RESPONSE TO CLIMATE CHANGE: BANGLADESH EXPERIENCE

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ABSTRACT: Due to the anticipated adverse global effects of climate change and consequent sea level rise (SLR) Climate refugees are the inevitable reality of our time. The management and resettlement of these climate refugees will exert a serious pressure on already dense urban centres of Bangladesh. Assuming the climate change forecasts to be true it calls for immediate action to limit the impacts of change; to reduce the vulnerability and to help the affected populace to adapt in place. The paper is a review on autonomous and planned adaptive measures taken at local and national level of the country in response to the current and anticipated geo-climatic risk. Review shows that, the GOB launched its National Adaptation Programme of Action (NAPA) in 2005 which highlights the main adverse effects of climate change and identifies adaptation needs. Adaptation measure in agriculture is already in progress which in fact widens the opportunity for socio-spatial adaptation in vulnerable area. To date, adaptation in human settlements motivated by climate change has been observed to be minimal and mostly limited to coastal afforestation and construction of community and family shelters by the government and non government organization. Both short term and long term strategies are required for sustainable development. Embedding adaptive measures within the urban settlement infrastructure is either very costly or very slow. It is likely to be easier if action is taken in rural areas where development is still sparse as opposed to the dense urban area. In early 90's attempt had been taken for the development of cyclonic surge resistant settlement at *Urir Char* but the concept was not widely implemented. Urir Char experience proved its resilience and responsiveness to the context. The study concludes that, adaptation is the most viable and manageable of the responses to climate change especially for the least developed country like Bangladesh. The local coping measures to reduce vulnerability to existing climate related hazards (erosion, water logging, flooding, surge, cyclone) can also serve as means and guide for adapting to climate change.

Keywords: *adaptation, climate change, climate refugee, vulnerability, human settlements.*

1. Introduction

The world has began to witness the consequences of climate change with the increased frequency of Tsunami, cyclones and devastating floods which is seriously affecting its helpless populace and leaving them in limitless miseries. Being a delta Bangladesh stands to be the worst affected one. Particularly the coastal regions comprising 28% of total population are the most vulnerable of all and identified as an 'extreme vulnerable coastal delta' where more than one million population is estimated to be displaced by current sea level trends within 2050 (Ericson et al.,2006). The scenario will be much worse as indicated by UN Intergovernmental Panel on Climate Change (IPCC) where they predicted 15 million of climate refugees for 1m rise in local sea-level (IPCC, 2007). The resettlement of these displaces people (climate refugees) will pose a serious problem for densely populated country like Bangladesh (Mowla & Choudhury, 2011).

Historically coastal settlements are exposed to the risk of different geo-climatic hazard like cyclone, tidal inundation, water logging, salinity and erosion. The impending threats of climate change and sea level rise in near future, as predicted, will further intensify the severity and extent of the hazard including permanent inundation coupled with increased salinity and erosion due to intensification of tidal action and periodic cyclone. This may cause serious injury to existing human settlement, fresh water supplies, destroy agricultural land and local economy and thus cause severe damage of overall coastal ecology. As a consequence affected population will force to migrate to upper land especially in dense urban center which may create serious social and environmental crisis in the cities. To arrest mass exodus of population and reduce the vulnerability of coastal settlement to climate change, it thus calls for preemptive response in settlement planning and design.

Of the two fundamental responses to climate change: mitigation and adaptation, adaptation is

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often considered as the most viable and manageable responses to contend with, especially for the least developing country like Bangladesh. The term adaptation can be defined as adjustment or coping mechanism with its surrounding that helps improve the quality of life under strenuous circumstances (Mowla & Zereen, 2005). It thus refers to changes in processes, practices or structures to moderate or offset potential damages or to take advantage of opportunities associated with changes. It involves adjustments to reduce the vulnerability of communities, regions or activities to climate change and variability (IPCC, 2001). The following paper is an overview of existing adaptive/coping measures taken at local to national level of the country in response to the current and anticipated geo-climatic risk. The review also incorporates information about the future risk of climate change and proactive measures taken elsewhere in the world to adapt with. Extensive review of relevant literature, field observation and author's own experience are the tools to assess the effectiveness of these measures.

