A Study on the Suitability of Polderization in ICZM Programs in Bangladesh

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ABSTRACT

To restore the coastal zone, Bangladesh launched Integrated Coastal Zone Management (ICZM) programs in 1960s. Simultaneously, polderization projects with embankment as a part of the adaptation program of ICZM was introduced. Polderization aimed at combating natural disasters, hence, protecting people and crops. To assess the suitability of polderization this study determines the main role of polders in respect to environment, society and economy. An extensive literature review with a field study on three polders in Chittagong district was conducted for the assessment. The literature review mostly highlights the impacts of polders on shrimp farming and rice harvesting and vice versa. The field research includes visiting, surveying and photographing two polders in Patenga and Kumira and surveying polder in Sandwip in Chittagong. The survey contains both individual and group interviews. The polder in Patenga performs best with its current structure and regular maintenance work; whereas, the polder in Kumira has been damaged by ship breaking yards and the polder in Sandwip island has lost the entire embankment in the western side during previous cyclones and floods events. Therefore, an effective polderization system is urgently needed to secure coastal lives and crops in Bangladesh from natural phenomena. The implementation of a sustainable ICZM programs can enable the polders to maximize their suitability since ICZM encompasses several coastal issues such as planning, designing, constructing, maintenance, funding and rehabilitation works for its adaptation programs.

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1 INTRODUCTION AND BACKGROUND

1.1 Tropical cyclone Prone Bangladesh due to its Geographical location

Bangladesh is an active deltaic region with its dense river system and tectonic movements. The major portion of the country is situated on a flat terrain. The lower part of the three river basins: Padma, Meghna and Brahmaputa drain off to the Bay of Bengal crossing over the floodplain which houses eighty percent of the population. At the south, the Meghna estuary along with the 730 km long shoreline meets the mouth of the Indian Ocean and the Bay of Bengal (Brammer, 1990)

The stretched coastline contains fertile lands, the world's largest mangrove forest, which is an enriched biodiversity and minerals. It provides the inhabitants with livelihoods via tourism, industries, fishing, sailing, marine resources, easy transportation and natural aquaculture. Nonetheless, lives of the people of coastal region of Bangladesh are very vulnerable since they face frequent cyclones (Etkin, 1999) and associated disasters such as storm surges and floods. The geographical location as well as the global climate change in the twentieth century are causing deaths and massive economic and environmental damages in the coastal regions (ADRC, n.d.)

According to IPCC Third Assessment, frequencies of tropical cyclone in Bangladesh will be intensified. The peak intensity and precipitation may increase to worsen the situation of the inland and riverine flooding. moreover, the higher mean sea level will intensify the storm surges (Ali, 2010), hence the highly growing population are becoming more vulnerable to tropical cyclones(Berge, Kron, Loster, Rauch, Schimetschek, Schmieder, and Wirtz, 2001).

Bangladesh experienced the deadliest cyclones in 1970, 1990, and 1992 and in 2007 (Ali, 1995). An increasing trend of wind speed in the cyclones has been noticed (Khan, n.d.). The severest phase of a cyclone is the storm surge. It is positively related to the wind speed of the tropical cyclones. It not only washes away people, and cattle it also causes massive destruction to the crops, vegetation and infrastructures (Enamul, 2003).

1.2 Integrated Coastal Zone Management (ICZM) Program

ICZM is a mechanism which has been followed by many nations to manage the vulnerable issues such as erosion, tourism, deforestation and salinity intrusion in marine and coastal zones through multi-faceted systematic processes. The Pakistan government adapted this mechanism in 1960s. ICZM programs were re-introduced in 1980s by the Bangladesh government. They were harmonization and co-ordination in integration, adoption of process approach, linkages in national planning mechanisms, implementation through respective agencies, participatory decision, monitoring and evaluation, efforts to fill knowledge gaps and priority setting on issues of the coastal zone. Bangladesh government had set several concrete and significant principles and policies on ICZM program (Karim and Mimura, 2008). Experts found out the Bangladesh needs policies directly addressing the problems in coastal zones, coordination of different sectors, proper planning, capacity building and more importantly implementation in order to make ICZM sustainable (Islam, Xue and Rahman, 2009). This paper discusses about several spheres of ICZM in Bangladesh in section 2.

1.3 Polderization

The term ‘polder’ refers to low-lying lands protected by dam, levees or embankment adjacent to any surface water bodies such as lake, big canals, rivers, seas or oceans (Figure 3.1).The low lands are protected from being inundated by weather phenomena like cyclones, storm surges and floods. The Dutch initiated polderization centuries ago. Besides protecting their low lands (Van der Vlist, 1998) they are reclaiming lands (Hoeksema , 2007) from the river and sea by applying well constructed polders (Klapwijk, 1998) . Then, countries like America and Germany adapted this idea to protect their urbanization developed on lands at the bank of rivers or seas which are lower than the mean sea level (Huang, Rauberg, Apel, Disse & Lindenschmidt, 2007 and Wheby, 1980).

As one of the adaptation programs of Integrated Coastal Zone Management (ICZM), Bangladesh government introduced polders to its coastal zones with the aid of the Netherlands in

1960s (Choudhury, n.d.). Bangladesh has 5,017 km embankment protecting the polders in coastal areas from the Bay of Bengal (Figure 3.3). The primary goals of launching polderization in Bangladesh were to protect the coastal inhabitant from regular natural disasters and to boost the agricultural production (Shaw, 2006). Bangladesh Water Development Board (BWDB) formerly know as Water and Power Development Authority (WAPDA) is in charge of maintaining and conducting the rehabilitation project of the polders (Thomas, 1974).

Due to the poor maintenance, coastal polders in many places have started creating water logging, hence, salinity intrusion to the agricultural fields. Thus, it decreases the production of Aus (*Oriza Sativa L. var.)* rice, one of the leading genres of rice which grows in the coastal areas. Additionally, the local people often damage the embankment deliberately to develop shrimp farming in the polders. Moreover, in 1980s, 274 ha of rice fields were transformed into shrimp ponds in the polders of Satkhira, a district in the southwestern part of the country. Since then, the area of shrimp farming has been increasing alarmingly (Figure 4.3) boosting the country's economy by exporting processed shrimps whereas the production of Aus has been decreasing

1.4 Approach

An extensive literature review online and field works have been conducted. The online research was conducted to review literature on polders in different countries. It also helps to find out project completed on the ongoing activities in polder in Bangladesh. The wide use of Google maps assisted to create the graphical view of polders. The field research includes visiting 2 polders- polder no. 61/1 in Kumira (a muddy beach), Sandwip Boat ghat, Sitakundo and polder 62 in Delpara village, Patenga (a Sandy beach) in Chittagong city. Polder no. 72 in Sandwip was not visited. People of an age range of 26-70 were provided with semi-structured and open ended questionnaires. The data were collected through subsequent visits to these coastal areas in 2 months period. Before conducting the field survey and research, an Engineer of Bangladesh Water Development Board (BWDB), Chittagong division 2 was interviewed to get the knowledge of different facts of the polders in Bangladesh and their maintenance programs. Based on his information, the three sites were selected to visit, interview, analysis and create case studies. Mostly, respondents of older ages were targeted since they have the wisdom to

provide more information and explain better of how the embankment were playing role in their lives. People between 26 and 40 years were interviewed as well in order to know the opinion and experienced of the later generations about the role of polders in their lives and livelihood. Some group discussions were also carried out during the field visit. However, most of the interviews on Sandwip Island were covered by phone. The respondents are from different walks of life; they are owners of grocery shop, and restaurant, some are fishermen and teachers. One respondent is a primary school teacher in Sandwip, and another three are university faculties. The questionnaire includes questions on three categories; the impact of polder on the social, environmental and economic aspects. Each category has a set of questions probing into more details.

1.5 Objectives

The objective of this study is to determine the suitability of the polders as a part of Integrated Coastal Zone Management (ICZM) in Bangladesh which covers:

- How the activities (agriculture and shrimp farming) are damaging the polders and vice versa and how these activities are influencing the surrounding natural environment, human society and the national economy.
- The current status of the polders
- How predicaments of the polders can be tackled.

