Kibria and Islam 2006)[13].

The obstruction by the permanent embankments led to accelerated silt deposition and sediment accumulation in the rivers and channels in the area. The situation was further exacerbated by the absence of any provision for regular and routine maintenance dredging in the CEP. In addition, river flows during monsoon season brought vast volumes of water, which simultaneously carried extremely high sediment loads washed down from the Himalayas. The polders and other structures impeded this sediment-laden flood flows.

Waterlogging crisis: a new entry into the lexicon of disaster

Consequently, the floodwaters accumulated upstream of the polder embankments and the drainage structures. This caused widespread flooding and also deposited silt and sediment in the riverbeds and channels. Since the 1980s vast tracts of land went under water for up to six months in a year. The crisis, known as waterlogging, has become a chronic crisis and plagues the region till now and rapidly spreading to engulf more areas in southwest coastal region. The effect was the reduced carrying capacity of the rivers and channels, which led to further flooding due to severe congestion of drainage, which progressively became worse (PDO-ICZMP 2005)[14]. The cumulative impact was felt in terms of a decrease in income; worsening of sanitation conditions; loss of livelihood; and problem in gaining access to residents' homes, agricultural land, and infrastructure facilities and migration of people in search of income opportunities. Waterlogging also generated strong competition for the rapidly

[13] Islam, Shahidul and Kibria, Zakir (2006), *Unraveling KJDRP*, Uttaran, Bangladesh

[14] PDO-ICZMP (2005), Drainage Issues in Coastal Zone, Working Paper (WP045), Integrated Coastal Zone Management Plan Project, Water Resources Planning Organization (WARPO), Ministry of Water Resources, The Government of the People's Republic of Bangladesh

diminishing resource base, heightened tensions and conflicts between sectors of society, for example between agriculture and shrimp farming, and created a volatile social situation.

People's movement against structural interventions on the river system in southwest

Institutional response to mitigate the drainage congestion and waterlogging crisis remained confined to the structural interventions. ADB approved a project preparatory technical assistance (PPTA) in 1985. Subsequently, in 1986, ADB approved the Khulna Coastal Embankment Rehabilitation Project (KCERP) together with advisory and operational technical assistance to provide support to the Bangladesh Water Development Board (BWDB). However, before any major civil works for the KCERP were started public protests and civil actions including the cutting open of the embankment in Beel Dakatia forced the Government to suspend the planned implementation of the KCERP in 1990. The embankment was cut open to release the floodwaters that had become stagnant and at the same time to allow tidal inflows to let the water circulate. People affected by waterlogging formed committees and decided to reintroduce tidal flows and drainage into polder 25 in Beel Dhakatia. In September 1990 they breached the polder embankments at four locations. By 1992, more than 1,000 ha of lands emerged and farmers cultivated rice on the newly formed land in October 1992. In October 1997, citizens breached the right embankment along the Hari River just upstream of Sholgati Bazaar to enable tides to enter and leave Beel Bhaina freely. By 1999, Beel Bhaina had raised land levels and the Hari River, which

was heavily silted up before, was triple its width and its depth had increased hugely (to 10 meters deep near Sholgati Bazaar), showing again that free movement of tides will certainly keep the river channels open for drainage. The general land level within this beel rose by an average of 1 meter due to tidal sediment deposition. At places close to the opening, land rose by some 2 meters.

The Khulna-Jessore Drainage Rehabilitation Project (KJDRP) was formulated with finance from the ADB assistance 1993 and was designed to remedy congestion by rehabilitating the tidal drainage system that had become clogged as a result of silt deposition. The Coastal Embankment Rehabilitation Project (CERP) proposal was the most environment-friendly, had the least major civil works, and used natural processes to flush out the sediment in the river system with storage proposed in the Beel Kedaria tidal basin. However, the land acquisition requirement was cited as the major reason for dropping this proposal. Local communities, frustrated with experiences of earlier structural interventions on the river system in the region, were apprehensive of the Khulna-Jessore Drainage Rehabilitation Project (KJDRP) from the very onset. They were opposed to the engineering options proposed by the project. Paani Committee, a citizen's platform campaigning for community participation in planning and demanding a solution to the waterlogging crisis, and Uttaran, engaged the implementing agency, the Bangladesh Water Development Board (BWDB) and financer of the project, the Asian Development Bank (ADB).

