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Polder to De-polder: an Innovative Sediment Management in Tidal Basin in the Southwestern Bangladesh

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Synopsis

The southwest region of Bangladesh has been affected by the perennial waterlogging due to excessive riverbed siltation. An introduction of tidal basin concept by temporary de-poldering at some places has significantly protected the circumstances. The paper looks at the historical practice of sediment management, the evolution of polder and de-polder, and investigates some technical aspects evolving the processes. The temporary restoration of tidal flooding by de-poldering has started from age-old practice, proves technically one of the effective methods of sustainable water/sediment management in the tide-dominated river system. Although an embankment along the coast is required, sediment management is also essential for sustainability. It is the example of building with nature and a resilient measure for water-logging, drainage congestion, and river siltation.

Keywords: *beel*, de-polder, polder, siltation, waterlogging

1. Introduction

The southwest (SW) region of Bangladesh shown in Fig. 1 has been suffering badly from river siltation and drainage congestion over the last few decades. Tidal rivers bring large concentrations of sediment from the sea into the river system. Before polderization, major parts of incoming sediment deposited naturally on the low-lying land (*beels*).

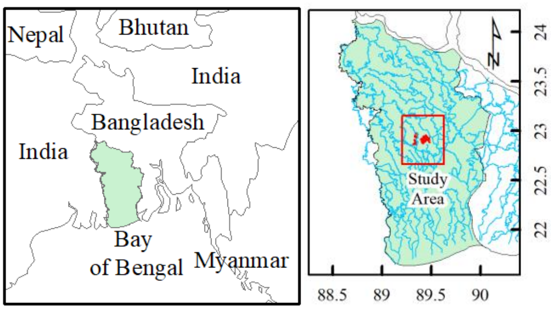


Fig. 1 SW region of Bangladesh

The precipitation in the region is very seasonal and the distribution is highly uneven (shown in Fig. 2). Almost 90% of total precipitation occurs during six months from May to October and remaining six months are dry. The rainwater is trapped due to poor drainage congestion in the region.

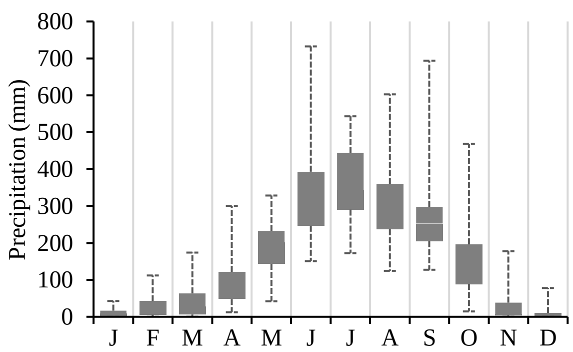


Fig. 2 Mean monthly precipitation of SW region of Bangladesh (1981 - 2010). The box plot shows inter annual variability of monthly discharge.

2. Polderization

The construction of series of polders (earthen embankment encircled around the depressions keeping the main tidal channels outside) started in the 1960s to prevent land and livelihood from floods, saline intrusion to facilitate increased agricultural production. The initial outcomes of the polders were quite rewarding. A significant increase in agricultural productivity for 10 – 15 years was seen. It allowed 2 rice harvests or sometimes even 3 harvests annually compared to 1 earlier. But the obstructions by polder system prevented the spreading of the natural tidal flows and restricted siltation on the *beel*s which led to accelerated silt deposition in the rivers and channels. The deposition on the riverbed for the longer time period left the floodplains inside the polders lower than the riverbanks outside the polders.

Fig. 3: Map showing prevailing waterlogging in the coastal polders (Source: Bangladesh Delta Plan, 2015)

Photo 1: Photo showing permanent waterlogging in SW region: Tala, Satkhira on August 2011 (Source: Awal, 2014)

The subsequent drainage congestion and water logging problem adversely affected the homesteads and livelihood seriously (shown in Fig. 3 and Photo 1). The sediment management became most challenging and the flood risk on embanked polder regions should be understood precisely.

2.1 Historical sediment practice

For millennia the Bengal delta has been home to a dynamic interplay of water, sediment, and land. The SW region of Bangladesh is characterized by an agro-ecological system with numerous morphologically active tidal rivers. The river would inundate vast tract of *beel*s two times in a day. Large volumes of sediment used to deposit on *beel*s shown in Fig. 4 that are now enclosed within polders.

