Ministry of Water Resources

Bangladesh Water Development Board

Coastal Embankment Improvement Project, Phase-I (CEIP-I)

Long Term Monitoring, Research and Analysis of Bangladesh Coastal Zone (Sustainable Polders Adapted to Coastal Dynamics)

Component 6: Updating of design parameters and specifications for construction works, and management practices of the polders including development of performance monitoring mechanism

6.2+6.3: Polder Management Plan and Performance Monitoring

June 2022

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Long Term Monitoring, Research and Analysis of Bangladesh Coastal Zone
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Memo No: CEIP/LTMRA/0722/192 31 July 2022

Project Management Unit
Coastal Embankment Improvement Project, Phase-I (CEIP-I)
Pani Bhaban, Level-10
72, Green Road, Dhaka-1205

Attn: Mr. Syed Hasan Imam, Project Director

Dear Mr Imam,

Subject: Submission of the Report "D-6.2 & D-6.3: Polder Management Plan and Performance Monitoring"

It is our pleasure to submit herewith five copies of the Report Titled ***"D-6.2 & D-6.3: Polder Management Plan and Performance Monitoring"***.

This report as part of Component 6, provides a review of approaches for management of polders with emphasis on active participation of beneficiaries and local stake holders (Component 6.2) and a development of Performance Monitoring Mechanism (Component 6.3).

The report includes 5 chapters which begins with an introduction Chapter. Chapter 2 describes the present management situation in the polders. Chapter 3 focusses on possible management improvements. Chapter 4 discusses the development of a performance monitoring mechanism, and the last chapter of the report presents the conclusions.

Thanking you,

Yours sincerely,

Dr Ranjit Galappatti
Team Leader

Copies: Engineer Fazlur Rashid, Director General, BWDB
Dr. Zia Uddin Baig, ADG (Planning), BWDB
Dr Kim Wium Olesen, Project Manager, DHI
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ACRONYMS AND ABBREVIATIONS

BDP2100- Bangladesh Delta Plan 2100

BWDB- Bangladesh Water Development Board

CEIP- Coastal Embankment Improvement Project

CEP- Coastal Embankment Project

CERP-Coastal Embankment Rehabilitation Project

FGD- Focus Group Discussion

GBM- Ganges Brahmaputra Meghna

GIS- Geographical Information System

IPCC- Intergovernmental Panel for Climate Change

IPSWAM- Integrated Planning for Sustainable Water Management

IWM- Institute of Water Modelling

KII- Key Informant Interview

LCC- Life Cycle Costs

LGED- Local Government Engineering Department

LGI- local Government Institute

LRP- Land Reclamation Project

MCA- Multi Criteria Analysis

MoWR- Ministry of Water Resources

PPMM- Participatory Polder Management Model

TRM- Tidal River Management

ToR- Terms of Reference

UP- Union Parishad

WARPO- Water Resources Planning Organization

1 Introduction

1.1 Scope of work

The project ‘Long term monitoring, research and analysis of Bangladesh Zone’ focusses on ’research, monitoring, and analyses of Bangladesh coastal zone towards long term sustainable polder development and management with attention to geo-morphological, environmental, economic and ecological aspects’. As part of this project a large amount of data has been collected and specific studies have been carried out at various time and spatial scales on the impact of climate change and human interventions on salt intrusion, morphological changes, bank erosion, and polder drainage. Based on the understanding of the long term and largescale dynamics of the delta and research into sustainable polder concepts a polder management plan was developed, describing future interventions for the polders so that these polders should provide their inhabitants a safe environment to live in and sufficient opportunities for their livelihoods.

Based on these data and model results from the different Components, the Project has prepared an investment plan to improve the resilience of the communities living in Bangladesh’s 139 polders to hydro-meteorological events. In order to do so, measures and strategies have been defined and evaluated in an economic cost-benefit analysis (CBA) in order to assess the economic rationale of the proposed interventions.

The proposed measures are an outcome of the assessment process that has been done in the Polder Development Plan (Deliverable 5A-3) that outlines the type of interventions that are considered for the polders. The current report, which is part of Component 6, provides a review of approaches for management of polders with emphasis on active participation of beneficiaries and local stake holders (Component 6.2) and a Performance Monitoring Mechanism has been developed (Component 6.3).

1.2 Approach and setup of the report

The report begins with an introduction in Chapter 2 into the present management situation in the polders, explaining the concept of polder maintenance and the challenges faced. Chapter 3 focusses on possible management improvements taking into account lessons3learned from the past. Chapter 4 describes the development of a performance monitoring mechanism, giving an overall framework with specific monitoring suggestion for the operational water management and water infrastructure maintenance. The conclusions are presented in the final chapter of the report.

2 Description of present management situation

2.1 Polder maintenance

Polders are human artefacts that need constant maintenance in order to keep fulfilling their purpose, in safeguarding their inhabitants from flooding and proving a safe place to live and possibilities for a sustainable livelihood in the form of agricultural production. If polders are not (properly) maintained, they may lose their functions to protect the land will be reduced. In general, three types of maintenance can be distinguished[1]:

- Preventive or routine maintenance,
- periodic maintenance and
- emergency work.

