Chapter

Temporary De-Poldering for a Long Term Flood/Sediment Management in the Southwestern Bangladesh

Rocky Talchabhadel, Kenji Kawaike and Hajime Nakagawa

Abstract

Southwestern Bangladesh has been seriously affected by perennial waterlogging over the last few decades. It is primarily due to excessive riverbed siltation outside the polders after the construction of embankments along both sides of the tidal rivers. These embankments de-linked the huge natural floodplains and restricted a gradual process of natural deposition inside the polders. An introduction of the tidal basin concept by temporary de-poldering (embankment cut) at some designated locations has substantially solved the issues. The current chapter looks at the historical practice of flood/sediment management, the evolution of embankments and their de-poldering, inclusion of Tidal River Management (TRM) in long term flood/sediment management, and discusses a technical aspect of flood/sediment dynamics across the tidal river system. The process of restoring beneficial tidal flooding by cutting embankment at certain locations, commonly known as TRM, is not a novel method. The TRM has started from age-old practice and proves technically one of the effective methods of sustainable flood/sediment management in the tide-dominated river system. It is an example of building with nature, where little human interventions are needed, and a resilient measure for waterlogging, drainage-congestion, and river-siltation.

Keywords: *beel*, de-polder, polder, siltation, Tidal River Management (TRM), waterlogging

1. Introduction

For millennia the Bengal delta has been home to dynamic interplay of sediment, water, and land. The southwestern region of Bangladesh, comprised mainly of the Khulna, Jessore, Satkhira, and Bagerghat (shown in **Figure 1**), is characterized by an agro-economical system with numerous morphologically active tidal rivers and brackish water regime. Before the lowlands were enclosed by earthen embankments, that keep the main tidal channels outside the polder, the tidal river would inundate vast tract of lowland two times in a day. In addition, there were less population pressure and lower level of agricultural production. In the past *Zamindar*s (landlords) were managing the water resources in an open-wetland ecosystem of

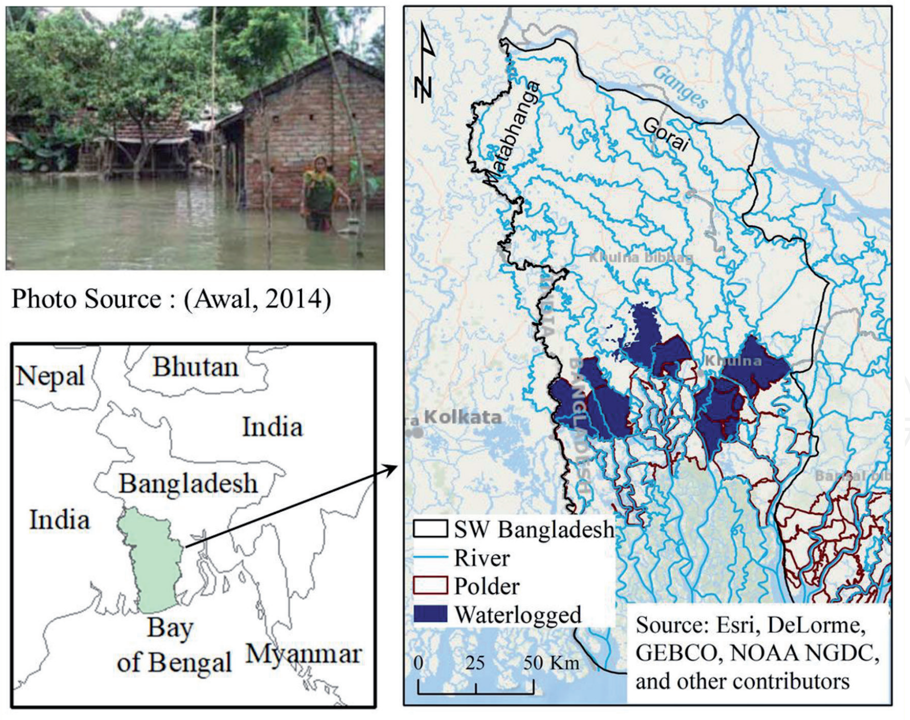

Figure 1.
Map showing prevailing waterlogging in the coastal polders across the southwestern (SW) region of Bangladesh. A representative photo [1] shows permanent waterlogging in Tala, Satkhira in august 2011.

southwestern delta. They used low earthen embankments during eight dry months of the year (commonly known as "*ostomasi bundh*" in local *Bengali* language) for prevention of tidal intrusion and protection of agricultural lands. After the harvest, the embankments were dismantled or swept away by natural river flood during monsoon [2]. The flood water during the monsoon enabled the deposition of sediment, nutrients in the form of over land irrigation, and soil nourishment and also allowed for seasonal fishing [3].