During the period of *Zamindari* (large landowners), the tenant farmers had to pay large portions of their income, to *Zamindar*s. Since the income of *Zamindar*s largely dependent on the crop production, they built low earthen dikes to prevent salinity intrusion and cultivate indigenous varieties rice. After the harvest, the farmers would partially dismantle the temporary embankments to allow flood waters to enter into the previously enclosed areas. The practice of the *ostomasi bundh* (eight-month embankment) with 1 harvest per year, was more practice at that time. In the rainy season, farming communities exchanged saline water of their fields with river water when it became almost sweet to minimize the salinity of the land. Thus the environment, ecosystem, and bio-system that evolved in the coastal area were in balance. It was a unique system of land-water interface developed over hundreds of years of practice and experience.

In 1951, the *Zamindar* system was abolished. As a result, there was no one to take the responsibility for repair and maintenance or construction of new ones. In addition, there were disastrous floods in 1954, 1955 and 1956 which caused large-scale damage to human lives and food crop (Gain *et al.*, 2017). With increasing population pressure, there was ever-growing demand for food production. So there was a greater eagerness for flood control in order to bring more land under cultivation all-round the year (Haque *et al.*, 2015). Hence the government recognized the need for protection of the coastal area.

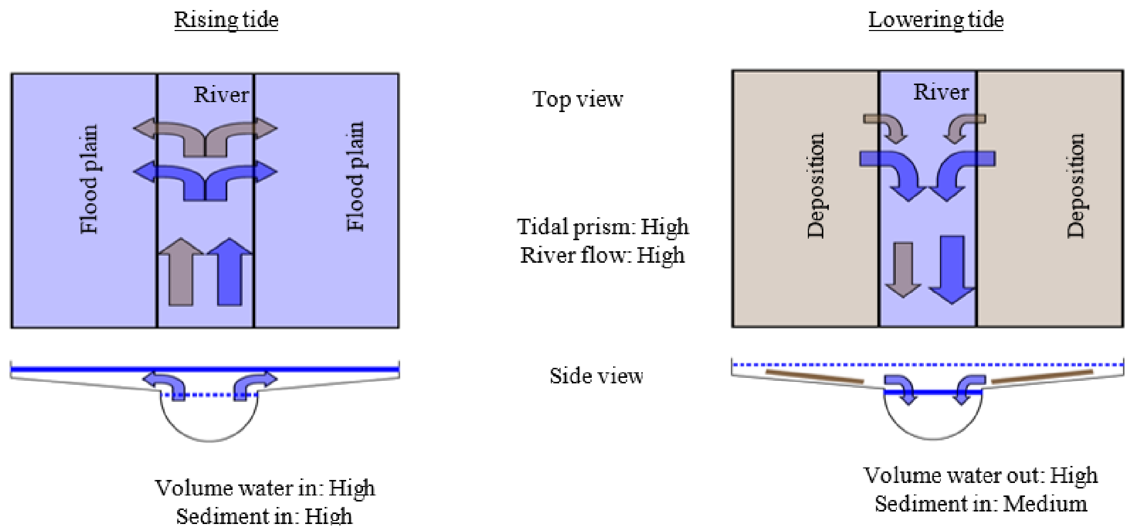


Fig.4 Morphological state of rivers before the construction of coastal polders (Source: Leendert Ferdinand de, 2013)

3. From Polder to De-polder

The presence of embankments on both sides of the river gradually prevented the slow process of land formation on flood plains leading to severe siltation in the river bed. Adding to the problem, the Farakka Barrage across the Ganges River reduced the freshwater flow since 1976. These tidal rivers cannot effectively drain the nearby lands and polders anymore, which results in serious waterlogging. 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, 1988 triggered large-scale long-standing waterlogging problems.

In an apparent move to address waterlogging especially in the *beel* Dakatia, the largest *beel* in Bangladesh's SW region (shown in Fig. 5), 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 (Haque *et al*., 2015).

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 (Gain *et al.*, 2017). The restored open connection with the river immediately initiated tidal dynamics and sedimentation processes within the *beel*. The temporary restoration of tidal flooding by de-poldering came to be known conceptually as Tidal River Management (TRM).