2.1.1 Preventive or routine maintenance

Routine maintenance is regular upkeep and maintenance of the polder system including all its elements to ensure good functional order. Routine maintenance includes small ongoing repairs and replacements. It is needed to keep the overall polder system including all its elements in good functional order thereby reducing the need of periodic maintenance eventually avoiding high rehabilitation costs. Preventive maintenance is carried out round the year, almost continuously or as and when required. The works include:

- All activities related to vegetative covers on embankment, i.e. new (or re-) planting; enrichment planting; and maintenance of vegetation;
- Small earthworks on the embankment;
- Cleaning, greasing, and painting of structures;
- Cleaning khals and outfall drains from aquatic weeds and floating debris and removing of silt in wet condition.

2.1.2 Periodic maintenance

Periodic Maintenance intends to bring the components of the hydraulic infrastructure back to its design standard. The works are more expensive than preventive maintenance. Periodic maintenance has the character of repair works and is identified during the field assessment at (more or less) regular intervals.

2.1.3 Emergency work

Emergency works cover unforeseen interventions that require immediate actions to protect the polder as a whole or a part thereof from the adverse effects of flooding, associated with damage of lives and properties, or effects hampering one or more economic productions sectors, e.g. uncontrolled saline intrusion, negatively affecting agricultural production. This type of work requiring immediate attention includes the closure of an embankment breach, the repair and replacement of flap gates, or the construction of cross dams over canals if a structure fails.

[1] Adapted from CEIP-1 Vol. X: Sustainability Reports - Part-1: Operation & Maintenance Report (2012).

2.2 Current management problems of polder embankments and related infrastructure

Polder embankments, regulators, khals, roads, bridges, culverts and similar infrastructure all require maintenance as tear and wear tends to degrade them, affecting effective operations. The delta is a harsh environment, with torrential rains, heat, salinity and fast flowing rivers constantly battering these human artefacts. Subsidence of the soil creates additional problems because roads and dikes gradually get lower, off-setting the connection with bridges and regulators and thus weaken the embankment. River erosion is a common feature through which embankments can collapse. Furthermore, soil erosion (for instance through overgrazing of cattle and goats) may create gullies in embankments and weaken them.

In polders that are used as shrimp ponds, local fish farmers dig tubes through the embankment in order to get water in and out of their pond. For instance, in polder 15 it has been reported that there are more than 500 of such tubes in the embankment. These tubes (called Ninety pipe because of their size) can seriously threaten the bank stability and with that increase probability of flooding.

Often embankments are important for transport. However, some of them are not designed with proper roads, their use of which may lead to embankment damage, collapse and slope failure. Embankments are also often used as highwater refuge, a location for semi-permanent or permanent houses, cattle sheds etc. (see Box 1). Although these multifunctional uses support local livelihoods, it does put an extra burden on their primary function, i.e. flood control.

All primary, secondary and tertiary canals and drains need regular clearing of weeds and obstacles to function effectively. Also, gates need regular greasing, annual painting and minor repair, especially in a harsh environment along the coast where saline water easily causes corrosion. When regular maintenance is absent or ineffective, water management for the benefit of agriculture in the polder becomes very difficult.

2.3 Reasons behind maintenance challenges

Embankments need regular maintenance. For instance, repairing loose bricks and blocks of the slope and bank protection, keeping the embankment road in good condition, avoiding disruption of the dike vegetation, filling rodent holes and rain cuts etc. These small, day-to-day (preventive) maintenance tasks are to be distinguished from major repairs after a storm or serious river bank erosion. But in most cases these regular tasks are not executed. One reason is given by Wester & Bron who already in 1988 noted that the poor condition of many embankments is partly because of the multiple use of them (see Box 1): because they are a public good that provides benefits to a wide range of people, nobody feels directly responsible for them.

Box 1: Multiple use of embankments

A field visit to Polder 15 (by Mohammad Nesaruddin, Sociologist of the team, in March 2022) revealed the following uses of the embankment:

(a) **Transportation**: Most of the embankments are used for transportation purposes such as travel and transporting goods by van and motorbike. It has been found that the majority of inhabited areas are situated close to the embankments.

(b) **Built houses** on the slope of the embankment: Inhabitants that have no own land, mainly built houses on the (land side) slope of the embankments. Some of them lost their houses due to river erosion and natural disasters.

(c) **Anchoring boats on the river side slope**: The majority of the households in the polder have boats and nets for fishing in the surrounding river and khals. However, they have no opportunity to enter the khals within the polder by boat. Therefore, they anchor their boat on the river side slope of the embankment.

(d) **Pipe setting** on the embankment for entering/de-entering salt water for shrimp (bagda) cultivation. This is not so much a use of the embankment, but a re-assignment of its function. In places, more than 500 pipe sets are installed through the embankment within the polder area. The people claim that the sluice gates alone are not enough to have sufficient salt water enter into their (shrimp) farm land. Therefore, they set additional pipes in the embankment.

(e) **Hat/bazar on the embankment slope**: The majority of the Hats / Bazars are situated on or close to the embankment (for easy access).

