DGIS/DANIDA GOB

MINISTRY OF WATER RESOURCES

BANGLADESH WATER DEVELOPMENT BOARD

MEGHNA ESTUARY STUDY

DRAFT MASTER PLAN

VOLUME 3 : WATER MANAGEMENT AND DRAINAGE

September 1998

DHV CONSULTANTS BV

in association with

KAMPSAX INTERNATIONAL
DANISH HYDRAULIC INSTITUTE

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SURFACE WATER MODELLING CENTRE
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ABBREVIATIONS

ADC	Assistant District Commissioner
ADP	Annual Development Plan
BRDB	Bangladesh Rural Development Bureau
BWDB	Bangladesh Water Development Board
CDSP	Char Development and Settlement Project
CERP	Coastal Embankment Rehabilitation Project
CMG	Canal Maintenance Group
CPP	Compartmentalisation Pilot Project
CPP-II	Coastal Protection Project, Phase 2
DAE	Department of Agriculture Extension
DC	District Commissioner
DDCC	District Development Co-ordination Committee
DOF	Department of Fisheries
DPHE	Department of Public Health Engineering
dS/m	deci-Siemens per Metre
EC	European Community
EMG	Embankment Maintenance Group
FAP	Flood Action Plan
FCD	Flood Control and Drainage
GPP	Guidelines for People's Participation
HYV	High Yielding Variety
LCS	Landless Contracting Society
LGED	Local Government Engineering Department
LLP	Low Lift Pump
LRP	Land Reclamation Project
MES	Meghna Estuary Study
MHWL	Mean High Water Level
MOWR	Ministry of Water Resources
NBB	Needs Based Budget
NGO	Non-Government Organisation
NMIDP	National Minor Irrigation Development Project
O&M	Operation and Maintenance
PC	Polder Committee
RWMA	Rapid Water Management Appraisal
SPC	Sub-Polder Committee
SRDI	Soil Research and Development Institute
SRP	Systems Rehabilitation Project
STW	Shallow Tubewell
TDCC	Thana Development Co-ordination Committee
TNO	Thana Nirbahi Officer
TR	Technical Report
WM	Water Management
WMC	Water Management Committee
WUA	Water Users Association
WUC	Water Users Committee
WUG	Water Users Group

1. INTRODUCTION

The main purpose of this report is to elaborate water management and drainage issues for th MES master plan and development plan. Secondly, it also provides an outline of water management interventions which have been proposed in the feasibility and pre-feasibility studies, where empoldering is one of the main interventions.

Most but not all interventions as proposed in this document have been incorporated in the feasibility studies. The main reason is the considered implementation period of five years in the case of feasibility studies. This period covers the main investments such as the construction of embankments, sluices and improvement of drains and to some extent the introduction of compartments for safety and water management reasons.

Solving problems related to drainage congestion and improving the control of water levels inside a polder requires the implementation of a number of interventions in a gradual and logical order. These start with a review of the institutional framework required to improve water management in a polder. The feasibility studies describe these first steps towards this situation. However, this document provides a more detailed description of possible physical and non-physical interventions, which need to be considered beyond the implementation period of five years.

The report is based on findings, lessons learnt and data collected by various completed and on-going BWDB water projects relevant for the MES area. The most relevant projects for the water management and drainage study are, Char Development and Settlement Project (CDSP), Southeast Regional Study (FAP 5), the Operation and Maintenance Study (FAP 13), Compartmentalisation Project (CPP), Land Reclamation Project (LRP) and the System Rehabilitation Project (SRP).

A number of field visits, field surveys and inventories of the MES area have been carried out for the collection of additional data. Also the project areas of some of the above mentioned projects have been visited, in particular CDSP, CPP and SRP.

The report describes in chapter 2 the present situation in the MES area related to water management, drainage and salinity paying attention to land formation, submerged, unprotected and protected land and topics such as water and soil salinity, existing polders and present water management practices in the MES area. Chapter 2 concludes with experiences of three relevant water projects, CDSP, CPP and SRP.

Chapter 3 defines the objectives of water management and terms used in this relation such as participatory water management.

Chapter 4 deals with interventions related to water management. First an overview is given of the scope for empoldering, which is considered a main intervention that provides the tools for water management. Secondly it describes the potential of all physical and non-physical interventions; in particular the introduction of compartments in polders and the institutional framework for water management in polders.

2. PRESENT SITUATION

2.1 Land and water in the estuary

2.1.1 Planning zones

Land formation is a slow natural process. Relevant features of new land, from a water management point of view, are land levels, natural drainage and salinity of surrounding water bodies. These features differ from place to place in the Estuary. Three planning zones can be distinguished in the Meghna Estuary. Land in each zone is characterised by typical features. The three zones are presented in Figure 2.1.

Southwest Zone; Zone A

In this area new land emerges in the form of chars, south of Bhola. The formation of new land starts with the development of small chars in a southeastern direction. Then, small chars join large chars and finally join islands like Bhola. New accretions enlarge the chars and the land in an eastern direction, increasing the width of chars. New, but another type of char is emerging in large rivers and channels, such as the Tetulia River and Shahbazpur Channel, gradually reducing the cross section of these large water ways.

A main characteristic of chars and land in the southwest zone is the existence of a dense network of natural rivers and creeks, named khals. These khals form a natural and adequate drainage system of chars. The presence of many fresh water rivers, which are fed from the north, by the Meghna River, ensures a supply of fresh water. This supply of fresh lighter water and the siltation at the outfall of large rivers, reduces the intrusion of saline water from the Bay of Bengal in this zone.

The yearly intrusion and retreat of saline water in this part of the estuary is shown in Figures 2.2 and 2.3. Permanent fresh water is found in the middle and upper part of the Tetulia River. The maximum intrusion of saline water in this river is shown by the salinity contour of 2 dS/m of the month of May. Water with lower salinity levels is considered fresh and can be used for irrigation.

Central Zone; Zone B

The central area is mainly formed by the two islands Hatia and Manpura and a number of small chars between the Hatia channels in the west and Shahbazpur channel in the East. Sedimentation does occur in the Shahbazpur channel and south of the existing chars and islands. The Shahbazpur channel is still a very large open channel.

The area shows a similarity with the southwest zone. As in the southwest zone, due to sedimentation, chars emerge in the channel and south of the existing large chars (Manpura and Hatia). Small chars will join older large chars and form islands in a north-south direction. Chars of this zone have an adequate natural khal system but surrounding waters are most of the year saline, as can be seen in Figures 2.2 and 2.3.

Northeast Zone; Zone C

In the northeast area of the estuary, south of Noakhali, a different type of land formation takes place. Land formation happens in a predominantly southeast direction. A key difference with the southwest zone (zone A) is the absence of rivers conveying fresh Meghna River water from the north to the south. Moreover, strong siltation takes place in khals and channels connected to the Bay of Bengal (e.g. the Noakhali Khal). The absence of north-south rivers and an adequate system of natural khals hamper the drainage of this area, in particular in the area west and south of Noakhali, like the Sudharam Thana.

Figure 2.1: MES main planning zones

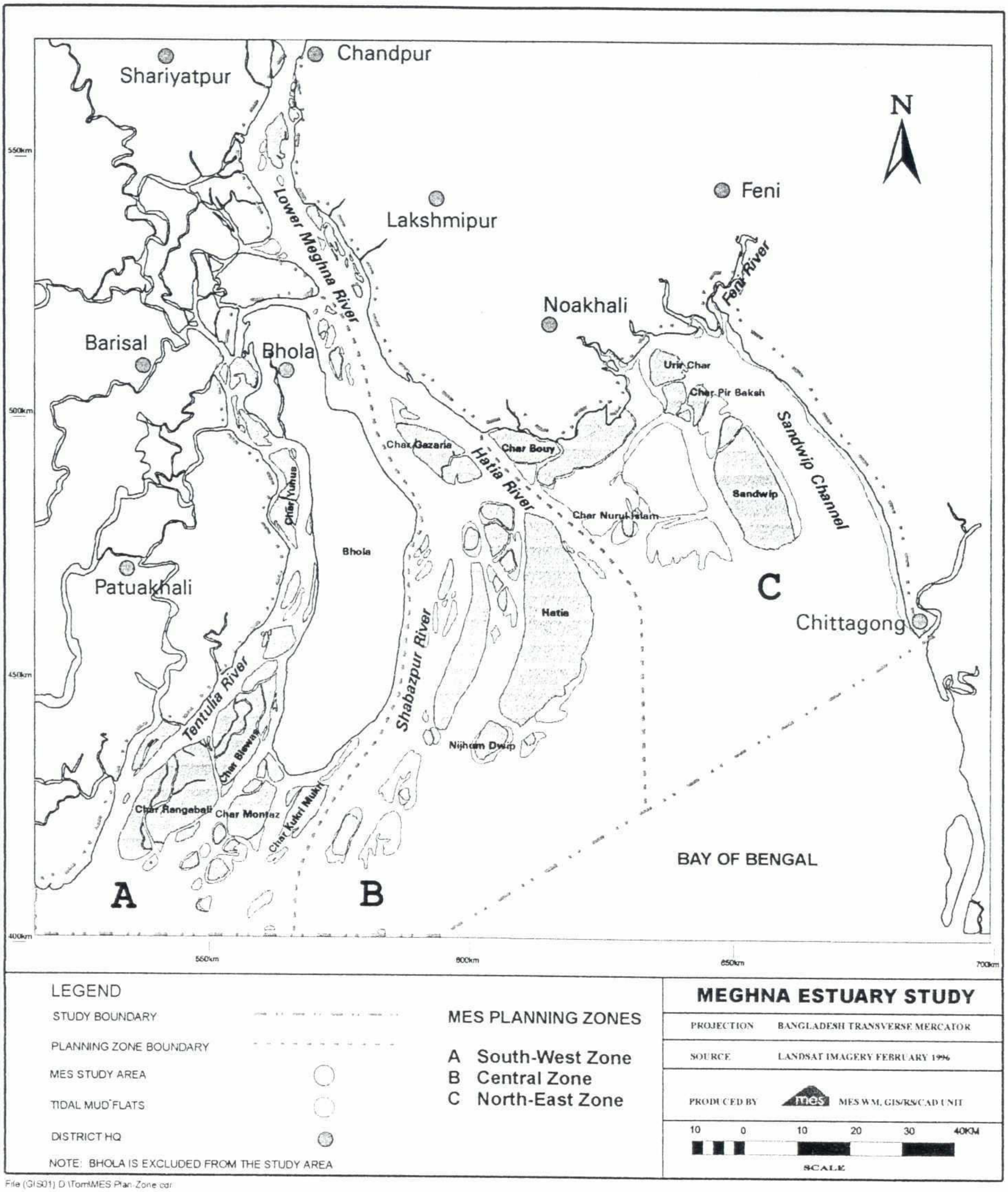

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Figure 2.2: Intrusion of saline water in the estuary

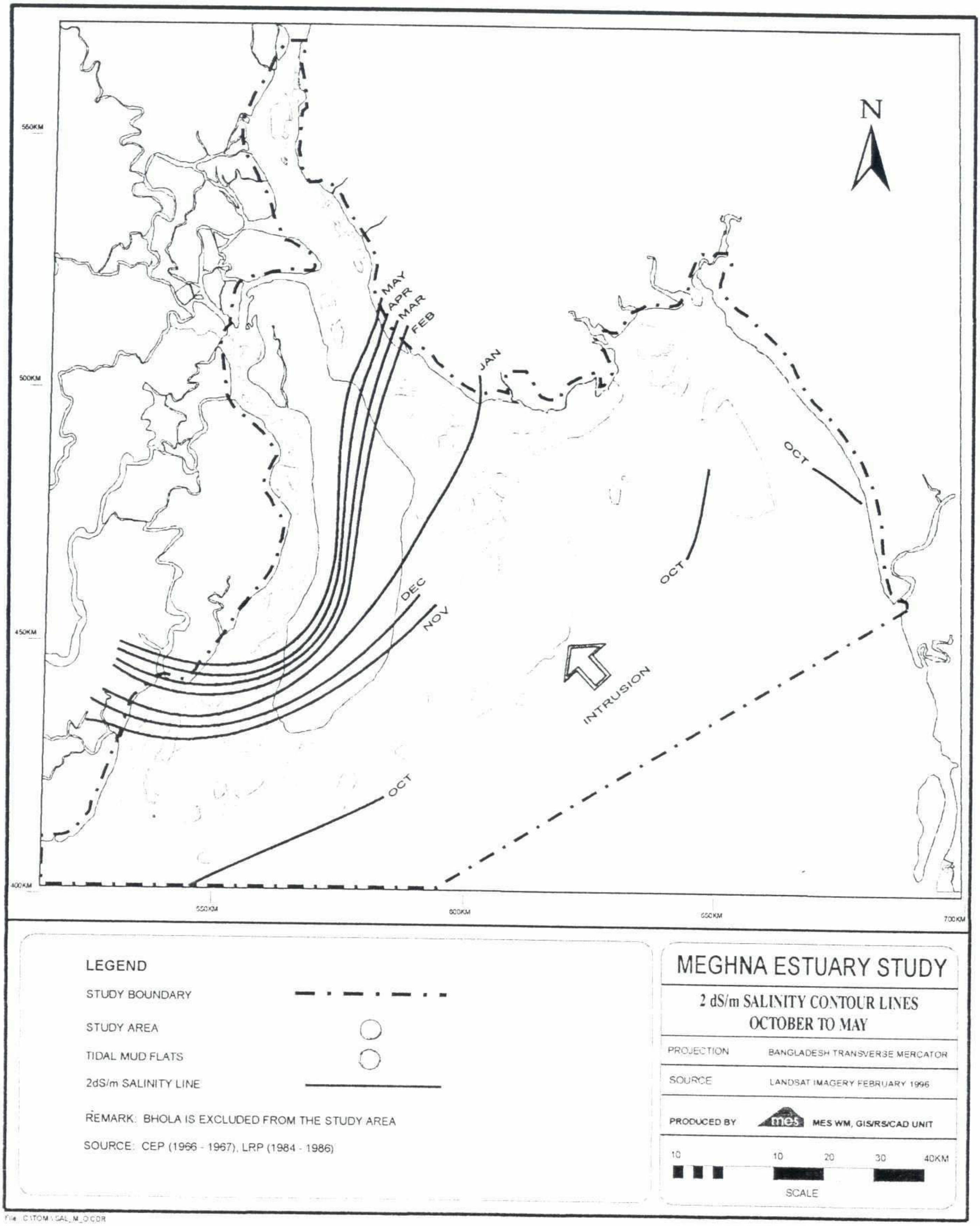

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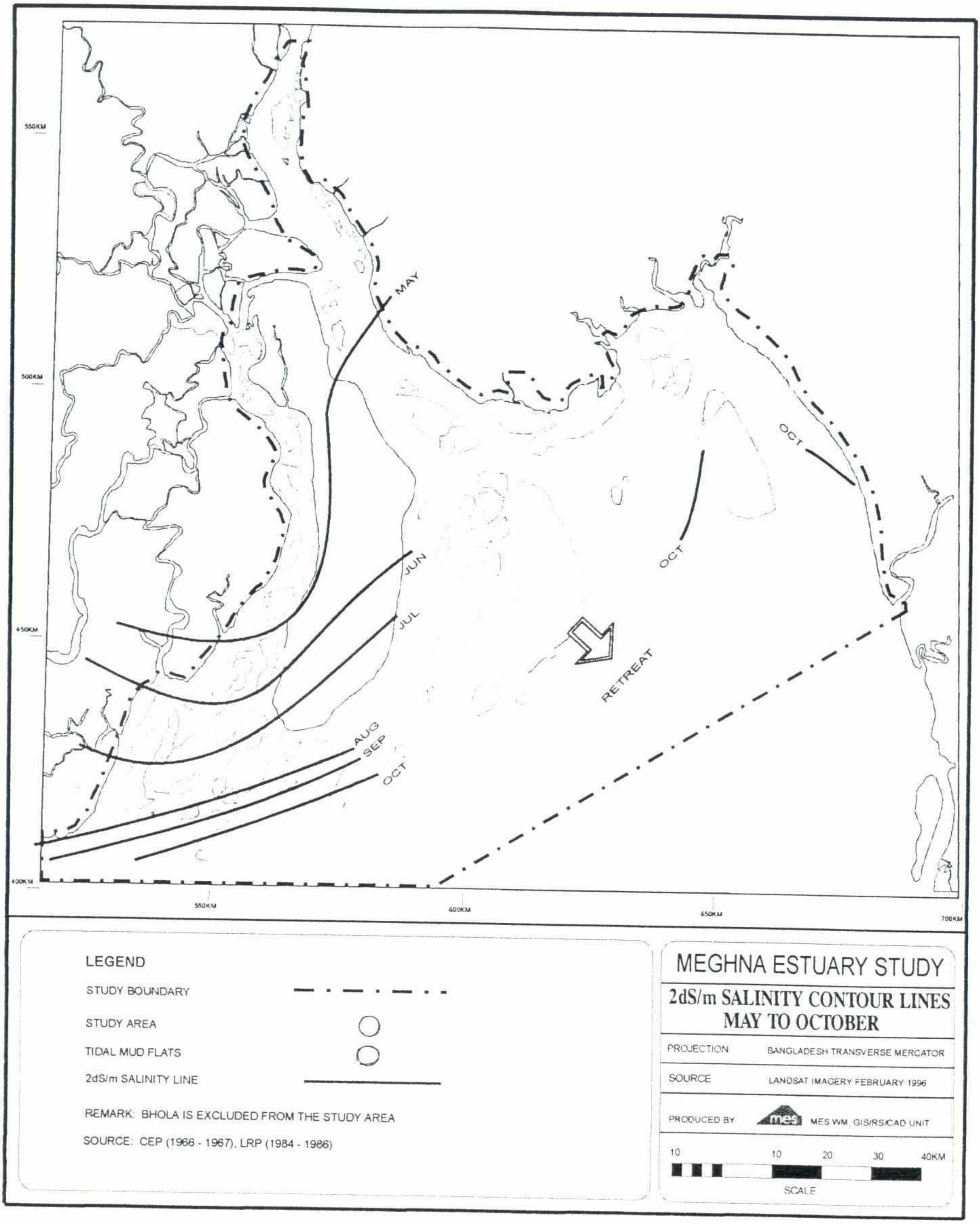
Figure 2.3: Retreat of saline water in the estuary



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Recent satellite images show the formation of new land, like Char Buiyan and large new mud lands in the south of this zone. Polders constructed in this zone are draining directly or indirectly into the Bay of Bengal via khals that run in a southern direction towards the bay. These khals are subject to strong sedimentation. It seems that in the medium term drainage of the northeast zone needs to be secured in a western direction towards the Lower Meghna River and Hatia channel.