After the abolition of *Zamindari* system (land holding by *Zamindar*s), the maintenance became disrupted. In addition, there were disastrous floods in 1954, 1955 and 1956 which caused large-scale damage to human lives and food crop [4]. In order to meet the food demand of rapidly increasing population there was a need of all-round the year cultivation which requires a proper flood control [5]. In the 1960s, the Coastal Embankment Project (CEP) constructed 123 polders in southwestern coastal region of Bangladesh. Polders were constructed to protect land and livelihood from floods, salinity intrusion and to facilitate increased agricultural production. Daily tidal intrusions became a thing of past [6] and with two-three harvests annually the agriculture-based economy gained significantly for 10–15 years.

At the same time, coastal embankments denied the entry of the tides into the polders and gradually prevented the slow process of land formation on flood plains. As a result, unintended heavy loads of riverbed siltation [7] altered the natural river flow seriously and tidal rivers lost their navigability. Several rivers completely dried within a few years to few decades. The floodplains inside the polders gradually lowered than riverbed outside the polders and closed the exits of the sluiced gates. Adding to the problem, the Farakka Barrage across the Ganges River reduced the freshwater flow since 1976. In the southwestern region of Bangladesh, the Matabhanga and Gorai Rivers (shown in **Figure 1**) are the main distributaries of the Padma River for freshwater upland flow. Moreover, due to the heavy siltation at the rivers' mouth, their distributaries virtually gets no water from upstream in dry season. These tidal rivers could not effectively drain the nearby *beel*s (low lying land or natural depression) inside polders anymore, which results in serious waterlogging (shown in a representative photo in **Figure 1**). There is water everywhere but not drinking water.

2. Emergence of de-poldering

Since the 1980s, vast tracts of land went under water semi-permanently; the rainwater in the region could not drain resulting to a long-standing waterlogging problem (for more than 6 months in a year). Major flood events in 1987, and 1988 triggered large-scale long-standing waterlogging problems. In an apparent move to address waterlogging especially in the *beel Dakatia*, the largest *beel* in southwestern region of Bangladesh (shown in **Figure 2**), the Khulna Coastal Embankment Rehabilitation Project (KCERP) was introduced in the late 80s with support from Asian Development Bank (ADB). There was lack of consultation with local concerned people and their needs were hardly reflected in the project design. The waterlogging problem further deteriorated leading to widespread public protest [5].

The project was ultimately suspended as local people cut the embankment at four places during a *mahashamabesh* (mass community mobilization) with the intention of draining away water from the *beel* in September 1990. They believed the tidal flow could be restored through breaching, the land would rise through the accumulation of silt and the stored water coming out could push through the narrow river [4]. The restored open connection with the river immediately initiated

