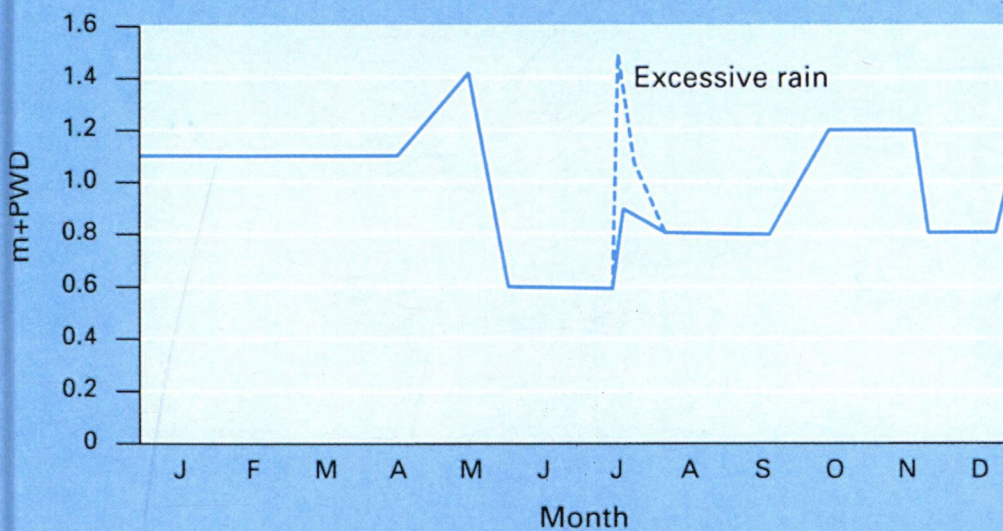


An Integrated Approach for the Improvement of Flood Control and Drainage Schemes in the Coastal Belt of Bangladesh

Preferred water level in polder 43/2A



During the past decades huge investments have been made in flood protection, drainage and irrigation schemes to reclaim and develop many polder areas in Bangladesh. In these areas a careful water management is required to get optimal results from the investments in the physical infrastructure and enable the farmers to have a better living. However, in many instances the actual water management in the Flood Control and Drainage (FCD) schemes has been below expectation, resulting in lower yields than were envisaged during the feasibility, design and construction stages.

In order to formulate suitable water management strategies for this type of areas research has been conducted in a pilot polder 43/2A. In the framework of this research water management strategies and practices have been developed in consultation with the farmers considering the needs of agriculture, fisheries, navigation and environment. As per requirement in the field and considering the results of the hydrodynamic simulations, a new water management strategy has been developed. This strategy is designed to achieve the maintaining of preferred water levels during the year which will give optimal benefits that were not thought of earlier. The strategy has been prepared to match the normal practice of the farmers. This has also resulted in recommendations for land use zoning, linked to topography, soil and water management conditions. Based on the developed criteria and water management strategy a land suitability analysis has been performed for the present and potential conditions in polder 43/2A.



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by

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SUMMARY

General

Bangladesh is a country of limited resources. The present population is 130 million, having an area of 147,570 km². The current population density of 849 people per km² is already the highest of any nation other than the tiny city-states. The country is basically a delta formed by the alluvial deposits of three mighty rivers: the Ganges, the Brahmaputra and the Meghna, it has a complex river network of about 230 rivers occupying about 6% of the area. An important feature of the rivers is that 57 are cross boundary, coming from India and Myanmar. These river systems drain a catchment of about 1.72 million km², out of which only 7% is located in Bangladesh. Rests 93% of the catchment situated outside in China, India, Nepal, Bhutan and Myanmar. Bangladesh has been suffering from the twin problem of 'floods and droughts' for centuries.

Initially the Zamindars constructed low dikes and wooden box sluices and maintained them for protection against saline water intrusion and floods. Unofficially the Zamindars have continued this maintenance job even though they were relieved from that duty when the British ruler abolished the Zamindari system. In absence of Zamindar's initiative, the local farmers often started to make bunds themselves, which were technically poor and insufficient. After taking over the works by the Government more attention was given to the construction of polders. Lack of technical know how and financial constraints hampered the polderisation. Polder construction has increased the scale of production and introduced hopes for further development.

