Dynamic Polder Management in Bangladesh

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Abstract
Managed deltas are social-ecological systems that provide flood- and food security. However, land subsidence and sea level rise render deltas vulnerable to flooding, the impact of which is exacerbated by population growth and urbanisation. These stresses affect institutional requirements for delta systems. Polders can mitigate these threats by offering flood protection and increased food production. In Bangladesh, polders increased yields, but at the delta level, they affected rivers' drainage capacity and siltation. At the polder level, they caused land subsidence and waterlogging. In response, in 1990, local people themselves breached dykes of the Dakatia beel polder, to re-allow tidal flows. This eroded silt from the tidal channels enabling drainage of waterlogged areas, and re-allowed sedimentation inside polders, raising soil surfaces and fertility. Ever since, Tidal River Management has been experimented with, however, its full potential has not yet been reached due to fundamental knowledge gaps regarding physical and institutional boundary conditions. Rather than being an obstacle, sediments provide a high potential for a Building with Nature approach, which works with rather than against the forces of nature.

Discussion
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Rather than being an obstacle, sediments provide a high potential for a Building with Nature approach, which works with, rather than against, the forces of nature. The challenges and failures of Tidal River Management practices in certain areas are:
The governance and power dynamics over water and polder management, in particular the major conflicts between aquaculture and agricultural activities.
The importance of agriculture as a key livelihood activity in the area and the opportunities to improve the range of livelihood options.
The need to improve local community participation in decision-making processes, through Water Management Organisations, in order to promote social justice and equity in water resource development.
The key role of the Bangladesh Water Development Board (BWDB) as the implementing government authority with regard to water management.
The opportunities for business development such as brick making from sediments, producing fertilisers by extracting nutrients from sediments and agricultural production of salt-tolerant crops.

The nature of problems varies across deltas (Figure 1). Social pressures are driven by economic and/or demographic conditions, whereas natural pressures are related to river flow, sedimentation, erosion, tides and storms.

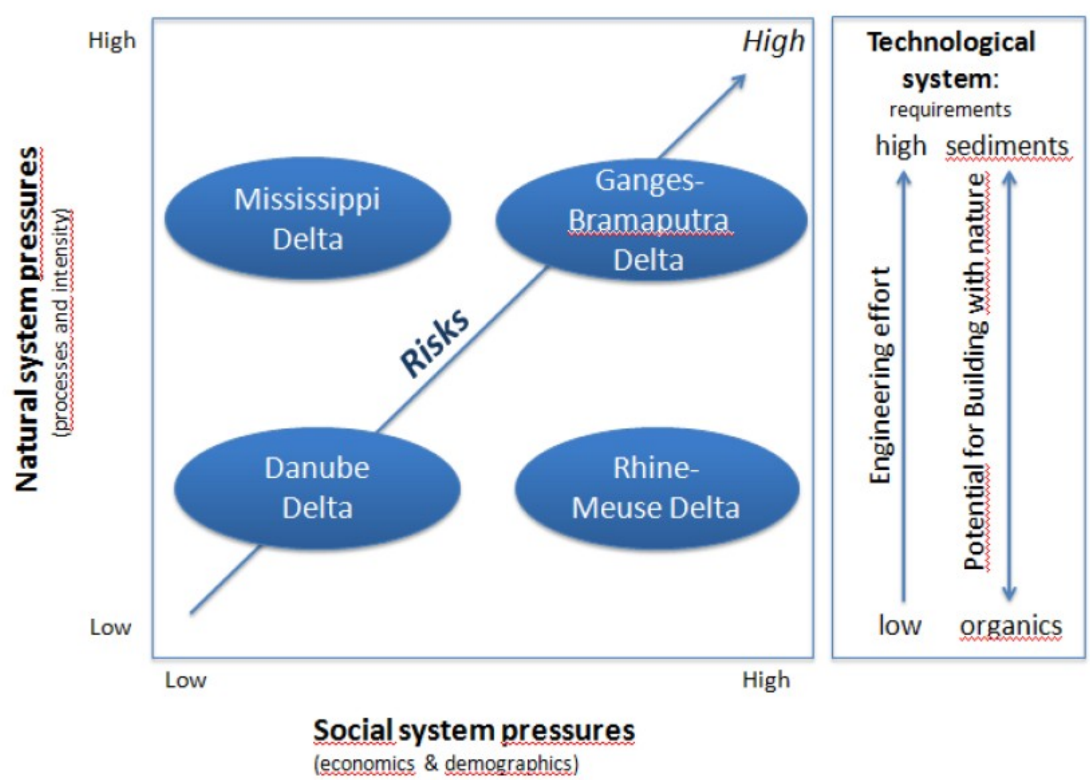

Figure 1. Social and natural systems' pressures for deltas of several major rivers