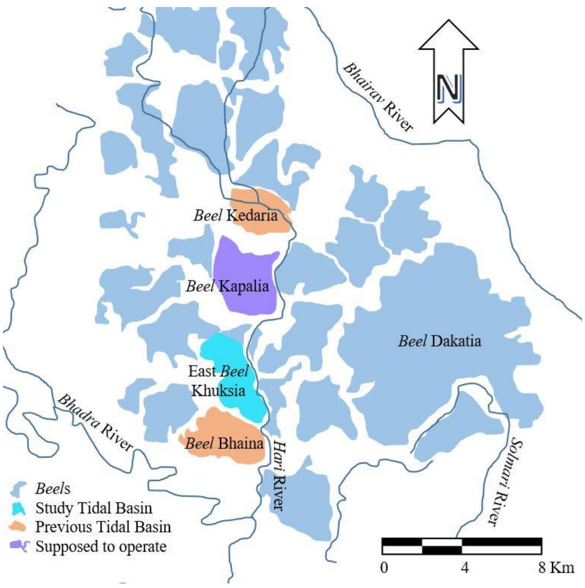


Fig. 5 *Beel* Dakatia, *beel* Kedaria, *beel* Kapalia, east *beel* Khuksia and *beel* Bhaina have been mentioned in the article text and indicated here; other *beels* are visible in shape and locations

Following the suspension of KCERP, the Khulna-Jessore Drainage and Rehabilitation Project (KJDRP) was formulated in 1993 with support from ADB. Its core objective was rehabilitating the existing drainage infrastructure to reduce congestion and enhance protection from tidal and seasonal flooding. 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 (Haque *et al.*, 2015). 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 (Staveren *et al.*, 2017). The waterlogging scenario in SW 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.

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 an important step in terms of combining open and closed approaches: it advised the construction of a number of engineering works, but it also argued for the inclusion of a TRM concept on scientific study (EGIS, 1998).

Table 1. Summary of description of operated TRM

Technical Context	**Informal - Local people proactive** ***Beel* Dakatia** 11000 ha **(1990 - 1994)**	 ***Beel* Bhaina** 600 ha **(1997 - 2001)**	**Formal** ***Beel* kedaria** 600 ha **(2002 - 2005)**	 **East *Beel* Khuksia** 800 ha **(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 continous operation	No breaching of embankment, operated through 21 vent Bhabodah regulator (6 months per year)	Formal De-poldering and continous operation
Peripheral Embankment	No	No	Yes	Yes
Land Heightening	Not measured exactly; Around 10 % of such a large area significanlty land heightened	Around 60 % uniformly silted; Average of 0.8 meter land heightening (1.5-2 m at cutpoint 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 m at cutpoint 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 activisits	Local Communities and NGOs, Social and political activisits	Local Communities and NGOs, Social and political activisits, Government institutions, research organizations, donors and so on	Local Communities and NGOs, Social and political activisits, 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 labourers, NGOs, civil society organizations) as well as between local stakeholders and government insitutions (local government, Union Parishad, Upazilla, distirct administratives, BWDB,)	

(Source : Gain et al. 2017; Leendert FD 2013; Mutahara et al. 2017; Rezaie et al. 2013)

An iconic public embankment cutting in *beel* Dakatia proved to be the centerpiece of the debate 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 poldered 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 area has gone from Polder to De-Polder. The descriptions of operated TRM are summarized in Table 1.

4. De-poldering for sediment management

Dredging and excavation are not eco-friendly and cost-effective. 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 in a particular flooding plain is not a new way of sediment management. But TRM involves taking full advantages of the natural tide movement.

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 Fig. 6. 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. It takes full advantages of natural tide movements with little human interventions. 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*). Photos 2,3, and Fig. 7 show how TRM helped in land reclamation from waterlogging and inundation, an increment of river navigability by increasing river depth and width, and solution of drainage congestion of SW region.

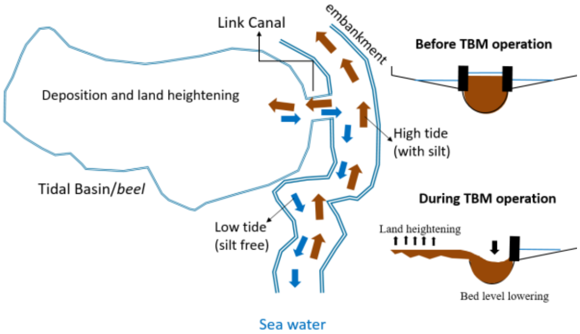


Fig. 6 Tidal basin concept: free play of tidal flow in selected *beel* (Source : Talchabhadel *et al.*, 2018)