Due to a lack of fresh water rivers, saline water surrounds chars, like Urir Char and islands like Sandwip for most of the year. High tidal water levels occur in this area due to a funnelling effect, in particular with storms. Under these conditions saline water may penetrate the exposed main land south of Noakhali.

2.1.2 Submerged land

Submerged land is land with a level below mean water level. It is most of the time inundated and known as mud land. Accretion of new land out of submerged mud land is in most cases a long process when left to nature. An intervention like the construction of a cross dam will accelerate this process and new land may emerge five or more years earlier. The creation of new land is possible in all three zones mentioned above.

A very large potential for new land exists in the northeast zone (Zone C), south of Noakhali and west of Sandwip. Through natural accretion large mud lands have already been formed. It has to be seen if and when these lands will emerge above mean water level and whether cross dams or other methods can be used to stimulate natural accretion.

In the southwest zone (Zone A) and the central zone (Zone B), a large number of relatively small cross dams can be used to link smaller chars to larger chars or islands. As mentioned earlier, linkage of chars to other chars is a natural process in these zones. Physical protection and development of new and old land will be the aim of such interventions. In the case of a medium cross dam, like the proposed Hatia - Nijhum Dwip cross dam in the central zone, a substantial area of new land can be reclaimed and empoldered.

2.1.3 Unprotected land

Unprotected land has a level above the annual mean water level. If unprotected land is adjacent to protected land, the current drainage and water management conditions of the protected land have to be taken into account if empoldering is considered. Examples are land accreted south of Hatia (central zone), Char Jabar and the accretion of Char Clark (northeast zone). Isolated unprotected larger chars, are getting rare but still exist, like Char Kukri Mukri, Char Bara Baishdia and Char Yunus (southwest zone). But even these chars may be linked later on to large islands by the construction of cross dams. Water management and drainage issues are limited to protected land, where water management systems, named polders, have been created.

One of the first forms of vegetation on unprotected char land is Uri grass. This grass develops as soon as the land level raises above mean water level. Other grasses and reeds or mangrove trees will gradually replace Uri grass when accretion continues and the land level increases. Grass, reed and mangrove stimulate accretion of finer soil materials and improve the top layer of the char. Land below mean high water level (MHWL) will be used mainly as grazing land for buffaloes and bullocks, if not covered by forest.

Crop cultivation starts on land above MHWL despite the lack of protection and occasional inundation by saline water. The first farmers may settle, albeit on a seasonal basis. The first crop cultivated during the monsoon is a relatively salt tolerant local rice variety. Yields are fairly low, around 1,000 kg/ha.

2.1.4 Protected land - polders

Land with a level above MHWL may be considered for empoldering. Flood protection is realised by the construction of a primary flood protection embankment. The crest level will prevent flooding up to high water that occurs with a frequency of once in 20 years. Drainage can be ensured by natural gravity and the construction of drainage sluices. In the southwest and central zone (Zone A and B), polders are formed by ring embankments and named "Khulna Polders". In the northeast zone new polders are formed by a long sea facing embankment that protects a new strip of land adjacent to older existing land. Such polders are named "Chittagong Polders"[1].

Empolderment of unprotected land improves the potential for agricultural production by prevention of occasional storm damage to standing crops and gradually lower soil salinity levels. However, slow desalinisation, drainage congestion and failure of embankment and sluices form important reasons why crop production levels of polders have remained below expectations.

2.1.5 Water salinity

Salinity of surrounding open water plays an important role in defining the scope of water management. Salinity levels of surrounding open water bodies vary strongly inside the study area.

A saline flood increases soil salinity and is considered a major constraint for agricultural production in the study area. Serious crop damage occurs when standing crops are flooded by saline water. Moreover, desalinisation gains obtained during the years of flood protection may be partly or totally lost.

A relevant water salinity level is 2 dS/m (deci-Siemens per meter), which is near to 1.0 ppt (part per thousand). Water with this or lower salinity levels is not harmful for most crops and can be used for surface water irrigation or in case of controlled flooding. The use of (fresh) irrigation water will reduce soil salinity. Deep percolation of irrigation water will form a fresh shallow ground water lens and reduces seasonal resalinisation (see chapter 2.1.6).

Surface water forms the main source for irrigation in the MES area. Storage of water in polders is possible, but water quantities are not sufficient for irrigation at a larger scale. Flushing of water in the protected area is required. The salinity level of the surrounding water bodies determines whether this is an option or not.

Four areas may be distinguished in the case of water salinity. The areas are shown in Figure 2.4. Important boundaries are the 2 dS/m salinity contour for May and October, both extremes. In area I, above the 2 dS/m contour of May, the use of surface water for irrigation is a real option and not restricted by water salinity levels.

Area II is characterised by a period of two to three months of saline water in surrounding rivers. If there is a possibility to retain fresh water inside a polder, surface water irrigation is possible in the dry season.

The land in area III is surrounded too long, more than three months, by saline water. No irrigation of any importance is possible in this case. In polders, Aus rice and Rabi crops can be grown without irrigation and improved yields of Aman rice can be ensured if soil salinity is sufficiently reduced. The construction of minor seasonal embankments to protect the land against saline floods in the months of February to June is an option. The water levels of tidal floods in these months are lower than the tidal floods during the monsoon, July to October. However, experiences at Nijhum Dwip and Urir Char show that the damage due to overtopping by spring floods in the post-monsoon is severe and may require complete reconstruction of such an embankment.

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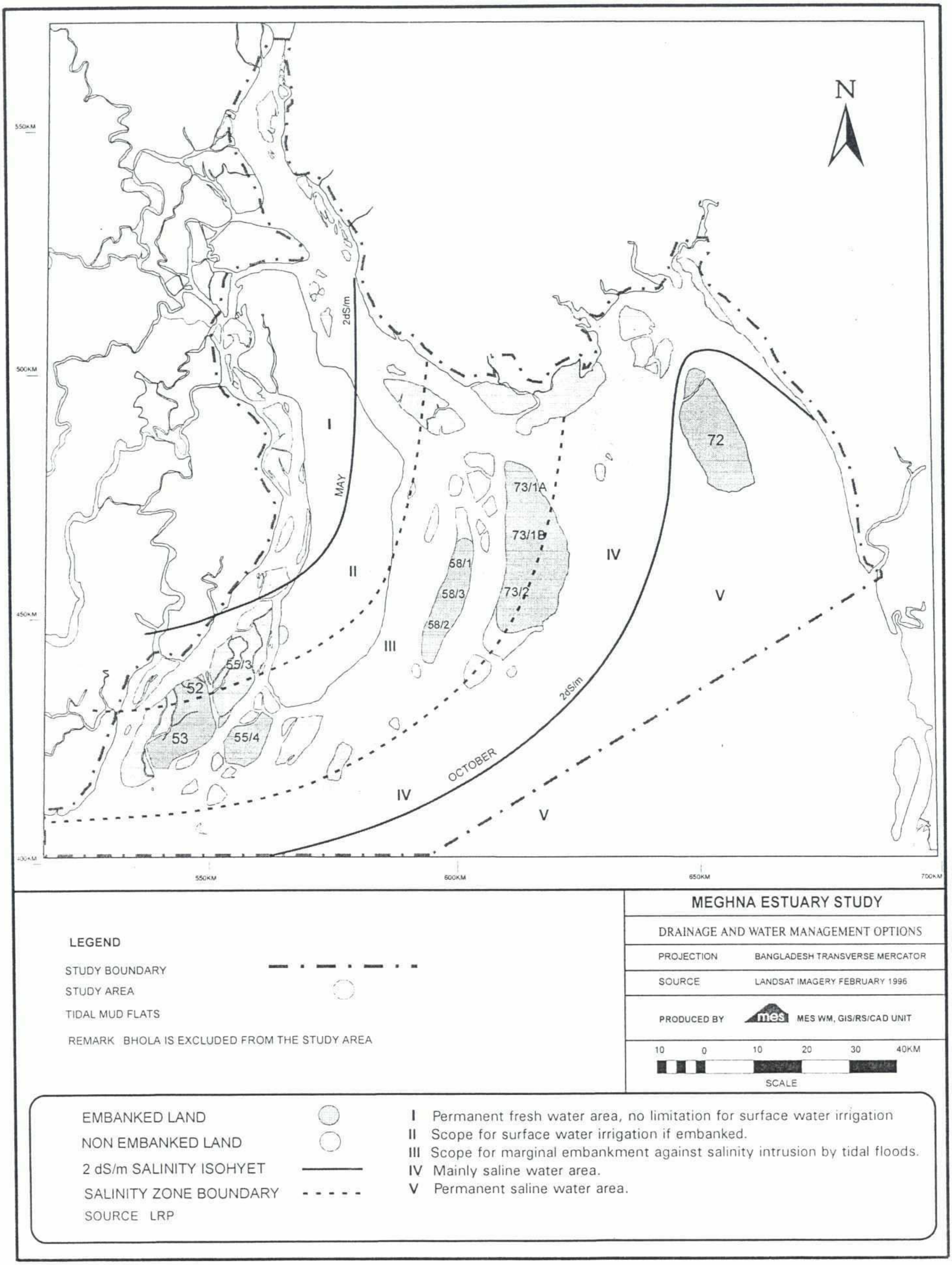
[1] Typical polders defined by SRP, TR50, Feb 96

Figure 2.4: Boundaries of fresh water in the estuary



Area IV is characterised by near to permanent saline water. The water salinity levels are less predictable in this area. Storms and peak discharges of the Meghna River will strongly influence salinity levels in this area. The tidal amplitude is much stronger, in particular in the north east near Urir Char. Full protection with high and large coastal embankments is the only option in this area to prevent intrusion of saline water.

2.1.6 Soil salinity

Source of soil salinity

Soil salinity is an important agricultural constraint in the Meghna Estuary. Throughout the estuary it is possible for farmers to grow one crop a year, an Aman rice crop during the monsoon (Kharif). As will be discussed hereafter, the cultivation of crops after the monsoon (Rabi) or before the monsoon (pre-Kharif), is limited to older higher unprotected land or land protected by an embankment.

Soil salinity levels in the MES area do fluctuate considerably within a year. During the monsoon (July to October) soils of most chars are slightly saline but remain below 5 to 10 dS/m. These lower levels allow the cultivation of local, saline tolerant, but low yielding Aman rice varieties. After the monsoon, from November onwards, soil salinity levels increase and reach a peak in March and April with levels above 15 dS/m. High post and pre-monsoon soil salinity levels prevent farmers from cultivating crops in the Rabi and pre-Kharif seasons.

There are three main reasons for the yearly fluctuation of soil salinity, which is characteristic for the estuary. In the first place an increase of soil salinity due to the intrusion saline floods and secondly by a strong capillary rise of saline groundwater in the dry season. The third reason causes a decrease of soil salinity during the wet season, the abundant monsoon rainfall.

Saline floods

All unprotected chars are yearly flooded by high water springs (tidal high water), in particular by the fortnightly high water springs after full and new moon. The level of high water springs is also influenced by the discharge of the Meghna. The highest high water springs occur during the monsoon when the Meghna has the highest discharge. Therefore unprotected chars in the estuary are occasionally flooded during the monsoon, and depending on their land level also in the pre and post-monsoon period.

The danger of saline floods depends also on the location of the char and the month in which the flood takes place. Figures 2.2 and 2.3 showed that water salinity levels are lower during the monsoon (July-October). These figures also show that pre-monsoon and post-monsoon storms may flood most of the young and lower chars in the estuary with saline water.

Capillary rise

The second reason for the yearly fluctuation of soil salinity is the capillary rise of saline groundwater. LRP found that the topsoil and subsoil of accreted land consist of layers of very fine sandy loam, silty loam and silty clay loam to a depth of more than three metres.[2] These fine textured, deep silty soils are found throughout the estuary and form the land unit named Young Meghna Estuarine Floodplain.[3] These soils possess strong capillary characteristics, capable of bringing saline groundwater to the soil surface from several meters deep. Through evaporation of water at the soil surface, the salts remain at the surface and soil salinity levels in the upper root zone will increase during the dry season. This process starts in November, when evaporation losses exceed the rainfall and ends in June with the first monsoon rains.

[2] LRP, Technical Report 21, 1984
[3] Geography of the Soils of Bangladesh, Hugh Brammer, UPL, 1996

Rainfall

Heavy rainfall occurs during the monsoon. Part of the rainfall will percolate through the saline subsoil and salts are washed down to deeper groundwater layers. This leaching process will reduce soil salinity levels during the monsoon period. As explained before, when pre-monsoon soil salinity levels are not too high, the leaching effect of monsoon rainfall will allow the cultivation of Aman rice during the monsoon on virtually all older and higher chars in the estuary.

Natural desalinisation

Natural desalinisation of the subsoil starts when land levels rise as a result of sedimentation. The pre-monsoon and post-monsoon soil salinity level of low mud land is close to that of sea water, 30 to 40 dS/m. When the land level rises due to sedimentation the time and frequency that the land is flooded by saline water decreases. At the same time the leaching effect of percolating rainfall is starting, resulting in lower soil salinity levels.

In areas with strong accretion, as in the case of cross dams, soil salinity levels of new land, which is above MHWL will drop below 15 dS/m within 10 to 15 years.[4] Mid-monsoon soil salinity levels of 15 dS/m are considered the maximum salinity level for the cultivation of local salt tolerant rice varieties.

Mid-monsoon soil salinity levels of unprotected land will continue to drop but finally stabilise around 5 to 10 dS/m for older unprotected char land. Seasonal increase of soil salinity will occur in the post and pre-monsoon periods. Intrusion of saline floods and a capillary rise of saline groundwater in the dry season are responsible for resalinisation of the soil. This again is followed by desalinisation through percolation of rainfall during the monsoon. In this way, a natural balance will exist between resalinisation and desalinisation.

The construction of a flood protection embankment will disturb this balance of resalinisation and desalinisation. The flood embankment removes the main reason for salinisation, the intrusion of saline floods. Seasonal resalinisation by a capillary rise of saline groundwater will continue, but so will the leaching effect of monsoon rainfall. Further desalinisation will depend on the removal of salts from the subsoil.

2.2 Existing polders in the MES area

2.2.1 Main features of polders

The Coastal Embankment Project started in the sixties with the construction of a large number of polders in the coastal area, including some on chars inside Meghna Estuary Study area. Polders in the MES study are fairly recent, with the exception of the polders on Hatia and Sandwip. The construction of new polders continued till the early nineties. The main objectives of polders are,

- to protect lives, property and crops against storm floods
- to stop the intrusion of saline water.

In Bangladesh, polders are constructed on existing land with a level near or above mean high water level. In the MES area, two typical polders are found. The largest group is formed by polders built on chars and entirely surrounded by open water. The second smaller type of polder is found along the eastern coastline with only one sea facing embankment. SRP recently conducted a study on water systems in Bangladesh and named the first group "Khulna Polders" and the second group "Chittagong Polders".[5]

[4] Feasibility Study on the Sandwip Cross Dam, LRP, 1987
[5] SRP, TR 50, Vol. 1, 1997

Polders along the coast line are found in the northeast zone, from the Feni river southwards to the Karnafuli River, Polders 60, 61/1, 61/2 and 62. These polders have been studied by FAP 5. The MES study focuses on polders located on chars inside the estuary. An example of a Khulna-type polder is polder 55/4, shown in Figure 2.5. This polder is located on Char Montaz, south of Bhola.