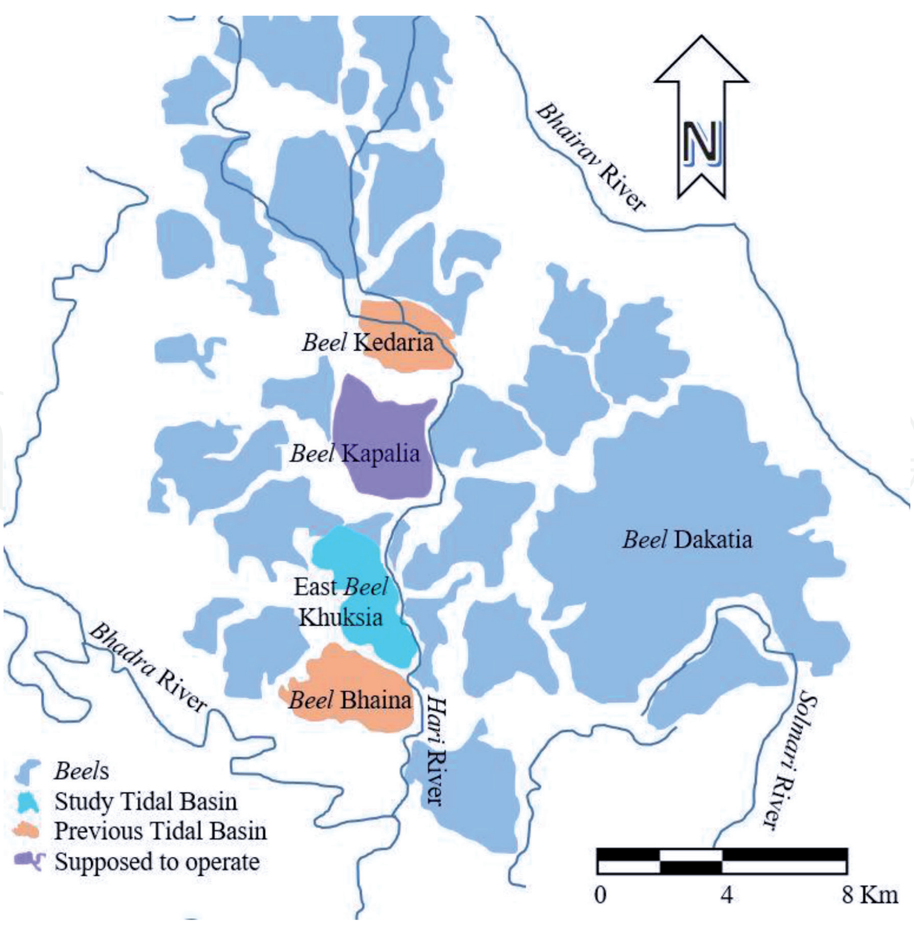

Figure 2.
Location of Beel *Dakatia,* beel *Kedaria,* beel *Kapalia, east* beel *Khuksia, and* beel *Bhaina in Hari-Mukteswari River system. Note: Other* beels *(unnamed) are visible in shape and locations (adapted from Talchabhadel et al. [8]).*

tidal dynamics and sedimentation processes within the beel. Approx. 1000 ha of high land had been gained in the *beel* Dakatia via public cuts (i.e. without any technical studies on design of de-poldering).

To solve drainage congestion issue, enhance flooding protection (both tidal and seasonal), and rehabilitate existing drainage infrastructure the Khulna-Jessore Drainage and Rehabilitation Project (KJDRP) started in 1993. For Bangladesh Water Development Board (BWDB), the public cutting of embankments was unacceptable because it went against the law. The cuts were closed in *beel* Dakatia by BWDB in 1994; the land level was elevated substantially. The *beel* Dakatia public cutting enhanced the tidal free flow and restored the navigability of the river by increasing both depth and width within a short span of time. But then, the river largely died when the cut points were filled up.

The river was almost rescued by local people through their intuitive knowledge but ultimately it died. The dry river bed is covered by paddy field and homesteads. Although international consultants had incorporated plans for controlled tidal flooding in the early 1990s, BWDB did not include the practice in the KJDRP, arguing that it misrepresented the real problem and that it was not scientifically grounded [3]. The waterlogging scenario in southwestern region was intensified in 1997 flood (monsoon) season. The water could not be drained away overland, nor could it be discharged. In post flood season, local people had cut the embankment of *beel* Bhaina for quicker drainage needed for Boro-rice cultivation on their land. Although rapid drainage and recession of water occurred from *beel* Bhaina due to high magnitude of head difference the *beel* could not be brought under Boro-rice cultivation by closing the cut-point. It became gradually wider and deeper and went beyond the capacity of the local people to close. But at the end of the dry season, they observed that land level of *beel* Bhaina was raised, on the other hand, depth of Hari River increased significantly. The temporary restoration of tidal flooding by de-poldering came to be known conceptually as TRM. The basic idea in this process is to allow high tides bringing muddy water flow with a thick concentration of sediment into designated tidal basin and releasing the tidal flow back into the river during the low tides. During the repetitive process of such tidal restoration, a large chunk of sediment deposits on the tidal basin which otherwise would deposit in the river channel if there were no de-poldering. In addition, during low tides the flow even washes away sediment from river bed making the river congestion free and more navigable.