Photo 2: Land reclamation in Arua village in between 2005-2011 (Source: Rezaie *et al.*, 2013)

Photo 3: Revival of Hari River near Bhabodah regulator in between 2006-2011 (Source: Paul *et al.*, 2013)

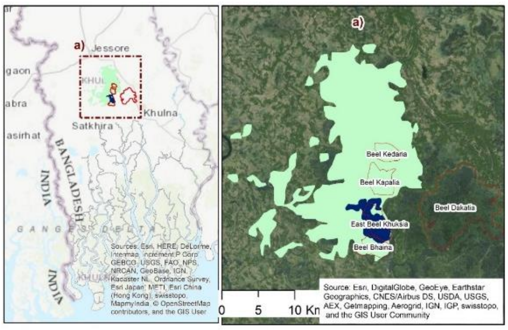
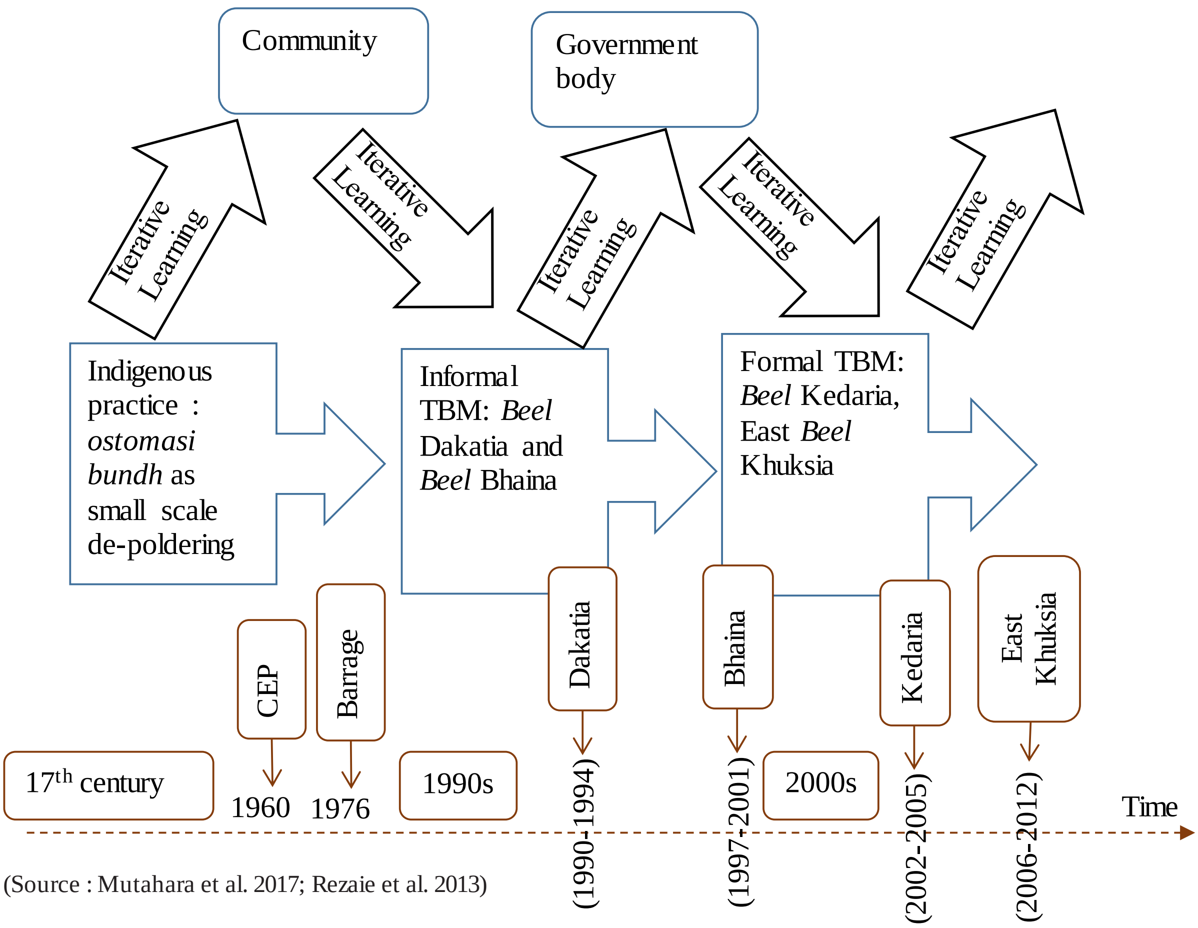


