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Review Article

Review of an Integrated Strategy of Climate Change Adaptation Using Tidal River Management

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Abstract: Climate change and its variation have significant impact on coastal areas of Bangladesh. It's a region predicted by experts to be one of the hardest hit by climate change induced sea level rise. Tidal River Management (TRM), a unique indigenous ecological knowledge of river management, was found to be an effective tool to combat climate change induced issues at some zones and is used by reputable organizations like Bangladesh Water Development Board and Asian Development Bank. In this study, the benefits of TRM were investigated and analysed using secondary resources from research literature and field investigations. This review furnishes the evidence of the outcomes of TRM to successfully manage coastal areas, which are at risk of water logging and sea level rise.

Keywords: River Management, Climate Change, Coastal Area, Disaster, Adaptation

1. Introduction

Climate change and its associated phenomena of sea level rise, salinity intrusion and increased number of cyclones are raising concerns for Bangladesh. Bangladesh has a long and vulnerable coastal area with an active deltaic zone. Deltas have already been recognized as the most vulnerable areas due to climate change (IPCC, 2007). The Bengal Delta has already been experiencing the adverse effects of climate change. Among other areas of Bangladesh the south-western region is more vulnerable towards climate change induced sea level rise. Most of the area of this region lies at elevation of 0 to 2 meters from sea level (IWM & BISR, 2009; FCB, 2011; EGIS, 1998). Along with the adverse effects of climate change this low laying Delta plain is experiencing a severe water logging problems since early nineties because of the coastal embankment. In this region livelihood, agriculture, ecosystem and human settlements are the worst victim of the polderization. About one million people have been affected by 1997 and 114,000 hectares of land remain under water throughout the year (Allision, 2001; Ali, 2002; Chowdhury, 2010).

TRM has emerged as an indigenous process to tackle the climate change and water logging issues in the southern belt of Bangladesh. TRM allows the natural siltation system (Islam, 2006) to elevate the land by 1-3 meters within 3-5 years time. The concept of TRM has been recognized and funded by the Asian Development Bank (ADB) with the main intention of developing an adaptation tool to address the issues of climate change impacts issues in the entire southern belt of Bangladesh and later, to transfer the knowledge to tackle comparable problems in similar geographical areas. In order to make the indigenous concept scientifically viable and sustainable, scientific and socio-economic studies need to be conducted; however, the precedence and the availability of secondary data are difficult to acquire as the concept of TRM is still quite new.

This review paper aims to evaluate the opportunity of TRM as a tool for adaptation to climate change in the south-western tidal plain and for the solution of existing drainage congestion problem. Proper management of sediment of the south western region through TRM process could be a long term solution to the climate change adaptation, water logging and soil subsidence in this region.

2. Study Area

The study area of interest is mainly the coastal belt of Bangladesh. The total area is about 79,000 km^2 where 1,800

km^2 areas are inundated, which is 23% of the total area. TRM is being considered as a climate change adaptation option for entire Satkhira district, four sub-districts of Khulna district and three upzilas of Jessore district. These areas are mainly being selected because the tidal rivers of these areas have no or negligible upstream flow and carries a significant amount of sediment during the dry season between the month of December and may. Table 1 depicts the population size, inundated area and total area of various sub-districts.

3. TRM as a Climate Change Adaptation Tool

The coastal belt in Bangladesh is an active flood plain and huge amounts of sediment are carried out by the rivers to these flood plains which eventually elevate the land resulting in congestion (Sarwar and Khan, 2007). Management of this sediment in a scientific and sustainable way can lead towards the adaptation of climate change issues in the coastal areas of Bangladesh.

Table 1. *Total area, inundated area and population by Sub-district.*

District	Sub-district	Inundated Area (km^2)	Total Area (km^2)	Population (Lakh)	Percentage of Inundated Area (%)
Jessore	Abhaynagar	60.97	247.00	2.32	24.68
	Keshabpur	60.68	259.00	2.25	23.43
	Manirampur	63.28	445.00	3.82	14.22
Khulna	Dumuria	196.88	454.00	2.75	43.37
	Fultala	26.69	57.00	0.71	46.83
	Koyra	143.03	1775.00	1.92	8.06
	Paikgachha	162.55	411.00	2.46	39.55
Shatkhira	Assasuni	145.25	402.00	2.44	36.13
	Debhata	117.29	176.00	1.21	66.64
	Kalaroa	23.98	233.00	2.22	10.29
	Kaliganj	232.57	334.00	2.59	69.63
	Satkhira-S	177.17	801.00	3.93	22.12
	Shyamnagar	244.45	1968.00	3.16	12.42
	Tala	124.74	344.00	2.91	36.26
Total		1779.53	7906	34.69	23

The entire area is crisscrossed by sediment laden tidal river network. This unique characteristic has made the area suitable for TRM process. From the experience of Bill Bhaina, it is evident that TRM would be the best possible and sustainable option for tackling the existing water logging problem and predicting hazards due to climate change induced sea level rise. According to IWM the sediment concentration of tidal water in Bill Bhaina is 4881 mg/l, which is quite high.

TRM has the potential to bring some benefits to the socio-economic sectors. The following sectors could be optimized with quality life and environmental conservation.