(f) **Boat and Net making/repairing**: The embankments offer enough space for boat and net making / repairing activities. Additionally, the inhabitants claim that it is easy to sail in the river from the embankment.

(g) **Drying fish:** Again, the space on the embankment is used by some people for drying of fish on the slopes.

But there are more reasons why carrying out maintenance is a challenge in many polders. To illustrate this, we will provide some historical background to the polders in Bangladesh and the responsibilities for their maintenance. Consecutively, the role of the Bangladesh Water Development Board is explained. For a deeper insight in the issue, polders have to be regarded as a socio-hydrological system, which can identify key factors determining the willingness or unwillingness of local population to contribute to maintenance. Finally, the issue of power is explained through a real story about Polder 22.

2.3.1 The historical perspective

Three major shifts are identified in the role of participation in polder management: first, from indigenous local systems managed by landlords to centralized government agencies in the 1960s; second, from top-down engineering solutions to small-scale projects and people's participation in the 1970s and 1980s; and third, towards depoliticized community-based water management since the 1990s (Dewan et al., 2015).

From the 1950s to the late 1990s the BWDB constructed polders to protect coastal communities from flooding, established drainage and irrigation systems and employed local gatemen, called *khalashis* for the operation of sluices. This initial construction was seen as an infrastructural investment in the hands of engineers, without any participation from, or consultation with, local communities (Dewan et al., 2015).

The 1970s and 1980s saw a proliferation of social mobilization NGOs that promoted women's empowerment and the strengthening of the rights of the landless. The 1980s saw the emergence of "Embankment Maintenance Groups", later to be renamed as Landless Cooperative Societies (LCS). The LCS concept was based on creating groups of landless labourers and giving them direct contracts to carry out earthworks rather than using commercial contractors. Later, in 1988, this concept was institutionalized by the BWDB as an earthworks and poverty alleviation tool (Datta &

Nishad, 1997). This was also codified in the Guidelines for Participatory Water Management, requiring that at least 25% of all earthworks in a project must be contracted to LCSs (MoWR, 2001).

At the end of the 1990s the Landless Cooperative Societies were renamed into Labour Contracting Societies (as in the National Water Policy of 1999). This new type of LCS focuses on poverty alleviation through providing income-generating activities to the landless, without necessarily including them in either decision-making processes or the operations of water infrastructure. Unlike in the 1980s, there was very little mentioned of the landless or of pro-poor targeting in the 1990s, other than having a 'landless representative' in the WMO. Rather, all the segments of the society – the landed and the landless, the agriculturalists and the non-agriculturalists, the poor and the nonpoor – are lumped together and represented through one single institution, the WMO (Dewan et al., 2015).

2.3.2 The role of BWDB and WMGs

BWDB owns the water-related infrastructure in the polders. In each district BWDB has a special wing called Operation and Maintenance for the polders and an O&M office headed by an executive engineer. However, findings from Naz & Buisson (2015) indicate that BWDB executes repair work only occasionally, when funds are available. These funds are typically only given after some disaster takes place or when minor maintenance becomes major and attracts the attention of higher authorities or donors. An example of what happens after a major disaster is illustrated in Box 2. This shows that the BWDB played a very active role in repairing the embankment and roads after cyclone Sidr. However, regular maintenance work is usually left over to the water management groups.

Apart from the major repairs, which is the job of BWDB, all the other maintenance should be done by the Water Management Groups (WMGs). According to the Guidelines for Participatory Water Management, these WMGs are tasked with: (i) preventive maintenance of the medium and minor hydraulic structures, bridges, culverts, etc.; (ii) preventive maintenance of the main embankment and secondary embankment; (iii) routine/annual maintenance (desilting) of field channels, drains etc.; (iv) clearing weeds, obstacles from secondary and tertiary channels, canals drains etc.; (v) regular greasing of gates; and (vi) annual painting and minor repair of minor gates and replacement of fall board. However, even if these repairs are referred to as minor, they are most of the time beyond the capacity of the WMGs (Naz & Buisson, 2014).

Box 2: notes from the field (Polder 43-2F)(Dewan & Das, 2012)

Polder 43-2F was affected both by Aila (2009) and Sidr (2007). Throughout the coastal zone there seems to be a similar response to major disasters where the local people first try to repair the embankment together through mud using voluntary labour and all working together. There is usually a coordinating, organizing person. Most commonly it is the Union Parishad, and could also be local influential people, mosques or NGOs. In this polder, all the villagers first went into the cyclone shelter until the immediate danger was over. Two days after Sidr the local people (including LCS earth workers) and WMGs repaired the embankment through voluntary labour. The Union Parishad and NGOs provided emergency relief. Roads were blocked by broken and uprooted trees after Sidr. Then local people removed those with the help of BWDB who played an active role in repairing the polder after Sidr. In Kalagachia, it was noted that the BWDB ignores their pleas for regular maintenance works of the embankment (breaking and river erosion) but are very active when the community face major disasters.