2. Climate Change and Risk of Inundation

Signs of climate change are already evident now and that cannot be overlooked. While there is still considerable uncertainty about course and magnitude of changes, there is little doubt that the rise of sea level is a long lasting unavoidable phenomenon. There is, however, very limited factual information regarding the trend of sea level rise in Bangladesh. Except few recent studies, the mostly agreed scenarios are largely speculative and not assessed by modelling (CEGIS, 2008a). Department of Environment under GoB (1993) mentioned a potential future sea level rise for Bangladesh is 30-50 cm by 2050. Ahmed and Alam (1998) studied the SLR value by using general circulation models (GCM) for the year 2030 and 2050. Their estimate was 100 cm change of sea level (90 cm sea level rise and 10 cm local rise due to subsidence) by the middle of 21st century (*CEGIS, 2008b*).

It has been now widely accepted that settlements in the low elevation coastal zone (LECZ: 0-10m) will be affected largely by the anticipated sea level change. The extent of impact of sea level rise in Bangladesh was viewed at first by UNEP (1989). It was speculated that 1.5 m SLR by 2030 would affect 16 % of land area (22,000 Sq. km) with 15 % of total population (17 million people). Due to uncertainty in UNEP study, World Bank (2000) has also studied on that. It speculated that 10 cm, 25cm and 1 m rise in sea level by 2020, 2050 and 2100; affecting 2%, 4% and 17.5% of total land mass respectively.

A comprehensive study has been conducted on the impact of relative sea level rise on coastal area of Bangladesh jointly by IWM and CEGIS (2007) (fig1). In the study the physical impact of relative sea level rise for the year 2020, 2050 and 2080 assessed using the mathematical modeling tools MIKE 11 and MIKE 21. The result shows that about 13% more area (469,000 ha) will be inundated in the monsoon due to 62 cm sea level rise by the year 2080 . Though in dry season the affected area will be reduced to 10% (364, 00 ha) but salinity will intrude more landward in this period. The most vulnerable areas are the areas without polders like Patuakhali, Pirojpur, Barisal, Jhalokathi, Bagerhat, Narail. But problem will be more severe in the area protected by polder. About 32% area will be deeply inundated due to overtopping of embankment. Of them 25 polders in southwest region may experience severe drainage congestion and 13 polders embankment will be overtopped due to increased water level in the peripheral river .The eastern coast is, however, will comparatively less affected due to drainage congestion or rise in water level. But the area will expose to the risk of storm surge inundation due to increased intensity of cyclone in future. Cox's bazaar, chittagong district and Hatiya is the most vulnerable to such risk as sea level rise. (IWM and CEGIS, 2007).