These polders are built on older char land and consist of a primary ring embankment in which drainage sluices have been placed. These sluices are linked to the larger natural khals that already existed. A brief description of all polders located in the MES area is presented in Data Volume MES-110: Water Management and Drainage Data.

2.2.2 Potential

Polders create a number of potentials, in particular scope for improved agriculture, through:

- introduction of better yielding Aman rice varieties and to some extent the introduction of modern high yielding Aman varieties

- increase of Rabi crop cultivation, oil crops and vegetables

- introduction of a second rice crop, the rainfed Aus rice crop (pre-monsoon rains)

- on a very limited scale, the introduction of the irrigated Boro rice crop; irrigation takes place by low lift pumps and is only possible when polders are surrounded by permanent or nearly permanent fresh water rivers.

As a result crop intensities of new polder areas have increased from 100 per cent in the case of unprotected land to between 150 per cent and 200 per cent. Not only crop intensities have increased, also yield, in particular of Aman has gone up. Better yielding, and in some cases even high yielding Aman varieties have replaced the low yielding salt-tolerant crops.

Further development is expected after the completion of new rural infrastructure such as administrative centres, roads, markets, water supply, electricity etc. Most of this infrastructure can not be developed without flood protection.

2.2.3 Constraints

Since the construction of the first polders in the sixties a number of constraints have been observed that hamper further growth. Most of these constraints are related to a poor control over water levels (quantity) inside the polder, and to some extent to water salinity (quality).

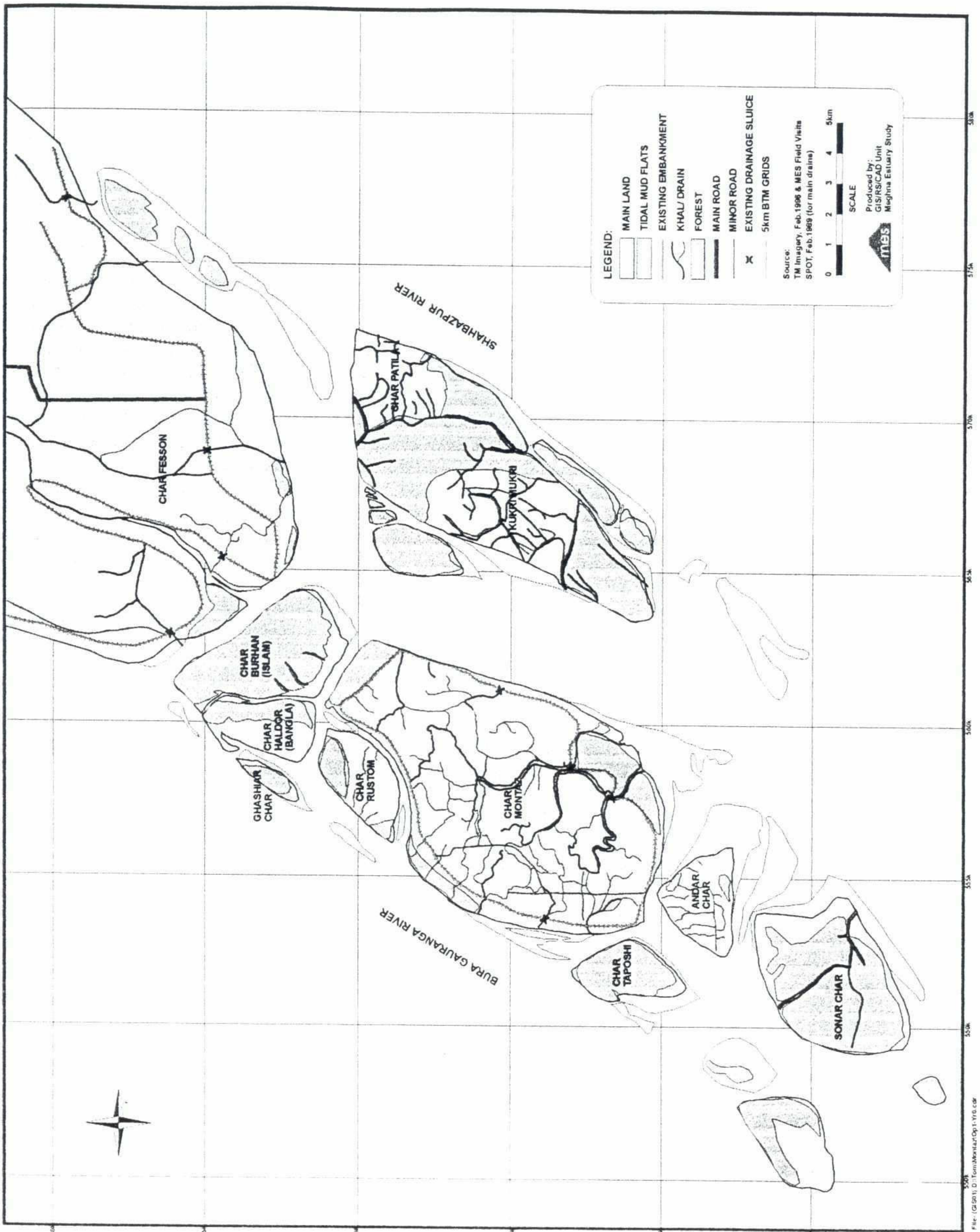
In short the constraints are:

- drainage congestion inside the polder, in particular in July and August flooding the young Aman crop
- low water levels inside the polder during the post-monsoon period, stimulating seepage losses and damaging the standing Aman crop
- intrusion of saline water due to lack of maintenance of embankments and sluices and due to storm damage.

Physical interventions to date

Over the last 30 years several, mainly physical, interventions have been implemented with more or less success by BWDB, LGED, Union Councils and the local population. In a number of cases temporary but recurrent interventions started by the local population has been followed by more permanent solutions of public organisations:

Figure 2.5: Char Montaz with Polder 55/4



- Public cuts in the ring embankment to solve local drainage problems along the embankment.

- Construction by farmers of earthen cross dams in the khals of the polder to retain water levels in the khals and to slow down seepage of water from Aman rice fields (October/November). However, the same cross dams may cause additional drainage congestion in the rainy season.

- Introduction of small surface sluices to drain water from local depressions along the embankment (Also an attempt to reduce the public cuts). Surface sluices are also used to flush in water in May/June to raise water levels in khals and wet the fields for land preparation.

- Introduction of a pulley system to lift flap gates of drainage sluices to flush water (and fish fry) in the khal system of the polder to wet the soil and lower field for land preparation in May and June and to reduce seepage and percolation of water from Aus rice fields.

- Introduction of vertical lift gates for existing drainage sluices to allow water retention inside the polder. The standard flap gates of sluices Vertical lift gates, if well operated, may make most of the cross dams in khals redundant. Raised water levels in the khal system of polders to prevent plots from drying due to seepage of water from plots into the khals. This should also reduce the use of cross dams in the khals.

- The construction of more bridges and culverts. LGED and Union Councils constructed several new roads and footpaths, initially with insufficient bridges and culverts, which resulted in local drainage congestion.

- Although it has only a temporary effect, mitigation of deferred maintenance by (costly) rehabilitation programmes. Components of these programmes are a) Re-sectioning of embankments, b) Repair of existing sluices and c) Re-excavation of drainage khals. Recent examples are the on-going Coastal Embankment Rehabilitation Project (CERP) and Systems Rehabilitation Project (SRP). An example of a recently rehabilitated polder in the MES area is Polder 72/3, South Hatia.

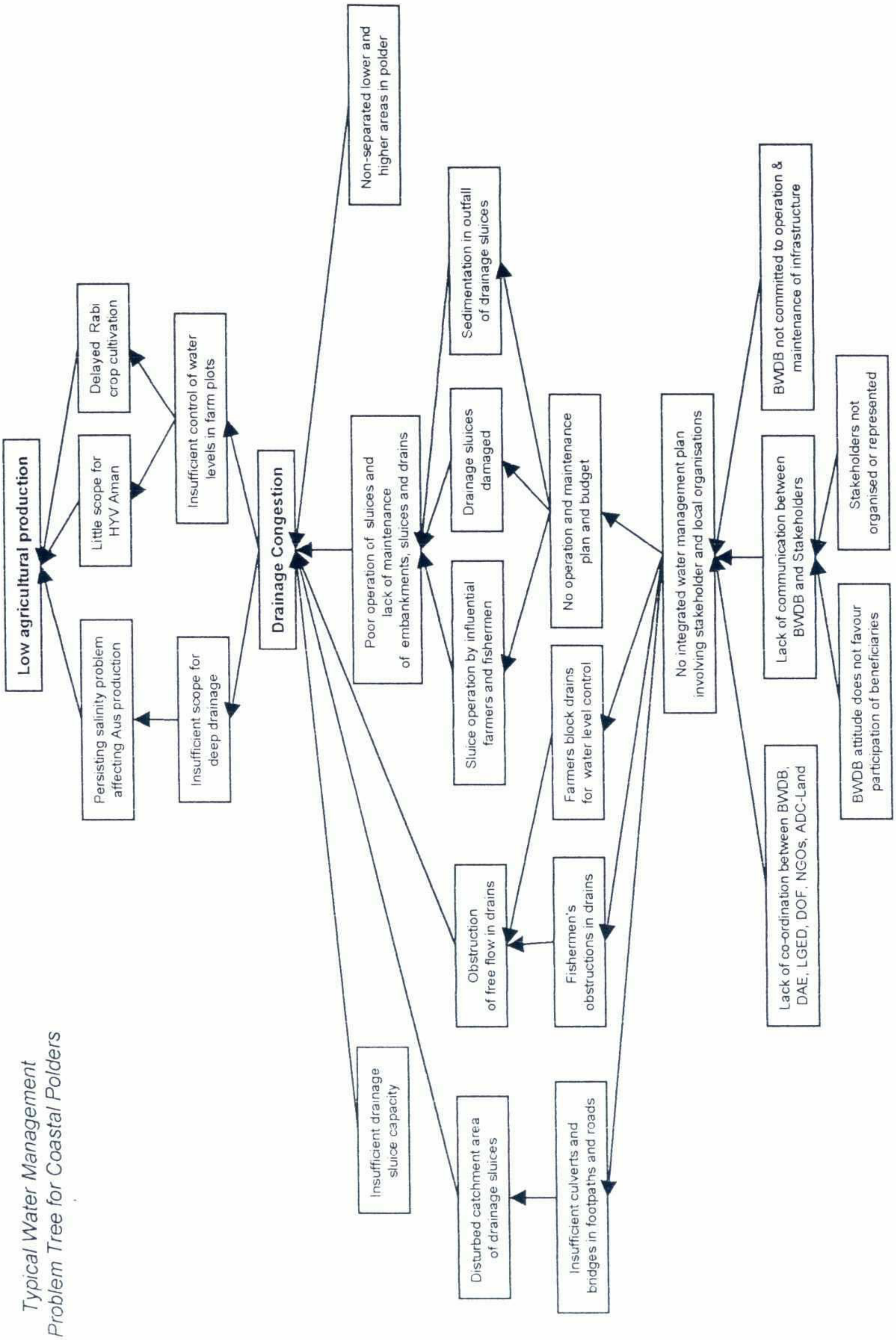
Consensus and conflicts

Not only farmers benefit from the above interventions. Sufficient water in the khals during the dry season is also desired by fishermen and town dwellers and those living on homesteads for domestic purposes (washing, vegetable gardens). However, not all stakeholders agree on the timing of sluice operation. Flushing water in a polder in April can be beneficial for fishermen and shrimp cultivators. However, since most of the surrounding rivers are still saline in that month not all farmers agree with flushing water in the polder in that month. In particular those farmers who own low land that may be inundated with saline water affecting crop production. Hence even among farmers, those with higher and those with lower lands, differences in opinion may exist in when and how long sluice operations should take place and which water levels should be kept in the khals. Similar differences in opinion exist on the operation of embankments (cuts) or cross dams in khals.

Possible causes of drainage congestion

Despite the implementation of a number of the above mention physical interventions, drainage congestion remains a problem in most polders. Figure 2.6 shows the interrelation of various problems related to drainage congestion as it has been observed in polders in and near the MES area. Institutional problems are shown at the base of the problem tree. To remove constraints such as drainage congestion requires institutional as well as physical interventions, as will be dealt with in chapter 4.2 and 4.3.

Figure 2.6 Water management problem tree



2.3 Water management in polders

2.3.1 Local institutions in water management

In the bottom line of causes related to drainage congestion are causes related to institutional aspects. It means that water management will be as good as the co-ordination and co-operation among organisations related to water management, among stakeholders and between organisations and stakeholders.

To improve the institutional aspects, the Ministry of Water Resources issued in 1994 Guidelines for People's Participation (GPP) for all water development projects. Besides a new participatory approach, the GPP introduced for the first time a more comprehensive institutional framework for water management. Figure 2.7 shows the organisational chart for water management as promoted by the GPP. The GPP also elaborate on participation of water users in planning, operation and maintenance and are found in line with improved O&M concepts formulated by BWDB under SRP[6] (see also chapter 3.3.4).

However, the introduction of a participatory approach and improved O&M concepts in water management are only introduced gradually in all BWDB projects. So far, the implementation of GPP or new O&M concepts have not been introduced in polders located in the MES area. This means that no project councils for the co-operation of organisations and water user organisations for O&M have been established yet.

Under the present circumstances, interventions affecting water management in polders tend to be carried out in a less co-ordinated manner. For example, BWDB does not participate in the development of a road network by Union Councils and LGED. Their participation is required to prevent that catchment areas of sluices are being obstructed by insufficient bridges and culverts. Where roads are constructed on embankments, BWDB design criteria, such as a riverside slope and crest level, are not respected by LGED (Polder 55/1). Influential stakeholders continue with the operation of sluices in their own interest. Khals are leased by ADCs in districts to fishermen, without realising that the main function of these khals is drainage.

As far as O&M of the hydraulic infrastructure is concerned, BWDB is responsible. Figure 2.8 shows the O&M Sub-Divisions and O&M Divisions present in the MES area. However, the hydraulic infrastructure BWDB looks after is limited to embankment and sluices built by BWDB.

All infrastructure inside the polder, in particular the drainage system, is not maintained by BWDB[7]. Modifications may be realised by BWDB in a few cases, but most re-excavations are planned and carried out by Union Councils, a good number of them under Food for Work programmes. BWDB is the owner of embankment and sluices, but the ownership of drains (khals) lies with the district administration (ADC-land).

Surveillance of embankments and operation of sluices are in the hands of embankment and sluice khalashi, both employees of BWDB. Sluice khalashi were assisted by sluice committees (mostly farmers), initiated by BWDB. In 1997, most embankment and sluice khalashi have officially been withdrawn by BWDB to reduce staff costs. In practise however, sluices operation had already been taken over by sluice committees or influential individuals with a direct interest in operation. Embankments and sluices are visited occasionally by Sectional Officers of BWDB for inspection.

Being a semi-government organisation, BWDB is not integrated in regular co-ordination meetings such as TDCC and DDCC at thana and district level. Relationships with other organisations related to water management are not encouraged.