2.3.3 Polders as socio-hydrological systems

To be operational, polders need to be maintained periodically to deal with embankment erosions as well as on occurrence of emergency events to repair embankment breaches caused by storm surge. But the lack of proper maintenance is posing a major threat to flood protection and human livelihood in the region. Because deferred or insufficient government support is quite common, a substantial portion of the maintenance work has to be taken up by the local people themselves. This brings with it the collective action challenge of maintaining the polders, a task difficult to achieve in the absence of well-functioning institutions, such as WMO's (Yu et al., 2016).

In order to better understand the relations between polder infrastructure and humans, polders need to be regarded as socio-hydrological systems (SHS): at the heart of socio-hydrology is the notion that human behaviour and social processes are endogenous part of the overall water cycle. That is, as hydrological processes are managed for the benefit of humans, social aspects such as behavioural norms and social memory also change, the effects of which are then fed back to influence hydrological processes.

With their SHS model, Yu et al. (2016) show that the willingness to contribute to the maintenance of the embankments is both a function of flood safety level and outside (of the polder) wage rates. Clearly, the more people may find labour outside of the polder, the number of people willing to contribute to the maintenance is decreasing. But the model also shows that there is an optimum of flood safety within which people contribute to collective action: if the embankments are very low and flooding occurs too regularly, there is too much poverty and society may disintegrate, people will leave the polder. More surprisingly, with high flood safety levels, social memory is lost and people take the embankments for granted and social cohesion is reduced.

Thus, there is a finite range of embankment height over which cooperation can continue and remain resilient in the long run. Outside this range, collective action eventually collapses. The model of Yu et al. suggests a range between 2 and 10 year return period, beyond which the cooperation starts to decline and with zero cooperation corresponding to a one in 100 year return period. Although this model cannot be used as a general outcome for all situations and polders, the take-away message is that by increasing the current safety level of most polders (in the order of one in 10 years) to a one in 25 or 50 years would probably result in a reduced willingness for voluntary participation in embankment maintenance.

2.3.4 The role of power and empowering

In the last decades polder management is steered towards a form of participatory water management in which WMOs are considered to play a key role. Although theoretically this would make sense, as the local people are the beneficiaries and would know best how to manage their own environment, things have often turned out differently. Literature in the past decade shows many examples from the field that the decentralized polder management fails. One of the reasons is that communities are not equal and homogenous. Instead, many conflicts exist over land and water use related to deep inequities embedded in society. Land ownership, landlessness, ‘illegal grabbing’ of government land and canals for own use, are issues and conflicts that are reoccurring in the coastal zones where land is decreasing due to river erosion, salinity and demographic pressures (Dewan, 2012; Naz and M-C Buisson, 2015).

Neglecting the role of conflict in water management could result in a distorted perspective on how polders function and what are the underlying problems and reasons. Take for example the issue of waterlogging and salinity: this is often blamed to unfavourable external environmental factors and ineffective drainage. But then, how can the difference between two adjacent polders be explained: Polder 22 and Polder 23.

When one looks at the Google Earth Engine map of the water occurrence change intensity (1984-1999 to 2000-2020) for coastal Bangladesh there is a large area of green colours, denoting new and already existing permanent water in the southwest (Figure 2-1). This is not surprising, because this area is known for its permanent waterlogged areas. But on a closer look, one can distinguish a very small white spot within the green zone: this is Polder 22 (see the *red circle* in Figure 2-1). This is peculiar. It is next to Polder 23, which has been completely turned into permanent water. Without question the physical conditions of the two polders are almost entirely similar: land elevation, rainfall regime, river regime, salinity etc. Hence the question remains, *why is Polder 22 not waterlogged?*