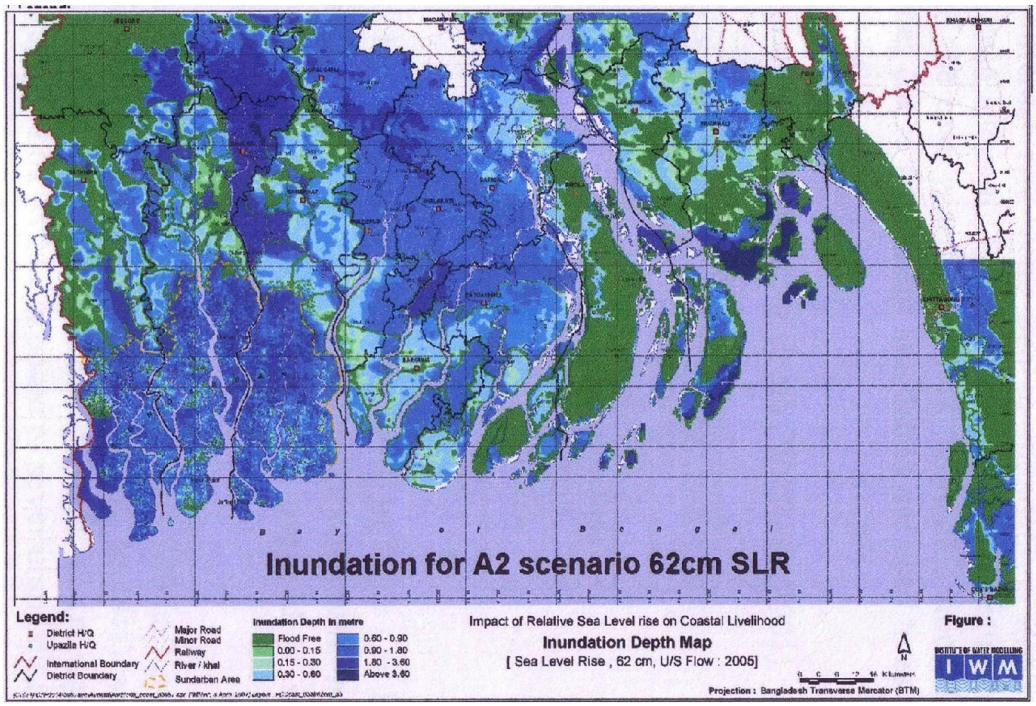


Figure 1 Inundated area for 62 cm (A2) sea level by the year 2080. Source: IWM & CEGIS, 2007

3. Review on Adaptation Options to Address Coastal Inundation

Choice of adaptation measures depends on particular impacts and geographical factors in each country (Jarungrattanapong & Manasboonphempool, *2009).*Adaptation options are also constrained by economic, social, technological, and political conditions. Focusing on structural adaptation to the impact of global warming and sea-level changes on coastal systems, adaptation options are usually identified as one of three possible approaches (Nicholls 2003; Mclean et al. 2001):

Protection, aims to protect the land from the sea so that existing land can continue, by constructing hard (or semi-hard) structures (e.g., seawalls, sandbags) as well as using soft measures (e.g., beach nourishment)

Accommodation, implies that people continue to occupy the land but make some adjustments to avoid the impacts, for example, by elevating buildings on piles, growing flood-tolerant or salt-tolerant crops.

Retreat, implies that all natural system effects are allowed to occur and human impacts are minimized by pulling back from the coast. This approach involves no attempt to protect the land from the sea.

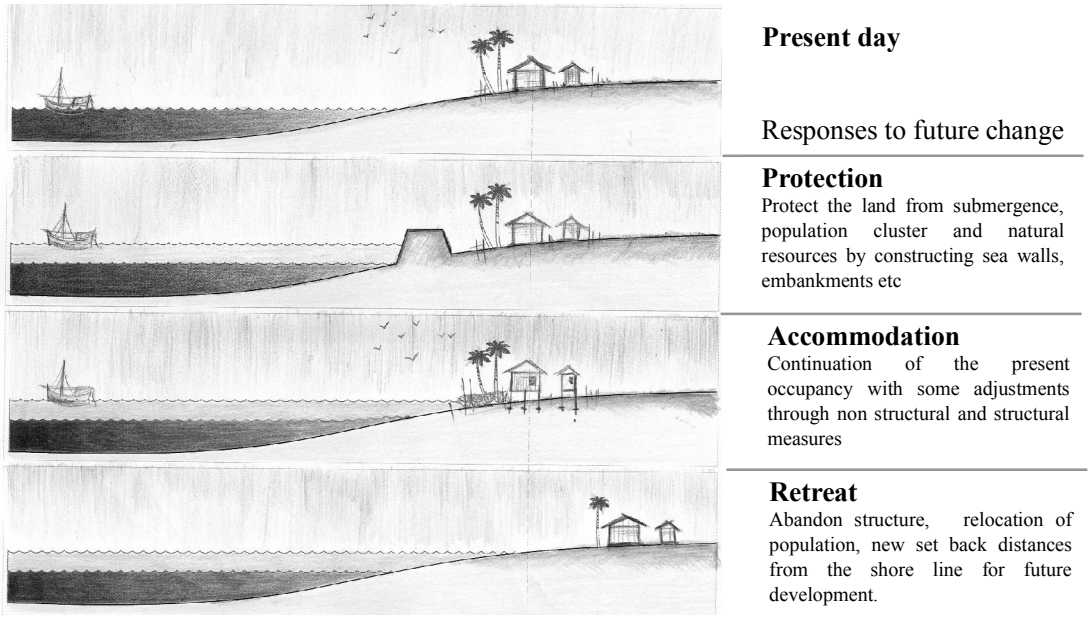


Figure 2 Biljsma *et al.* (1996) identified three possible coastal response options to sea-level rise, which were adopted by IPCC (2001).