2 CYCLONES IN THE COASTAL ZONES AND INTRODUCTION TO INTEGRATED COASTAL ZONE MANAGEMENT (ICZM) PROGRAMS IN BANGLADESH

The 730 km of coastline meets the mouth of the funnel-like shape formed by the Bay of Bengal and the Indian Ocean (Figure 2.1). The complicated coastline of Bangladesh is divided into three territories- western, central and eastern coastal zones (Ali, 1999). The Sundarbans in the South-

west, estuaries of three mighty rivers in the south, Karnaphuli- Halda- Sangu Rivers and Arakan ranges shoreline in the south-east present a distinct feature of shoreline of Bangladesh (Coastal Zone mana…, 2010) (Broactus, 1993) . Beside the position of its coastline, the distinctive geography of Bangladesh lying down between the Himalayan range in the North and

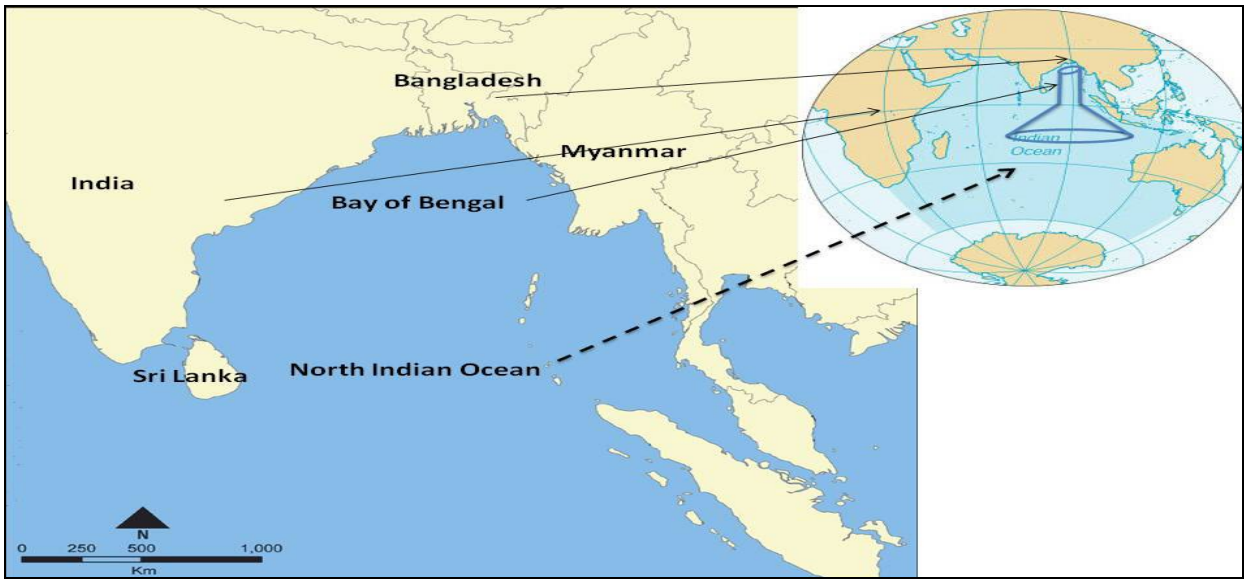


Figure 2.1 The geographical location of Bangladesh Facing the Mouth of the Funnel shaped Bay of Bengal in the south (Adapted from The Seas Project. Org)

the Bay of Bengal in the south (Seal and Baten, n.d.), is an active delta due the strong river network and tectonic movement (Brammer, 1990). Hence, Bangladesh ranks as one of the top natural disaster prone countries in the world (Lein, 2000), and the fifth most natural disaster prone country among 173 countries in the world (The Daily Star, 2012).

One third (about 50 million) of the entire population lives in the coast of Bangladesh. Ten percent of this zone is barely one meter above the mean sea level and one- third of this area is under tidal excursion (Coastal Zone mana…, 2010). The coastal zone experiences tropical cyclones with wind speed of different ranges almost in every year (Khalil, 1992). Hence, people's life and the land inundated by regular tides and cyclones are the main concerns .

Bangladesh is hit by about 0.93% which is almost one percent of the world's total tropical storms and cyclones (Ali, 1995). The death tolls around 5000 occurred in 16 tropical storms in Bangladesh out of 35 globally from the year 1877 to 1995 (Khan, n.d). It comprises of fifty-three percent of world's such death by cyclones. The long stretched coastal region of the country in the south is hit first. The deadliest cyclone events happened in 1970, 1992 and 2007 which causes death tolls of 500000, 148000 and 4234 respectively. (Dasgupta *et al.*, 2011) (Figure 2.2)

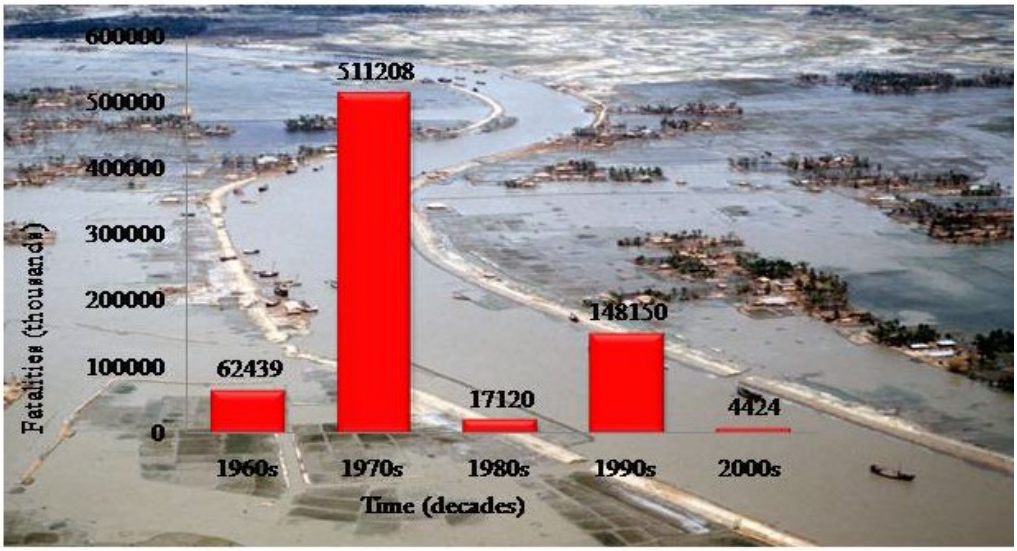


Figure 2.2 Fatalities due to the Tropical Cyclones in Bangladesh from 1060s to 2010s. the 1970 cyclone alone killed about 5,00,000 people (Adapted from Dasgupta *et al.*, 2011)

Wind speed is the main determining factor to measure the intensity of a cyclone hitting the coastline of Bangladesh. Figure 2.3 provides the pattern of wind speed of the cyclones since 1960s. With a substantial number of fluctuations, the wind speeds of cyclones have increased dramatically since 1960s to 2010s in Bangladesh (figure 2.3 (b) (Enamul, 2003). The recent devastating cyclone was Sidr in 2007 which hit the South and South- Eastern coastal districts of Bangladesh with a wind speed of 260 km/h (Figure 2. 3)

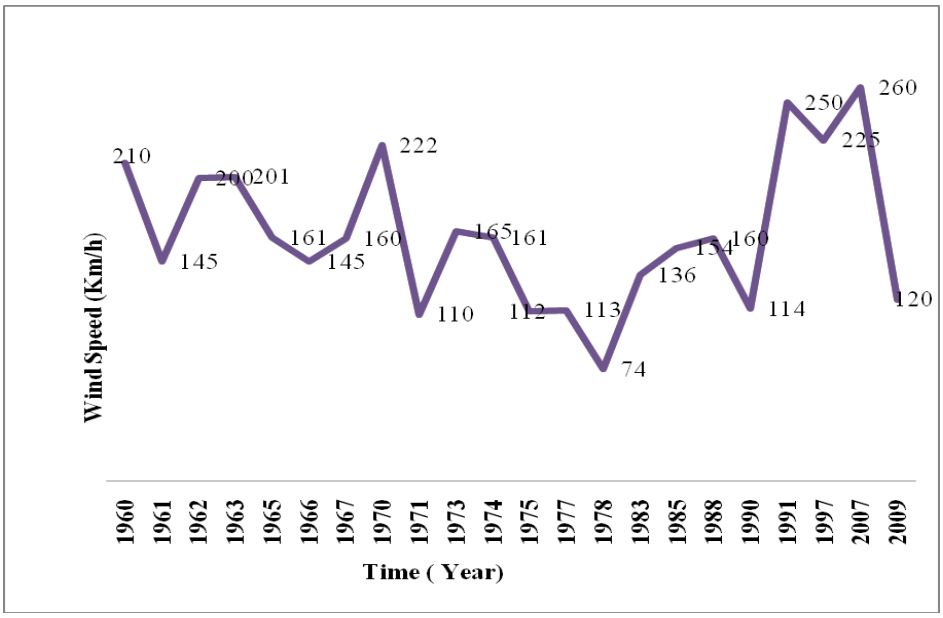


Figure 2.3 The very fluctuating trend of wind speed of tropical cyclones since 1960s in Bangladesh. (Adapted from Ali, 1995, Khan, n.d.)

Due to climate change, cyclones and storms have become more frequent and more intense between the decades 1990s and 2010s. According to the IPCC Third Assessment, frequencies of tropical cyclone will change in the coast; the peak intensity may increase by 5% to 10% when with an increase in wind speed (Choudhury, 2001) precipitation may increase to 20% to 30%. Additionally, lands subsidize due to the tectonic movement. Higher mean sea level is expected to intensify storm surges. Therefore, the problems of coastal inundation and salinization would be worsened more (Agrawala, Ota, Ahmed, Smith and Aalst, 2003).

Storm surge, the most overwhelming phase of a cyclone, hit Bangladeshi coasts with a typical height ranging from 1.5 to 9 meters. Some may reach up to a height of 15 meter (Khan, Singh, and Rahman, 2000). The higher wind speed has the potential to cause a storm surge with a higher water level (figure 2.4). For instance, the 1991 cyclone hit the south eastern part of Bangladesh with a massive wind speed of 235 (figure 2.3), and kept inundated the areas with 30 feet high storm surge for five minutes (Haque, 1992). It killed nearly 148, 000 people, led10 million people homeless (Bangladesh Disasters- Cyclones, 2003) and destroyed 1,130 km embankment (Khalil, 1992). The other devastating storm surge in Bangladesh inundated the coastal areas

under 7 meter in 1970 and swept away thousands of people and cattle and caused devastating damages to the economy (Nicholls, 2004).