It brought the attention of the donor agency to apply these phenomena in all the *beel*s adjacent to Hari River sequentially as a tool to remove waterlogging from the inundated *beel*s. A socio-environmental impact study carried out by research institute EGIS (now Center for Environmental and Geographic Information System - CEGIS) in 1998 was crucial in the debate of open and closed approaches of flood/sediment management: the study supported closed and embanked approach (i.e. polder), but it equally argued for the inclusion of a TRM (de-polder) [9].

An iconic public embankment cutting in *beel* Dakatia proved to be the centerpiece of the discussion on open (de-polder and temporary water retention) versus closed (embanked and detached catchment) approaches. With *beel* Dakatia and *beel* Bhaina together, there was a decade of local people driven TRM. The attention to environmental issues and an emphasis on social participation have (forcefully) created some space for de-polder in the domain of embanked flood management. Since the *beel* Bhaina was taken up by KJDRP, it is considered as the first TRM officially. In 2002, BWDB incorporated TRM in *beel* Kedaria, then in east *beel* Khuksia in 2006. It showed that, over time, a dominant paradigm suggesting poldering was supplemented by some incidental occasions of de-poldering. The description of operated TRMs are summarized in **Table 1**.

Technical Context	**Informal - Local people proactive**		**Formal**	
	Beel Dakatia	*Beel* Bhaina	*Beel* Kedaria	East *Beel* Khuksia
	11000 ha	600 ha	600 ha	800 ha
	(1990–1994)	**(1997–2001)**	**(2002–2005)**	**(2006–2012)**
Strategy	No technical planning	No technical planning, started by local people and undertaken by BWDB later	Planned and approved by BWDB	Planned and approved by BWDB
Embankment Opening	Public Cut in 4 places	Public Cut and continuous operation	No breaching of embankment, operated through 21 vent Bhabodah regulator (6 months per year)	Formal De-poldering and continuous operation
Peripheral Embankment	No	No	Yes	Yes
Land Heightening	Not measured exactly; Around 10% of such a large area significantly land heightened	Around 60% uniformly silted; Average of 0.8 m land heightening (1.5–2.0 m at cut point and 0.2 m in the far end); Net silt deposition = 6.48 million m^3	Insignificant Siltation; Net silt deposition = 0.5 million m^3	Around 50% uniformly silted; Average of 1.2 meter land heightening (1.5–2.0 m at cut point and 0.5 m in the far end)
Compensation	No	No	No	Yes (not easy to get)
Stakeholder Participation	Local Communities and NGOs, Social and political activists	Local Communities and NGOs, Social and political activists	Local Communities and NGOs, Social and political activists, Government institutions, research organizations, donors and so on	Local Communities and NGOs, Social and political activists, Government institutions, research organizations, donors and so on
Conflicts	Local conflicts were resolved		Conflicts exist among local stakeholders (shrimp-field owners, local farmers, landless people, daily-wage workers, NGOs, civil society organizations) as well as between local stakeholders and government institutions (local government, Union Parishad, Upazilla, district administrative, BWDB,)	

Table 1.
Summary of description of operated TRMs (both informal and formal) [2, 4, 10, 11].

3. Shifting of Tidal River Management

The people of *beel* Kedaria were very much in favor of TRM to raise their land, but it did not meet their expectation. Although there was no waterlogging in the area during the operation the landowners lost their interest to operate TRM by submerging their land without any yield and compensation for three years. This created a negative impact on TRM and ultimately BWDB could not find any *beels* to operate TRM in the year 2005. The riverbed silted up immediately after stopping the operation of TRM shown in **Figure 3**. After the termination of TRM, the riverbed rose almost by 4–6 meters due to reduced tidal prism. It clearly indicates the area will remain inundated if TRM is not operated in any of the *beel*s. To solve the problems in the long run, TRM operations are to be shifted/rotated effectively in different *beel*s. It is reported that the shifting of TRMs from downstream to upstream yields larger sediment deposition than from shifting TRMs from upstream to downstream [6].

The challenges of operation are social and institutional. People are unwilling to provide their land since they cannot do economic activities like agriculture or fisheries. To overcome this challenge a compensation mechanism for crop and fisheries has been established then after. During the operation of TRM in east *beel* Khuksia, compensation mechanism was developed.

The plan of shifting of TRMs has been included in long-term policy for the southwestern region. Planned large-scale rotational TRMs were then developed in major river systems. Such as Hari-Mukteswari river system: East Khuksia, Kapalia, Baruna, Payra, West Khuksia and Singha by 2047 [12]; Kobadak river system: Pakhimara, Hariharnagar, Raruli, Rajapur Harinkhola, Delua and Jalalpur by 2045 [13].