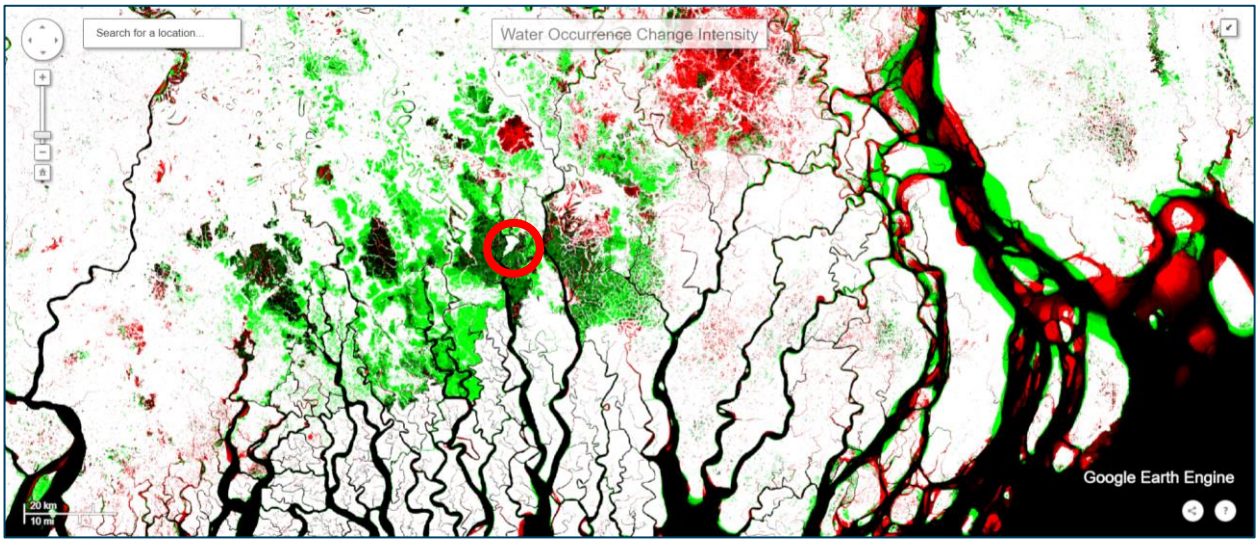

Figure 2-1: Water occurrence change intensity (1984-1999 to 2000-2020). Light green means increase, red means decrease, dark green means no change. http://global-surface-water.appspot.com/map

The reason is simple and yet of great importance to the discussion on polder problems and development in the southwest: Polder 22 is the only polder which has been able to remain a completely shrimp-free zone. Yet, the bloody cost that the people paid to remain shrimp-free is something that cannot be ignored. In 1990, a local landless leader named Karunamoyee Sardar was shot and killed while leading a protest movement against Wajad Ali, a local shrimp boss who was attempting to open the polder to shrimp production. Karunamoyee's death galvanized the landless movement in Polder 22 and there have been only unsuccessful attempts to bring shrimp production inside this polder's embankments[2].

Figure 2-2 Landscape of Polder 23 (left) and 22 (Source: Paprocki and Cons, 2014).

The landscape of the two polders are also in sharp contrast (Figure 2-2). Polder 23 is almost exclusively filled with ghers (shrimp farms) and completely denuded from trees. Salinity of nearby homesteads has risen considerably, killing fruit trees and making the growth of vegetables impossible. People can therefore not rely on their own backyard and have to buy their food on the market. The landscape of polder 22 is green with rice fields surrounded by trees and villages.

[2] https://ejatlas.org/conflict/successful-protests-to-remain-a-shrimp-free-zone-in-polder-22-bangladesh

The absence of shrimp farming in Polder 22 has led to comparatively low levels of landlessness within the polder (30 percent, as opposed to 84 percent in Polder 23). Moreover, it has made Polder 22 a safer place to live in the context of climate change, as its embankments have not been compromised by shrimp aquaculture. The embankments in this polder are not breached at even a single point, and communities in this polder do not suffer from the problems of salinity intrusion to the extent that other polders do (Nath et al., 2019). Instead, in Polder 23 the landscape has been depopulated, forcing former peasants to seek precarious employment in urban areas on a permanent or semi-permanent basis (Paprocki and Cons, 2014).

What happened in Polder 23 is the result of a mixture of forces, of which the salinity issue plays only a minor role. During the second half of the 1980s, major international banks and development agencies began financing projects for promoting commercial shrimp production in Bangladesh. These projects allowed for large scale land grabbing, by any means necessary, in the coastal districts for commercial aquaculture. This transition from agriculture to aquaculture was facilitated by armed representatives and strong political leaders who used sluice gates in the polders designed to drain the polders. Once the land is waterlogged, there wasn't much the local communities could do, unless local anti-shrimp community groups or village committees could regain control of the sluice gates to let the water out (Adnan, 2013).

There is ample evidence that the transformation of polders into bagda ghers (saltwater shrimp) has led to a deteriorated environment, an ecological disaster, increased poverty, decreased food security, increased landlessness and violence and increased livelihood vulnerability (Thornton et al., 2004; Nath et al., 2019; Paprocki and Cons, 2014).

What we can learn from Polder 22 and 23:

- Waterlogging in the SW region is not necessarily a result of bad drainage conditions. It is often the result of a deliberate introduction of shrimp farming.
- It is not high salinity that triggers the development of shrimp farming. It is the other way around: shrimp farming results in high salinity.
- Local communities can ensure good drainage conditions in a polder if their social cohesion is strong.
- Shrimp farming has increased poverty: landlessness in polder 23 is 84% compared to 30% in polder 22.
- Shrimp farming is an ecological nightmare: soils get high salinity, so that no agriculture is possible and homestead fruit trees die off.
- Shrimp farming often weakens embankments as pipes are constructed in them to let water in.

The often dominant role of shrimp owners on the water management in a polder is well documented See for instance Box 3: "What is not in dispute is the overwhelming dominance exercised by gher owners in deciding when the gates are to be open and closed, along with other aspects such as gate maintenance. The vacuum created by the demise of the Khalashi system has been exploited by gher owners who have, either individually or collectively, taken over the effective control of the gates and adjoining canals. They have formed their own committees to operate the gates, and in many instances, have recruited gatemen privately." (De Silva and Das, 2012). See also Thomas, 2020; Adnan, 2013.

Box 3: notes from the field (Polder 3)(De Silva and Das, 2012)

The embankment is in poor condition, as well as the overwhelming influence of informal (and illegal) pipes (approximately 85) used by gher operators to access saline water.