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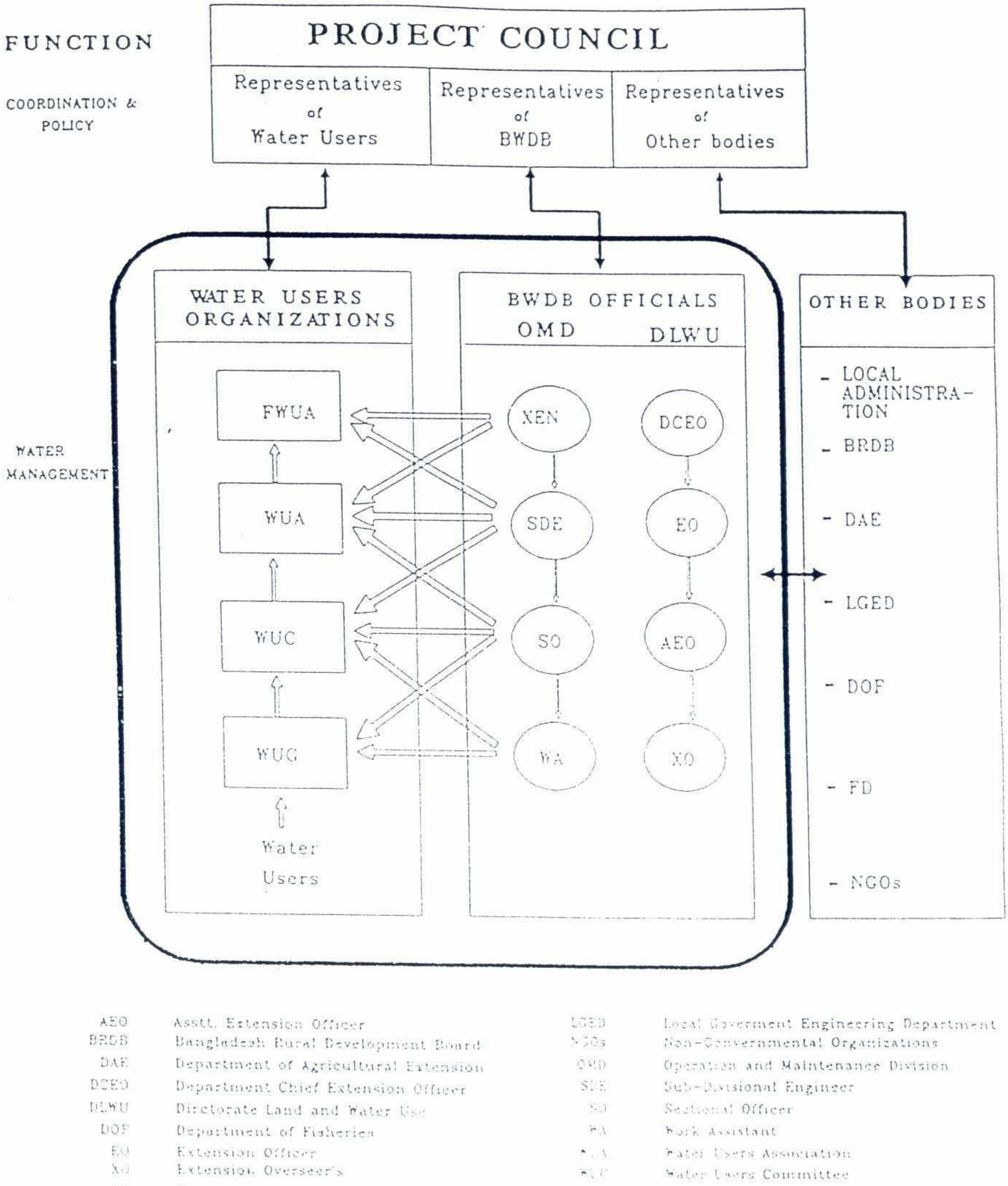
[6] SRP, Final Draft O&M Plan, Vol.1, 1994

[7] MES field visits to polder 55/1, 52/53 A&B, 55/3, 72/3

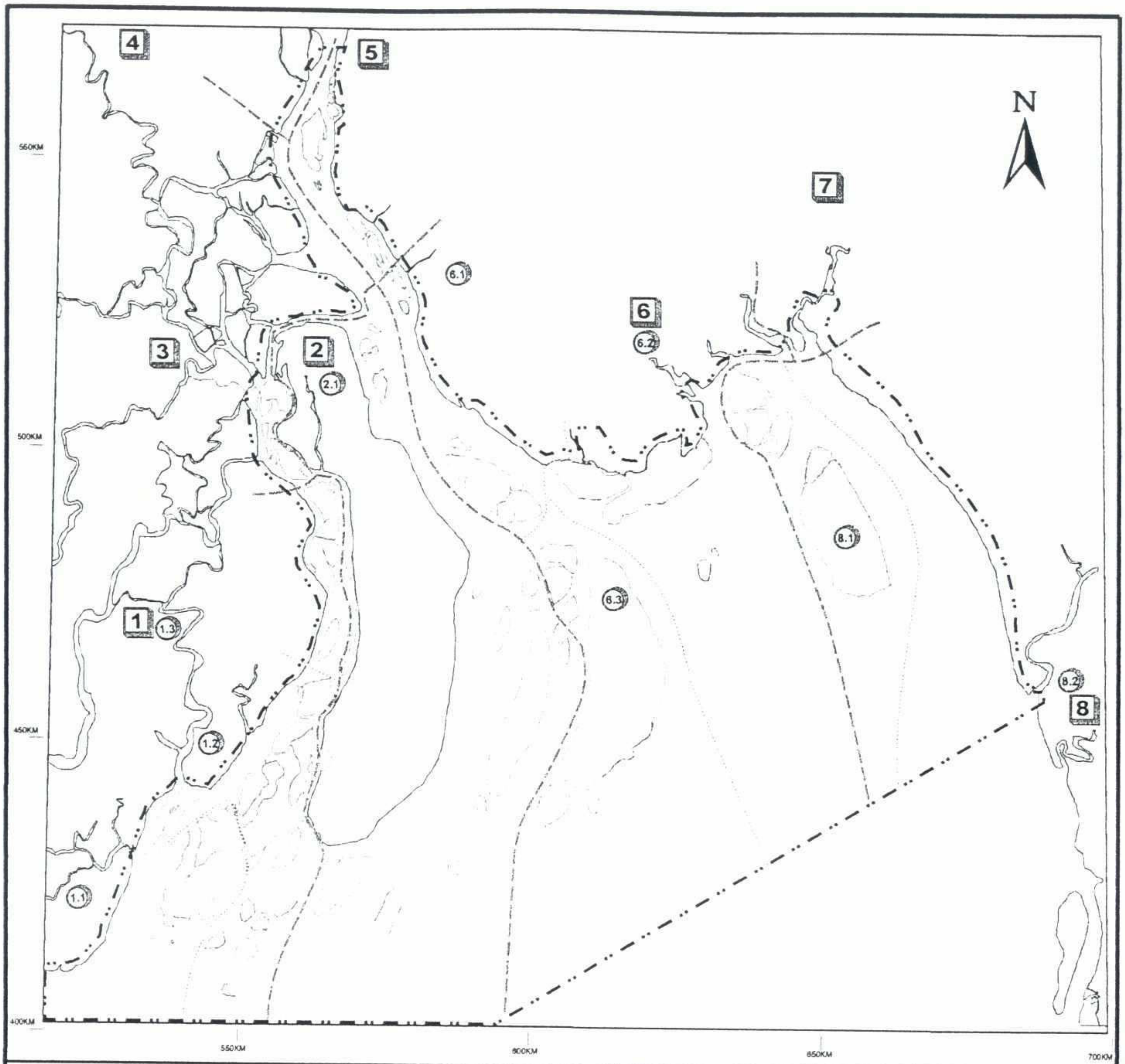
Figure 2.7: Institutional framework for FCDI projects



AEO	Asstt. Extension Officer
BRDB	Bangladesh Rural Development Board
DAE	Department of Agricultural Extension
DCEO	Department Chief Extension Officer
DLWU	Directorate Land and Water Use
DOF	Department of Fisheries
EO	Extension Officer
XO	Extension Overseer's
FD	Forestry Department
FWUA	Federation of Water Users Association
LGED	Local Goverment Engineering Department
NGOs	Non-Governmental Organizations
OMD	Operation and Maintenance Division
SDE	Sub-Divisional Engineer
SO	Sectional Officer
WA	Work Assistant
WUA	Water Users Association
WUC	Water Users Committee
WUG	Water Users Group

Source: Guidelines for People's Participation, Molar, 1994.

Figure 2.8: Jurisdiction of BWDB O&M Divisions



LEGEND

- STUDY BOUNDARY
- STUDY AREA
- SUBMERGED LAND AREA
- O&M DIVISION BOUNDARY
- O&M SUB DIVISION BOUNDARY
- O&M DIVISION HQ — 1
- O&M SUB DIVISION HQ — 1.3

REMARK: BHOLA IS EXCLUDED FROM THE STUDY AREA

MEGHNA ESTUARY STUDY

BWDB O&M JURISDICTION

PROJECTION	BANGLADESH TRANSVERSE MERCATOR
SOURCE	LANDSAT IMAGERY FEBRUARY 1996

PRODUCED BY mes MES WM, GIS/RS/CAD UNIT

SCALE: 10 | 10 | 20 | 30 | 40KM

O&M DIVISIONS:

1	PATUAKHALI
2	BHOLA
3	BARISAL
4	FARIDPUR
5	CHANDPUR
6	NOAKHALI
7	FENI
8	CHITTAGONG

O&M SUB DIVISIONS:

1.1	KHEPUPARA
1.2	GALACHIPA
1.3	PATUAKHALI HQ
2.1	BHOLA HQ
6.1	LAKSHMIPUR
6.2	NOAKHALI HQ
6.3	HATIA
8.1	SANDWIP
8.2	CHITTAGONG HQ

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2.3.2 Experience with the Guidelines for People's Participation

In line with the Guidelines for People's Participation (GPP) of 1994, the project council is the overall co-ordinating body that involves all Government and Non-Government Agencies who carry out activities that affect water management in a polder.

Experience with project councils in other polders and projects[8] reveal some practical constraints in the functioning of these councils. The bottom tier for project council is the thana and in case a polder crosses a thana boundary and covers two or even three thanas, the project council is created at district level. The members of the project council are nearly identical to those of the TDCC or DDCC. The only difference is the presence of BWDB in the function of secretary of the council. Moreover, the project council is an advisory and co-ordinating body, without formal power or budget. Further, few BWDB officer were trained or prepared for their new role. These and other specific factors have contributed to a poor performance of most project councils.

Rapid water management appraisals carried out recently by SRP concluded that the role in water management of the local government, in particular that of the union councils, goes a long way and is greater than thought so far. Another outcome of these appraisals was that the present GPP stresses the interest of farmers at the cost of other stakeholders such as fishermen. SRP finally concluded that the GPP has been developed mainly for irrigation systems of BWDB and does not deal with the greater diversity of the many flood control and drainage systems, such as polders, haors and beels.

Although it is fairly early to conclude, the experiences with water users' organisations so far are mixed. In the case of polders near to the study area, like 55/1, three tiers of water users' organisations have been established. Water User Groups (WUG) at the bottom, Water User Committees (WUC) at a sluice level and one Water User Association at polder level. Water users' organisations are formed by BWDB and depend for their functioning on BWDB. Some active WUGs have been formed in pilot areas of polder 55/1, where khals have been re-excavated and small hydraulic structures have been constructed. However, such activities were not taken up in other parts of the polder, resulting a majority of inactive WUGs. The need for WUGs in polders is not well defined. WUCs and the WUA are active as long as these organisations are really involved in planning and implementation of O&M. This happened to some extent in polder 55/1, where improved O&M concepts have been introduced. Rotation of BWDB staff and lack of training of BWDB staff and water users' in applying improved O&M concepts and a lack of O&M funds hampered the functioning of a new WUA and WUCs.

2.3.3 Operation and maintenance budget

In case of a BWDB project, O&M can be financed by an Annual Development Plan (ADP) if reservation has been made for O&M. Most polders are now completed, some of the older ones have been rehabilitated (e.g. Hatia, Sandwip) and are no longer a project. Funding of O&M has to come from the National Revenue Budget.

One of the constraints of BWDB is the shortage of O&M funds. If polders are considered completed, an ADP is no longer prepared. Hence, only the revenue budget of BWDB can be used for O&M. The revenue budget of BWDB has basically two headings, "establishment" and "works". O&M costs are made under the heading "works". So far too little revenue fund is available for adequate O&M.

Due to insufficient revenue funds no planning of maintenance takes place and only emergency maintenance works are carried out. Even in case of an emergency, it is not unusual that these works are delayed due to shortage of funds.

[8] SRP, TR 50, Water Management in Flood Control and Drainage Systems in Bangladesh, April 1997

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2.3.4 Operation and maintenance of polders

One of the main reasons for shortage of O&M is the absence of proper O&M methods, standards, planning, budgeting and monitoring. The introduction of new O&M concepts developed under SRP may form a first step in the right direction. The concepts emphasise planning, budgeting and monitoring. However, still little is known about cost-effective and adequate O&M methods and O&M standards.

Maintenance

The new O&M concepts recently developed under SRP and adopted by BWDB will gradually be applied in all FCD and irrigation projects. The new O&M concept distinguish preventive, periodical and emergency maintenance. As mentioned before, these concepts have not yet been introduced in polders in the MES area.

Preventive maintenance is a form of on-going maintenance for embankments, sluices and drains in order to safeguard proper functioning. Minor damage and normal wear and tear are repaired. Preventive maintenance can be planned ahead based on maintenance criteria and scheme inventory data. The works are implemented by Embankment Maintenance Groups, EMGs (mainly destitute women), Canal Maintenance Groups, CMGs for drains and by BWDB staff in the case of sluices and other structures. Experience with them is mixed. The local population encourages the use of EMGs. Still little is known about the required intensity and supervision of EMG by BWDB is weak.

Periodic maintenance is based on needs expressed by water users, inspection, surveys and concerns damage that is beyond normal wear and tear. The embankment, sluice or drain will be repaired to its design condition. Where possible Landless Contracting Societies, LCSs (earth works) will be involved in periodic maintenance works, next to regular private contractors. Preventive and periodic maintenance should prevent the need of pre-mature and expensive rehabilitation programmes. Emergency maintenance is carried out in case of unforeseen damage that may occur, for example, during storms. A separate fund should be set aside for such works.

There is a danger that expectations of water users participating in planning of periodic maintenance are too high. Periodic maintenance requires considerable funds. If BWDB-Board cannot convince the government that O&M funds are required, disappointment will quickly end all initiatives and field work concerning maintenance.

Operation

In the case of Polders, operation is related to drainage in the first place, but also to control of water levels of khals inside a polder. As mentioned earlier, sluice khalashi have been withdrawn by BWDB. Since WUC have not yet been formed, operation is in the hands of former sluice committees or, in most cases, in the hands of local influential persons. This leads to uncontrolled operation by only a few stakeholders. Such a situation provokes a number of conflicts among farmers, fishermen and shrimp cultivators (Polder 73/2, 55/3, Baggar Dona Polder CDSP). Sluices are used for drainage, fishing, water retention and flushing water in the polder by various stakeholders with conflicting interests.

Not only sluices are used by the local population, the same happens with embankments and khals. Embankments are used for flood protection and drainage (public cuts), but also as roads, markets, housing, tree plantation and vegetable growing. Khals are used for control over water levels (cross dams), drainage, irrigation (Low lift pumps) and fishing.

The use and operation of sluices, embankments and khals are beyond the control of BWDB or any other agency. It is not the use itself, but the unplanned and unco-ordinated use that contributes to a situation of sub-optimal water management. Where new institutions have been

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formed to improve water management and realise the participation of water users, project councils and water user organisations, they have not yet been able to improve this situation.

2.4 Experience of three BWDB water projects

2.4.1 Compartmentalisation Pilot Project, CPP

The Project

The CPP pilot project is located near Tangail in the flood plain of the Jamuna river. The physiographical and hydrological features are strongly influenced by this large river. The main project area is known as the Tangail pilot compartment, an area of 13,000 hectares, the size of an average polder.

The compartment is protected against flooding by a U-ring embankment. The Tangail compartment is divided into subcompartments, semi-independent hydrological units, separated by subcompartment embankments. Each subcompartment is again divided in one or, mostly, more chawks. A chawk is a recognisable unit where boundaries are formed by village roads, settlement area etc. Chawks are not necessarily hydrological units. However, water levels in a chawk can and will be influenced by the operation of minor inlets and outlets, such as small regulators and culverts and small cross dams.

The Tangail compartment has a natural drainage system formed by a main channel, the Lohajang river, with branches linked to a number of subcompartment drainage sluices. Some of the subcompartments of the Tangail compartment are not really independent hydrological units. A number of subcompartment outlets drain into an adjacent subcompartment instead of a river branch (drain), which makes operation far from simple.