In Hari-Mukteswari river system, *beel* Kapalia was planned to be operated as TRM from 2012 onwards for a period of 5 years, but violent protests prevented this. Some of the major reasons are compensation mechanism and lack of trust in government. East *beel* Khuksia was operated for 7 years but the initial plan was to only operate for 4 years. BWDB is currently bringing back the planned operation of TRM in Hari-Mukteswari river system (including *beel* Kedaria) by addressing pertinent social, economic, technical, and political problems. Meanwhile, BWDB is replicating the TRM concept in other receptive river system such as Kobadak river system. *Beel* Pakhimara is at present operational since 2015.

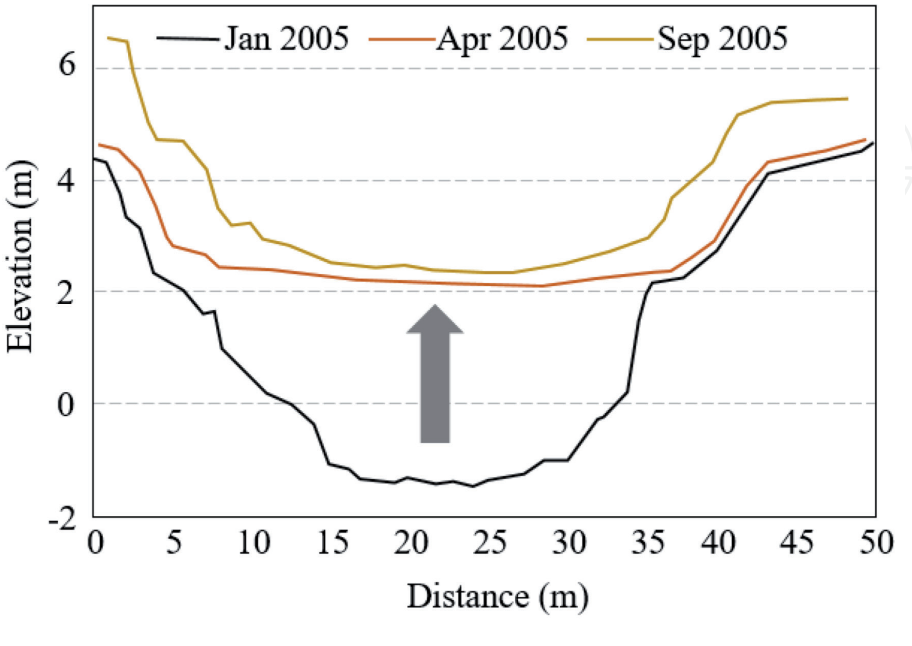

Figure 3.
Impact on Hari River morphology at Ranai after termination of Tidal River Management operation in beel *Kedaria (source: IWM [12]).*

4. Tidal River Management for flood/sediment management

Dredging and excavation are costly and are not eco-friendly. They are again more time consuming to manage huge drainage congestion. In addition, the deposited sediments by excavating again fall into the river through runoff in a rainy season. De-poldering and then controlled flooding (during TRM process) in a particular *beel* is not a new way of sediment management. However, the method involves taking full advantages of the natural tide movement with little human interventions. This concept involves temporary de-poldering to allow *jowar-bhata khelano* (free play of tidal flow) in selected *beel* through a link canal shown in **Figure 4a**. At high tide, muddy water enters with a thick concentration of sediment and deposits large chunks of sediment on the selected *beel*. At low tide, relatively clearer water erodes the river bed, increasing the depth of the river. This process is a participatory approach where the people of the identified tidal basin have to provide their land remain flooded for an intended period (about 5 years depending on tidal prism and area of the *beel*). **Figures 4a–c** and **5** show that TRM reclaims land from waterlogging and inundation, increases the river navigability by increasing river depth and width, and provides solution of drainage congestion of southwestern region.