4. Adaptation examples – Netherland Experience:

The Dutch have always fought against the harshness of the sea and have attempted to preserve existing and to reclaim more land areas. Presently, about one quarter of the Netherlands' total territory lies below sea level and are protected by dykes. Without dykes, this part of the country would be permanently flooded and more than 60% of this area with its 10 million inhabitants would be threatened by storm surges. At Oosterschelde, a high-tech bridge was completed in 1986 that can quickly be turned into a dyke (fig 3). If a heavy storm is approaching, shields with a weight of many tons come from the bridge down into the water in order to prevent flooding due to storm surge. It is one of the largest coastal engineering projects ever completed in the world and a major engineering achievement. (Germanwatch, 2004)

Apart from these high cost engineering measures of protection, a new way of living afloat is emerging in the Netherlands. Planners, hydrologists, architects and others introduced living on water as a proactive response to predicted sea level rise (SLR). The designers of Netherlands are putting their efforts to develop a sustainable model for floating neighbourhood where houses are built over a hollow concrete basement with expanded polystyrene which can float up to certain flood limit. The main objective of this new concept floating home in Netherlands is to prevent any damage or loss from flooding due to the increasing of water level in Netherlands year after year (Yang, 2007).

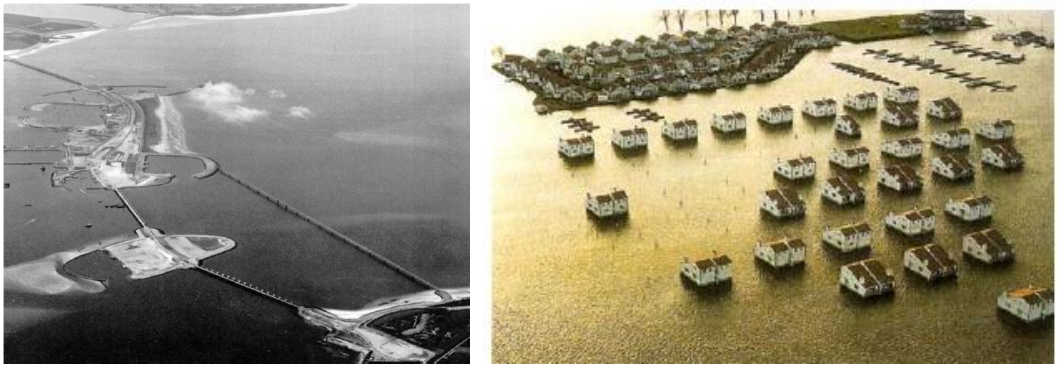


Figure 3 Storm surge barrier at Oosterschelde (left) and floating neighbourhood in Netherlands

5. Adaptation examples -Bangladesh Experience :

Unlike the Netherlands, however, there hardly exist any hard measures of protection such as modern dykes in Bangladesh. Due to its fragile geophysical context construction of big, modern dykes is problematic as well. If sea levels rise up to 1 meter, "normal" flood waves can be expected to increase from presently 7.4 meters to 9.1 metres (World Bank, 2000). This shows clearly that coastal dykes must be very high to really protect the inhabitants. Being a least developed country Bangladesh lacks both the financial and technical support for such mega construction. Even if a complete dyke construction could be financed, it would destroy valuable agricultural areas (Germanwatch, 2004). Since 1989, this issue has aroused local protests against a World Bank project that foresees to construct 8,000 kilometres of river dykes.

But with the help of international co-operation Bangladesh also achieved successes: Over the last three decades, the government has invested over 10 billion dollar to make the country more climate resilient and less vulnerable to natural disasters. 'Coastal Greenbelt Projects' (1995-2002) implemented by Forest Department of Bangladesh involves mangrove plantation along nearly

9000 km of the shoreline (MoEF, 2009). Experiment and experiences shows that planting mangrove along the coastal belt would help stabilize the land, create more accretion leading to more land and also raise the level of land so that inundation by sea-level rise is reduced. Mangroves also reduce the wave height due to their ability to dissipate wave energy. It has been estimated that a 100 - 200 m wide mangrove belt reduces wave heights by 20 to 25% (MoWR, 2000). Besides under Coastal Embankment Rehabilitation Project (CERP) 1300 km of embankment plantation, 7500 of strip plantation, 665 ha of foreshore plantations were carried out.