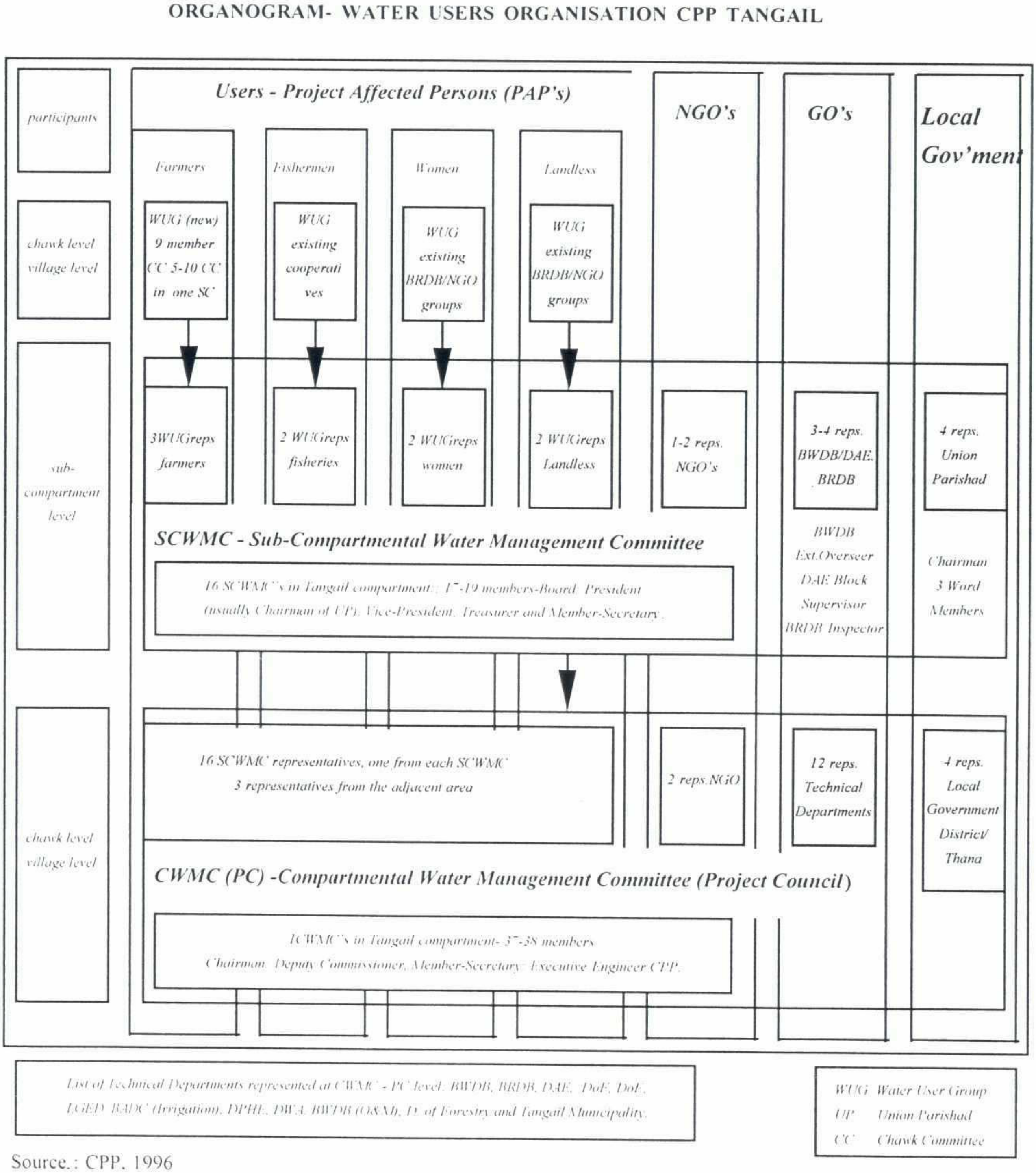
Controlled flooding

The main objective of CPP is to achieve a situation of controlled flooding and drainage for the compartment and subcompartment areas. The main source of flooding is the Jamuna river and a second source is the monsoon rainfall. When high river floods threaten the Tangail compartment, the U-ring embankment should prevent harmful river flooding in one out of 20 years.

The runoff of excess rainfall forms a threat as well, in particular during high river water levels when drainage of the compartment is difficult if not impossible. In such a situation, drainage of excess rainfall by higher upstream subcompartments would accumulate into the lower downstream subcompartments and will cause deep and damaging floods of these areas. In that case it is important that higher subcompartments restrain from draining excess water. Hence, controlled flooding in the case of the Tangail compartment means flood protection and the creation of storage of excess rainfall in each subcompartment combined with a well planned and co-ordinated method of sluice operation.

Controlled flooding requires a disciplined operation of regulators and good communication. It also requires adequate insight and understanding of decision makers at subcompartment level (water management committee leaders) about possible effects of operation of each of the sluice regulators. Even more important is the willingness to co-operate in the interest of the entire compartment. This is not any easy task to realise from a technical as well as a social point of view. The aim is to achieve a situation of desired controlled flooding of subcompartments at least once in five years.

Figure 2.9: CPP project institutional framework



Source.: CPP, 1996

Water management institutions

An interesting aspect of CPP is the set-up of a physical water management infrastructure and a tailored institutional frame work for water management, which starts at the lower chawk-level (a tenfold of hectares) and ends at compartment level. Three tiers of water management organisations have been established for the Tangail compartment, as shown in Figure 2.9.

At the bottom tier, the chawk, separate WUGs are formed by farmers, fishermen, women and landless. Hence, all stakeholders are organised and not only farmers. Where stakeholders were already organised, these organisations have been as much as possible incorporated, in stead of establishing new ones.

The second tier, the subcompartment, is covered by a Water Management Committee (WMC). The WMC, consist of representatives of WUGs (Stakeholders) and Local Politicians such as the UP Chairman, BWDB as well as other Government Agencies (DAE, BRDB etc.) and NGO representatives. If the GPP were followed in this case, only a Water User Committee would have been formed at this level, mainly consisting of farmers. Given the need for co-ordinated and integrated decision making following from the controlled flooding concept, the composition of the WMC seems to be the right choice.

The third and top level is formed by a project council, at compartment level consisting of representatives from the Administration (DC), Local Government, BWDB and other representatives from the WMCs. The project council is directly involved in decision making for sluice operation.

It is still too early to conclude the workability of such an approach, but the demand of operation at subcompartment level clearly requires such an institutional set-up. Remarkable also is the greater involvement of the Local Government compared to the frame work proposed by the GPP of MOWR.

2.4.2 Char Development and Settlement Project

CDSP carries out an integrated development programme for five polders. Two of these polders, Baggar Dona I (1,600 ha) and II (1,800 ha) were completed earlier under LRP. In the Bagar Donna polders maintenance and improvement works, such as the excavation of khals have been carried out. Two new polders, Batir Tek (1,500 ha) and Majid (1,300 ha) near completion, and a new polder on the Muhuri Accretion near the Feni closure has been planned.

Institutional framework for water management

In the Baggar Dona polders of CDSP, a polder committee (PC) and sub-polder committee (SPC) exist for planning and implementation of integrated development programmes. These programmes actively involve a number of government agencies, like LGED, BWDB, DPHE, DAE, DOF etc. The emphasis is on construction of polders, rural infrastructure and the settlement of landless. Water management receives little attention at this stage.

Where polders have been completed, like the two Baggar Dona polders, sluice committees have been established since 1995 but their status and authority is not very clear. Operation was still done by BWDB sluice khalashi but it is not clear who was directing these khalashis. During a field visit in December 1997, it was found that the PCs are very active in various development issues but hardly active in water management affairs.

One of the main constraints is that the PC and SPC are not functional water management organisations organised along hydrological boundaries. Their jurisdiction follow administrative boundaries instead and complicates decision-making concerning water management issues. Under present conditions, undesired public cuts of protection embankments and cross dams in main drains proved to be difficult to solve by the PCs and SPC. No project council exists, as proposed in the GPP, but water management issues are discussed in the TDCC.

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CDSP recognises the short comings in the operation and maintenance of the hydraulic infrastructure and is presently preparing new institutional guidelines for water management in CDSP polders, in line with the Guidelines for People's Participation of MOWR. This may lead to a review of the role of the present PCs and SPC or the introduction of dedicated water management organisations in line with SRP concepts.

Drainage study

More of interest is the drainage study[9] carried out by CDSP in the two completed polders Bagar Dona I and II. The objective of this study is to increase the insight in the relations between water management, salinity, drainage, agriculture and fisheries. Monitoring is done of sluice operations, drainage and salinity at field level, water salinity and water levels inside the polder, agricultural production and the catch of fish in khals.

At the stage of writing of this report it was too early for final conclusions, but the information collected so far indicates[10] that:

- It is questionable whether a deep drainage flow exists. Even if it exists, it is a very small flow, and ineffective in removing the salt from the sub-soil due to prevailing soil characteristics.
- Operation of drainage sluices is limited to the monsoon period. Vertical lift gates of drainage sluices remained closed from mid-November until end of March.
- Soil salinity differs considerably from plot to plot and even within plots. No correlation has been found that explains this pattern and differences seems to be related mainly to local soil conditions rather than cultivation practises or location of the plot inside a polder. This conclusion is in line with findings of LRP.
- Excavation of khals, if not required to improve surface drainage, has no clear benefits. The amount of storage is very limited. The same is true in case of irrigation. When water is required for irrigation (February/March), salinity levels of water surrounding the polder is too high for flushing water in the khals. The opinion of farmers and other stakeholders about desired water levels throughout the year was not yet sufficiently known.

CDPS's conclusion about the deep drainage flow seems to be contrary to the final conclusion of LRP, where it was said that the deep drainage flow is the major agent in the (slow) desalinisation of the soil. The findings about sluice operation are in line with was has been observed in the MES area. The main purpose of excavation of khals is to improve drainage of excess surface water. In saline areas like the area of CDSP (northeast zone) flushing water in a polder has little advantages.

2.4.3 Systems Rehabilitation Project

The Systems Rehabilitation Project (SRP) started in 1990 and the main objective was to rehabilitate about 80 FCD and irrigation systems, to improve O&M of rehabilitated systems and to involve water users in rehabilitation and O&M of the systems. Institutional development and participatory concepts gained gradually in emphasise when it became clear that rehabilitation only made sense in combination with a sustainable form of O&M. Such O&M required the participation of the local communities. The main results of SRP are, apart of the rehabilitation of 35 sub-projects, the formulation and testing of improved O&M concepts and the development of a first approach toward participation in water projects.

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[9] CDSP, Status Report on Drainage Study, TR 6, April 1997
[10] CDSP, Mission Report 30. Land and Water Engineering-V, October 1997

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The O&M concepts are described in two key O&M reports[11] and have been referred to in the various chapters of this report. Field experience in implementation of these concepts are limited and not impressive. One of the lesson learnt was the necessity to develop cost effective O&M arrangements and to continue to support improvements of O&M capabilities in BWDB.

The SRP O&M concepts stand not on their own, but are strongly linked with the participatory approach in O&M. However, the first attempt to develop such an approach was not very successful and did not clearly describe the role of water users' organisations and BWDB field staff in planning, budgeting, implementation and monitoring O&M.

Also the GPP, derived from the participatory approach developed under SRP, has been more successful in raising the awareness of the need for a participatory water management approach within the BWDB, in stead of providing a workable concept that could be made operational in the field.[12]

The main lessons learnt from SRP in relation to water management are:

- water management is a matter that requires the formal involvement of other organisations besides BWDB and the distribution of rights and responsibilities need to be spelled out in a water management policy and legal framework

- within the organisations involved in water management, it is important to lay responsibilities for water resources management at the lowest appropriate level (this opens up possibilities for co-ordination at field level); the strengthening of existing local institutions is preferred over the establishment of new organisations

- the (historic) role of the local government needs to be strengthened in the future and should play a mediating role in local institutions to achieve agreed water management practises despite conflicting interests between stakeholders and at the same time, local government should ensure that the interests of all stakeholders are represented.

3. OBJECTIVES IN WATER MANAGEMENT

The overall objective of water management in polders is to ensure a sustainable development and management of a polder.

Human interventions for water control

Water management in a polder can be seen as the total of human interventions to control water levels (quantity) and water salinity (quality) in drains, fields and ponds through flood protection, flushing, draining and retention of water using all available hydraulic infrastructure such as embankments, sluices, khals, cross dams, bunds, regulators, culverts etc.

These human interventions are the result of social and institutional interactions, organised and non-organised of stakeholders and organisations with different interests, methods, resources and strategies regarding water control inside a polder.

Participatory water management

Participatory water management is a form of water management, in which stakeholders are organised, actively involved and have a final say in all water management interventions. Participatory water management is based on agreed objectives for water quantity and quality control, a transparent process for planning, budgeting, implementation, monitoring and decision-making and is carried out through organised interventions.

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[11] SRP, TR 33, Improved O&M in Water Projects, October 1994, and O&M Plan, Vol. 1 and 2, June 1994
[12] SRP, Final Evaluation Study of the Systems Rehabilitation Project, November 1997

4. SCOPE FOR INTERVENTIONS

4.1 Scope for empoldering

4.1.1 Planning zones

The creation of polders is possible in all three planning zones. The potentials and constraints of polders differs from zone to zone, but mainly due to a different potential for irrigation with surface water and the need to improve the natural drainage system in case of empoldering.

In all planning zones, groundwater is no option for irrigation. Fresh groundwater is found at around 25 to 30 metres deep. This water is presently used for the supply of fresh drinking water. Not much is known about the quantities and yearly replenishment. However, the depth alone excludes its use for irrigation seen the high costs for development and operation of deep tubewells.

Prevention of resalinisation by maintaining embankments and sluices, and perhaps, improve the physical protection by the creation of compartments requires equal attention in all three planning zones.

Southwest zone, Zone A

As mentioned earlier, accreted chars and islands in this area have a dense network of khals. Sedimentation of these khals occurs but at a slower rate compared to the northeast zone. These khals form a natural and adequate drainage system when polders are created in this zone. Minor modifications of khals will be required due to the obstruction of drainage caused by flood protection embankments and to link most depressions of the polder to drainage sluices.

The supply of fresh water by rivers from the north and siltation at the outfall of these rivers in the south reduces and even stops intrusion of saline water from the Bay of Bengal as shown in Figure 2.2. Permanent fresh water is found in the middle and upper part of the Tetulia River. The maximum intrusion of saline water in this river is shown in Figure 2.4 by the salinity contour of 2 dS/m. Lower salinity levels are considered fresh and can be used for irrigation.

The availability of fresh water in the dry season creates a scope for surface water irrigation using low lift pumps (LLPs). Figure 4.1 show the present distribution of LLPs per thana. Irrigation with LLPs will accelerate the desalinisation process. Fresh irrigation water will percolate into the soil and wash the salts down to deeper layers. LLPs are successfully used to irrigate a Boro rice crop on the main land west of Bhola, although in the last 15 years the number of LLP has not much increased[13], as shown in Figure 4.2. Constraints in promoting surface irrigation in the southwest zone are:

- *Drying khals*, which require re-excavation. Average water levels of the open water bodies surrounding polders are lower due to less discharge of the Meghna. Excavation of khals may provide a solution. In some cases lifting by large pump stations is required to fill the smaller khals with water in the dry season (Barisal Irrigation Project).

[13] BBS, Upazilla Statistics (1979-1983) and DAE, National Minor Irrigation Census, 1996

Figure 4.1: Number of LLP per thana (1996)