This concept is technically feasible, environmentally friendly and socially acceptable [11, 15]. The experiences of TRM operated so far, exhibited that there was no

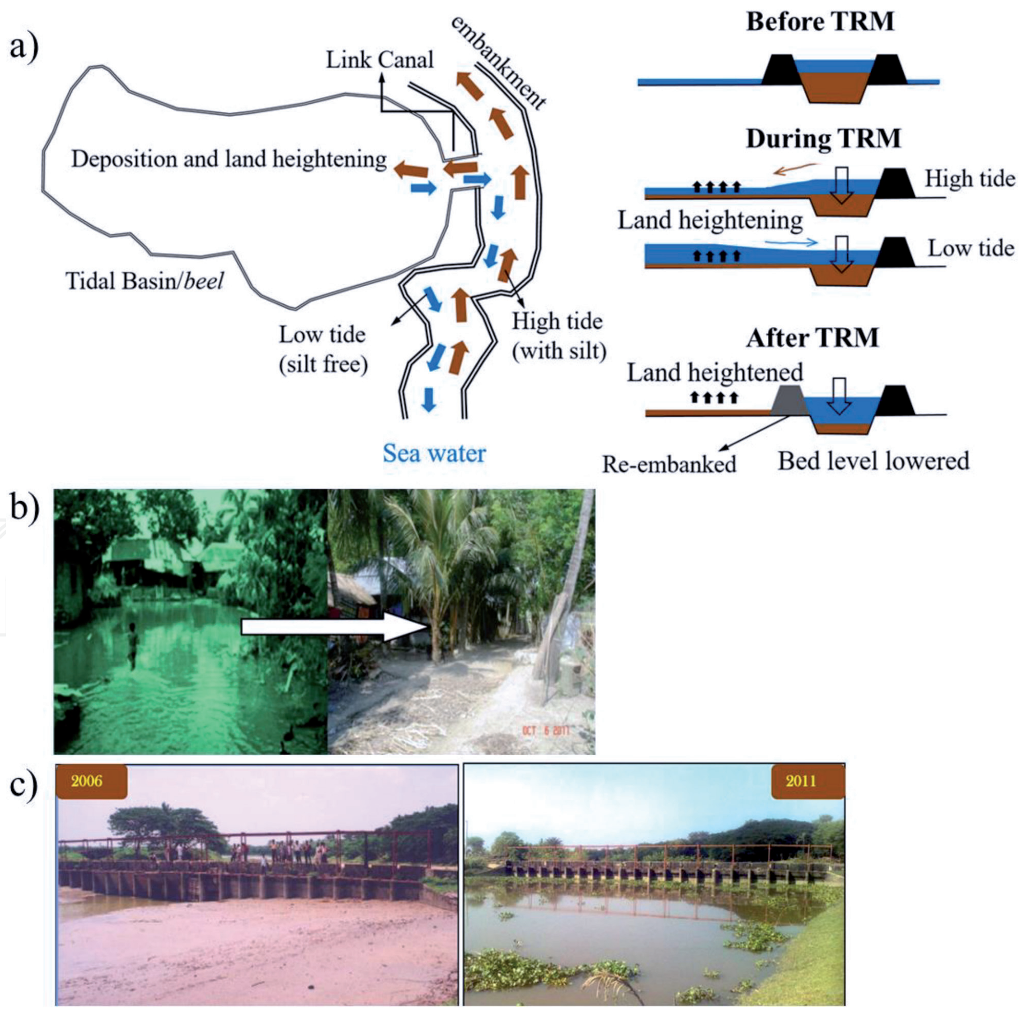

Figure 4.
(a) Tidal basin concept: Free play of tidal flow in selected beel, *(b) land reclamation in Arua village in between 2005 and 2011 [11], and (c) revival of Hari River near Bhabodah regulator in between 2006 and 2011 [14] (adapted from Talchabhadel et al., [8]).*