In many directly affected coastal areas shelters on concrete pillars were built. There are a total of 2,583 cyclone shelters and 924 school buildings (PEDPII) located in the coastal districts. And concentration of shelters is higher in the east coast (Noakhali, Feni, Chittagong, and Cox's Bazar) than the west coast (MoFDM, 2009). Usually, these shelters are built on 5 meter high pillars. Often, they are used as school and thus have duel functions: to protect the inhabitants during disaster and to improve education in normal time. Comparing the damage and loss data of recent cyclone with the past of similar intensity and track it is observed that the death toll in last 4 decades has been significantly reduced. To protect the livestock the newer shelters are built with Killa or raised platform. The multipurpose cyclone shelter is a concrete example of institutional adaptation to extreme climatic events in Bangladesh (MoEF, 2009).

Figure 4 Multipurpose cyclone shelter, coastal afforestation and embankment are the key adaptive measures taken by the GoB.

In addition GOB has developed early warning systems for floods, cyclones and storm surges and is expanding community based disaster preparedness. Climate resilient varieties of rice and other crops have also been developed (MoEF, 2001). However, these measures cannot prevent loss of houses and other infrastructure. In 2005, the GOB launched its National Adaptation Programme of Action (NAPA) which highlights the main adverse effects of climate change and identifies adaptation needs.

Moreover Bangladesh is the pioneer one to initiate the CBA in practicing from different projects to build local capacity in the regional level. Now there are nine other countries around the world are implementing CBA following the footsteps of Bangladesh. These are Bolivia, Guatemala, Jamaica, Kazakhstan, Morocco, Niger, Namibia, Samoa and Vietnam (Huq et.al 2009). In agriculture sector CBA includes floating gardens for cropping and vegetables, cage culture, community based rich-fish farm in the low lands; cultivation of saline resistant varieties of rice and other crops to improve productivity and nutritional security; e.g. cultivation of mele reed (*Rahman et al 2009*).

5.1 *Autonomous adaptation in coastal settlement of Bangladesh*

The people of Bangladesh have adopted over generation to the risk of floods, droughts and cyclones. In areas where inundation is a risk, they raise their houses on mounds above the normal flood level and adjust their cropping patterns to take advantage of the flood waters. Farmers in all parts of the country adapt to local flooding and rainfall patterns by growing a range of indigenous and high-yielding varieties of rice and other crops. Rural roads, paths, tracks and other infrastructure such as schools are also raised above flood levels where possible.

In coastal zone of Bangladesh, people are taking different measures both proactive and reactive to

cope with existing natural disasters. Both structural and non structural measures are taken to cope with the context.

5.1.1 *A case of cyclone prone area of exposed coast*

Settlements in foreshore area and offshore islands are exposed to the risk of sea born hazards like cyclone, salinity, erosion etc. and occasionally inundated under 4-6m high tide and sea surge from Bay of Bengal. In response to past cyclonic hazard experiences both short term and long-term adaptation techniques is employed. The coastal belt of Patuakhali, Noakhali, Nijum dip and Chokoria is protected by planned afforestation of mangrove plantation. Settlements in foreshore areas are predominantly linear or semi dispersal in pattern following the embankment or communication network taking advantage of slightest variations in ground level. Cyclone shelter is the spatial focus of the settlement here around which densification is taking place. Cyclonic storm and high wind seems the most obvious factor in the development of the local house form. Majority of the traditional CI sheet and thatch roofed houses in this area have hip roof. The slope of the roof of this type varies from 30- 35 deg which have the best record of resistance against cyclonic wind as found in lab experiment. Besides the traditional CI sheet house with enclosed patio and rear opening of Patuakhali, Barguna or Barisal area is proved to be effective by reducing the probability of damage to main unit cause by uplift force from cyclonic wind. The island people of Sandwip, Kutubdia, Urir Char, Hatiya who are at risk of inundation have raised the height of the plinth form six to eight feet above crop land. One can observe differences in plinth height on the island and in mainland areas. Creating a shelter belt by plantation of trees around the homestead is another important adaptation technique for saving life, houses and properties in wind and sea surges. Household generally avoid plantation of trees that has wide spreading braches in windward side to minimize the damage from flying branches or fallen trees during cyclone. In linear settlement a layering in homestead plantation is observed. In first layer palm trees like Tal, Coconut and Betel nut are usually planted followed by shrubs (3-4 m high bushy trees) in front of the homestead. Shrubs of dense foliage act as wind and wave breaker and protect the houses form the direct impact of cyclone. The practice of plantation also provides privacy of household in normal time.