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Deltas experiencing low natural pressures can be maintained by relatively low engineering efforts. However, the required engineering effort increases significantly when deltas experience high natural pressures. This is problematic because many of these deltas are situated in regions with dramatic demographics and low economic development, thus with insufficient investments.

Bangladesh's Coastal Embankment Project (CEP) combined the construction of embankments to decrease external flood risk and salinity intrusion with an infrastructure to drain internal excess water. Polders increased yields up to 300%, but obstructed the flow of sediment-laden rivers during the monsoon. This caused catastrophic flooding and siltation of the river water system. The drainage function of the polders became blocked which caused vast areas to become waterlogged, leading to decreases in agricultural production, and firewood , shortage of drinking water and epidemics of water-borne diseases. Land subsidence caused additional soil salinisation by capillary rise and increasing flooding depths in polders after storm surges. Furthermore, conflicts grew between rice and shrimp farmers over letting in either fresh irrigation water or letting in saline water for aquaculture.

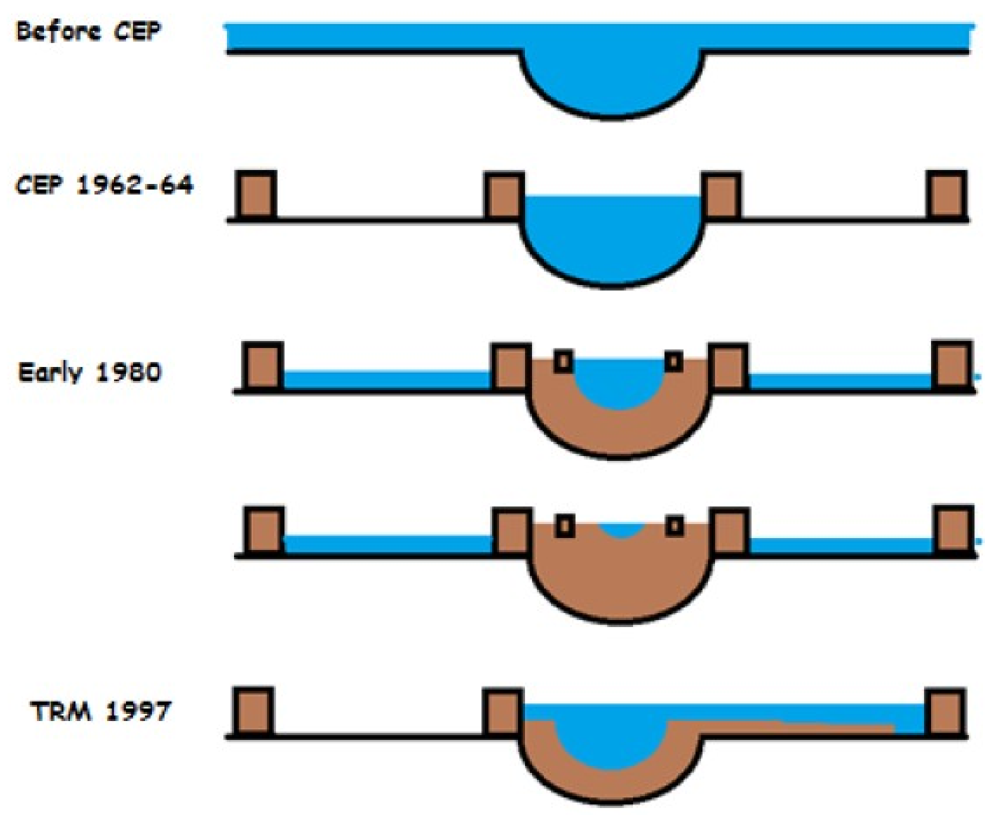

Figure 2: TRM explained

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Rather than being a hindrance, sediments provide a high potential for a Building with Nature (BwN) approach, which works with rather than against the forces of nature. Based on our experience with this approach, we recognise the potential of developing TRM on a river basin scale. It potentially provides solutions to many interrelated problems at different scales. However, the full potential of TRM has not yet been reached:

1. Re-allowing sedimentation in polders requires understanding the sedimentary budgets of both individual polders and river reaches that feed these polders. This means that at the delta-scale, a comprehensive scheme of polder revival must be designed that considers upstream-downstream dependency along different delta river branches. Also, the bio-physical aspects of a revival cycle of a polder where re-sedimentation is temporally allowed should be further explored to optimise food production potential.
2. The implementation of rotation schemes of polders depends on the capacity of local and regional scale governance arrangements. Identified polder rotation schemes should match stakeholders' capacity and willingness, social structures and food production schemes. Due to delta level and polder level physical interrelations, local and regional governance structures must be aligned.

Bangladesh's southwestern coastal region presents delta problems to the extreme. It has largely been embanked into polders, has a dynamic physical environment and powerful natural processes, the social environment is characterised by population pressure, limited financial and technological capacity and complex governance arrangements. Therefore, it provides an excellent case-study.

Upstream areas are more dominated by river discharge, although still affected by tides, and sediment concentration depends on the river load. More downstream, water levels and sediment concentrations are increasingly determined by tidal fluctuation and salt water may be a nuisance. Local people believe that the soils were more fertile prior to the embankments.

Polders at different geographical locations will have different optimal rotation schemes as type of sediment, soil fertility, risk of salinisation and accretion rates are different.

The production and use of public goods (such as water, sediment and polder management infrastructures and facilities for the development of business models and functional innovation systems) requires institutions for collective action. Without such institutions, actors are expected to underinvest in and over-harvest from the resources.

Regarding the governance of its delta, Bangladesh suffers from a spatial misfit – i.e. the institutional arrangements in place fail to adequately take into account the nature, functionality and dynamics of river flow characteristics. TRM-related interventions at both the delta and polder level are technological innovations. In order to take root, these innovations need to match the technological innovation system (TIS) in place. This TIS needs to allow for the customisation of interacting delta and polder level solutions.

Sustainable polders in Bangladesh result in:
Increased food security for the local community because of more resilient water management practices.
Increased flood protection for the local community because of more resilient flood protection measures.
Financial benefits: (i) communities and the national government have less financial expenditures on the polders, and
(ii) increased entrepreneurship and innovation in the polders enable the development of businesses.
Institutional benefit: Institutional arrangements guarantee good delta-level governance and polder-level organisation.
Environmental benefit: The building with nature approach ensures interventions that are in tune with natural processes.
Technological benefit: A national Technological Innovation System (TIS) provides customised solutions to delta problems.
Managed deltas are social-ecological systems that can provide flood- and food security. However, land subsidence and sea level rise render deltas vulnerable to flooding, the impact of which is exacerbated by socio-demographic stresses that affect institutional requirements for delta systems. Deltas experiencing low natural pressures can be maintained by relatively low engineering efforts. However, the required engineering effort increases significantly when deltas experience high natural pressures. This is problematic because many of these deltas are situated in regions with dramatic demographics and low economic development, thus insufficient means to invest. Sediments provide a high-potential alternatives based on Building with Nature (BwN) principles. However, the physical and institutional boundary conditions for the successful implementation of BwN, remain largely unknown.

Re-allowing sedimentation in polders requires understanding the sedimentary budgets of both individual polders and river reaches that feed these polders. This means that at the delta-scale, a comprehensive scheme of polder revival must be designed that considers upstream-downstream dependency along different delta river branches. Also, the biophysical aspects of a revival cycle of a polder where re-sedimentation is temporally allowed should be further explored to optimise food production potential. The successful implementation of rotation schemes of polders depends on the capacity of local and regional scale governance arrangements. Identified polder rotation schemes should match with stakeholders' capacity and willingness, social structures and food production schemes. Due to delta- and polder-level physical interrelations, local and regional governance structures must be aligned. The successful implementation of dynamic polder management also depends on viable business models that guarantee income generation for polder residents engaged in agricultural production and a national technological innovation system capable of generating customised solution to polder management problems (that can be commercialised).