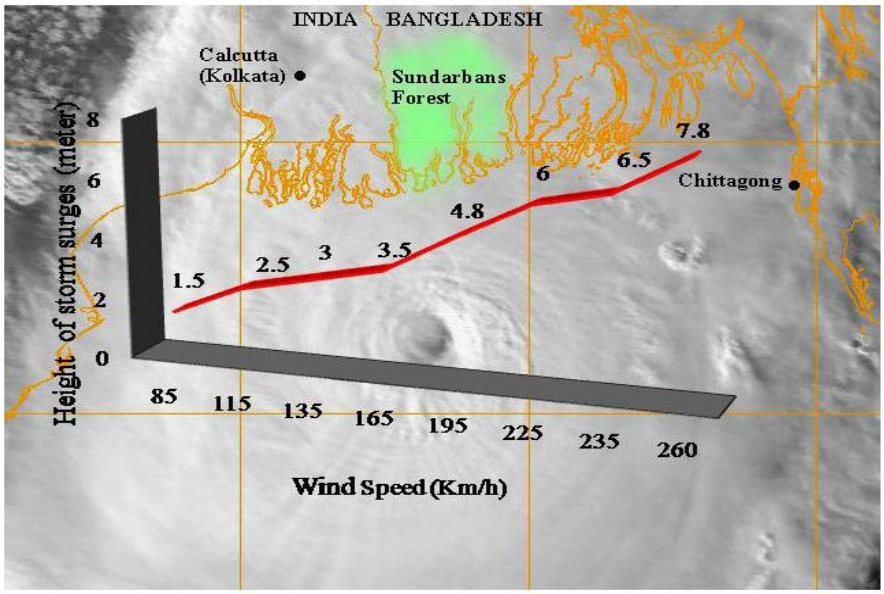


Figure 2.4 The positive relationship between the height of storm surge and wind speed of cyclones (Adapted from Powell, Houston, Amat and Morisseau-Leroy, 1998 and US Naval Research Laboratory)

To mitigate the impact of these natural hazards experienced in the coast, Government of Bangladesh (GoB) took substantial steps. (Karim and Mimura, 2008). For instance, integrated coastal zone management (ICZM), the most popular mechanism to deal with the coastal issues, was adapted in 1960s. the details of the a general idea of ICZM including a hypothetical diagram of ICZM and a chart showing its ideal activities, ICZM programs in Bangladesh, its Policies and programs are presented below:

'Integrated Coastal Zone Management (ICZM)' mainly aimed at managing vulnerable issues in marine and coastal areas through multi-faceted systematic processes. Its inaugurating purpose was to enhance the efficiency and effectiveness of countries' existing coastal governances so that a sustainable use of coastal resources can be achieved (Post and Landin, 1996).Moreover, nations launched ICZM responding to natural resources, deforestation, tourism, erosion, salinity

intrusion in the coastal areas. Many countries have developed and implanted ICZM by getting inspired by successful application of ICZM by Philippines, China, Indonesia, Viet Nam and Malaysia in their own coastal zones (figure 2.5) (Bangladesh: National Programme of Action …, 2003).

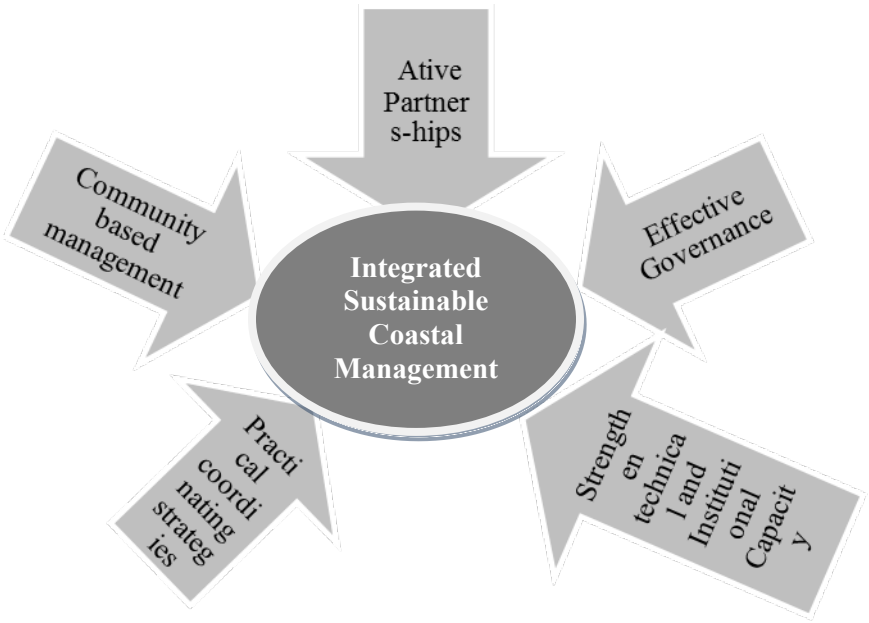


Figure 2.5 A Hypothetical Diagram of an Integrated Coastal Management (Adapted from World Bank. Org and PEMSEA.org)

GoB (Government of Bangladesh) stated, "*ICZM offers a means of balancing the competing demands of different users for the same resources and of managing the resources to optimize benefits … it is an effective framework for dealing with the conflicts arising from interactions of the various uses of Coastal areas." (GoB, 1999)* (Integrated…in Bangladesh, n.d. and Huda, 2004)

The principles and goals initiated in 1980s by the Government of Bangladesh to implement ICZM activities referred in figure 2.6 were:

- Integration through harmonization and coordination;
- Adoption of a process approach;

- Linkage to national planning mechanisms;
- Implementation through respective line agencies;
- Co-management and participatory decision;
- Gender equality;
- Participatory monitoring and evaluation;
- Supporting national policy of decentralization and development of the private sector;
- Interventions based on the best available knowledge; efforts to fill knowledge gaps;
- Priority setting on issues of the coastal zone. (Integrated…in Bangladesh, n.d.)

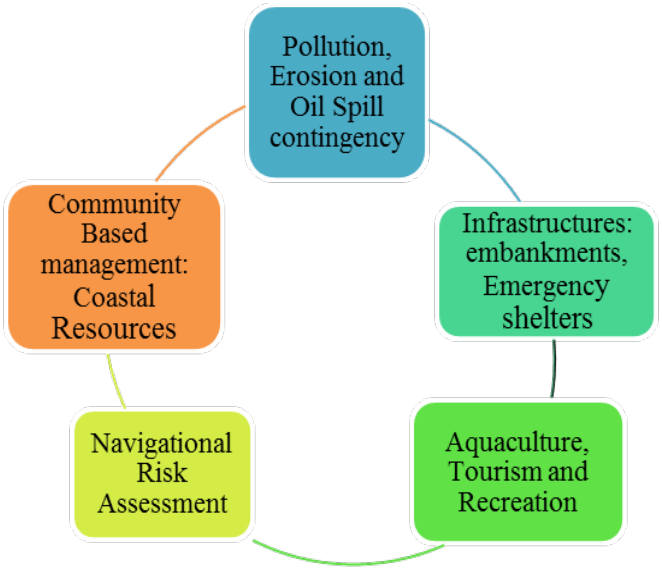


Figure 2.6 Series of activities should be included in a sustainable Integrated Coastal Zone Management (ICZM) Programs (Adapted from The World Bank, 2011)

The policies received the next priority for a sustainable ICZM after the principles and goals in Bangladesh. The notable policies set by GoB were: "ICZM: policy and issues (1999)", "Program Development Office for ICZM (2002 – 2006)", "Coastal Zone Policy (CZP), (2005)", and Coastal Development Strategy (CDS), (2006) (Integrated…Management, n.d.).