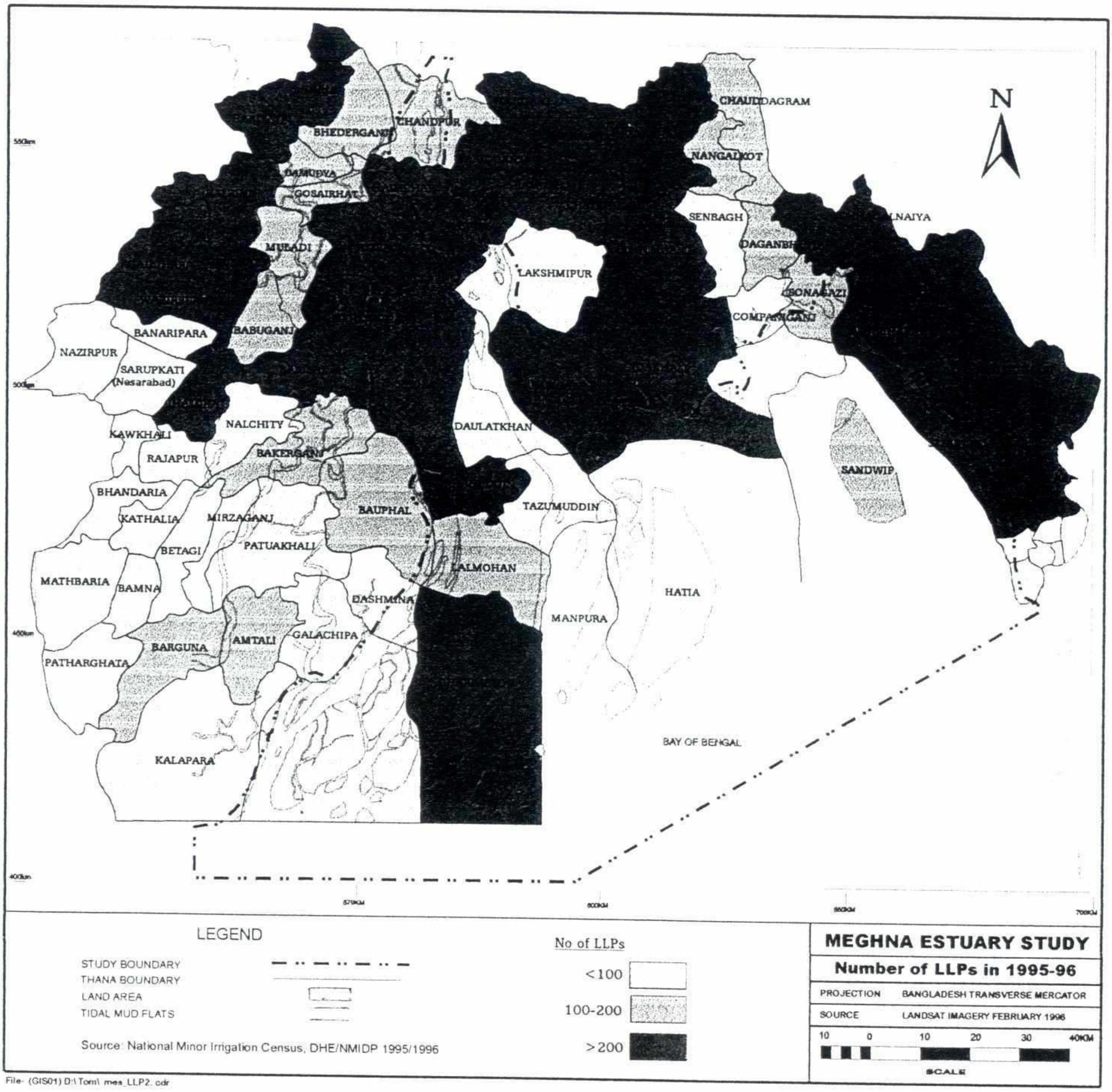

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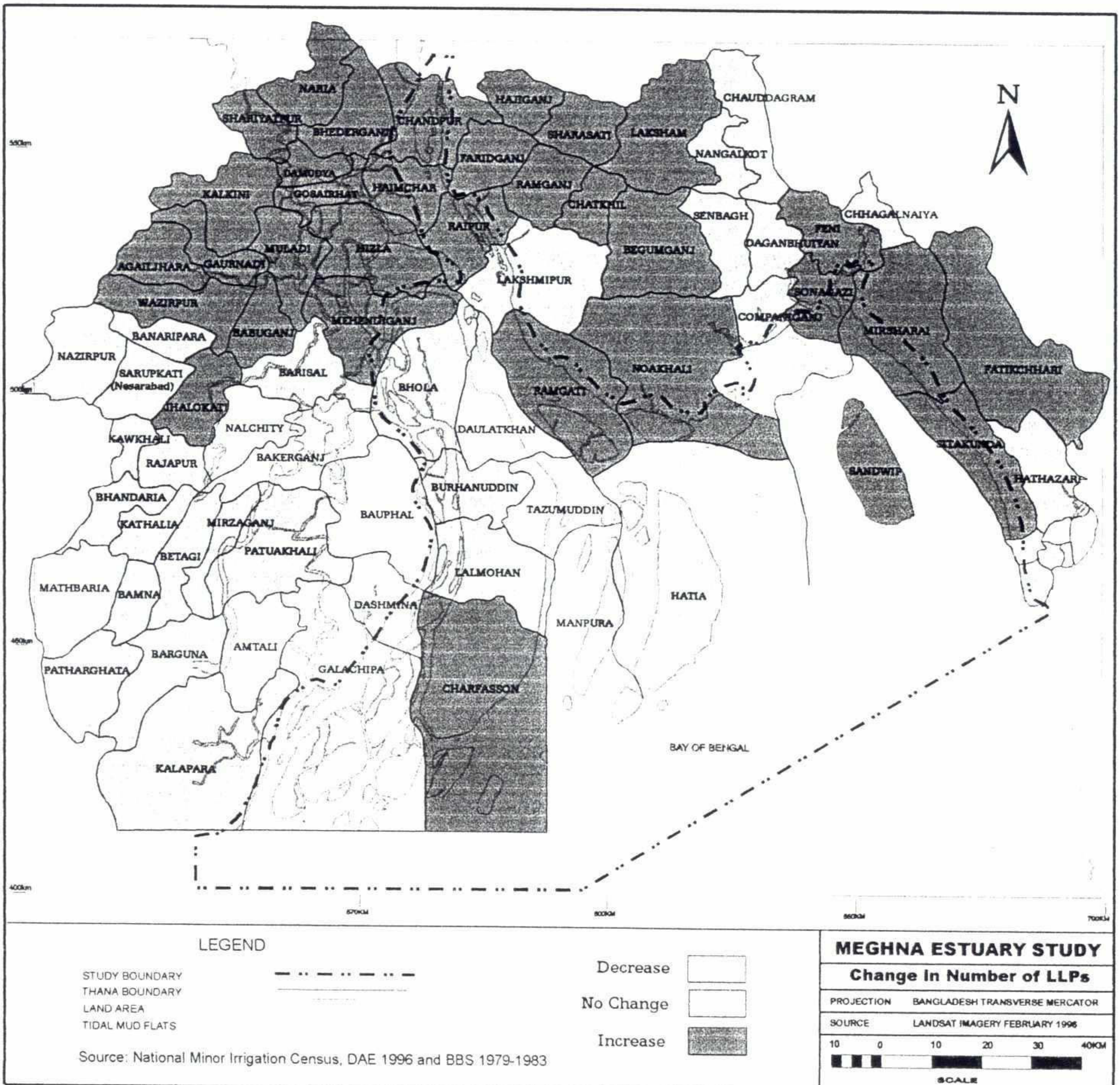
Figure 4.2: Change in number of LLP (1983-1996)



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- *Soil salinity*. In the late eighties DAE and Grameen Bank introduced LLP schemes for the cultivation of Boro in the South West of Bangladesh, amongst others in Polder 55/1. The cultivation of Boro, as well as LLP, was new to the farmers of this polder. For a number of reasons this intervention failed and has contributed to a decrease in LLP as shown in Figure 4.2. One of the reasons frequently mentioned by farmers was the high soil salinity, even by farmers adjacent to a permanent fresh water khal. Too little irrigation gifts may be one of the reasons. Not only pumped fresh water, but also saline groundwater will be used for evapotranspiration of a standing Boro crop. Frequent and abundant irrigation (leaching) with fresh water is required to reduce the evapotranspiration of saline groundwater and to prevent an upward movement of salts. However, the promotion of LLPs at Bhola has been more successful and underlines the scope for surface water irrigation in this zone.

Irrigated agriculture requires a well developed local market with readily available inputs such as fertiliser, pesticides, diesel, mechanics, spare parts and last but not least agricultural credit. These conditions may be difficult to fulfil in remote polders.

Central zone, Zone B

As in the southwest zone, khals form a natural and adequate drainage system in case of the empoldering in this zone.

However, there is no scope in the central zone for flushing in fresh water during the dry season and fresh groundwater is only found at large depths (25 to 30 m) and in small quantities. Irrigation during the dry season is therefore non-existing and no significant number of LLPs are found in this area.

Northeast zone, Zone C

A main difference with the southeast zone is that no fresh water is diverted from the Meghna River into the northern area of the northeast zone. No important rivers and channels exist in this area. Due to the absence of fresh water rivers, there is little scope for surface water irrigation by LLP during the dry season. Although the number of LLPs has increased over the last 15 years their absolute number is still low.

The limited increase of LLPs in this area seems to be related with the successful introduction of HYV Boro rice, cultivated in the few low pockets where fresh water bodies remain available during the dry season. An example is the large Begumganj depression, north of Noakhali. The area is low and deep flooding prevents the cultivation of Aman rice during the monsoon. Irrigated Boro crop has become an important rice crop in this area.

Shallow groundwater is too saline to be used by shallow tubewells (STW). STWs are only used where shallow fresh groundwater is found, which is the case more land inwards at a large distance from the MES area, see Figure 4.3.

Flushing water from the Bay of Bengal in the drainage system of polders is hardly an option in this planning zone since water salinity levels in this part of the estuary are high most of the year. Overall, the scope for irrigation is rather bleak in the northeast zone due to the absence of fresh surface water or fresh shallow ground water.

4.1.2 Land levels for empolderment

The height and size of the ring embankment depend on criteria set for flood protection and the level of the land. For drainage, the dimensions of drainage sluices and the modification of a natural khal system depend also on the level of the land and the water levels and fixed drainage criteria. The higher the land compared to water levels, the lower the embankments, the smaller the drainage sluices and the fewer the required modifications of a natural creek system. In other words, the higher the land the better the economic scope for empolderment.

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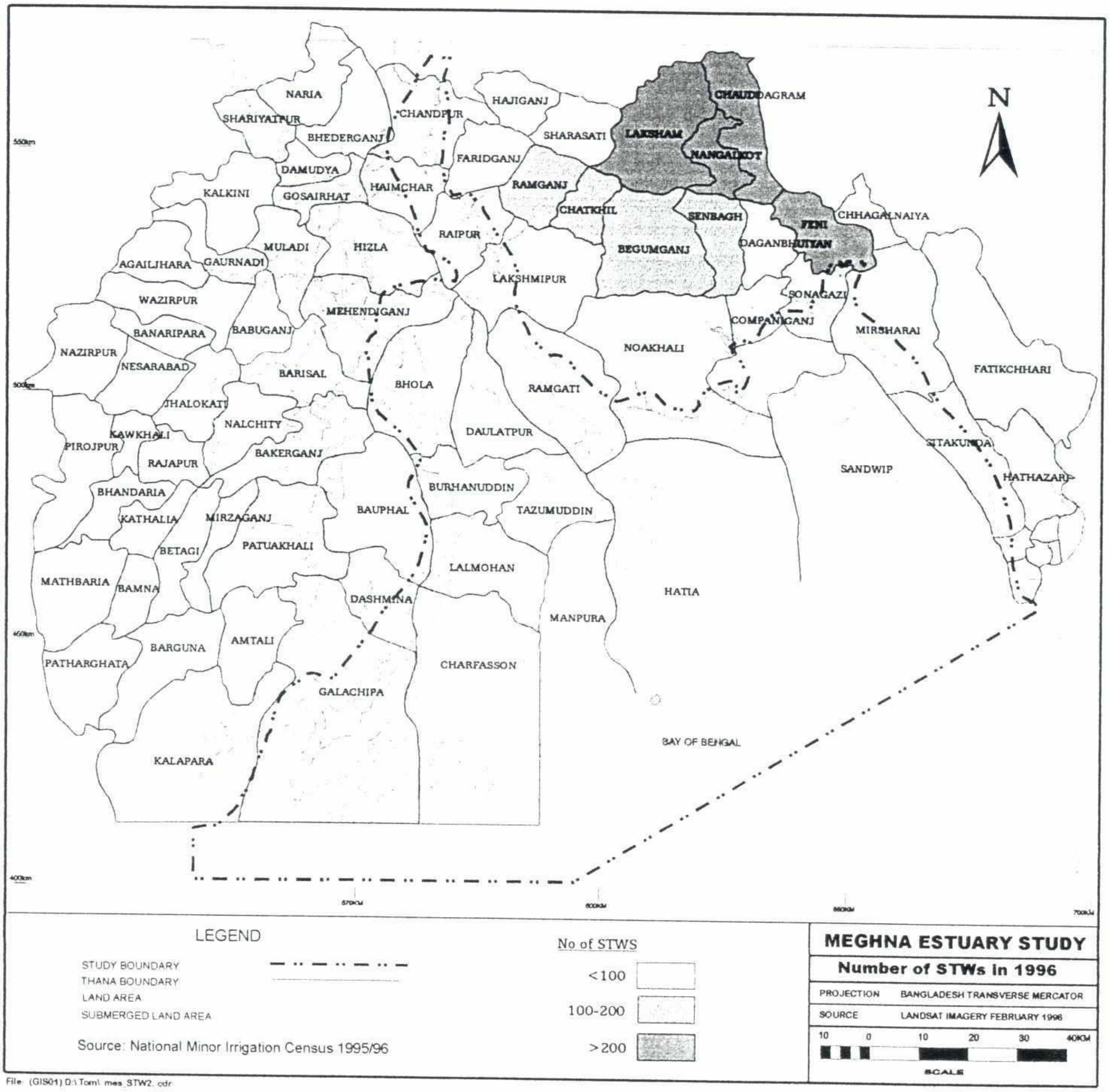
Figure 4.3: Number of STW per thana (1996)



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If land has reached the annual MHWL, it means that it is only flooded by high water levels during the month of June till September, when the maximum discharge of the Meghna is expected or possibly at other times due to the effect of depressions in the Bay of Bengal. In practice it means that with land levels of more than annual MHWL, even during the wet season, drainage will be possible for more than 80 per cent of the day. It also means that the land with a level of annual MHWL is not flooded for 90 per cent of the time in a year.

The annual MHWL is not a fixed level for the entire estuary. Water levels and thus land levels of chars differ from place to place. The lowest annual MHWL is found in the southwest zone (Zone A) and the highest annual MHWL are found in the northeast zone (Zone C). The absolute difference in the annual MHWL may be more than 3.0 metres within the Estuary. Several polders have already been constructed on old char land inside the MES area. It has been found that the land level of old char land, such as Kukri Mukri and Nijhum Dwip is equal to or higher than annual MHWL. The same was found with the existing polder on char Montaz, Polder 55/4. Natural accretion of land beyond this level is extremely slow and may take a tenfold of years. Accretion up to this level is important since the fertile top-soil is formed at the end of the accretion process. The *local* annual MHWL may thus be regarded as a preliminary limit at which to consider empoldering.

The final answer for empoldering at MHWL will be provided by the outcome of the feasibility study. Not only the investments to be made are important, also the future land and water use. The feasibility studies suggest that the annual MHWL represents a minimum land level for empoldering. Earlier empolderment at lower land levels will result in higher investments and may lead to projects with low internal rates of return.

4.1.3 Desalinisation

Interventions to accelerate desalinisation

Field research in the pilot polders of LRP (Baggar Dona I and II) revealed that during the monsoon significant desalinisation takes place, when rainfall percolates through the saline subsoil. By this leaching process salts are washed down till they reach a deep groundwater flow in more sandy layers starting at three to five meters below the ground level. LRP concluded that, a deep drainage flow in the period of July to November, draining an estimated total of 500 to 1000 mm, is considered the main agent for desalinisation. However, CDSP could so far not prove the existence of a deep groundwater flow and even when existing, it was thought not to be very effective in removing the salts due to unfavourable soil characteristics.[14]

a) Flood protection embankment

Soil surveys of the Baggar Dona Pilot Polder of LRP showed that four years after the construction of the flood protection embankment the mid-monsoon salinity levels are reduced below 2 dS/m and that pre- and post-monsoon soil salinity levels dropped from 8 dS/m to less than 4 dS/m[15]. This would mean that during the monsoon, less saline tolerant HYV Aman varieties could be introduced four years after the construction of the embankment. Also the introduction of moderate saline tolerant post-monsoon Rabi crops and a pre-monsoon Aus (rice) crop may start four years after the construction of a flood embankment.

b) Bunding and deep khals

LRP found that the desalinisation results are not only caused by the construction of a flood protection embankment. Other measures are adequate levelling of plots and the construction of field bunds, which favour ponding of rain water and increases the amount of rainfall that percolates through the subsoil. Also the availability of large and deep main khals, which are responsible for deep drainage contributed, according to LRP, to the removal of salts from the

[14] CDSP, Land & Water Engineering, Mission Report 30, October 1997
[15] Technical Report 21, LRP, 1984

subsoil. The minimum required depth recommended for these khals is two metres, with a spacing of two to three kilometres.

c) Flushing of plots

Other measures, which have been studied by LRP, are desalinisation of the top soil by flushing techniques, practised by a number of farmers. The effect was found to be very limited. The construction of smaller and shallow minor and field drains are considered not effective in removing salts due to a very low transmissivity of subsoil layers[16].

Resalinisation during the dry-season by the capillary rise of saline groundwater remains a recurrent problem. LRP expected that it might take 25 years before a fresh groundwater layer of 10 meters deep will be formed. Desalinisation of fine-textured soils found in the estuary is a slow process. The pF-curve of such soils shows that even at high suction levels (a dry soil) a high amount of (saline) soil moisture is available, which makes this soil very difficult to leach.

CDSP measured in the same Baggar Dona polder of LRP, eight years after embankment, pre-monsoon soil salinity levels of 2 to 4 dS/m, indicating slightly saline soils.[17] Polder 55/4 on Char Montaz is one of the most recent polders in the study area and was completed in 1991. Farmers explained that although soil salinity was indeed reducing, the cultivation of a pre-monsoon Aus crop was not yet possible due to soil salinity. According the farmers, Aus cultivation may be possible after another two to three years, hence 10 years after construction of the embankment. The cultivation of a post-monsoon Rabi crop was no longer restricted by soil salinity in this polder.

A soil survey conducted by SRDI in 1994 on South Hatia showed pre-monsoon soil salinity levels of 1 to 3 dS/m inside the flood protected area of polder 73/2. Outside the flood protected area values of 3 to 9 dS/m where found. A value of 2 dS/m is considered a non-saline soil.

d) Irrigation

Irrigation with fresh water will reduce the capillary rise and thus resalinisation during the dry season, if sufficient irrigation water is used. The main constraint here is the availability of fresh water during the dry season stored in the ground or in surface water bodies.

Main conclusions

1. The construction of a flood protection embankment in combination with other measures such as the re-excavation of main khals or drains to a depth of not more than two metres and the construction of adequate field bunds will reduce soil salinity levels to less than 2 dS/m during the monsoon and less than 4 dS/m during the pre and post-monsoon, four years after the construction of the embankment. However, whether the excavation of khals really contributes needs to be seen.

2. Four years after construction of the flood protection embankment, the cultivation of HYV Aman can be introduced. Post-monsoon Rabi cultivation will be possible shortly after the construction of the embankment and can be extended gradually with the introduction of less saline tolerant crops. The cultivation of a second pre-monsoon rice crop, like Aus, may be possible five to 10 years after the embankment has been completed.

Precondition

A precondition for desalinisation is the condition of embankments and sluices. Damaged or broken embankments and sluices allow again the intrusion of saline water in polders. The

[16] Technical Report 13, LRP, 1983
[17] Land and Water Engineering, Mission Report 12, CDSP, 1995.

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condition of embankments and sluices is affected by cyclone storm surges but most damage is caused by lack of maintenance[18].