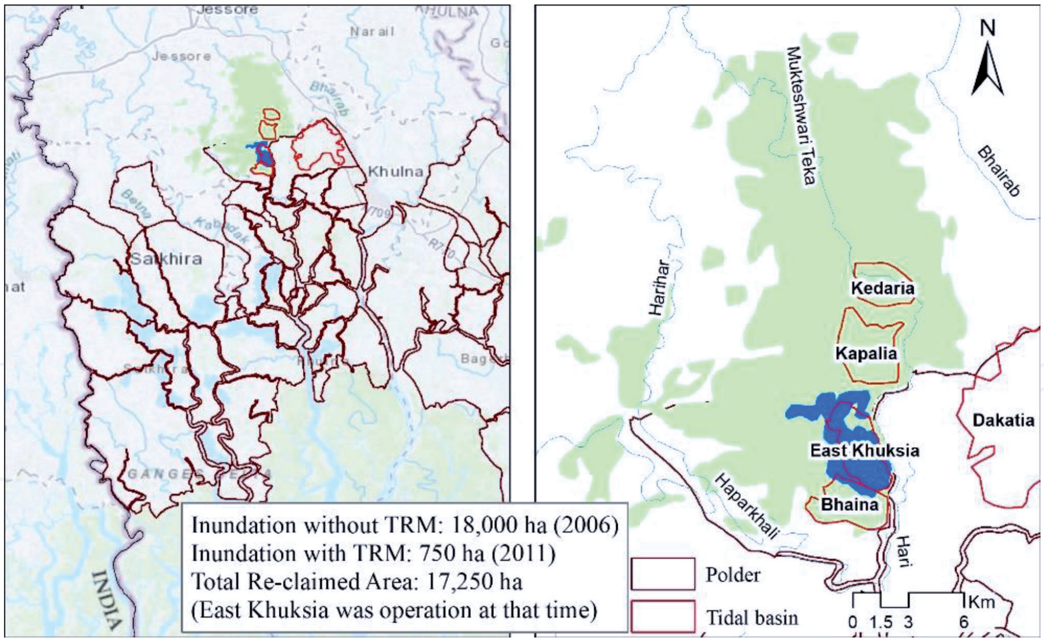

Figure 5.
Comparison of inundation area with and without operation of TRM (adapted from Talchabhadel et al., [8]).

drainage congestion and waterlogging problem throughout in the river system and the selected *beel*s were heightened significantly. Though the TRM operated *beel* is not suitable for practicing any agriculture, about 20–25 surrounding *beel*s located upstream could have favorable ecological conditions for better agricultural production. And, TRM can increase drainage capacity to a long distance up to 20 km of the lower stream at a single intervention from the place of TRM implementation [16].

Several studies have been conducted qualitative/quantitative analyses of TRM and its relation to disaster, ecosystem, environment, agriculture and suggested the appropriate design of TRM. Some studies [17–19] have analyzed the effectiveness with different interventions like crossing dam, dredging, and compartmentalization. Some [20–22] have suggested optimum opening sizes of link canals connecting the tidal basin and tidal river. The TRM is effective when there is no upland flow or the upland flow is reduced, therefore, crossing dam at upstream of cut point is recommended during the operation of TRM. There have been still issues related to non-uniform sediment deposition across the selected *beel* despite of several studies based on experimental and numerical simulation. Higher sedimentation occurs close to the opening and decreases gradually to the further end of the *beel* [23]. To solve this issue, one option could be construction of embankment on both sides of main channel inside tidal basin and allowing siltation from most remote areas and cutting embankment part by part from remote end to link canal or introduce compartmentalization [18]. Also, the alignment of link canal controls the area of high shear stress [22]. A relationship between the tidal prism and minimum area for a tidal equilibrium can be established using historical data of nearby tidal rivers while designing the link canal [17, 21].

A combination of TRM with some degree of dredging/excavation could serve effective drainage and sediment management. Most importantly, the operation of TRM should be continuous. In the absence of sequential or shifting of TRMs, the acquired benefits might be wasted due to repetitive heavy siltation. Therefore, there should not be any time gaps between closing of one *beel* and operation of successive TRM *beel* [24]. Effective operation of TRMs could contribute to flood alleviation in southwestern Bangladesh and more than 100 beels are suitable of operation of TRM process [7]. However, during the operation of TRM agriculture is affected for a few years in operated *beel*. A systematic program of TRM is therefore necessary in order to increase overall agricultural production by reducing flood susceptibility and managing sediments. A manageable size of the tidal basin at one intervention is around 1000–2000 ha.

5. Toward sustainable solution

TRM evolved into an environmentally accepted flood/sediment management practice based on indigenous knowledge and it contributes to land heightening, flood resistance, and food security. However, the socio-political use of TRM complicates its implementation and there have been well-documented failures of TRM implementation. The effectiveness of TRM has not matched the expectation of majority of stakeholders. The challenges include engineering, socio-political, and institutional. Overall, a key barrier to the successful implementation is a proper management of compensation. Though the compensation mechanism started in east *beel* Khuksia, there were conflicts among different stakeholders (farmers, landless people, daily-wage workers, shrimp-field owners, NGOs, local organizations) and between these stakeholders and government bodies (BWDB, local government, district administrative) are prevalent [6]. The conflicts are related to compensation amount, procedure of compensation, land use practices, employment, shifting of TRMs and overall coordination.