While approving the 'Coastal Zone Policy' 2005, the policies focuses of GoB were:

- Economic development in the coastal areas

- Mitigation of risks

- Sustainable management of coastal resources

- Proper land utilization planning

- Taking measures against salinity intrusion

The initial steps taken by the ICZM officials in Bangladesh covered guidelines, introducing associated concepts, plans and establishing more broader delineation of the coastal zones of Bangladesh . Guidelines in order to protect the water bodies, the concept of zoning were introduced as a management tool, some plans were created to operate ICZM effectively. Finally, GoB has established explanation of coastal zones and set goals of ICZM, thereby, harmonized different agencies in coastal zones. However, the challenges faced were: policy failed to address the coastal management, poor implementation despite adoption of CZP (2005) and CDS (2006), and unclear distinction of land to conserve the coastal lands, thereby, secures its people (Islam, Xue and Rahman, 2009)

Some donor agencies such as European Union, European Community, UNDP, PHRD and World Bank assisted the Government of Bangladesh in making the ICZM successful. Besides the plans, a few projects and studies were also initiated with collaboration with these international agencies. They are listed in the Table 2 below:

Table 2.1 A time-line of the the significant ICZM Programs Conducted by Government of Bangladesh (1960s- 2000) (Huda, 2005)

Year	**Significant events**
1960	Launching of Coastal Embankment Project
1986	Completion of the National Water Plan (NWP), Phase I, Water Development and Flood Control

1989	Cyclone Protection Project II jointly sponsored
1992	Integrated Management of Coastal Zones by FAO, study titled "Multi-purpose Cyclone Shelter Programme" (MCSP)
1993	Tropical Research and Development Inc. Feasibility Study: Integrated Coastal Zone Management for Bangladesh
1995	Cyclone Shelter Preparatory Study (Cyclone Risk Area Development Plan) was launched.
1998	February – March: ICZM Formulation Mission (WB, NEDA and WFP. August – WB proposal to use CERP and other projects (CDSP, MES, SEMP, FFP, FRMP etc.) as a building blocks of an ICZM Plan.
1999	September – Policy and Human Resources Development (PHRD) Grant to help ICZM project preparation
2000	Establishing Project Development Office to prepare ICZM approach

Islam, Xue, and Rahman conducted a project in Bangladesh where they implemented an ICZM Program like Ximane ICZM program planned by China. China attained a huge achievement in 'Marine pollution prevention and mitigation', 'Protection of endangered species', and in 'Preservation of scenic spots' via ICZM program. However, the limitations in generations of information to filling gaps, application of ecosystem linkages, dissemination of information to assist decision making, harmonizing sectoral policies, plans and laws and improved governance make this ICZM project to achieve lowly (Islam, Xue and Rahman, 2009).

3 COASTAL EMBANKMENTS/ POLDERIZATION

3.1 Polders?

Polders are low- lying areas at the bank of water reservoirs like ocean, sea, or rivers. These areas are usually lower than the water bodies adjacent to it. Natural incidences like tide, waves, and storms, floods, cyclones and storm surges arisen from the water bodies often expand to these lands and inundate them. Eventually, lives and livelihood of people living in the lands are damaged. As stated earlier, thousands of people die in each decade by cyclone and storm surges

in the coastal areas in Bangladesh. Thereby, this low- lying areas are protected by artificial barriers like embankments or levees constructed between the reservoirs and the lands (figure 3.1 and figure 5.1).

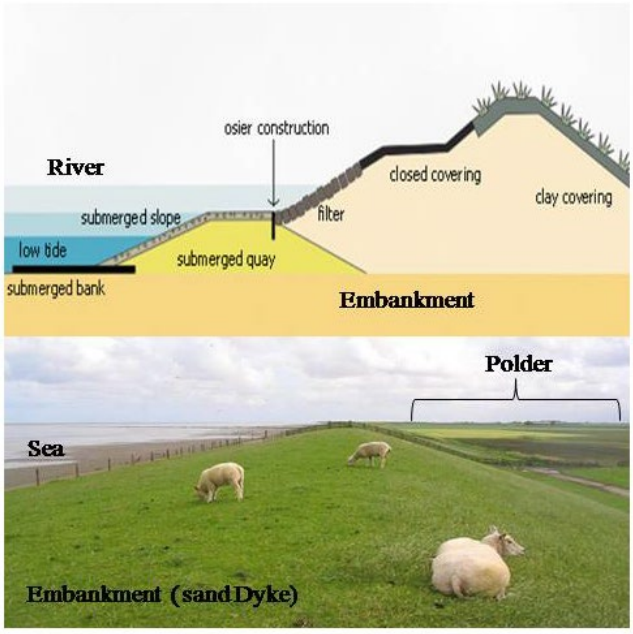


Figure 3.1 The diagram at the top shows an engineered structure of an embankment to protect polders in the Netherlands. The diagram below shows a polder, embankments and a reservoir (sea)(Adapted from SeaOnScreen. Org)

The embankment of the polders varies depending on the geo-morphology and the technology available in a respective country. For example, most of the embankments in Bangladesh have been constructed by earthen material such as mud and soil. A few embankments are provided with extra protection by setting wall between the embankment and the sea made of stones and boulders (Figure 3.1 and figure 5.3). The embankments are mainly made of stones, rocks, mud, and sands. On the other hand, sophisticated science is applied in planning and designing of both polders and embankments in the Netherland. So do Germany or the USA. However, embankments in Bangladesh are not very science oriented.

The length, width and height of embankments depend upon the geographical locations they are set on. However, their length is higher than their width in most of the cases. The width of the embankment crest is smaller than the width of the base. They have hill-like slopes. Their main

function is to hold back water from inundating the lands inside polder. They are used on several purposes.

The term polder associated with the land protection from sea floods by building dam was first used in Holland about ten centuries ago. Later flood plains, lakes, and shallow reservoirs were called polders which needed protection from adversities like natural disasters. Different attributes led the polders to be classified as: seashore, flood plain and low-lying areas. The polders located in the seashore, flood plains and low-lying areas are protected from the sea-water flooding, river floods, lake and reservoir floods respectively (Rusetski, n.d.).

3.2 Polders in Bangladesh

Polders/ coastal embankments are the principal infrastructure for coastal management in Bangladesh. The undivided Pakistan government launched constructing polders in 1960s in coastal areas of present Bangladesh with support of Dutch Government. Most of them of the polders in Bangladesh are earthen embankments along rivers (Dasgupta *et al*, 2012).

There are 68 polders in the coastal zones of Bangladesh. These polders are named numerically (1, 2, and 3). Each polder has sub-polders which are named like 61/1, 61/2 or 64,1A, 65/A and 65/5A. For example, the polder number 64 is located in Bashkhali, in Chittagong, in the eastern region of Bangladesh. The names of its sub- polders are 64/1A, 64/1B and 64/C. Some other polders are: 61/2 in Mirsharai, 61/1 in Sitakundo, 63/ 1A and 63/ 1B in Anowara and 62 in Fauzderhat. Thus, there are 123 polders formed by 5,017 km of embankments (Figure 3.3). Among these, 49 are sea facing. These polders are situated at the shoreline which works to push back the water of the Bay of Bengal. The remaining 74 polders are called interior polders which prevents high level water of any dangerous level from canals or rivers which are linked to the sea.

Bangladesh Water Development Board (BWDB) is in charge of maintaining and rehabilitation work of polders. It maintains three types of embankments around or in polders: sea dyke, interior dyke and marginal polders.

Embankments associated with the polders have been built on basis of the topography, geography and inundation level during high tides and storm surges. Not all polders are surrounded by embankments. The islands like Sandwip were surrounded by embankments along all of its sides. A single line of embankment made of boulders (this type of embankment is called protective embankment) is set along the coastline of Mirsharai, Sitakundo, Potenga and Bashkhali. Bashkhali with Bay of Bengal at West and a canal named Chaktai at South entering from the sea are surrounded both by sea- dyke and interior- dyke (Figure 3.2).

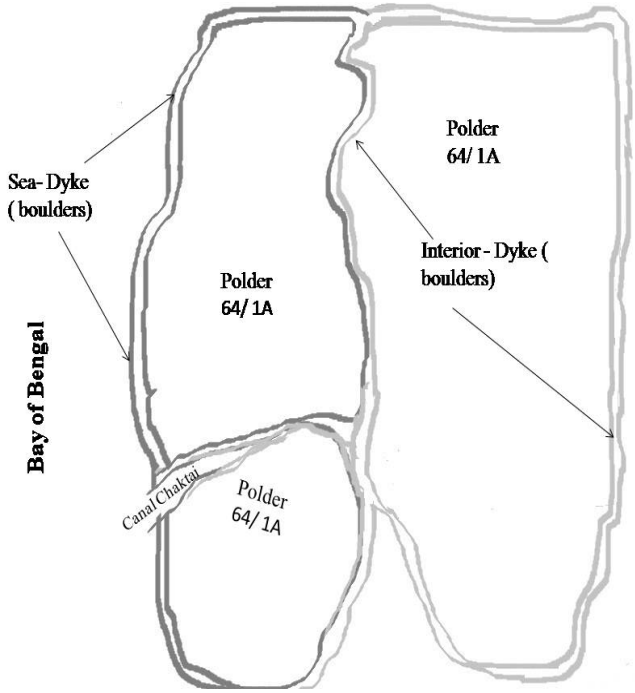


Figure 3.2 A conceptual diagram of three adjoining polders in Banskhali, Chittagong.

3.3 The purposes of constructing polders

The main purposes of polder construction in Bangladesh were:

- To protect the low-lying area from high tides and wave during monsoons and tidal surges (Paul, and Rahman, 2006)
- protect 1.5m ha of land of which 0.8 million ha land is cultivable

- as the first line of defense against sea level rise
- To combat tidal intrusion aiming to boost agricultural production (Shaw, 2006).
- To promote shrimp culture (in some extent) (IRIN, 2007).