4.2. Physical interventions in polders

4.2.1 Objectives of empoldering

So far the objectives for empoldering have been to protect lives, property and crops against storm floods and to stop the intrusion of saline water.

At present, with the construction of over 60 polders in the coastal area and the realisation of physical protection from saline storm floods, more emphasis needs to go to:

- reduction of drainage congestion
- improvement of polder water level control.

4.2.2 Improved flood protection

Primary embankments

In line with CPP-II (FAP-7) and SRP (EC) a 1:20 years flood frequency is considered the design height of embankments. Overtopping and breaching of earthen embankments is still likely in case of a cyclone storm surge. Therefore in most polders an increasing number of additional protection facilities have become available, such as an early warning system, cyclone shelters and killas for livestock. Nevertheless, floods of saline water will affect the standing crop as well as agricultural production in the years to come. A second line of defence may be realised with proper planning and a limited investment.

Secondary embankments

Small as well as large polders are protected by one single ring embankment, a first but also last barrier against flooding. In case such an embankment is breached, a few thousand hectares will be exposed to saline floods.

Secondary flood protection embankments can improve physical safety of exposed polders larger than, say 3000 ha. Secondary embankments will provide a second line of defence against storm surges. These embankments will divide the polder into compartments and in case of a breach in the primary embankment, intrusion of saline floods may be limited to one compartment only. If properly planned, the functions of a secondary embankment are multiple and therefore more likely to be economically effective. In the case of a new polder, a secondary embankment can be used for:

- flood protection
- rural roads.

Secondary embankments can be used as rural roads and reduce the need for additional roads. An advantage of roads that follow hydrological boundaries, like the road on top of an embankment, is that these roads do not require any culvert or bridge, which also will reduce the costs of a rural road network.

An additional advantage may be the creation of explicit drainage compartments, drained by a drainage sluices. Polder compartments of around 2000 ha may simplify water management inside polders.

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[18] CERP-I, 1998

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4.2.3 Reduction of drainage congestion

Despite the provision of drainage sluices, in many polders cases of severe drainage congestion have been reported. As mentioned by SRP[19], "after flood protection the next step is to alleviate the drainage impediments created by the first intervention".

Measures taken so far stress physical interventions to solve the problem, but there are equally important causes of drainage congestion that require non-physical interventions as mentioned in chapter 2.2, Figure 2.6. To improve the drainage congestion, it is necessary to tackle the problems of drainage congestion, starting at the bottom of the problem tree.

The plan of action should contribute to the solutions presented in the so called solution tree. The solution tree is based on the earlier mentioned problem tree and is shown in Figure 4.4. Solving the drainage problems even starts with interventions linked with the solutions at the bottom of the solution tree.

Nevertheless, physical interventions are required as well. Promising physical interventions to improve drainage congestion will be discussed in this chapter. Non-physical interventions will be discussed in more detail in chapter 4.3.

1) Surface sluices connected to minor drains along the embankments

Drainage congestion often occurs along the embankment where low pockets can no longer drain their excess water due to the construction of a flood protection embankment. The embankment crosses a large number of smaller khals. Promising interventions are:

- installation of surface sluices in the embankment.
- construction of a minor drain along the embankment.

The placement of surface sluices, connected to minor drains will help to solve local drainage problems. To further improve the drainage along the embankment and to reduce the number of surface sluices, the construction of a minor drain along the embankment should be considered. Excess water along the embankment can be conveyed through this minor drain to surface drains or drainage sluice.

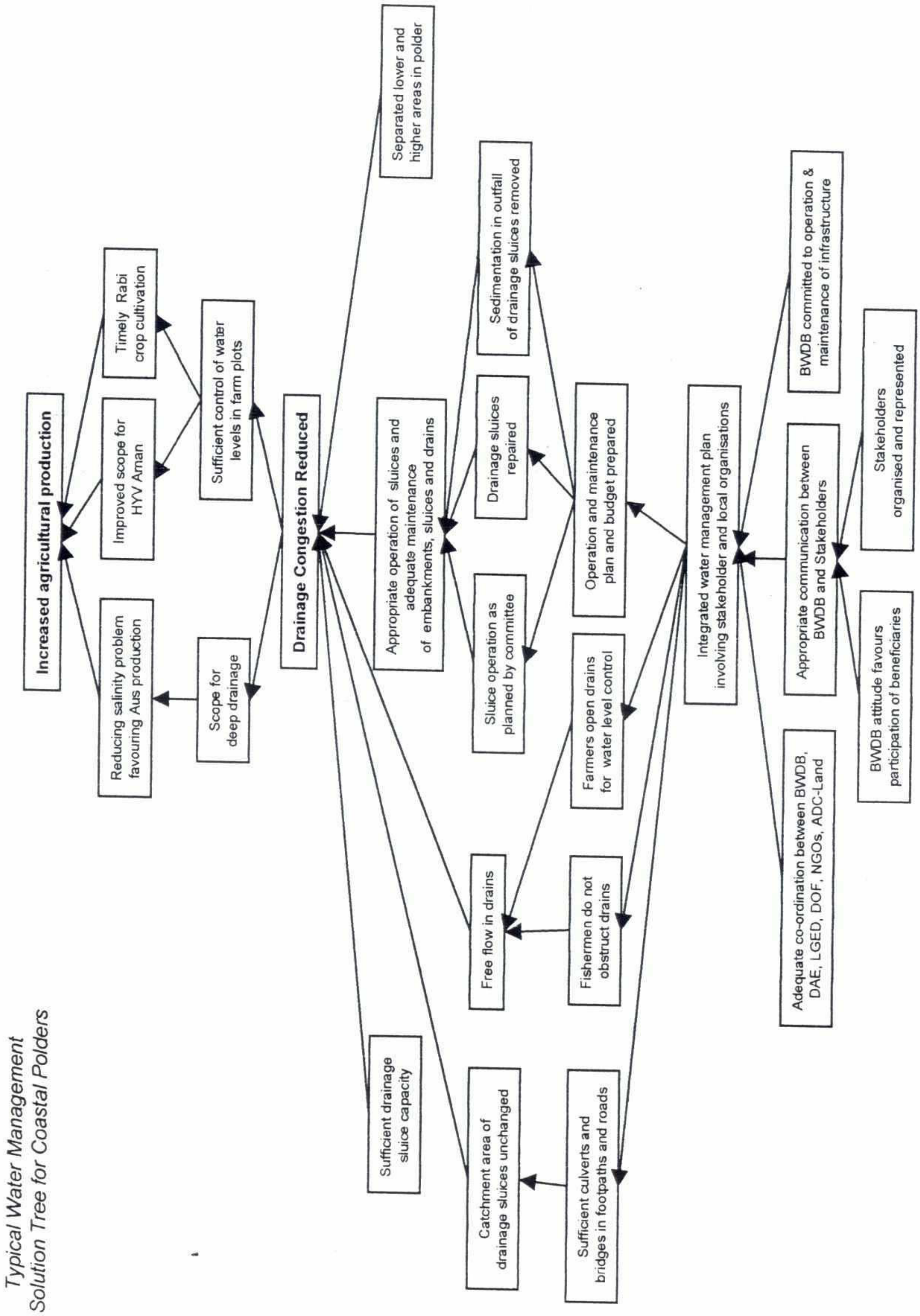
2) Re-excavation and excavation of drains

To reduce the drainage congestion located more inside the polder is more complicated. The following physical interventions are possible:

- re-excavation of bottlenecks in the drainage network, as proposed in a number of rehabilitation studies, but not always implemented (Polder 73/2, 55/1)
- construction of connecting drains, to link a blocked khal with a khal connected to a drainage sluice
- removal of cross dams and obstructions used for fishing
- construction of additional culverts and bridges in rural roads and footpaths.

[19] SRP, TR 50, Water Management in Flood Control and Drainage Systems, Vol 1, April 1997

Figure 4.4: Water management solution tree



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3) *Minor embankments, outlets, protection bunds and regulators*

The physical interventions required are partly the same as mentioned in the previous chapter 4.2.2 emphasising drainage. The following interventions may be considered:

- construction of low minor embankments on both sides of main drains, where such drains pass through low areas
- construction of simple pipe outlets in these embankments to allow drainage of lower areas
- separation of higher and lower areas by promoting protection bunds around low areas
- to control separate water levels in low and higher areas, small regulators may be placed where water retention is required for higher areas and may replace cross dams, to improve operation.

The above mentioned interventions will contribute to an improved control of water levels in polders. An important condition of any of the above interventions is that the desired effect as well as eventual side-effects are predictable.

The need for the above interventions is difficult to assess by only detailed drainage studies. The drainage network of polders consist of a large number of inter-linked khals with irregular cross sections and a changing number of culverts, bridges and cross dams. Such details are difficult to incorporate in models or flood routing studies.

Certainly the implementation of the last two interventions are beyond the mandate of BWDB and requires co-operation with other agencies and stakeholders. A trial and error approach, based on local knowledge, a drainage plan and locally supported solutions seems to be the most promising approach in solving various existing drainage problems[20].

It should also be said here that the present information on drainage congestion is of an indicative nature only. In this respect, it is recommended to start simple monitoring of local rainfall, water levels in main drainage khals and near sluices, as well as the operation of drainage sluice gates. Such information may provide a better insight in the extent and magnitude of drainage congestion, and effects of interventions.

4.2.4 Polder water level control

The overall mode of sluice gate operation supported by farmers in the southwest zone is the following:

- *End of the dry-season, April to June*: Vertical gates are opened and flap gates pulled up. Initially the drains are filled with slightly saline water. Later on, when water salinity has dropped, water levels in the drains are raised to flood and soak the fields (expected in June). Fishermen prefer to open the sluice gates earlier, March and April, to let fish fry enter the khal system.
- *Monsoon, July to September*: Vertical lift gates still open and flap gates are left down. The emphasis is clearly on drainage.
- *Post monsoon, October to December*: Vertical gates closed and flap gates are still left down. No drainage is allowed. Water levels around the polder are lowering. The main rice crop, Aman, still requires a water layer in the field. The emphasis now is on water retention to prevent early depletion of the rice fields. Fishermen are reported to open sluices occasionally in this period, to increase the catch of fish near sluices.

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[20] SRP, Water Management in Secondary Unit Galachipa, Polder 55/1, Technical Note 20, 1993

- *Dry season, January to March*: Vertical gates still closed and flap gates are still left down. Water retention inside the polder is the main objective.

Farmers, the majority of the stakeholders, have a clear interest in control over water levels in their fields and in khals adjacent to their fields. Where possible they will manipulate water levels by interventions, such as cutting or constructing field bunds, cross dams and protection embankments as well as influence the operation of sluices. Al these actions indicate a need to further improve water control inside polders.

4.2.5 Polder compartments

Introduction

Even when planned and implemented in a co-ordinated manner, there is a real risk that the local effects of each of the above interventions or the sum of the interventions is not very predictable. The number of interventions of stakeholders and organisations such as LGED, Union Councils and DOF are enormous. It might be virtually impossible to foresee all interactions between these interventions. Planning interventions for water management is hardly possible if a large polder is not further divided into independent hydrological units and sub-units. Without such a division, planned interventions, such as the construction of a cross dam or a protection bund may not, or may only partly, result in the desired effect, but it may also create unforeseen side effects and subsequently lead to unnecessary conflicts among stakeholders.

Tangail compartment

Compartmentalisation implemented in the Tangail region under CPP, has been introduced to obtain a situation of controlled flooding. As mentioned in chapter 3.5.1, controlled flooding was realised by blocking the inflow of flood water from the Jamuna river and preventing deep harmful floods in lower subcompartments by storing excess water in each subcompartment.

The geographical and hydrological conditions of the 13,000 ha Tangail compartment differ from those of a coastal polder. Polders are flatter areas and lack deeper beel areas as found in the Tangail compartment, which are used to store excess water. The creation of subcompartments in the Tangail compartment has a hydrological justification, it opens the possibility for controlled flooding. Such a clear-cut justification seems to be absent in the case of polders. Storage in the khal system of polders is very limited, but also less needed. Drainage by gravity is possible throughout the year due to a daily changing tidal water level.

Still, there is a second more general hydrological reason. What has been said in the case of a polder, is true for any large water management system. Water management can benefit from a division of a water system into sub-systems, when that is possible and appropriate.

Compartments in polders

A division of the polder into independent hydrological units is possible. At present only two independent hydrological units exist in a polder. Firstly, the polder itself and secondly the bunded field of a farmer. The most logical option for an intermediate hydrological unit, from a water management and drainage point of view, is the catchment area of a drainage sluice.

The main reason to create compartments in polders is to create manageable hydrological units. The effects of interventions carried out to improve drainage and control of water levels are more predictable and its effects are better known in a smaller unit. At least three, but possibly four, tiers of hydrological units can be created to improve water management in a polder. These tiers are:

1) polder
2) drainage sluice compartment

3) subcompartment
4) bunded farmer's field

In the Tangail compartment, the creation of a physical infrastructure consisting of subcompartments and chawks has been linked with an appropriate institutional framework. As such water management operations and operators are organised along hydrological boundaries. It is the hydrological subdivision combined with the creation of an adequate institutional framework for water management which makes it possible to co-ordinate the interventions of stakeholders and organisations and predict their effects.

Practical aspects

Polders are large and vary size. In the MES area, polders vary from 3,100 ha (Choto Baishdia, polder 52/53A) to 76,200 ha (Sandwip, polder 72), with most of the polders between 5,000 and 20,000 ha. The most important hydraulic structures are the drainage sluices. The capacity of these sluices should be sufficient to drain the entire polder. Therefore, the entire polder can be subdivided in catchment areas, one linked with each drainage sluice. Detailed drainage studies review sluice capacities by creating virtual compartments. An example is the rehabilitation study carried out by SRP for polder 73/2, South Hatia. However, these compartments do not exist in reality, because no real hydrological boundaries exist. The creation of compartments was used in flood routing studies to review the capacity of each sluice assuming a virtual catchment area.

Size of compartments

Polder compartments will depend on the capacity of the drainage sluice. Most drainage sluices in the MES area are standard box-culvert drainage sluices with two, three or in a few cases more vents. The catchment areas of these sluices vary from 800 to 1,200 ha. Compartments can be further subdivided into semi-hydrological subcompartments, recognised by stakeholders as a geographical unit and as a drainage unit.

Hydrological boundaries

The most suitable hydrological boundary of a catchment area, or compartment, of a polder is an embankment. Suitable natural ridges hardly exist in polders, and if they exist, are located along the large khals where most of the homesteads are found. Land levels of 80 to 90 per cent of the area inside a polder seem to vary within 0.60 metre. For example, an embankment with a height of up to 0.9 metre and a crest width of not more than one metre may in principle be sufficient. Such embankments are not larger than one of the many existing footpaths. Therefore, polder compartment embankments can be rather small and affordable. On the other hand, more solid compartment embankments will form a much firmer separation between two compartments. Such embankments are less likely to be cut by the local population. Therefore a combination with the existing road network or secondary protection embankments is strongly recommended.

The integrated planning of internal embankments, roads and drains is possible in new or relatively new polders. Savings in developing roads over hydrological boundaries can be considerable, because culverts and bridges are not required for these roads. At the same time, catchment areas of sluices remain intact.

In existing polders, an appropriate local co-ordination body, should decide on what will be the hydrological boundaries in a polder. Existing roads or the alignment of a future road plan should be used, or the alignment of a secondary protection embankment. Bridges and culverts in roads that form hydrological boundaries need to be closed or removed and in other roads additional culverts and bridges may be placed. Where roads or protection embankments have not yet been constructed, minor embankments will be sufficient. Modification of sluice capacities should also be considered. This may be a less costly option in some polders.

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The following steps are required in defining compartment boundaries:

- A topographical map with contour lines at an interval of 25 cm, 1:10,000 or 20,000.
- An up-to-date inventory of all physical infrastructures inside a polder (base map).
- Implementation of a rapid water management appraisal as developed under SRP and a first consultation of all stakeholders.
- The formulation the outline of an integrated water management plan that describes present and the near future situation. Both situations will be illustrated by GIS maps showing the present and future land and water use in the polder. For example fishery areas (khals and ponds), khals used for drainage, khals used for navigation, ponds used for drinking water, washing or other, roads and footpaths including structures like culverts and bridges, sluices, embankments, town and homestead areas, markets, cultivated land etc.
- Formulation and approval of a present and future drainage plan, indicating the hydrological boundaries of catchment areas, khals used for drainage, hydraulic structures like sluices, culverts and bridges and the road network.
- Detailed drainage studies and analyses of the cost effectiveness of different options.
- Formulation and approval of a phased plan of action for the modification of the existing infrastructure such as sluices, drains, roads and road structures, embankments, cross dams etc.
- Elaboration of a water management plan, which includes the O&M for all drainage infrastructure indicating the responsibilities and roles of the different parties involved.

Schematic example

Figures 4.5 and 4.6 illustrate in a schematic way how an existing polder may be changed to a polder with compartments. Once created, additional new compartments can be added as is shown in Figure 4.7. Figure 4.8 shows the development of subcompartments. Hereafter, a description is given for each of these figures.