At that time an environmental impact assessment was not mandatory for ADB financed projects. Sustained advocacy and campaign by local communities, Paani Committee and Uttaran necessitated an environmental and social impact assessment study, which was commissioned to the Environmental and Geographical Information Services (renamed Center for Environmental and Geographical Information Services). The 1998 study not only concurred with the correctness of the open cut demonstrations by the communities in Beels Dakatia and Bhaina, but also gave scientific and engineering support to formalize that practice as the most suitable design option for these areas in dealing with waterlogging and drainage congestion problems. The environmental and social impact assessment report remarked that the tidal river management is environment friendly, cost effective and economically viable and acceptable to the people (EGIS 1997 and 1998)[15]. This finding led to the next revision in the project plan and the redesign of the project in 1999, for the last phase of the project starting in January 2000. The revisions accepted tidal river basin management and incorporated it in the project design.

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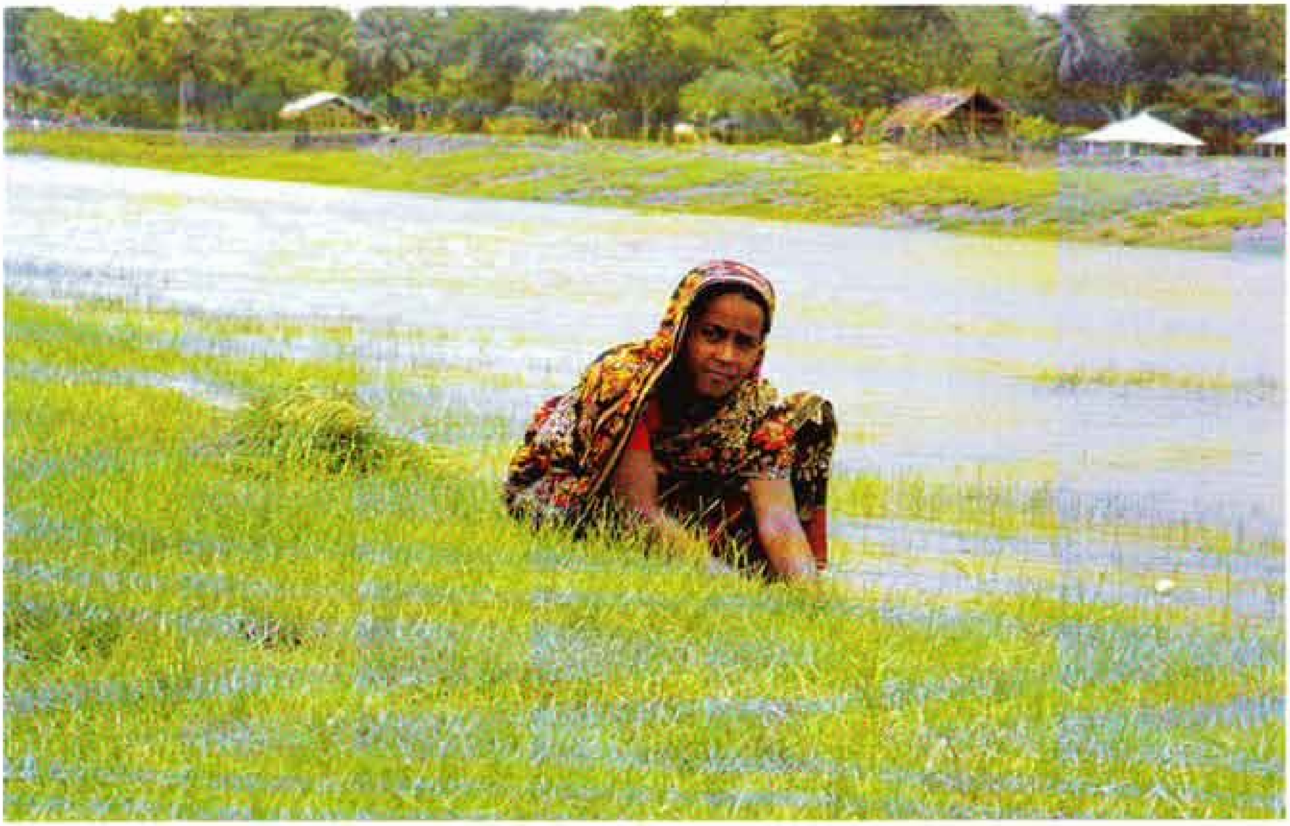
[15] EGIS (now known as CEGIS), (1998), Environmental and Social Impact Assessment of Khulna-Jessore Drainage Rehabilitation Project, Dhaka, Bangladesh

EGIS (now known as CEGIS), 1997, Proceedings on the Workshop on Tidal River Management (TRM)

Uttaran and Paani Committee's sustained advocacy, joined by international NGOs working on accountability of multilateral development banks, succeeded in persuading the independent Operations Evaluation Division (OED) of the Asian Development Bank to conduct a project performance evaluation report. OED, in its report, rated the Khulna-Jessore Drainage Rehabilitation Project (KJDRP) as unsuccessful and criticized the structural solutions ingrained in the project design. OED noted the ecological dynamics of the southwest region and appreciated the tidal river management as an effective strategy to manage sediments and outlined basic requirements for successful implementation of tidal river management (BIC 2009, ADB 2007)[16].