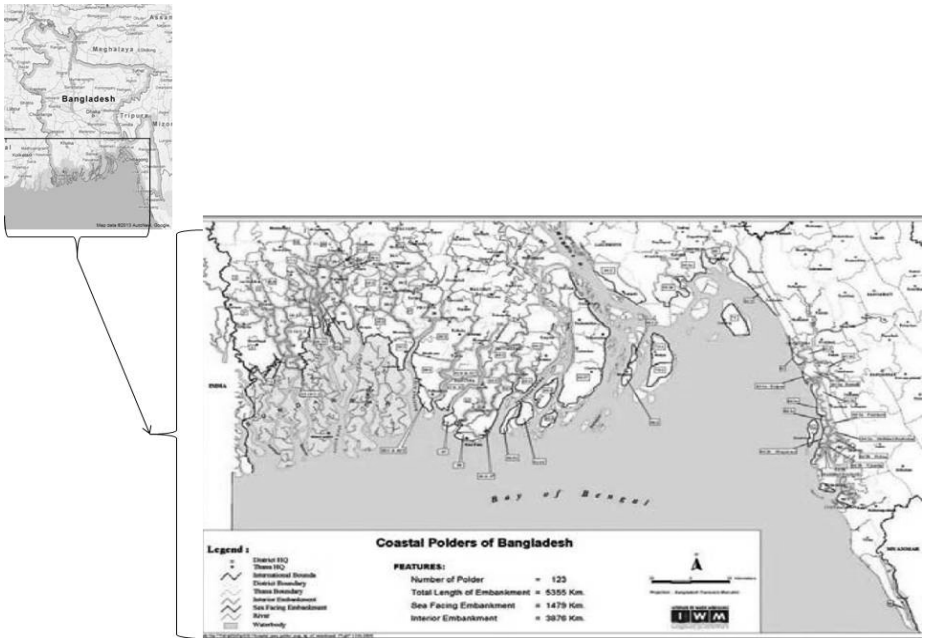


Figure 3.3 The map of Bangladesh and polders in the coastal zones (Adapted from Islam, 2006 and Islam, Bala and & Haque, 2010).

With ninety percent of the country's coastal population living in the polders, and over 80 percent involved in agriculture, the potential impact on food security for such communities cannot be denied as the IPSWAM official warned:

"*Unless the larger breaches are repaired immediately - with the harvest season upon us - many of these people living in the polders will lose their crops*,".

According to Ahmed, an official in Bangladesh Water Board, "not repairing the polders could spell economic disaster: We have no choice. We have no option." "We have to do it and we have to do it now," he added.

3.4 Places with high risk but with no polders

The districts located at the coastal zones without having any polderization are: Patuakhali, Pirojpur, Barisal, Jhalakati, Bagerhat, and Narail. These districts are estimated to be submerged by the Bay of Bengal if sea water rises only one meter due to climate change.

3.5 Coastal Polder/Embankments Development and Maintenance Programs

Some projects were undertaken by Bangladesh Water Development Board (BWDB) and Water Resource Planning Organization (WARPO) to construct, rehabilitate and develop embankment in front of or around polders. In order to provide the idea of the cost and types of rehabilitation projects carried on in polders, the table below is presented. This project covered extension, construction and reconstruction of polders and sluice gates between 1998 and 2007 (Rahman and Chowdhury, 2005).

Table 3.1 Period, location and cost of different rehabilitation projects of polders

Name of the Agency and Project	Project Period	Location	Total Cost (Project aid)
Polder-69 Extension	1998-99 2002-03	Cox's Bazar	151.56
Polder-69 Extension	1996-97 2002-03	Patuakhali	175.30
Polder 59/2 Extension	1998-99 2002-03	Lakshmipur	99.80
Polder 50/51, Barabaishdia FCD	1998-99 2002-03	Patuakhali	228.00
Polder 71, Kutubdia	1999-00 2001-02	Cox's Bazar	133.30

Polder 64/IA, 64/IB,64/IC Rehabilitation	2001-02 2003-04	Chittagong	352.09
Retired Embankment and Sluice, Polder 56/57	2001-02 2002-03	Patuakhali	125.00
Constuction/Rehabilitation of 5 sluices in Polder -65 & 5 sluices in Polder-64/B	2002-03 2003-04	Cox's Bazar	100.30
Rehabilitation of Damaged High Risk Polders in Coastal region (72 Polders)	2002-03 2006-07		1602.60 (1282.00)

(Adapted from Rahman and Chowdhury, 2005)

Some other maintenance programs also have been conducted by the help of foreign aids. For examples, DHV, Europeans leading project management, engineering and consultancy service providers with a headquarter in Amerfoot in the Netherlands conduced the rehabilitation works on sectors related to polders in Bangladesh with collaboration to MacDonald in 2000 (Khan, 2005). An overview of the rehabilation work is referred below:

Feasibility Study: on Polder 61/1 Sitakunda;

Char Development & Settlement Project –2 (BWDB): polder 59/3C in Companiganj sub-district, Noakhali, and in Lakshmipur; south eastern part of Polder 59/3B

Rehabilitation Of Damaged High Risked Polders in Coastal Region Project (72 Polders)**:** Rehabilitation of 72 high risked Coastal Polders to keep them effective for flood protection of 846,107 ha, secure agriculture in 477,950 ha, shrimp culture in3,761 ha, and salt production in3,430 ha area.

BWDB is encouraging community people in the polder areas to participate in decision making about polders. Community people who live there know better than anyone about the how to design, rehabilitate, manage and promote embankments and polders (Khan, 2005).

3.6 Problems with Maintenance of the Polders

The polders in Bangladesh receive inadequate maintenance and rehabilitation works. They have some serious limitations such as a faulty management of coastal polders which accelerates inland salinity ingression. This water logging has extended to 1500 km^2 Ganges tidal plane The main reasons of the salinity intrusion are:

- Intentional cutting and breaching polders by local people to promote shrimp farming.
- Undesired water logging in the sluice gates of polders or dikes
- As the riverbed outside polders increase through siltation over time, permanent water logging is occurring in the polder.

Other maintenance problems include: drainage congestion, shortage of fresh water and damaging of embankments (MOWR, 2012)

3.7 Limitations Of Polders

A few but remarkable limitations of polders in Bangladesh are:
1. Dynamics of the delta development process and its complex characteristics were not properly considered in designing the polders.
2. Reduced floodplain storage capacity during floods, increase in water levels and discharges in many rivers.
3. Open fisheries affected by water logging
5. Lack of understanding of polders hydro-morphological characteristics
6. Incapability to tackle climate change

3.8 Impacts of Polders: Flash Floods

Cahakaria Thana, Cox'z Bazar:

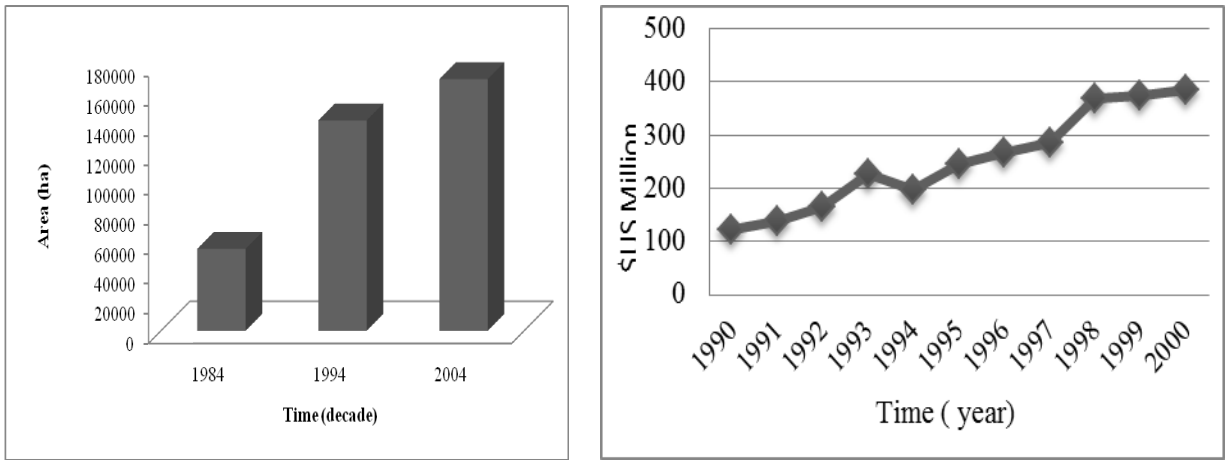
After the reconstruction of the embankments in 19991 around polder areas in Chakaria , a Sub-distric in Cox'z Bazar, the frequency of flash floods had been increased there. A study conducted by Choudhury, A Paul and K. Paul using hydrological data and human perceptions reveals that maximum water level (MWL) were exceeding the danger level from 1991 to 1997 significantly in Matamuhuri river which flows along Chakaria thana. Moreover, Both magnitude and frequency of flash floods were much higher in the post-embankment construction period (1991 1999) compared to the pre- embankment reconstruction period (1969- 1990). Hence, heightening and strengthening of embankments seemed to increase the magnitude along with the depth and duration of flooding in Chakaria Thana (Choudhury, Paul, A & Paul, B, 2004).

4 ACTIVITIES in Polders

This study discusses two major activities which are led by the community people in the polders. The next two sub-sections include detail information about these activities which are shrimp culture and rice cultivation.

4.1 Shrimp Industries

Bangladesh is one of the ten top shrimp exporters around the world (Cato and Subasinge, 2003). The construction of embankments in the coastal areas in early 1960s restricted the traditional shrimp farming which started back in 1930s.. Moreover, protected lands by polderization encouraged farmers to resume commercial shrimp farming in polders in Sathkhira, Khulna. Farmers could keep saline water in the polder for a longer time which boosted shrimp farming in the coastal areas of Bangladesh (Alauddin and Hamid, 1999). Since 1980s, the area under shrimp farming, settled in the polder has been increasing at an alarming rate (Primavera, 1997) (Figure 4.1).