Generally, the landless farmers and poor fishermen are the main sufferers of TRM implementation. Because they worked under landowners and they would not get the land compensation [25]. It is a high time to identify programs addressing their needs, for instance, provision for the cooperative fish culture. Shrimp farmers, who did not want to lose their leased land under any circumstances are against the TRM [4].

BWDB officials being primarily engineers and hydrologists, they may lack the skills and expertise to facilitate stakeholder [26]. The river channels should be kept open as far as possible. Unplanned drainage obstacles like *gher*s (shrimp aquaculture ponds) should be removed and appropriate policy should be developed to stop misuse of *khal*s (drainage canals). Sediment management for uniform distribution is required to improve TRM practices. Highly saline zones are unsuitable for the TRM sites as high saline sediment precludes agriculture. A temporary cross dam should be constructed in the dry season. If possible, the river should be re-excavated before the monsoon and the crossing dam should be made open during the monsoon. Peripheral embankment should enclose the selected *beel*. A simple mechanism of distributing the crop compensation has to be established. There is a strong need of an open, transparent and inclusive planning, implementation, and operation-maintenance of TRM.

The evolution of social learning, and participation of different stakeholders clear indicate a need for an approach that considers multi-dimensional (social, economic and environmental) consequences [4]. Also, bringing together people from different backgrounds, perspectives, values does not automatically lead to effective management. It requires a multi-loop process in improving a multiple-actor-based management practice [2]. Key criteria for successful TRM implementation are:

- Intensive consultation with concerned communities, and affected landowners

- Collaborative working (conflict resolution among different land-use groups, working agencies, and government institutions)

- Strengthening of local institutions
- Regular supervision by government institutions
- Continuous information and motivational campaign
- Interdisciplinary research (technical and socio-economic research for proper selection of *beel*s, their operation, and compensation distribution)
- Iterative learning (evaluation of success and failure to guide for the effective operation in next *beel*)
- Sequential implementation of TRM (no stoppage of operation at any cost)

A long-term strategy of Bangladesh Delta Plan (up to 2100) has highly acknowledged the TRM concept for solving waterlogging problems and making river alive. Restoration of tidal plain allowing tidal inundation is an effective measure for increasing the tidal prism, raising the low lying land (sediment-starved flood plain), and ultimately solving waterlogging issues with sustainable sediment management. In order to obtain faster drainage, pumping might be required in addition to gravity drainage of polders. The iterative learning in coming days will surely move toward the sustainable solutions. Although an embankment along the coast is required, sediment management is also essential for sustainability. The concept of TRM, evolved from indigenous knowledge and blended with scientific understanding, should go hand in hand with other water/sediment-related interventions.

6. Conclusion

Unlike excavating, TRM is eco-friendly, cost-effective (no need of large-scale engineering), and time-efficient (maximum utilization of natural tidal flow). It simply allows beneficial flood in raising low-lying land, scouring silted river, and improving drainage congestion. The TRM process restores the tidal prism and provides sufficient space for the river. However, internal roads, cultivation, and economic activities are hampered during the TRM operation period. The TRM concept is one of the effective measures of managing flood/sediment problems in tide-dominated river system.

Evolved from traditional wisdom, the TRM process is blended with scientific knowledge and it proves to be a sustainable way forward for effective flood/sediment management. However, a key barrier to the successful implementation is compensation. The landless farmers and poor fishermen are the main sufferers of TRM implementation. Programs focused for main sufferers are equally needed along with a simple mechanism of distribution of the compensation to land owners.

Since the TRM is a participatory approach, all the organizations and stakeholders connected with the different stages of the development process of TRM should be responsible for promoting the entire process. Multiple-stakeholders-based inclusive planning, operation-management practice with iterative learnings are necessary for successful implementation of TRM concept. With time we need to rethink and recalibrate the roles of stakeholders in order to manage possible conflicts and maintain impulsive monitoring and evaluation of all groups involved from local communities to government bodies. Therefore, the process need continuous updating based on the monitoring results.

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Conflict of interest

No conflict of interest.

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