5.1.2 *A case of waterlogged area of interior coast*

Water logging is the most pressing problem in southwest region of Bangladesh. Due to sedimentation of riverbed the drainage of tidal water is disrupted and most of the villages within the wetland basin remain inundated for almost 8 months in a year. During this period normal life of the inhabitants greatly interrupted as the homesteads with their farmland, roads and infrastructure submerge under stagnant water. To protect the human settlement from inundation, Tidal River Management (TRM) project was implemented in a rotational basis by water development board as part of a long term adaptive measures. The concept of TRM is adopted from indigenous measures of tidal river management locally known as *Jowar Bhata Khelano* which allow natural deposition of sediments into low land of *beel* area instead of riverbed and raised the land in the process. Apart from this measure of water resource management, adaption in settlement is mostly autonomous. A compact pattern of settlement is observed in the area historically prone to water logging. A significant ratio of the household in waterlogged village is adopted L-shape or more compact layout of linear and single block arrangement. Affected household often rebuild their ancillary structures close to the main house or even attached rather placing them at a distance which is a significant deviation from traditional practice of organizing the homestead as commonly observed in upland village. An increasing trend is observed to adopt permanent material for vulnerable components of the house. It is common practice among the villagers to lining the mud plinth with a layer of brick to protect it from erosion. Due to scarcity of dry land household used to practice horticulture at courtyard and over slope roof. Besides ring gardening and floating vegetation etc. are some innovative measures which are introduced by the local NGO.(Kabir, 2012)

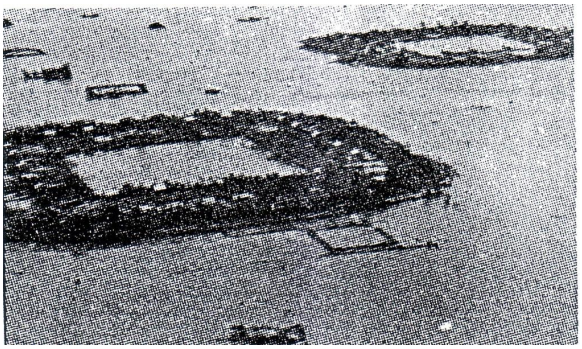
5.2 Planned adaptation in settlement pattern in coastal area Bangladesh

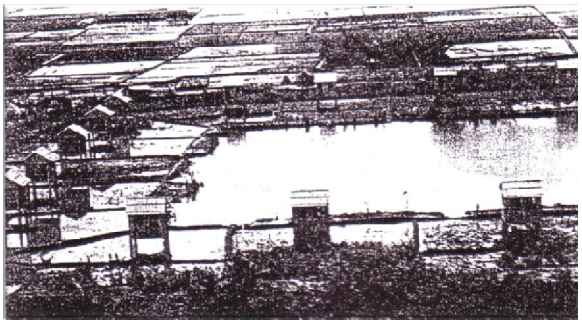
5.2.1 Urir Char project 1985: Nucleus Settlement

After the devastating cyclone of May 24, 1984, a national committee was formed by the government for designing, planning and rehabilitating the settlers and settlement of the Urir char, an offshore island located in the Meghna estuary. The project was developed by the coordinated efforts of Dept of Architecture, Public Works Dept. and Housing and Building Research Institute of the Ministry of Works, Bangladesh and was financed by Saudi Arabian government.