The FGD transcripts suggest that emergency responses are most often coordinated by the UP Chairman and Members who mobilize the local people to conduct emergency repairs. This is usually done through voluntary and immediate responses by the community. Gher owners are also motivated to contribute in the interest of saving their investments, and therefore often contribute money for these works. Farmers, land owners and others work voluntarily if crops/houses are at risk. In essence, during an emergency, people from all walks of life participate.

Maintenance of embankments and roads appears to be minimal, even though both the BWDB and any Water Management Organisations (WMOs) that exist are required to ensure the embankment is maintained. BWDB is considered to be unresponsive. […] The Union Parishads in fact emerge as the only active state institution in the water sector given their responsiveness to both emergencies as well as limited maintenance needs.

What is not in dispute is the overwhelming dominance exercised by gher owners in deciding when the gates are to be open and closed, along with other aspects such as gate maintenance. The vacuum created by the demise of the *Khalashi* system has been exploited by gher owners who have, either individually or collectively, taken over the effective control of the gates and adjoining canals. They have formed their own committees to operate the gates, and in many instances, have recruited gatemen privately.

2.3.5 Conflicting interests and sustainability of WMOs

In general, one can say that opening and closing of the gates is one of the most controversial and debated issues in the polders. The conflicts occurring between shrimp culture and agriculture, small and large farmers, and low and high land farmers are due to issues coordinating water quantity, quality (salinity) or timing. The timing of gate opening and closing is supposed to be decided jointly by all the members of the WMO but more often than not the decision is made by influential people to suit their own needs (Kenia and Buisson, 2015).

The in-depth analysis undertaken by Kenia and Buisson (2015) through quantitative data from extensive fieldwork in 44 villages across the coastal zone showed a lack of participation, which declines over time along with the interest and the legitimacy that community stakeholders accord to these organizations. Both transparency and financial accountability are very poor, indicating that most of these organizations became dormant after project and donor withdrawal. Finally, elite capture is a widespread issue across the study areas, and not only in locations with informal water management.

There are several indications that WMGs still play a minor role in operation and maintenance of water management infrastructure (J.J. Kessler et al. 2017):

- Even if preventive maintenance by WMGs is conducted, periodic major maintenance (responsibility BWDB) will remain necessary. If preventive maintenance is overdue it becomes less effective, leading to the typical cycle of build-neglect-rebuild. In most cases this will gradually lead to the WMGs losing interest or feeling incapable to address the situation and consequently also losing interest in operation.
- WMGs do not have a formal mechanism for water users to pay for water management, for example proportional to the benefits of the area of land being served.
- Most projects have indicated that WMGs can only continue to function well if they are well connected with other organisations, especially local government and BWDB. The role of local government in water management is not well defined. BWDB has established a Water Management Office to facilitate the establishment and continuing guidance of WMO, the staffing and funding of which has so far remained very limited.

The key message of the Blue Gold Grogram (BGP) is that presently, Bangladesh does not use the full potential of participatory water management for engendering local economic development. Infrastructure development and agricultural development are generally undertaken as separate interventions, often under a strong central coordination; while the capability of local stakeholders to utilise water resources and associate infrastructure for a dynamic development of agriculture goes largely ignored.

Water management groups achieve more when working with other people and entities. Therefore, Blue Gold stimulated to i) work with local governments and ii) to enter into specific O&M Agreements between WMA's and the BWDB for each polder.

During the Blue Gold Program, the most widely reported improvement in water management infrastructure was re-excavation and de-silting of khals. A significant percentage of WMGs also reported khal cleaning, sluice repairs, new or repaired culverts, better sluice operation and repaired embankments. Most of these works and tasks were undertaken by BWDB-BGP with WMG support, with the WMGs themselves mainly being responsible for khal cleaning and better sluice operation. Khal re-excavation (including de-silting) was the main type of work reported and was largely done using BGP resources, usually with support from the WMG. Khal cleaning (removal of weeds, cross-dams etc) was mostly done by the WMGs with their own resources (i.e. voluntary labour) and/or by groups of farmers. The same is true for the improved operation of sluices. This is an outcome of BGP's work in establishing and strengthening the WMGs. The construction and repair of culverts was primarily done by Local Government Institutions (i.e. Union Parishads), as culverts usually cross roads which are a government responsibility. WMGs tend to communicate with these LGIs to inform them on the need to construct or repair such works; WMGs subsequently help to implement the works, with -partial- funding of the LGIs. Where BGP funded work on culverts, this was usually channelled via Union Parishads and with WMGs having an active role in identifying the need for such works as well as in the implementation.

Lessons learned from community participation in water management during the Blue Gold Program are:

- Consultation of communities and their representatives is more meaningful if it starts well before the definition of infrastructure investments in implementation budgets.
- Local governments and representatives of decentralised departments are relevant and constructive partners in local water resources planning.
- Facilitated community planning should be complemented with coaching of community actions, e.g. for better agricultural production. A little encouragement helps people undertake the actions that they have planned for.
- Periodic review and adjustment is required to arrive at realistic ambitions, possibly in terms of higher productivity or profitability, and coherent and do-able actions

A crucial question is, however, how to sustain the proper functioning of the WMO's after projects such as IPSWAM and Blue Gold finishes. It has been found that the sustainability and activity of WMOs are strongly dependent on the presence of the project staff. If these were not to be there, the WMOs might collapse (Dewan, 2012).