Basic Requirement for Effective and Successful Tidal River Management (TRM)

Tidal river management is elegant in harnessing the tides themselves to carry out the deposition of sediment and silt to raise the level of low-lying lands and reclaim them for agricultural use. Any project area in particular and the surrounding areas must be considered as composite parts of the whole of the larger area that is subject to tidal



[16] Bank Information Center (2007), ADB Begins Evaluation of Controversial Khulna-Jessore Project, now closed, has flooded villages instead of facilitating drainage http://www.bicusa.org/en/Article.3230.aspx

Asian Development Bank (2007), Project Performance Evaluation Report on Khulna-Jessore Drainage Rehabilitation Project, Operations Evaluations Department, Manila, The Philippines movement and influence. Bangladesh is a country that is a classical tidal fan on a very large scale, with the apex in the north and the base in the Bay of Bengal, and the tidal rivers and channels forming large networks. The topography is flat and is generally only a few meters above the mean sea level. Some of the basic requirements for a successful rotational tidal river management (TRM) operation in the context of Bangladesh are discussed next. This section draws heavily from the project performance evaluation report on Khulna-Jessore Drainage Rehabilitation Project (KJDRP) by Operations Evaluations Division (OED) of the Asian Development Bank (ADB 2007)[17].

Embankment enclosure

Embankments must enclose the target beel and the tide allowed to enter through only one main opening in the enclosing embankment. The river channels must be kept open as far into the beel as possible. The tide must be allowed to enter and return to sea freely. This ensures that the incoming tide brings with it a huge load of sediment and as the tide enters and fills the enclosed beel, the flow cannot go anywhere further and the sediment therefore drops to the floor of the beel, and stays there. Over time this action results in raised land suitable for agricultural use. If the river channel within the

[17] Asian Development Bank (2007), Project Performance Evaluation Report on Khulna-Jessore Drainage Rehabilitation Project, Operations Evaluations Department, Manila, The Philippines

beel is kept clean of sediment, the tide returning to the sea takes with it some of the deposited sediments, and the river channel is clean for the next incoming tide and return flows.

Planning and operation of tidal river management

Beel areas are found all around the southwest coastal region of Bangladesh. Tidal river management gives tidal flofree access to selected low-lying beels. For effective results, the beels need to be divided into smaller beels, compartments with an average size of 500–600 hectares (ha). The relatively manageable size of the beels ensures rising of the land. Tides bring suspended sediment as they enter the beel. When they have nowhere else to go, they deposit the sediment on the beel land. When the beel area is small, the suspended sediment will accumulate into deeper deposits and raise the land faster than when the beel area is large.

When one TRM beel has achieved the desired raising of land, then another TRM beel will take the sediment load that comes in with the tide. As there are two tidal cycles every 24 hours, it is imperative that a new beel be prepared to receive the tidal inflows. This preparation has to be done while the first TRM basin is being operated, so that as

soon as the completed basin is closed off, the new basin will become the new operational TRM beel/basin. It is intuitive that the new beel must be adjacent to or near the recently completed beel. However, depending on the location of the river channels and the distance from the Bay of Bengal, the volume of sediment that comes with the tides varies considerably. Therefore, it is difficult to make a sequential list of likely beels without full use of computer modeling such as the one being carried out by the Institute of Water Modeling and Center for Environmental and Geographical Services. If this rotation of TRM beels is not carried out very systematically and in a planned manner, then the incoming tides are more than likely to drop their sediment in the river channels themselves, which will further accelerate such deposition and will hamper the drainage ability of the rivers, to the detriment of all.

To continue to benefit from the use of the TRM basins, it is therefore essential that the whole area be analyzed by digital modeling of flows and the sequence of rotation determined. It has been demonstrated that an average of 3 to 4 years is a sufficient period for an average beel to have its lands raised so that agricultural activities can be undertaken.