The proposed scheme was a nucleated dyke settlements elevated on stilts as opposed to the vulnerable scattered pattern of the settlement in Urir char. The master plan was conceived as an inclusive development of neighbourhood including all the physical components of settlement i.e. shelter, service and infrastructure. The settlement layout was kept open ended to allow growth as and when needed subject to a maximum of about 15 to 20 clusters (baries) per village. Natural process of land formation was allowed to work and afforestration was proposed on the seaward side of the island. The community facilities were located near the main road, as observed in the traditional linear pattern, at right angel to the proposed spine. A central community zone was developed along the main road where community services like primary school or mosque were provided. The Mosque and school were designed to serve as a community shelters for the neighbourhood during emergency. The spines were intended to be developed as road communication network, making possible easy hooking of services to the individual clusters (Mowla, 1998).

The core of the settlement was homestead conceived as a nucleus shelter on RCC stilts. A number of 20 homesteads were clustered around a community pond with a protective dyke around to form a para. Each homestead was given a land holding of one bigha and each para was provided with agricultural land 5 bigha per household around it. To cope with the natural hazard and dynamic process of the coast, the settlement layout was conceived in such a way as to allow natural process of siltation and land formation rather than other engineering means of protection by dykes or embankment. Molwa (1998) reported that the Urir char settlement has remarkably passed its first field test by withstanding furry of 1991 cyclone storm with no loss of life and property. The author observed that after 6 years of completion of the project the houses the homesteads, the clusters, the village and even the central community zone has grown exactly the way it was conceived by the designer. He also claimed that the natural process of siltation has taken place by 1991, proving it successful and sustainable as the natural siltation filled up the borrow pits, dug during the construction in 1985. The concept and technique of nucleus house was later adopted by the Grameen bank as a part of a sustainable development of the poor people. (Mowla, 1998)





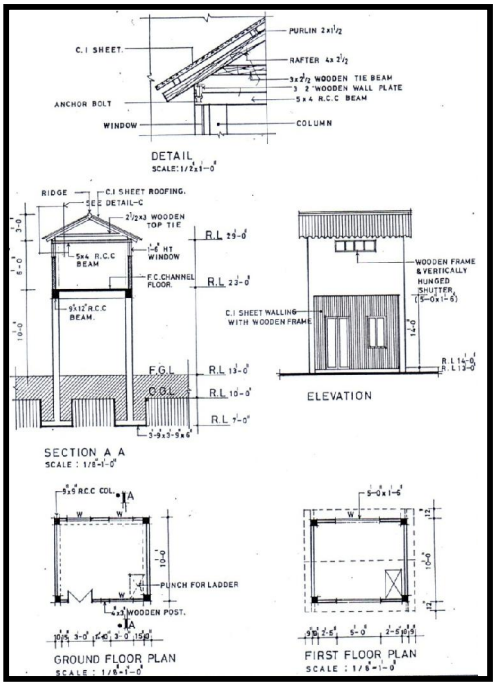


Figure 6 a) Nucleus settlement of Urir Char after the cyclonic surge of 1991. b) Stilt house details of nucleus settlement constructed in 1985

6. Discussion and recommendation :

The coast of Bangladesh is known as a zone of multiple hazards as well as opportunities. The entire coastal belt including the interior part of southwest region is subject to occasional and long term inundation due to tidal surge and water logging. In comparatively older settlement local people has adopted indigenous measures to protect their houses by developing more hazard responsive house form, homestead layout, vegetation pattern etc. Even if proved effective against present hazard context, the local measures may not equally perform in the changing context of climate and resultant sea level rise (SLR) as forecasted. This may lead to mass exodus of population towards the dense urban centre. Accommodating these climate refugees within the existing urban infrastructure is again impossible or very costly and slow. It is likely to be easier if action is taken to adapt in place where development is still sparse as opposed to the dense urban area. Adaptation by protection, accommodation and retreat should be the principal strategies to adapt with anticipated climate change. The recommended strategies of adaption to climate change for coastal Bangladesh is as follows:

6.1 Adaptation by Protection:

In foreshore area and offshore islands of exposed coast where cyclone and associated storm surges is the prime risk, protective measure like mangrove afforestation may be created as a shelter belt. Consideration should be given to selection of species, layering of plantation and width of the shelter belt as these are the factors that determine the effectiveness of a shelter belt. Social forestry and effective method of plantation in the homestead area is to be promoted involving participation of local people under the scope of '*Coastal Green belt'* project.