Large-scale land and water development schemes began in the early 1950s. At that time, after several years of studies, a team of United Nations (UN) experts proposed the Ganges-Kobadak Project lying in the greater districts of Kushtia, Jessore and Khulna. After the country had suffered from unprecedented floods in 1954 and 1955, a flood commission was constituted by the Government to look into the problems and to advise on remedial measures. Subsequently, they obtained the services of a UN Technical Assistance Mission in 1956, a team of experts on water resources management, known as the Krug Mission. This Mission submitted the 'Krug Mission report' in 1957 after a detailed review of the gigantic problems associated with the flooding. Based on the recommendations of the Krug Mission, the East Pakistan Water and Power Development Authority (EPWAPDA) was created in 1959 for the unified and co-ordinated development of the water and power resources in the present Bangladesh. This authority, with the help of the International Engineering Company Inc. (IECO), prepared a Master Plan for water resources development in 1964. This plan marked the beginning towards the formulation of an integrated plan for flood control and development of the water resources of the country. In the Master Plan the limited available hydrological data were presented and recommended actions were emphasising on systematic and scientific hydrological data collection and processing.

The Master Plan included a portfolio of 58 land and water development projects including 3 barrages on major rivers for implementation spread over 20 years, beginning in 1965. These projects envisaged flood protection for 5.8 million ha of land. Not all the identified projects were taken up for implementation due to lack of

funds. Irrigation within the flood-protected areas was foreseen, but emphasis was on flood control through a system of dykes and polders as in those days higher flood control through major water control schemes was seen as the key to increase agricultural production. Three alternative options were proposed:

- flood embankments with gravity drainage;
- flood embankments with tidal sluice drainage;
- flood embankments with pump drainage.

The Coastal Embankment Project was conceived and initiated by the then East Pakistan Water and Power Development Authority in the early sixties. Subsequently, it was proposed in 1967 that the Coastal Embankment Project be divided into two phases and that the first be expedited as part of the Grow More Food programme. Thus, the first phase was approved in April 1968. This phase consisted of 92 polders with about 4,022 km of embankments and 780 drainage sluices. The gross polder area to be protected under phase-I was estimated to be slightly more than one million ha. Phase-I was completed in June 1971. Polders under phase-II were classified as deferred in the revised programme and final project evaluation study. Phase-II included three categories of land areas such as:

- relatively non-saline areas;
- off-shore islands which were so far unsuitable due to erosion and sediment deposition;
- partially reclaimed and unreclaimed areas resulting from the construction of the Meghna Cross-Dam.

After the independence of Bangladesh in December 1971, the East Pakistan Water and Power Development Authority was bifurcated into two separate bodies, leading to the creation of the Bangladesh Water Development Board (BWDB) and the Bangladesh Power Development Board (BPDB). This was done with a view to undertake expanded water and power development programmes and speed up the execution of projects.

The emphasis on large scale works for high level flood control was dropped following the World Bank's Land and Water Resources Sector Study of 1972. Instead, the development of minor irrigation through low lift pumps (LLP) and tube wells, to some extent supported by complementary low cost Flood Control and Drainage (FCD) projects, was advocated.

In 1974 Bangladesh experienced a devastating flood. Considering the damage of that flood the Government realized the need for quick implementable FCD projects. FCD schemes are located in the floodplains of the rivers, or they are coastal polders. Embankments along the periphery provide protection against river, or sea floods, or against salt-water intrusion. Where necessary, hydraulic structures are placed in the embankments to drain khals (natural channels which connect the low-lying areas and the rivers). Many inland FCD schemes have field depressions that contain water during most, or all of the year, called beels. They are often connected to rivers through a network of khals or man-made canals and can only be drained when river levels permit. In most FCD schemes there are nowadays three distinct cropping seasons, namely: Kharif-I, Kharif-II and Rabi. From an agricultural perspective the FCD schemes are designed to:

- protect standing Aus against early river floods;

- expand the area under Aman by excluding flood waters from the schemes;
- retain water in the scheme during the post-monsoon period.

By taking into account the various characteristics of FCD schemes - such as the types of infrastructure, the topography, the main water management challenges and the typical conflicts - the water management schemes can be classified in:

- Hoar schemes;
- Chittagong polders;
- Khulna polders;
- Beel schemes;
- Floodplain schemes.

The multitude of water management options in FCD schemes makes water management in these schemes quite complex. Internationally, much has been written on improving water management in irrigation systems. This has resulted in the development of appropriate management models for irrigation systems. For FCD schemes this has not been the case and water management in FCD schemes remains much behind the management of irrigation systems.

During the past decades huge investments have been made in flood protection, drainage and irrigation systems to reclaim and develop many polder areas. In these areas a careful water management is required to get optimal results from the investments in the physical infrastructure and enable the farmers to have a reasonable living. However, in many instances the actual water management in the FCD schemes has been below expectation, resulting in lower yields than were envisaged during the feasibility, design and construction stages.