3 Management improvements

3.1 Lessons learned

Based on the literature review described in the previous chapter, we can list a number of conclusions and lessons learned regarding polder management:

1. Participation in water management has become depoliticized. This denies the inequalities that exist in polder management.
2. Local communities can ensure good drainage conditions in a polder if their social cohesion is strong.
3. Increased flood protection and economic development leads to less social cohesion and therefore less willingness to contribute (either voluntarily or through payments) to polder management.
4. Previous (donor funded) projects such as IPSWAM and Blue Gold showed remarkable improvements in participatory water management, but its sustainability could not be guaranteed after these projects ended.

3.2 A model for embankment maintenance

Participation in embankment maintenance is challenging and will become more and more difficult when safety levels are raised, employment becomes more diversified and the local economy more interwoven with the wider regional or country economic development. Therefore, the current division of responsibilities (such as routine maintenance by WMOs and regular and emergency works by BWDB) may need to be reviewed.

Embankments are the least controversial elements in a polder. All inhabitants have the same safety level provided by the embankment and have more or less the same benefit from it. Therefore, it should be possible to make suitable arrangements for cost sharing and delegating maintenance to a governmental entity. Contributions can be arranged based on land ownership (the more land, the more fee to pay).

As the owner of the embankment, the BWDB should be given *complete responsibility* to its maintenance and repair. The BWDB should enter into Service Level Agreements with the communities through the Union Parishad, who can oversee cost efficiency and timely execution of the work. Maintenance work can be contracted by the BWDB to the LCS, as done before, as a means of poverty alleviation targeting landless people.

3.3 Management of drainage infrastructure

The management of khals, sluices and flushing gates differs from that of embankments in the sense that it is a lot more complicated because of multiple interests of local communities. There are differences in opinion between stakeholders when to open and close the gates (e.g. between rice and shrimp farmers interests) and channels are used for various and sometimes conflicting uses. Therefore, participatory water management is crucial, but also requires a mechanism to make decisions in a democratic way. Several elements are needed for this:

1. **Data and information**: polder water systems are complex because of local gradients, interactions between khal and river, salinity gradients, groundwater – surface water interactions etc. Therefore, it is not always clear how the system reacts when a regulator is opened or closed. Modern techniques of data collection, community based monitoring systems

and models can be helpful to improve local knowledge and make better operation schedules. An example is the suite of mobile applications that are being developed in the WMKIP programme (see Box 4). Also more information on the topography is necessary to help farmers optimize their cropping systems (Yadav et al., 2020).

2. **Strengthening the role of local government institutions:** LGIs should take the lead for coordination and play a central role in organizing the different actors in water management (see next section).

3. **Training and capacity building: I**f the LGIs are to take this new and important role, they will need much support from water management institutions and further training to enhance their capacity in coordinating participatory water management.

Box 4: WMKIP water apps

As a part of the WMKIP project four water apps have been developed to date, including a polder water planner, khal excavator, culvert designer and sluice gate manager. The Sluice Gate manager app provides sluice operators and local decision makers with real time water conditions inside and outside the polder. This information can be used to support optimal timing to operate the sluice gate. The Polder Water Planner supports tactical decision making on effective interventions in polder water management. This app shows which measures at which locations are most effective and beneficial for the community. The information in this app is based on detailed computer model results of the polder water system. Participatory monitoring apps are used to collect information on the functioning of the local water system. It includes a Sluice Operator, to measure when a sluice gate is opened or closed, a Staff Gauge Reader, to collect digital water level readings by making a picture of a staff gauge, and a Water Level Reader, a dashboard showing real time water levels measured with loc-cost and low-maintenance automatic devices.

3.4 Strengthening the role of local government institutions (LGIs)

The role of local government institutions (LGIs) in water management should be formally recognized. The Union Parishad (UP), the lowest-tier rural local government, closest to the rural people and elected by them, has a realistic possibility of playing a vital role in water management. Union Parishad involvement would ensure long term sustainability of the process and balanced adjudication (Naz & Buisson, 2015).

The UP is embedded in the local government institutional structure, with access to rural employment schemes from the Upazila office along with NGO's and the LGED. Donors and the Bangladesh Government should establish a permanent maintenance funding mechanism and allocate it through the Upazila office (Dewan et al. 2014).

The 'Guidelines for Participatory Water Management' recognize the 'advising role' of LGIs. In reality, the line agencies often bypass LGIs, marginalizing their roles. It is proposed that the guidelines elevate the roles of LGIs to take the lead for coordination and play a central role in organizing the different actors in water management for several reasons (Tuong et al., 2014):

- LGIs, as institutions, are in a better position to give long-term perspectives than the project-dependent WMOs, which are registered as cooperatives and supposedly project-independent, yet they are often project-funded and collapse (or at least become dysfunctional) at the end of projects.
- UPs and other LGIs are already involved in conflict resolution.
- Community members have trust in UPs and other LGIs as elected bodies.
- Having a formal and central role in water management coordination would encourage UPs and LGIs to use Social Safety Net Funds for water infrastructure maintenance. Formalizing the role of LGIs in water management would also reduce the conflicts between LGIs and project-based WMOs, thereby encouraging the cooperation among the line agencies, LGIs and WMOs.