In polder area of interior coast where water logging is the key issue, *TRM* in rotational basis following the indigenous method of allowing natural sedimentation in low land and *beel* area is probably the best option for removing water logging. But implementation of *TRM* is often difficult because of social reason as inhabitants need to let their own land and homestead area for implementing the project. However, priority should be given to derive more practical solution considering greater benefits.

6.2 Adaptation by Accommodation:

The strategy involves structural and non structural measures to accommodate the inhabitants by improving their adaptive capacity and thus reducing vulnerability. Coastal people living in moderate and low risk zone should be encouraged to adapt in place by altering their settlement pattern.

The concept of *Urir char Model Settlement* should be adopted in foreshore areas and offshore islands in response to future risk where settlements are elevated on stilts and nucleated around a fresh water reservoir. Besides indigenous coping measures to reduce vulnerability to existing climate related hazards (erosion, water logging, flooding, surge, cyclone) can also serve as means and guide for in situ adaption to climate change. Moreover, community based adaptation must be encouraged where NGOs might play a role. Institutional initiative should be taken parallel to the development of the infrastructure and better access to the services and shelter (health facility, bazaar, school etc) at community level and access to amenities (fresh water supply, sanitation) at *para* or neighbourhood level. Measure like nucleated settlement, construction of safe house, rain water harvesting, use of renewable energy source and alternative livelihood options will improve the safety, liveability and opportunity within the risky areas and the tendency of people to migrate will decrease.

6.3 Adaptation by Retreat:

The strategy involves planned migration process undertaken at local or regional level to national level. People lives in high and highest risk zone, where problems like permanent inundation, erosion are acute, should be encouraged to resettle in the safer zone within the locality then to regional cities and gradually to bigger cities.

Despite of extreme vulnerability, a close scrutiny of historical trends and inundation risk map for future change clarify the fact that there exist zones in the coastal area which can be considered relatively safe from the risk. Since the affected area is predominantly rural and sparse in nature where density is still lower than the national average and far below the urban area, planned densification should be promoted in the safer zones under the scope of local and regional level adaptive measure. The process should start from preparation of master plan for vulnerability zoning at coastal area to identify of safer zone within the locality / region where planned densification can take place. The existing linear and semi dispersal settlements should be altered to more compact pattern of cluster settlement to encourage community based living where multipurpose community shelter become the spatial focus. Once the densification starts the construction of two storied house will give more scope for accommodation in safer area. The introduction of low cost housing through local NGO's can be a useful aid in the resettlement process. As an alternative option, the newly migrant population can save on construction cost by dismantling their existing structures and carrying them to their new settlement location. In the resettlement process household can adopt more permanent building material by avoiding their recurring losses they used to experience in every hazard. After the settlement layer land should be allocated for agriculture purpose. Invention of climate resilient crop and floating bed cultivation has widened the opportunity for agricultural adaption in risk area. Even though the farmland is located a distance away a good communication network will motivate the inhabitants to continue living in safer place. Good communication will also act as safe evacuation route in case of emergency.

7. Conclusion :

The successful implementation of adaptive measure specially at local level will increase the livability in risk area and will contribute significantly in reducing out migration (Mowla & Choudhury, 2011). In recent past people were responding well in hostile climatic situation like Sidr, Aila or Beel Dakatia, their experience may be shared in the SLP and CR management. Despite all constraints, Government has initiated some positive steps by formulating Climate Change Strategy Action Plan and National Adaptation Program of Action (NAPA). The policy should be revised in order to provide more importance and significance to issues related to in situ adaption to minimize migrant flow to the cities. The proposed adaptive measure can be regarded as 'guideline solution' for the revised policy. It should be noted that whatever strategies are taken, it should be responsive, contextual and not against the cultural norms of the inhabitants and nor it be against the dynamics of local geo-climate. The success of any adaptive measure will depend on the social acceptance of the measure and active participation of the people during its implementation.

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