Past experiences in the water sector development showed the necessity of a good water policy in Bangladesh. After detailed discussions the Government of Bangladesh finalised the National Water Policy in 1999.

Flood protection schemes bring about overall improvements, through the reduction of flood depth to ensure secure environments for living as well as for agriculture. However, they can also bring about drastic changes in the natural water regime, which may result in an imbalance in aquatic environments and ecosystems. For example, structural interventions disrupt the free flowing environment of the floodplains. Moreover, continued congestion or stagnation can prevent natural flushing and lead to the spreading of water-borne diseases that may threaten public health. Total elimination of floodwater can also severely impact groundwater recharge. FCD schemes generally cause negative impacts on capture fisheries which results from reduction of regularly inundated floodplains and beels and the blockage of past fish migration routes into the scheme area. In addition pesticides used in Rice lands may destroy fish species. Many fishermen have lost their livelihood or were diverted to river fisheries, leading to over-fishing in those areas, which are also adversely affected by the change in the fish migration potential. Flood control of FCD schemes has also provided opportunities for culture fisheries.

The land elevation within a polder is not all over the same. That is why conflicts arise on water management. The stakeholders in a polder do not have the same interests. So, conflicts are found in almost all FCD schemes. The operation and maintenance of

the FCD schemes is not upto the mark. A lot of effort is still needed to improve this situation.

Set up of the Study

This study describes the historical background of the development of water management in Bangladesh and the present status of the FCD schemes. The present land use situation and hydrological conditions with respect to the FCD schemes is presented. A review of coastal lowland development in South East Asia is given. A performance analysis of the different FCD schemes and the water sector in Bangladesh has been executed, which has been used as a basis to formulate a suitable approach for the improvement of the FCD schemes in the coastal belt of Bangladesh.

Most of the schemes that were implemented to increase the agricultural production are not performing as was expected. Injudicious planning of roads, canals and other infrastructure blocking the natural drainage ways cause many of the drainage problems, especially in low lying irrigation and drainage schemes. There is considerable scope for preventing and alleviating drainage problems by more integrated planning and water management. Many of the FCD schemes have been built quite a long time ago, consequently there is a need for improvement of the water management practices and to a certain extent modernisation to meet the requirements of integrated water management. The situation and hydrological conditions of the implemented schemes have changed with time. The user's demands are changing due to changed situations. The performance of the schemes is also reducing. The operation and maintenance of the schemes has been neglected substantially by the Government and the users. Involvement of the farmers and their opinion were not taken as an important aspect in project planning. New development possibilities in the water sector are reducing but not yet finished. In future project planning should also take into account the related aspects of water development and try to minimise possible negative environmental consequences.

In light of the above there was an urgent need to develop an appropriate approach for the improvement of the performance of FCD schemes, among others, by involving local people, especially in operation and maintenance, as well as in the preparation of improvement of schemes. It was also necessary to investigate whether these FCD schemes are operated and maintained as designed and improvements in the designs can be made.

Thus, the general objective of the research was to develop an approach for sustainable development and water management of FCD schemes in Bangladesh. Based on this, effective techniques, tools and institutional arrangements were developed to support the implementation of the concept.

Water Management Considerations

Soil conditions and water management practices, based on the relationship between hydrology and topography, mainly determine the agricultural development possibilities in the coastal area. This relationship is referred to as hydro-topography. Hydro-topography can be defined as the field elevation in relation to high or low river water levels at the intake point and in the field. Hydro-topography is expressed by the

irrigation possibilities during the dry season and drainage possibilities during the wet season. During high tides, water can flow into the polders, and during low tides water can be drained to the rivers. The actual hydro-topographical conditions of a polder depend on tidal river water levels, gradually changing field levels and topography. The hydro-topography is not uniform and constant in time and space. For example, it varies with micro-level variations of the topography. However, the hydro-topographical conditions define the range of agricultural and water management practices available to the farmers. The following hydro-topographical categories were defined by Suryadi for the tidal lowlands in Indonesia:

- A: tidal irrigated areas, in both the wet and the dry season;
- B: tidal irrigated areas, only in the wet season;
- C: areas just above (≤ 0.50 m) the average high water level in the wet season;
- D: high areas, water levels independent from tidal influence.

The researcher introduced these hydro-topographical categories based on the prevailing conditions in polder 43/2A.