4 Development of Performance Monitoring Mechanism

4.1 Framework for the Performance Monitoring Mechanism

Monitoring can be conceived as a process of observing and reporting with specific objectives in mind. Monitoring of maintenance brings out information on progress and quality. Monitoring requires objectives, goals, targets and interventions. Based on these, (performance) indicators are derived to be able to follow the output and outcome of interventions. It is important to distinguish output from outcome. For instance, an output of a project could be that embankments are raised to the desired standard height. However, that does not necessarily lead to increased safety (= outcome). For instance the dike could still break during a storm. Another example is improved drainage as output of a maintenance program. The outcome of such program would be increased agricultural production.

4.2 Monitoring of Operational Water Management

Monitoring of the operational water management can be done using participatory monitoring methods. For instance, the WMKIP introduced methods for monitoring water levels using specially designed mobile apps (see Box 4).

4.3 Monitoring of Water Infrastructure Maintenance

For the monitoring of the water infrastructure periodical reports are made based on field inspection of the canals, embankments and structures. Reports to be prepared on the condition of the canals (weed, obstacles, sedimentation), the condition of the embankments (erosion, subsidence and height, overtopping and unauthorized utilization of the embankments), the condition of the structures (concrete and masonry, earthworks, gates sluices).

Indicators are needed for an effective and efficient monitoring of maintenance. Table 4-1 presents a list of indicators belonging to the condition of water infrastructure in the polder.

Table 4-1 Indicators for maintenance of water infrastructure

Sl. No	Condition of water infrastructure	Indicator	Action
	Embankment		
1	General condition of the embankment surface	Gaps or holes at crest or slope, erosion gullies	Incidental earth works, filling of gaps and holes
2	Embankment vegetation on slope and toe	Dead or trampled vegetation, bare soil	Replanting, fencing against overgrazing, etc.
3	Slope and bank protection	Loose bricks, CC blocks deranged or lost	Repair of slope and bank protection
4	Embankment crest	Gaps and breaches	Emergency repair
5	Embankment road	Damaged road, damaged access ramp	Road repair
	Structures		
6	Functioning of the structure (opening and closing)	Partly or complete blocking of moving parts	Cleaning and greasing of moving and sliding parts and seal; Replace gates, rubber seals of gate, positioning flaps, damaged metal works, lifting devices etc.
7	Condition of the intake and outfall parts	Partly of complete blocking of intake and outfall	Remove silt and debris (water hyacinth, aquatic weeds and others); Repair head walls, wing walls, aprons of major structures etc.
	Channels (khals)		
8	Drainage capacity of khals	Partly of complete dysfunction of khal for drainage	De-silting, removing aquatic weeds, re-excavation of khals; Removing cross dams; Opening up or constructing culverts

5 Conclusions and Recommendations

Based on the previous chapters the following conclusions and recommendations regarding polder management can be given:

1. Current polder management is often challenged by a lack of sufficient maintenance and effective operation. The reasons are manifold, and include: i) unclear roles of stakeholders, ii) insufficient funds, iii) differences in interests and objectives, iv) conflicts between stakeholders and elite capture, v) insufficient data and information, vi) WMO's absent or not functioning properly, vii) insufficient capacity of institutions.

2. Future economic development and improvement of polder infrastructure could lead to less willingness by communities to contribute to polder management. This would require a professionalization and institutionalization of polder management depending less on voluntary contributions.

3. A clearer distinction needs to be made between embankment maintenance and polder water management. The former is a least controversial element in a polder as all inhabitants have the same safety benefit for it. Therefore, it should be possible to make suitable arrangements for cost sharing and delegating the entire maintenance of embankments to a governmental entity. Contributions can be arranged based on land ownership (the more land, the more fee to pay). As the owner of the embankment, the BWDB should be given complete responsibility to its maintenance and repair. The BWDB should enter into Service Level Agreements with the communities through the Union Parishad, in order to give sufficient representation to local stakeholders and mediate between conflicting interests.

4. For the day-to-day operation of sluices and maintenance of khals participatory water management remains crucial. But more attention should be given to make decisions in a democratic and inclusive way. This requires i) better data and information on a real-time basis, ii) strengthening the role of local governmental institutions and iii) training and capacity building of institutions.

5. The role of local governmental institutions (LGIs) in water management should be strengthened. A formal role of the Union Parishad in the water management would ensure long term sustainability and balanced decision-making.

6. For the development of a Performance Monitoring Mechanism a distinction needs to be made between output and outcome indicators. For the monitoring of the operational water management, modern technologies such as mobile apps that provide real-time information on water levels at key locations in the polder is highly recommended.

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