Fig. 7: Comparison of inundation area with and without operation of TBM. (East *beel* Khuksia was operation at this time). Inundation without TRM: 18,000 ha (2006); Inundation with TRM: 750 ha (2011); Total Reclaimed Area: 17,250 ha

This concept is technically feasible, environmentally friendly and socially acceptable (Rezaie *et al.*, 2013; Rezaie and Naveram, 2013). The closure of embankment after designated land heightening will again create a similar issue. During the year 2005, there was almost a year gap between an operation of next scheduled TRM (East *beel* Khuksia) and closing of TRM at *beel* Kedaria. The riverbed silted up immediately after stopping the operation of TRM. The necessity of continuous and sequential operation of TRM in another *beel* after completion in one *beel* was strongly figured out. Therefore, to solve this problem in entire basin, various *beels* are to be rotated one after another, the process is known was Tidal Basin Management (TBM). By doing so farmers of one tidal basin do not have to suffer for a long time.

People realized that the area will remain in water if TBM is not operated in any of the *beels*. 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 an effective mechanism of compensation for crop and fisheries should be established. The experiences of TBM operated so far, exhibited that there was no drainage congestion and waterlogging problem throughout in the river system and the selected *beels* were heightened significantly. It can increase drainage capacity to a long distance up to 20 km of the lower stream at a single intervention from the place of TBM implementation (Al *et al.*, 2018).

TBM simply allows beneficial flood in raising land, scouring silted river and improving drainage congestion. It is the example of building with nature and a resilient measure for water-logging, drainage congestion, and river siltation. It has evolved into an environmentally accepted water/sediment management practice based on indigenous knowledge (Al *et al.*, 2018). The evolution of TBM in social learning and stakeholders' participation is shown in Fig. 8.



(Source : Mutahara et al. 2017; Rezaie et al. 2013)

Fig.8 Evolution of social learning, participations of stakeholders in the operation of tidal basin concept

5. Towards sustainable solution

There have been well-documented failures of TBM implementation from engineering challenges (Khadim *et al.*, 2013), lack of proper socio-political discourse and institutional mismanagements. A key barrier to the successful implementation is compensation. The landless farmers and poor fishermen are the main sufferers of TBM implementation. They worked under landowners and they would not get the land compensation. Some programs focused for them need to be identified for instance provision for the cooperative fish culture.

- Shrimp farmers, who did not want to lose their leased land under any circumstances are also against TBM implementation (Gain *et al.*, 2017).
- BWDB officials being primarily engineers and hydrologists, they may lack the skills and expertise to facilitate stakeholder engagement (Gain and Schwab, 2012). 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 TBM practices.
- Highly saline zones are unsuitable for the TBM 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.
- Open, transparent and inclusive planning, implementation, operation-maintenance.

Fig. 8 shows the evolution of social learning, the participation of different stakeholders in the operation of tidal basin concept. It shows clear indication towards better future. Again, there is a clear need for an approach to TBM implementation that considers multi-dimensional (social, economic and environmental) consequences (Gain *et al.*, 2017). Bringing together people from different backgrounds, perspectives, values and so on does not automatically lead to effective management. It requires a multi-loop process in improving a multiple-actor-based management practice (Mutahara *et al.*, 2017).

- Collaborative working (conflict resolution among different land-use groups, working agencies, and government institutions)
- Strengthening of local institutions
- 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 TBM (no stoppage of operation at any cost)

A long-term strategy of Bangladesh Delta Plan (up to 2100) has highly acknowledged the tidal basin concept for solving waterlogging problems(Gain *et al.*, 2017). Restoration of tidal plain allowing tidal inundation is an effective measure for increasing the tidal prism, raising the low lying land, 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.

6. Conclusion

Unlike excavating, tidal basin concept by de-poldering is more eco-friendly, cost-effective (no need of large-scale engineering), less time consuming (maximum utilization of natural tidal flow). It simply allows beneficial flood in raising land, scouring silted river and improving drainage congestion. Evolved from traditional wisdom, the process blended with scientific knowledge seems to be a sustainable way forward. Although an embankment along the coast is required, sediment management is also essential for sustainability. A key barrier to the successful implementation is compensation. Multi-loop processes in improving multiple-actor-based management practice with collaborative, interdisciplinary and iterative learnings are necessary for successful implementation of tidal basin concept.

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