(a) (b)

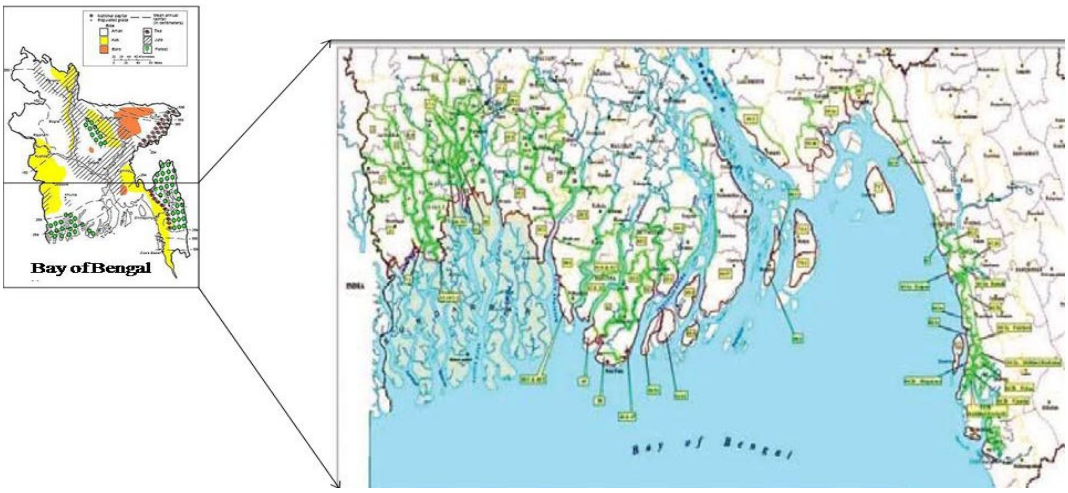
Figure 4.1 (a) Growing Shrimp farming area since 1984 to 2004 in the coastal regions of Bangladesh; (b) The increasing trend of earning foreign currency from shrimp farming over one decade (adapted from Primavera, 1997)

Around four million people in Bangladesh are directly benefitted by the shrimp culture. It creates employment for 11, 50, 000 people. Moreover, a total of 2, 23,095 Metric ton shrimp that contributes to 19,567.90 crore taka in the GNP were produced in 2007-2008 (Nupur, 2010). Shrimp exporting in Bangladesh contributed to 4% in GDP in fiscal year 2008-2009 (Paul and Vogl, 2011)

Deforestation of mangroves to expand shrimp farms causes the aquatic and fresh water species and their biodiversity to be disturbed or lost. Hence, natural protection against cyclones and storms are reduced now (Alongi, 2002). Most importantly, wastes and effluents from shrimp drainage pollute the environment (Nuruzzaman, n.d.).

4.2 Rice (Aus) production in the Polders

The coastal areas of Bangladesh cover more than 30% of the cultivable lands of the country when about 53% of the coastal areas are affected by salinity. Different types of rice/ paddies are the major crops cultivated here (Uddin and Karim, 1992).



(a) (b)

Figure 4.2 (a) Bangladesh showing the rice production areas, yellow color indicated the Aus production areas; (b) the polders in coastal zone, Bangladesh.

A considerable area of the coast is covered by the polders of different types such as marginal or sea dyke. Soil salinity levels have not decreased considerably within the poldered areas. This seriously constrained the adoption of HYV aman and HYV aus in these areas (Habibullah, Ahmed and Karim, 1999). The main constraints of Aus production in the polders are:

- Perennial water-logging due to inadequate drainage and faulty operation of sluice gate
- Facilities restrict potential land use of the low lands within the poldered areas. (Haque, 2006).

As shrimp culture occupied the agricultural land for Aus cultivation, it started degrading the soils quality. Aus (Oriza *Sativa L. var.)* is the second major rice produced in Bangladesh. The rice fields which overlap the empoldered area are in the western Satkhira in West of Bangladesh. Apart from this, the eastern coastal region with polders of the country such as Sitakundo, and Chittagong and the sub-districts of Chittagong such as Anowara, Bashkhali and Cox's Bazaar is another suitable location for Aus production.

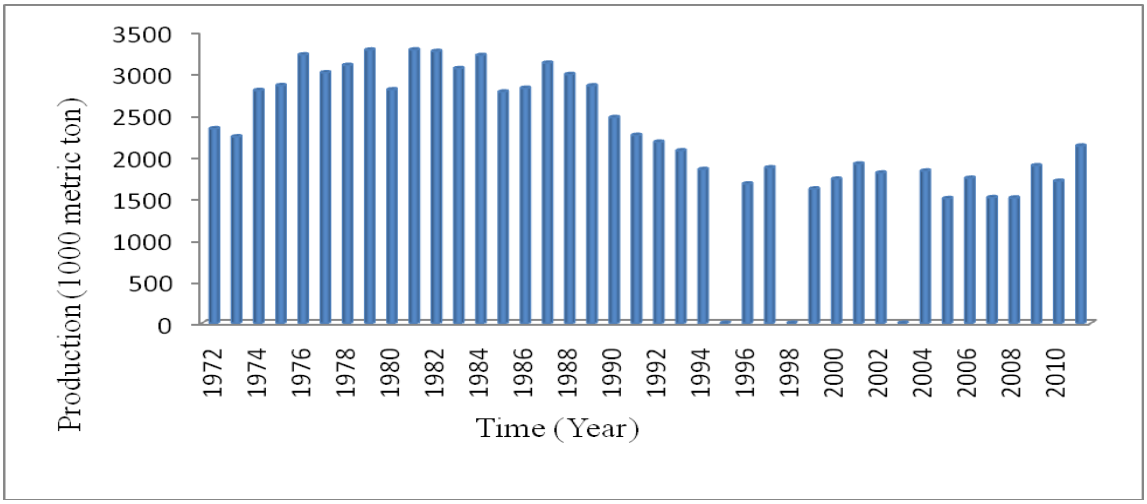


Figure 4.3 Aus production (thousand metric tons) from 1972 to 2010.

A total 274 ha of rice fields were transformed into shrimp ponds in Satkhira. Water logging by shrimp culture has degraded the quality of land by increasing soil salinity and acidity (pH< 5.5). Moreover, Ca, Mg, and B base minerals were leached out of fields. Accumulation of nitrogen (N), phosphorus (P) and sulfur (S) occurred as organic and inorganic fish meals added to shrimp farms have released N, P and S to the soils in the study area of Satkhira. As a consequence, not only rice production was reduced but shortage of feedstock for livestock also arisen there. Particularly in Damarpota village in Satkhira farmers observe that 81% of salinity increase, hence, decrease in net production of Aus rice due to the growing shrimp farms there (Ali, 2004).

5 A FEW CASE STUDIES TO ASSESS THE SUITABILITY OF POLDERS

5.1 Polder N0. 61/1, Kumira Ghat, Sitakunda, Chitatgong

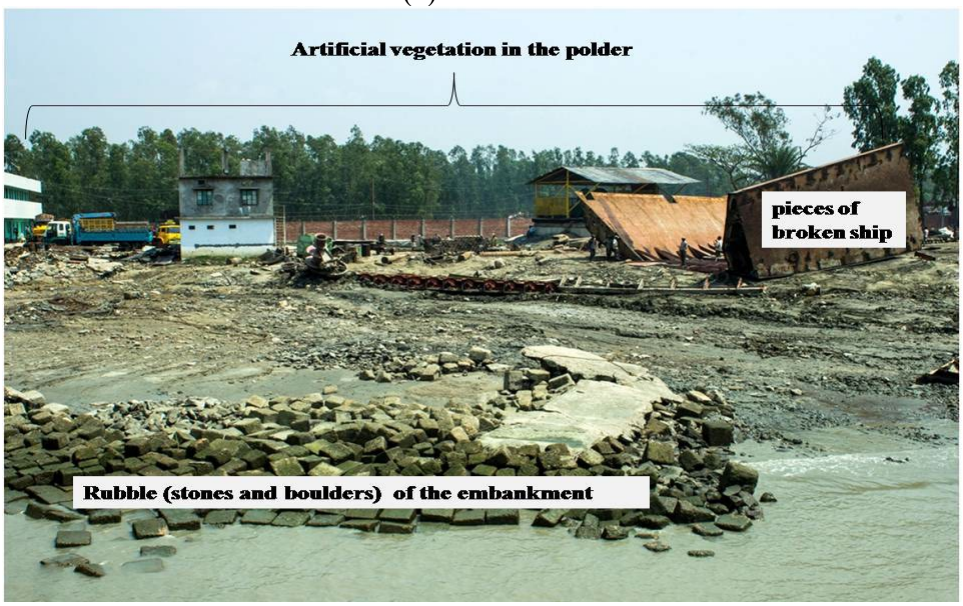
Kumira, occupying a part of the polder no 61/1, lies in the Sitakunda upazila in Chittagong Division which is located in the South-eastern part of Bangladesh. Sitakunda is situated at 22°37'North and 91°39. 7' East.