Water management needs are different for each type of land use and require different interventions. Rice crops call for inundated fields while Rabi crops need certain soil moisture in the land. The canals require such a water level that adequate conditions for irrigation and drainage are created and where applicable proper conditions for fisheries and domestic use of water. The focus of water management in the polder areas must therefore be on water level control and on preventing stagnant water conditions. In coastal lands there are two options that are drainage and flushing to improve adverse water management conditions. In order to achieve this hydraulic structures will have to be operated to store water inside the polder when it is required due to dry conditions, which means that gates will be open during high tide and remain closed during low tide, or to discharge water from the polder when this is required due to wet conditions, which means that gates will be closed during high tide and open during low tide.

The drainage condition plays an important role in defining agricultural and water management practices available to the farmers. The excess wet season rains are normally drained through the hydraulic structures of the FCD schemes. Lowering of the water level by drainage should be realized in such a way that fish culture and environmental issues are also properly taken into account. The drainage criteria of the FCD schemes should be developed on the basis of the inundation depth that may occur during heavy rains in the wet season. A water depth greater than 0.3 m for three days or more is not suitable for any Rice crop. So lowering of the water level by operating the hydraulic structures must depend on achieving the 0.3 m depth within three days.

An effective and sustainable water management scheme requires an institutional framework, which can ensure the democratic representation of the various water users and their interests. The set-up of the framework should be such that it can accommodate various interests of the different users. Efforts should be made to create opportunities for various users to participate in different stages of the scheme cycle. To achieve this a two tier institutional set up was developed. Suggested planning steps developed in this study for the improvement of water management in FCD areas are:

Step 1: Investigation of the stakeholders interest for improvement and willingness to contribute to the improvement and the resulting operation and maintenance;

- Step 2:* Assessment of the existing water management situation;
- Step 3:* Posting of a skilled guidance team in the scheme area;
- Step 4:* Intensive meetings with the stakeholders and interest groups regarding alternative water management options and their related benefits and problems;
- Step 5:* Establishment of a water management association and water management groups of the stakeholders;
- Step 6:* Development of a preliminary operation and maintenance plan. Provisional agreement with the concerned parties on the water management strategy, the required operation and maintenance and the role and contribution of each party;
- Step 7:* Identification of the required repairs and the share of each party in the repair;
- Step 8:* Repair of hydraulic structures (gates) and embankment;
- Step 9:* Start of operation and maintenance as per provisionally agreed water management strategy and based on the agreed roles, responsibilities and shares;
- Step 10:* Operation of the hydraulic structures and maintenance of the system at least for one wet season and one dry season. Discussion on the positive and negative consequences of the operation with the stakeholders and revision of it where agreed to be required;
- Step 11:* Finalization operation and maintenance plan by the water management association and water management groups;
- Step 12:* Transfer of the operation and maintenance responsibility and the ownership of the agreed parts of the system from Agency to the Association.
- Step 13:* Operation and maintenance by the Water Management Association and Water Management Groups.

With the changing requirements of the people flushing for irrigation becomes one of the major demands. The people in this area are still in favour of the flushing condition (gravity flow) they had before the schemes were constructed. But after the reclamation flushing possibilities have been reduced due to less openings (hydraulic structures) compared to the no scheme situation. The flushing option involves improvement of freshwater supply into the area. Flushing through hydraulic structures in the lower areas and low lift pumping, or traditional lifting, or inlet of water for irrigation in the higher areas. Flushing is mainly required in the month of April (pre wet season) for land preparation and transplantation of T. Aus. Hydraulic structure operation needs proper attention during flushing regarding inland fisheries in the area. Fish normally enters into the floodplain in this period and remains until it is grown enough. Flushing is also required in the dry season, subject to the tidal level fluctuation in the main river. If there is a dry spell in the wet season, flushing sometimes is important too. For basin irrigation for Rice small bunds are required in the field to hold water upto a certain depth. But no field bunds are practiced in this region of Bangladesh. Water from rain and irrigation cannot be stored in the field and may cause problems in the low-lying areas of the schemes.

The Pilot Area Polder 43/2A

Polder 43/2A was chosen for the case study of the researcher. The polder is located under Patuakhali sadar thana in Patuakhali district. The gross area is 5,100 ha and the net cultivable area 3,500 ha. The polder is surrounded by the Payra (Bighai) river

West to North and the Gulisa Khali river on East and South. The area consists of 19 administrative wards in three unions namely Bora Bighai, Chota Bighai and Matherbunia. The area lies in moderately flat land with a ground elevation varying from 1.10 to 2.10 m+PWD (Public Works Department datum). The land area surrounding the periphery is relatively high and the middle is relatively low forming a saucer shape.