Community consultation and concurrence of affected landowners

The tides in the river need free access to the whole beel area twice a day. Thus, it is important that the whole beel area set side for TRM must not be used for any other purpose. This requires a priori advance concurrence of all affected landowners to set aside their land for the duration of basin preparation. Intensive consultations and a clear agreement from the concerned communities and affected landowners are also preconditions for the selection of a beel for the next rotation. Furthermore, adequate advance planning is required from implementing and communities to ensure that the scheduled activities take place within the planned time frame.

Provision for compensation to affected landowners

While it is recognized that the land value would increase after the beel areas are raised and made suitable for agricultural production, it is also important to recognize that the landowners, particularly the poor ones who depend only on their land for their livelihood, would loose income from their land in one form or another during the time their land is used for TRM. There is a compelling reason for making an adequate provision for compensating landowners' lost income. Local communities continued to demand for compensation and therefore provisions have been made in the Development Project Proforma to provide compensation for the affected land in Beel Kapalia, the next TRM basin planned by Bangladesh Water Development Board. CEGIS conducted a study in 2007 to determine a compensation mechanism. However, the retroactive claims from landowners of prior beels used for TRM—for example, Beel East Khuksia and Beel Kedaria—have prominently surfaced, and the Bangladesh

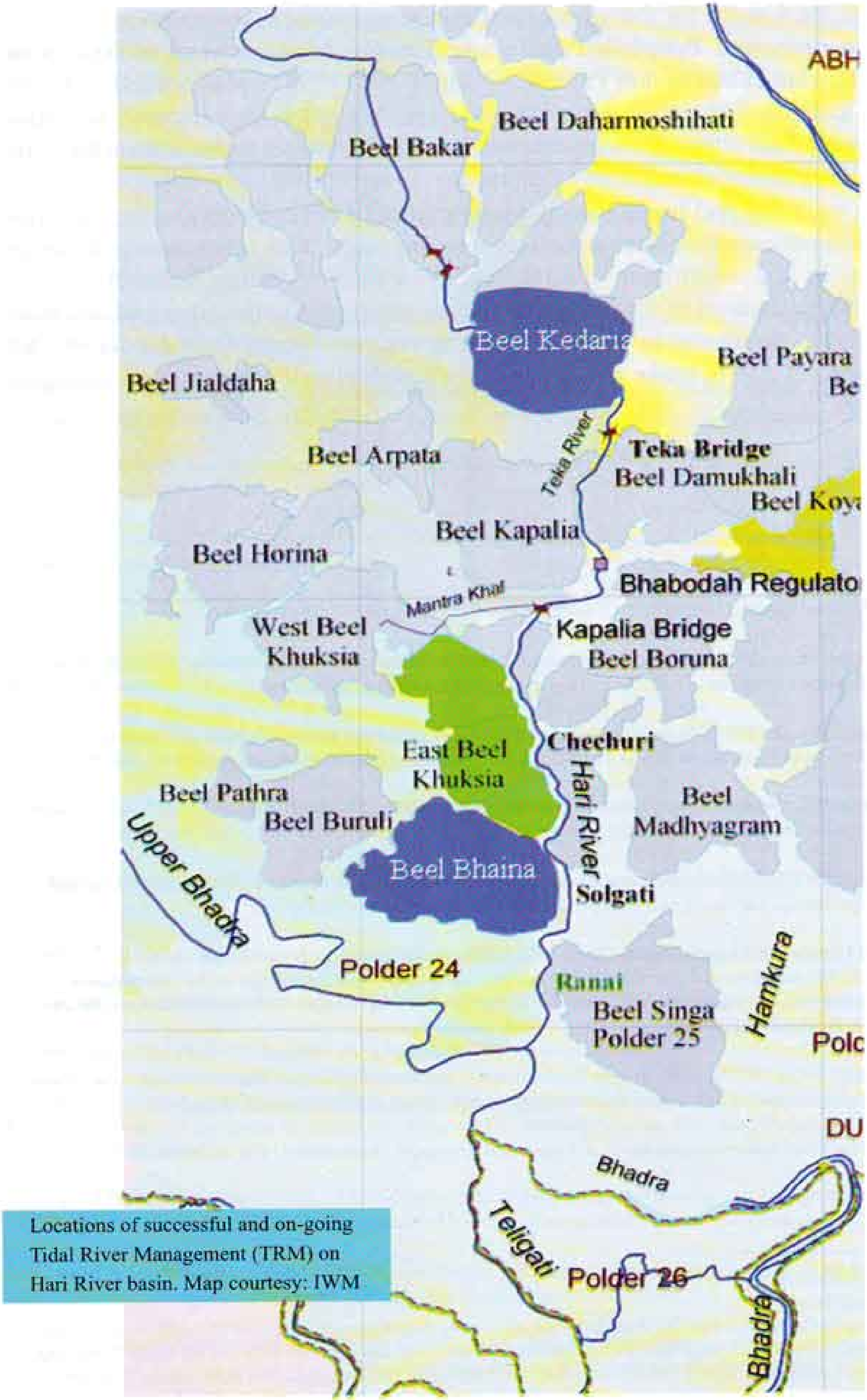
Water Development Board has problems in managing such claims. The landowners gave up their land for TRM for a period of 3 years in Beel Kedaria, but they did not allow its use in the fourth year when the next river basin was not prepared for rotation. As a result, the gains made earlier during the 3 years were reversed due to flooding.