The Sitakunda Sandwip Channel joins the Bay of Bengal in the north. Sitakunda is located between the Sandwip Channel in the west and the Sitakunda Range in the east. Since the eastern

side is bordered by high land, the low lying coast at the west Kumira is protected by a single earthen embankment at the west (Figure 5.1). This polder is adjacent to polder No. 61/2 in Mirsharai, a district of Chittagong north of Sitakunda. Next to it is 63 in Anwara sub-district in the south.

Canal Kumira enters to polder from Sandwip channel. The area contained by polder 61/1 is very densely populated. Most of the houses are not well-structured. The walls are bamboo mate and roofing is managed fragile tin shade. Very few houses are brick- built though.

(a)



(b)

Figure 5.1

Embankment of the polder no. 61/1. (a) Embankment between the polder and the Sandwip channel, (b) the occupied area of the embankment by a ship breaking yard.

Hence, the frequently occurring cyclones can damage the houses very easily. Most of people are tenants here who lost their own land by erosion during the 1991 cyclone. Some of them lost lands through allowing BWDB to build the embankment over their land.

There is a very little agricultural land. The Bangladesh government has planted many foreign trees on the slope of the embankment (Figure 5.1). The embankment is 26.77 km long barricading 18 hectare land. It is 6 meters high and 10-12 feet wide at the crest, according to the engineer, Mr. Swapan K Barua of the Bangladesh Water Development Board (BWDB), Division 2, Chittagong [Figure 5.2]. Unlike the embankment in polder no. 62 in Patenga, Chitatgong city (figure 8.1) and the technique of constructing both embankment and 'protective wall' have been applied on this embankment. It is made of earth material and has been strengthened by setting boulders on the sea facing slope.

This embankment is not overtopped by high tide or higher water levels during monsoon season. According to Mr. Abul Kalam, a 70 year old man, it was not damaged by the recent severe cyclones Sidr (2007) and Aila (2009). The part of the embankment located at the Ghat Ghar Road in Kumira was first built in the 1960s. Since then, many rehabilitation projects have been undertaken. The part of embankment at the south of the Ghat Ghar Road was built 5 years ago. In some places, the embankment is broken [figure 5.1 (b)].

People broke several parts of the embankment to set ships breaking yards alongside the channel, according to Mr. Barua. We could see the rubble of embankments adjacent to the Sandwip Boat Ghat lieing on the beach [Figure 5. 1(b)]. Mr. Kalam, expressed his frustration over the government people who failed to resist the owner of ship breaking from damaging the embankment. He also reported that if a mighty cyclone along with a surge of an unusual height strikes the coast of Kumira, a vast area will be inundated within a short period of time.

(a) (b)

Figure 5.2 Sluice gate of the polder 61/1 in Kumira [a. sea facing side; b. polder facing side of the sluice gate.]

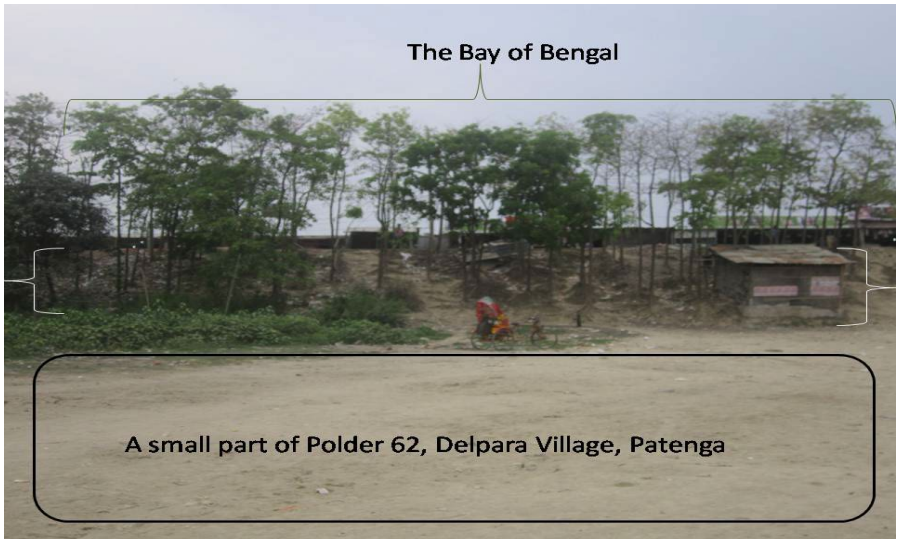
Canal Kumira enters from Sandwip channel to Kumira. Saline water during high tide and monsoon season used to enter this polder and inundate the human dwelling. To prote 61/1, a sluice gate was established 5 years ago. It plays a vital role in the polder man program. This well structured sluice gate allows only draining the runoff of rainfall polder. Saline water from the channel can't pass it and inundate the polder (Figure 5

5.2 Polder No. 62 in Patenga District, Chittagong

Patenga, located in the 22° 15' 14" North and 91°48'21" East, is a sub-district of Ch occupies a small portion of the polder no. 62 in Chittagong city facing the Bay of Be west. It has an embankment along with a protective wall. This embankment is the cc the embankment in polder no. 61/1 in Kumira in north. Polder no. 63 in the South ir sub-district is next to it.

The embankment is 6 meters high and 10-12 feet wide at the crest. It is built of earth The crest of the embankment is used as a road. The road in Patenga beach is constructed of pitch over broken pieces of bricks. Trees are planted on this slope slanted to the polder (Figure 1). However, the slope in other side of the embankment does not have any trees. Instead, it has

shops temporarily made by the local people who earn their livelihood from these. Trees protect erosion of the embankment. It is further protected by a protective wall (Figure 5.3).



(a)

(b)

Figure 5.3 (a) Tree plantation on the embankment of polder no. 62 in Patenga, Chittagong; b. the protective wall made of stones and boulders.

The distance of the protective wall from the embankments is about 100 meters (Figure 5.4). It is 10 feet wide and 3-4 meters high. Large stones and boulders (cubes of $2ft^3$ made of stones and cement) are used to make this wall (Figure 5.2 (b). It helps to push back the mighty waves and currents from the embankment as well as from the polder. Thus, it enhances the duration of the embankment. The Patenga shore was 1 km into the Bay of Bengal 50 years ago. Natural erosion by tidal wave and storm surges during cyclones had caused this land to get lost under the Bay of Bengal. It failed during the 1985 cyclone (wind speed 125 km/h) and the 1991 cyclone (225

km/h) (Hoque, Abdullah and Khan, 1997). Finally, the 'protective wall' was constructed in 1998 to strengthen the embankment as well the polder.

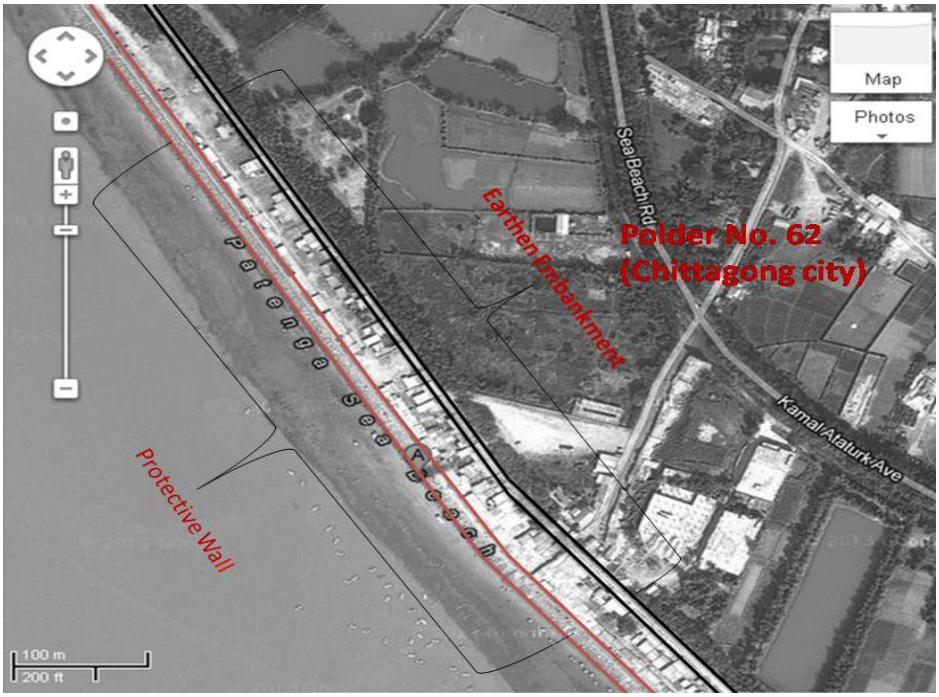


Figure 5.4 Polder no. 62, Chittagong city, Embankment, Protective wall and the Bay of Bengal (source: Google map)

There are agricultural land, human dwellings and fisheries in this part of polder no. 62 in Delpara village. Only one type of rice name IRRI is cultivated here. Vegetables such as tomato, guard and beans are more popular among the farmers. Most of the inhabitants are engaged with small businesses. There are a few shrimp farming projects going on which receive sea-water by suction pipe. However, this project has not yet succeeded since the shrimp farms are not directly in contact with the saline water. Instead fisheries of fresh water are thriving here.

Around 15 thousand people live in this village. Most of them are middle and poor income people. The majority of the dwellers are engaged with small businesses. Hence, many youths who used to be drug addicts or hijacker are now engaged with these business.