3.1. Agriculture and Livelihood

In the pre-polder condition, the local people would experience inundation twice in a day. Farmers used to cultivate lands and produce rice by building temporary dykes to protect their crop from tides during winter season. TRM could act here as a rescue tool for the lost livelihood and to secure it from the climate change induced sea level rise. TRM process would elevate the land by one to two meters in three to five years where the local people can start alternate rice and shrimp cultivation in the elevated tidal plains through TRM. Hence, it would bring about socio-economic development and environmental conservation.

3.2. Settlement

One of the major effects of TRM is that the adjacent settlements near TRM area become lower than the tidal plain (Subramanya, 2008). So, the settlements in low lying areas need to undergo minor changes such as, rearranging or rebuilding in a scientific way so it can be connected to a disaster resilient village. Alternatives for the settlements would be permanent or temporary relocation to the elevated area through TRM.

4. Basic Requirements for Successful TRM

TRM is sufficient in controlling the tides and carrying sediments and silt to raise the level of low-lying lands and reclaim them for agricultural use (Nicholls and Wong, 2007). Any area in particular must be considered as composite parts of the whole of the larger area that is subject to tidal movement and influence. Bangladesh is a country of classical tidal fan having flat topography where the tidal rivers and channels form large networks. The fundamental requirements of TRM operation is the evaluation of project performance and preparation of reports for the stakeholders.

4.1. Embankment Enclosure

The target wetland must be enclosed by embankments and the tide must be allowed to enter through only one main opening in the enclosing embankment. The river channels must be kept open as far into the wetland as possible so that the tide can enter and return to the sea ensures a huge load of sediment carriage, which will eventually enter and fill the enclosed wetland (SMEC, 2002). The flow becomes stagnant and the sediment therefore drops to the floor of the wetland

hence, raises the height of territory (Islam and Ahmed, 2004). The newly developed territory is highly suitable for agricultural use. If the river channel within the wetland 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. This is how TRM can control the embankment management of the coastal area.

4.2. Planning and Operation of TRM

Beels (Natural depression) and *gheers* (shrimp farm) are found all around the southwest coastal region of Bangladesh. TRM gives tide water free access to selected low-lying wetlands. For successful results, the areas need to be divided into smaller wetlands with manageable size ensuring sufficient period to have its lands raised so that agricultural activities can be undertaken.

4.3. Community Problems

The tides in the river need free access twice a day and the TRM must not be used for any other purpose and the landowners must 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 wetland for the next rotation. Furthermore, adequate advance planning is required to implement and communities need to coordinate so that the scheduled activities take place within the planned time frame.

4.4. Provision for Compensation

The land value may increase after the coastal areas are raised and made suitable for agricultural production. It is important to recognize that the landowners, particularly the poor ones who depend only on their land for their livelihood, would lose income from their land in one form or another during the time their land undergoes the TRM process. There is a compelling reason for making an adequate compensation for the landowners' lost income. Local communities would continue demanding for compensation. However, the retroactive claims from landowners of prior wetlands used for TRM have prominently surfaced.

4.5. Sustained Provision for Operation and Maintenance Requirements

The river channels must be kept clean and open for the tidal flows to proceed unimpeded. Much of the maintenance can be done by the local beneficiaries regularly on a daily basis. However, there is a continuous requirement to spread the deposited silt to locally lower areas within the wetland itself so that rising of the wetlands will be even. An area of approximately 6 km^2 was considered as an appropriate and manageable size for the Bill Bhaina basin for example (Mohal et. al., 2006). 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.

5. Key Benefits of TRM

The width and deep of every river is very important. TRM improves both the width and deep of rivers which are heavily silted before implementation of TRM in the wetland`s tidal basin of southern Bangladesh. The width of every river would become triple within only two years of TRM operation and its depth would consequently increase to almost 10 m just downstream of the basin. Due to TRM, sediments carried by the river are deposited inside the basin, causing heavy scouring of river bed downstream.

Discharge, time and density of fine sediments and Suspended Sediment Concentration (SSC) remains a major driving force of TRM outcome as all the other parameters can be controlled. Observations show that at a constant shear stress in saline water, the value of SSC increases with a reduction in flow depth and vice versa. Furthermore, increase in discharge per unit area increases the value of SSC. Successful implementation of TRM leads to river bed scouring in downstream of the tidal basin. Therefore, when TRM is implemented in a tidal basin and the next possible TRM destination is located downstream to the existing one, a higher depth of flow would automatically be available for the next TRM basin during its TRM operation. This would allow less discharge entering per unit area into the second tidal basin (as the cross-sectional flow at its upstream location would increase) and the value of SSC entering the basin would be reduced as well.

Additionally, the increased flow depth would also result in flow with less SSC into the second tidal basin. So, it is evident that during planning to implement TRM sequentially at a number of tidal basins, the tidal basins which are located downstream should first be subjected to TRM before the other basins located upstream are brought under TRM approach. The socioeconomic dynamics along with the TRM play key roles for better river management. TRM will bring good achievement if tidal basins are selected from a "downstream to upstream" approach, which will help the process to accomplish desired results in due time and thus satisfy involved stakeholders.

6. Conclusion

TRM practice generates debates and disputes regarding socio-technical benefits. Land development, land use, flood resistance and food security are all attributes of TRM, which clearly reflects the positive consequences of successful implementation. TRM can be extremely helpful in developing countries. TRM thus provides sequential selection of tidal basins, as well as predicting the final sedimentation to some extent before implementation of TRM. TRM can satisfy both the stakeholders and implementing authorities involved in the process, resulting in best possible outcome under an arguing social context.

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