Sustained provision for operation and maintenance

The river channels must be kept clean and open for the tidal flows to proceed unimpeded. The local beneficiaries regularly on a daily basis can do much of the maintenance. However, there is a continuous requirement to spread the deposited silt to locally lower areas within the beel itself so that rising of the beel lands will be even. An area of approximately 600 ha was considered as an appropriate and manageable size for the Beel Bhaina basin. As this maintenance is a regular activity, it is essential for the sustainability of the approach that a robust operation and maintenance arrangement including financing should be in place for successful completion of the conversion of the low lands into agriculturally productive farmlands.

The Way Forward: Scaling Up and Replicating the Tidal River Management (TRM) in Shouthwest Coastal Region for Climate Change Adaptation

Uttaran is working with Paani Committee, a community platform campaigning for sustainable management of rivers in the southwest region for more than a decade, and engaged national level knowledge institutions like the Institute of Water Modeling



Locations of successful and on-going Tidal River Management (TRM) on Hari River basin. Map courtesy: IWM

(IWM)[18] and the Centre for Environmental and Geographical Information Services (CEGIS)[19] to prepare a **People's Plan of Action for Management of Rivers in Southwest Region** (Uttaran and Paani Committee 2011)[20]. The plan, developed with community consultation throughout eleven river basins in the region, identifies locations where tidal river management can be implemented at a broader scale. The Plan envisions a regional and integrated approach. At this stage, it is important that government agencies and international development partners come forward to work closely with local communities to scale up and replicate tidal river management on river basins in the southwest coastal region. Climate change researchers and adaptation strategies need to study the indigenous ecological knowledge and practices for river basin management in southwest coastal region to learn finer details of tidal river management and to make best use of it in development of adaptation strategies for the region.

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Tidal River Management (TRM) is an age-old indigenous water, sediment and river basin management practice in southwest coastal region in Bangladesh perfected by local communities over generations. A huge area of land in the southwest coastal region of Bangladesh, a region predicted by experts to be one of the hardest hit by climate change induced sea level rise, is being raised using a unique indigenous ecological knowledge of river management and collective effort of local communities. The estuarine rivers in southwest coastal region witness two cycles of tides in every day. The high tides bring in muddy water flow with a thick concentration of sediments. The local communities cut the embankment, in an appropriate point, to let the river flow enter a floodplain. The natural high tide of river enters the floodplain, leaves a part of the sediment to be deposited on the floodplain and goes back to the ocean. Over time the deposition of sediments raise land level in the floodplain and enriches the soil. Since this process does not allow sediments to be deposited on riverbed, the depth of the riverbed also increases and makes the river congestion free. National level scientific and knowledge institutions like Institute of Water Modeling (IWM), Centre for Environmental and Geographical Information Services (CEGIS), and multilateral development finance agency Asian Development Bank (ADB) have acknowledged the concept to be an effective way to mitigate the waterlogging crisis that has been plaguing the region since the 1980s. Studies done by scientific institutions and community consultation has shown that Tidal River Management (TRM) can be scaled up and replicated on river basins throughout the southwest coastal region. It is the most effective method to raise land and make it cultivable, mitigate waterlogging crisis, increase navigability of rivers, reduce salinity and used as the most effective climate change adaptation strategy to protect the region from sea level rise. Tidal River Management (TRM) implemented at the initiatives of local people is such a method, which can be used to raise land low cost and keeping the natural process unaffected. Tidal River Management (TRM) is the most effective climate change adaptation strategy for southwest coastal region in Bangladesh. It can be used to face the challenges of sea level rise and hundreds of kilometers of land in Satkhira, Khulna and Jessore district in southwest coastal region of Bangladesh can be raised. A People's Plan of Action for River Basin Management in southwest coastal region on Bangladesh has been developed in consultation with local communities and in collaboration with scientific institutions. It is time for the policy makers to come forward and scale up Tidal River Management (TRM) throughout the region.

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