Chittagong is called the city of trade and commerce in Bangladesh. Several steel mills, the only one oil refinery of the country, Chittagong EPZ (Export Processing Zone) and Shah Amanat

Airport are the major economic and communication centers of the city. They are the sources of employments of millions of people. Polder no. 62 in being a barrier between the Bay of Bangle and Patenga is protecting all of them.

5.3 Polder no. 72, Sandwip District, Chittagong

Sandwip, an isolated island, is located 20 Km away from the mainland (WARPO, 2002). It is comprised of the sediment deposited by the Meghna Estuary (Bala & Siddique, 2009) (Figure 5.4). Meghna estuary is located at the central part of the coastline of Bangladesh (figure 5.4 (b)). The lower Meghna carries the combined flows of Brhamaputa-Buruganga-Meghna rivers typically ranging 8000 to 120,000 m^3/s (Kabir, Azam, Hye and, n.d) (figure 5.5)

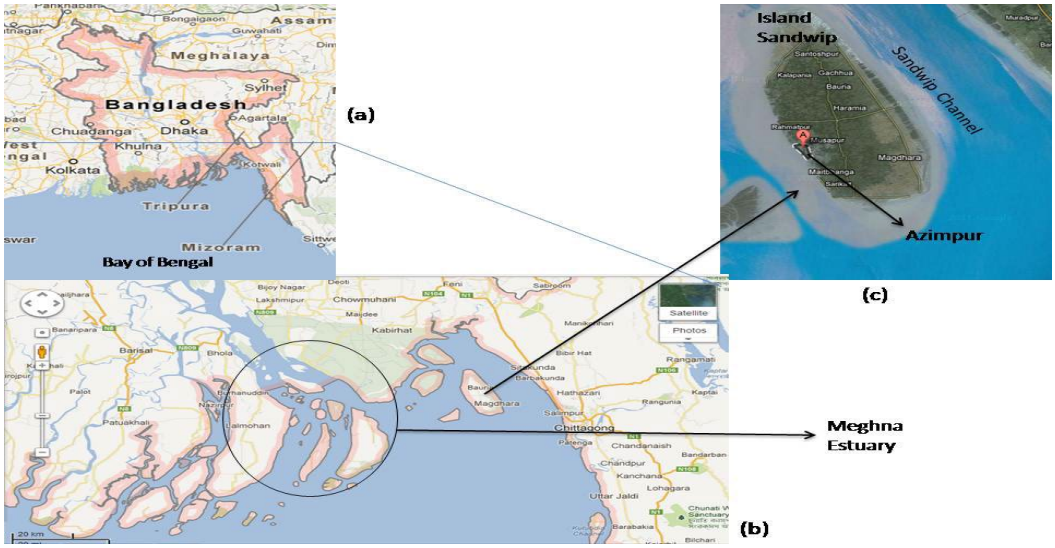


Figure 5.5 (a) Map of Bangladesh, (b) a part of the coastal zone of Bangladesh with Meghna Estuary at the center and Sandwip Island; (c) Map of Island Sandwip with Sandwip channel in its eastern side and the village Azimpur which has been eroded deadly. The embankment in the western side has been washed away by the regular tidal flow and annual flooding leaving the island in great danger. (source: Google map)

Both the monsoon and dry period simultaneously indicates accretion around Sandwip island, especially at the northeast areas (Kabir, Azam, Hye and, n.d). However, it takes approximately fifty years to form a new land around the island. On the other hand, 4 km lands are estimated to be eroded. Azimpur, a union council in the southern coast, has been eroded devastatingly (Figure 5.4 (c)). The local people are not happy with the accretion of land (locally known as 'Char') since it creates conflicts among communities. Besides this, they need to re-promote the human development which was lost due to the erosion which also requires more finance and time. Moreover, the erosion leads the thousands of people to migrate to Dhaka or Chittagong city. The urbanization that occurs in small extent in Sandwip town during the last decades is in great danger as well.

People can only grow melons, mangoes, pineapples, berries, coconuts and various crops now (Hashem, n.d.) as the soil turned to be highly salty by the storm surge caused by 1991 cyclone. Now, people can grow crops along the along the Bay of Bengal.

(a) (b)

Figure 5.6 (a) One of the 28 sluice gates; (b) an coastal embankment in Sandwip Island (Murdoch University, 2000)

The most devastating cyclones hit Sandwip island were in1966, 1985 and in 1991. The storm surge heights during these cyclones were 4.7- 9.1 m, 3-4.6 m and 7-10 m respectively. They drowned hundreds of thousands of people and cattle and, killed and left homeless thousands of

other (Molner, 2005 and Paul, 2006). In order to protect Sandwip from these natural hazards, Bangladesh Water Development Board strengthened the earthen embankment that encircled the entire island. In some places the embankment is 30-40 feet high and the width of the crest is 12 feet. It has 28 sluice gates (figure 5.6). However, the people living in the Western Sandwip have not seen any kind of maintenance or rehabilitation work done for the embankment there for eight years.

Government has planted mangroves at the northeastern side of the island. It functions as a natural barrier to hinder any tidal flow from eroding the earthen embankment away. Thus, the embankment at this side of polder no. 72 in Sandwip is in a satisfactory state.

6 ASSESSMENT

Embankment protecting the low lying polders is considered to be a effective infrastructure not only by Bangladesh Water Development Board (BWDW) but also by the local people. They do not worry more about losing their cattle or crops, the sources of their livelihood, by storm surges. They do not have to move to cyclone shelters during many storm events. Thus, by minimizing the sufferings from coastal flooding, polderization has brought about safety and security in the life of coastal people in Bangladesh.

However, this is not the scenario of all coastal polders in Bangladesh. The polders, for example polder no 62 in Patenga, performs best since it receives regular maintenance and rehabilitation works. Other polders, like polder no. 72 which has not received any maintenance works for eight years, are threats for their inhabitants. Therefore, regular maintenance is a determining factor for the effectiveness of polders.

Salinity intrusion in the polders is a concerning issue since it is degrading the soil qualities. In addition to the low maintenance, conversion of rice fields to shrimp farms in the polders is increasing the salinity of the polders. Besides this, shrimp farms release numerous toxic chemical to the environment which directly affects the rice production (Hossain, Uddin, & Fakhruddin,1991), hence, decreases the net Aus production in the coastal areas since the 1980s (figure 4.3).

Coastal embankments are designed to protect against a 20-year return period flood (Mirza, 2009) but this period is getting smaller due to the global warming. The frequently occurring cyclones with storm surges are becoming more intense. Therefore, for the increased durability of polders, government does not have a sophisticated science and technology in designing and constructing embankment in order to protect polders in the most vulnerable and resourceful zone.

The benefit achieved from the shrimp farms in the poldered area has a significant impact in national economy. It is improving country's financial status through earning the foreign currency which is growing gradually. However, the environmental degradation caused by the shrimp farming should not be neglected. The economic benefit which is received today might excel the damages and losses to the environment of coastal zones of Bangladesh imminently. Regular investigation, research and studies must be conducted to examine the alteration in condition of the soil and biodiversity in the polders, if any. The shrimp farming can not be totally banned. Therefore, sustainable, scientific and environment friendly method of the shrimp cultures should be launched.

To provide minimum protection against a one-meter rise in sea level, Bangladesh will have to upgrade 4,800 km of existing embankments and build 4,000 km new embankments. Such minimum protection against a one-meter rise in sea level will cost Bangladesh over U.S. one billion dollars at 1989 prices. These embankments would protect an area of 16,659 km^2 from a one-meter rise in sea level which means that the cost per km^2 of protected land would be approximately U.S. $50,000 (BWDB). However, Bangladesh lacks such a big fund, hence; a devastating cyclone like Sidr or Aila possibly will damage more.

The existing polders lack proper and on time maintenance. For example, the entire western part of the embankment in Sandwip has been washed away but no rehabilitation works has been done on this for the last 8 years. According to the analysis of past erosion patterns of the Sandwip west coast, it is anticipated that in the coming 25 years, 1000-2000 hector of existing land may be eroded by the sea. Eventually it will affect 5000-12,000 people (BWDB).

More importantly, ICZM programs in Bangladesh lacks a concrete framework, policies directly addressing the problems in coast zones, coordination into different sectors, planning, capacity building, and implementation. A sustainable ICZM depends upon factors like socio-economy, legal, institutional, bio-physical and project design.

Besides planning in ICZM, Bangladesh government must start implementing the plans with its alliance organizations and agencies from national and international boundaries. Examining the strength of the embankment to push back the tidal wave, floods and storm surge annually must be included in ICZM. A broader research on the change in environmental parameters in the polders should be conducted each year and they should be recorded for further analysis.

7 CONCLUSION

According to the local people living in study areas (in the coastal zones of Bangladesh) polderization is inevitable. It has been minimizing the impacts of the cyclonic storms and surges, securing livelihood and guarding the coastal harvesting. However, the fields research conducted within a short period of time which covers visiting only three polders among the total 68 polders cannot completely assess the suitability of the polders. The solitary concern with the polders is lack of proper maintenance. Government can implement the plans and policies of ICZM with the help of communities; thereby, it can successfully perform to initialize maintenance works on polders regularly and during the time of emergencies.

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