Before reclamation tidal water entered into the area through the khals. During the wet season, heavy rainfall together with tidal flows created severe flooding and drainage congestion in the area. This flooding and drainage congestion caused recurring damage to the crops, homestead and property resulting in huge losses to the people. To overcome the situation of continuous flooding and drainage congestion, the area was included under the proposal of the Coastal Embankment Project phase II (as 43/2). Due to the huge money requirement and non-interest of the donors the said project did not start in time. Later the polder (43/2) has been sub-divided into seven small polders, 43/2A is one of them. It was completed in 1988. The original objective of the reclamation was to increase food production by protection against floods, preventing of salinity intrusion and improving drainage. The whole area is surrounded by 40 km of peripheral embankment. Six drainage and surface drainage sluices (DS/SDS) at six connecting khals, out of sixteen, have been constructed. The other khals were closed completely by the peripheral embankment and closures.

The people of the area in general admit that their livelihoods have changed significantly since the completion of the polder. The general feeling is that the overall impact of the interventions has been positive. Some negative impacts on the livelihoods of the people are also present.

Both rainfed and irrigated agriculture are practised in the area. Some critical moments for Rice cultivation that were identified by the researcher are:

- for T. Aus (LV/HYV):
 - seedbed preparation and transplantation are not possible if insufficient rainfall occurs in April and May;
 - yields reduce when there is insufficient rainfall during the vegetative growth stage in the months of May and June;
 - sometimes the crops are severely damaged in the matured or ripening stage when there is excessive rainfall in the months of July and August;
- for T. Aman (LV/HYV):
 - it can not be cultivated in time in some years due to drainage congestion caused by excessive rainfall in the months of July and August;
 - it is sometimes damaged in the matured, or flowering stages when there is no, or limited rainfall in the month of October.

After analysing the overall water management situation in Bangladesh and examining the pilot polder 43/2A (model simulation) an approach has been developed to improve the water management in the FCD schemes. In developing this approach the needs of agriculture, fisheries, navigation and environment have been considered in an integrated way.

Modeling and Simulation

The polder area is crisscrossed by a large number of canals, few of them are very big and the rest is smaller in size (length and width). Considering the environmental issues, it was preferred that the canals within the area would remain almost full. While hydraulic gradients in the polder are marginal, for the hydrodynamic network schematization the polder area has been simplified to a reservoir type. The cross-sections of the arbitrary sections were taken from the contourwise area, which was determined with the Geographic Information System IDRISI Area module.

Two situations namely flushing and drainage have been developed for the hydrodynamic simulation. The flushing situation refers to the storing of water inside the polder area, which is used for irrigation. The drainage or flood situation has been investigated to determine the preferred water levels during the wet season and the drainage capacity to remove surplus water from heavy rain. The latter is required to determine the damage under the present cropping pattern and to develop a possible strategy for improvement. For both cases only the existing hydraulic structures and the embankment have been considered in the simulations.

Based on the rainfall depth duration frequency curves for the Patuakhali station the 3-day consecutive rainfall was determined and 1:5 or 1:10 year return period values were chosen for the water balance simulation with the hydrodynamic model DUFLOW to test the existing drainage capacity of the hydraulic structures.

The storing possibilities in the dry season (April-May) completely depend upon the tidal water levels in the river. Data of the station Mirjagonj show that water in the dry season can be stored only during spring tide. Normally two spring tide situations will be available in a month. Based on the collected data a sinusoidal curve was developed as a boundary condition. As per requirement of the farmers and considering the existing problems, the simulation was done month wise to find out the maximum possible water level that can be attained in the dry season, especially in April. During the wet season the simulation was done for the month of August while this is the critical month from the drainage point of view. The highest spring tidal values occur in this month. So results for this month will be more representative than for other months. Also the drainage capacity of the hydraulic structures could be verified.

The simulations show the benefits of gate operation in the present condition. The result also shows the present drainage congestion level inside the polder area if there is no proper gate operation. The results for two probable conditions (1:5 and 1:10 year return period), are on the safe side compared to the normal situation. The maximum dry season (April) water level could be attained after 14 days of operation. For storing there will be a gap of 7 to 8 days in the gate operation due to the available (spring) tidal water levels in the river.

Identification of hydro-topographical categories is the first step in delineating land suitability zones. In order to answer the question what kind of agricultural development would be feasible in different parts of the area, several factors must be taken into account i.e. the salinity intrusion, soil properties, the tidal range, tidal irrigation depth and level and the drainage level. From agricultural point of view the salinity level in this area was found safe for most of the cases. In order to develop an