The figures illustrate the concept of compartmentalisation of polders. The figures are schematic and neither the description, nor the number and type of interventions are complete in these examples. The reality is more complex, in particular as a result of social interactions between, and among, stakeholders and organisations. Moreover, the planning and implementation of compartments is a participatory process. Nevertheless, it illustrates a gradual introduction of compartments and subcompartments in polders as well as new additional compartments and the creation of a secondary flood protection embankment.

A typical "Khulna" polder

Figure 4.5 shows a classical example of a coastal polder of say 6,000 ha. The polder is created by the construction of a ring embankment in which drainage sluices and smaller surface sluices are placed by BWDB. Main khals are linked to the drainage sluices and surface sluices handle the drainage of lower areas along the ring embankment. On the right site of the polder accretion of new land takes place. Main rural roads have been constructed by LGED and in most cases, but not all, a bridge has been built where the road crosses a main drain or khal.

Figure 4.5: Polder without compartments (schematic)

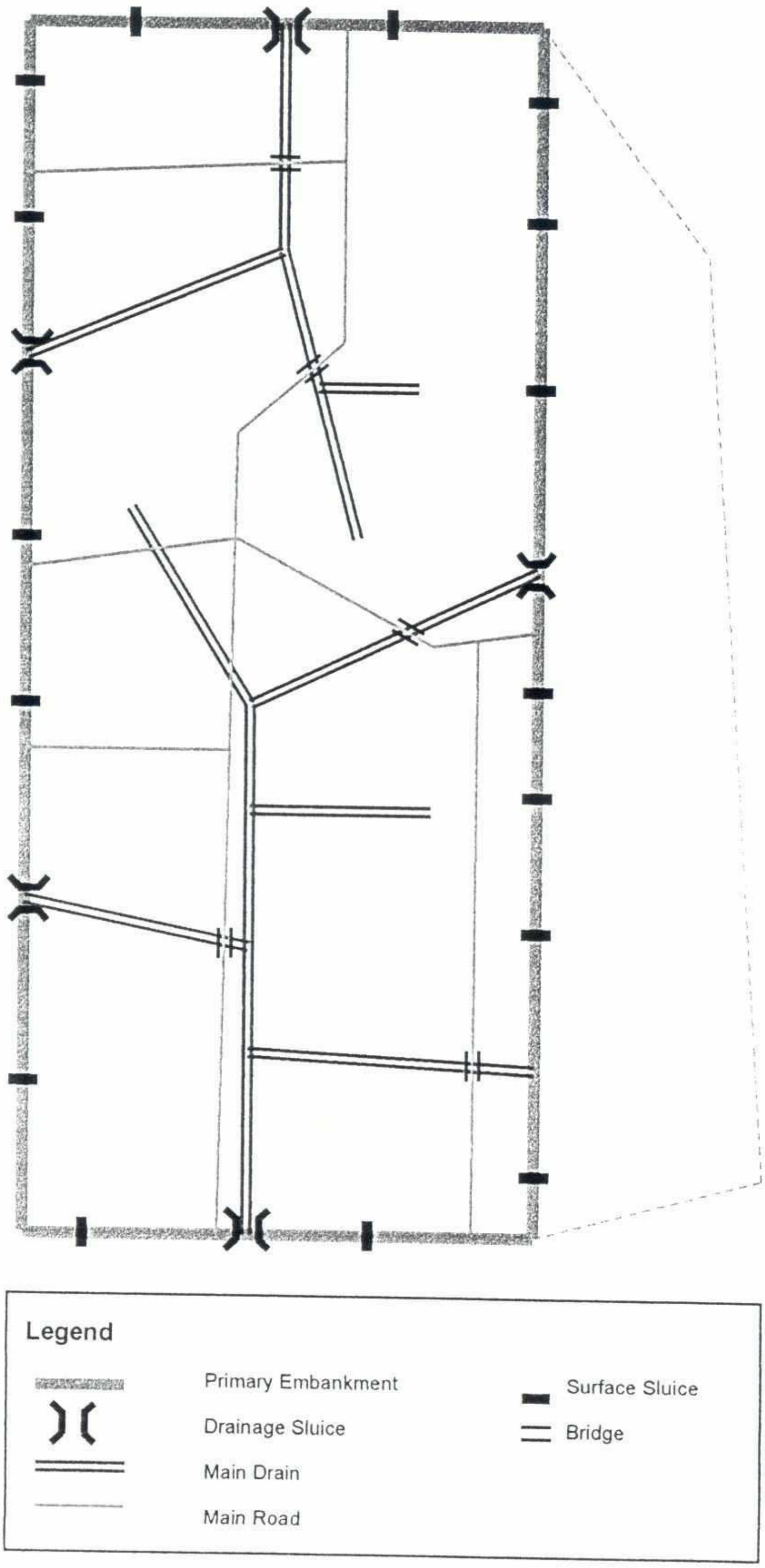


Figure 4.6: Polder with compartments (schematic)

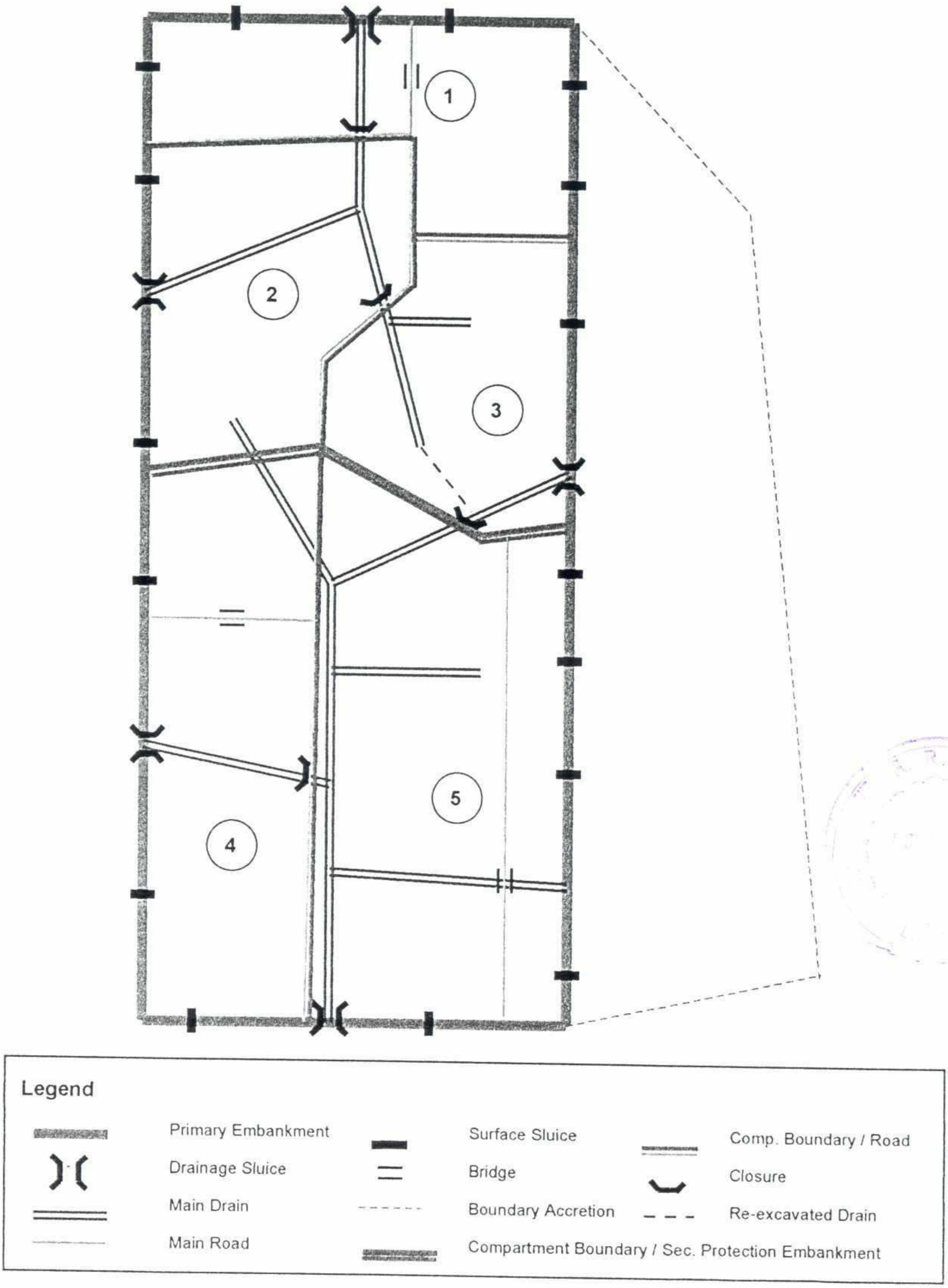


Figure 4.7: Polder with old and new compartments (schematic)

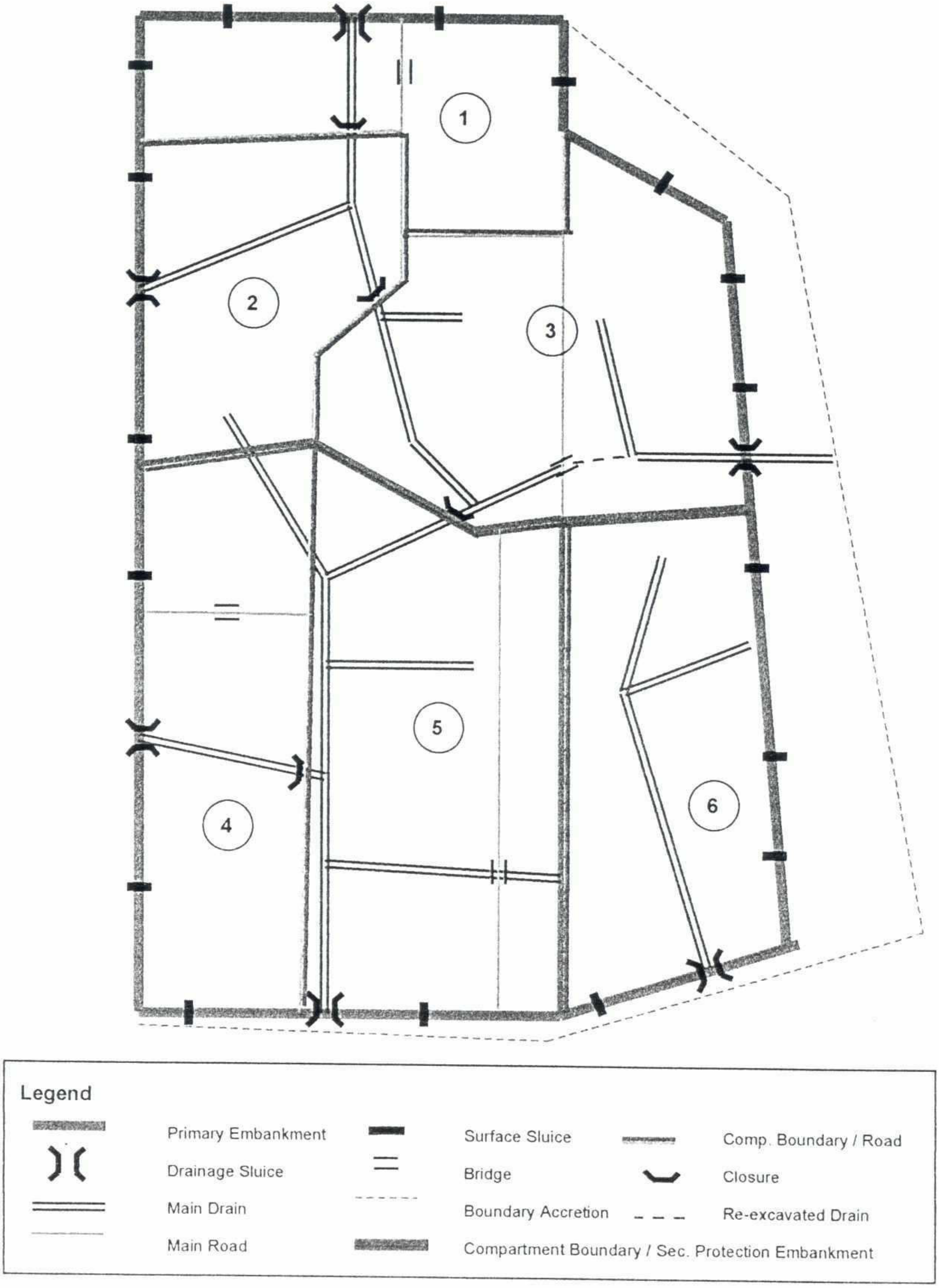
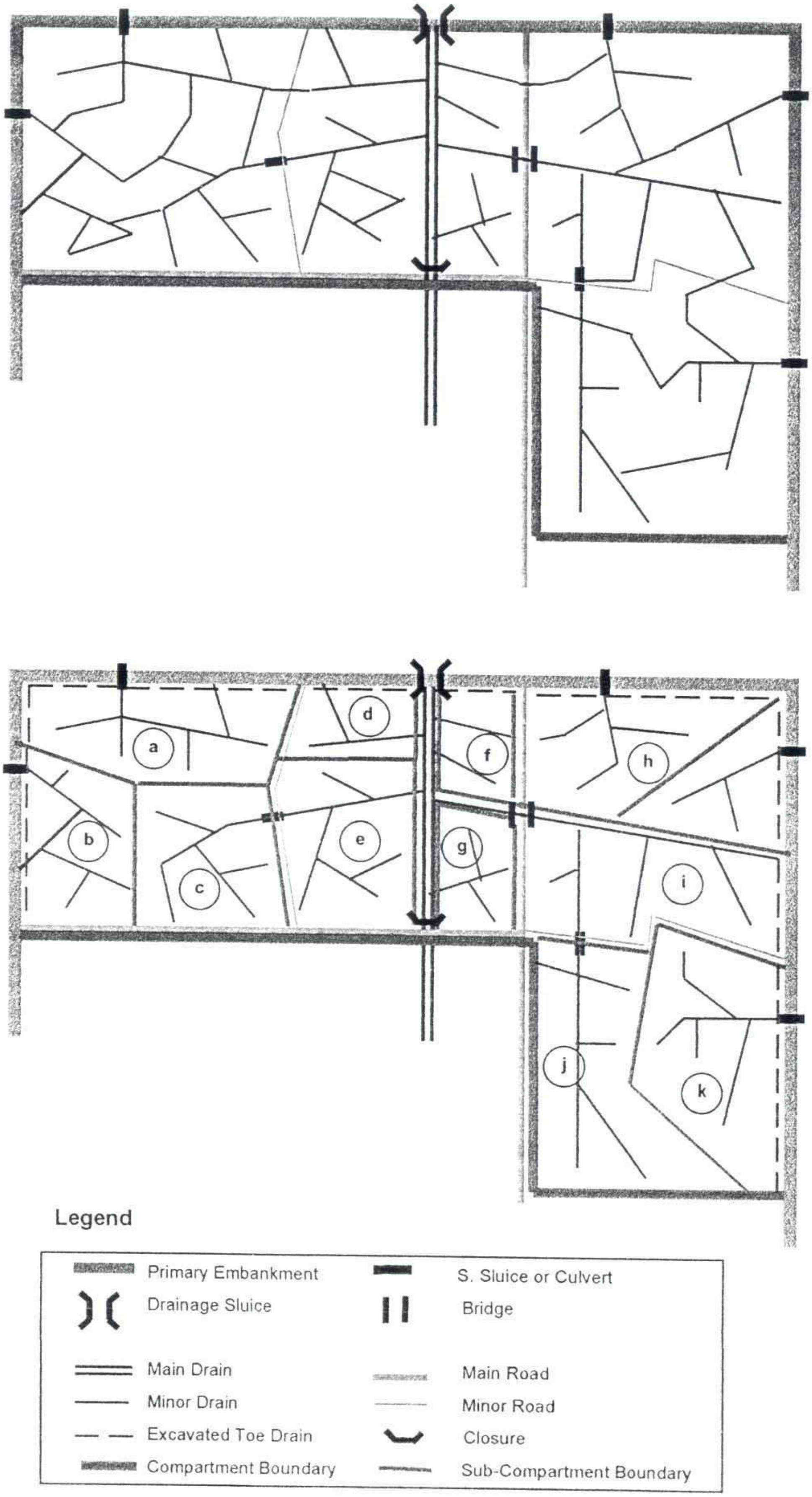


Figure 4.8: Development of subcompartments (schematic)



The usefulness of the road constructed in the right bottom side of the polder, parallel to the primary embankment is doubtful. The primary embankment could also have functioned as a main road. Minor drains, minor roads and small structures are not shown here.

The creation of compartments

Figure 4.6 provides a schematic overview of the creation of five compartments in a polder. The following main physical interventions have been implemented:

- The realisation of a secondary flood protection embankment by strengthening an existing main road. In case of a breach, only half the polder will be flooded, while the other half still can provide basic facilities to the local population, but also livestock (e.g. drinking water).

- The creation of five independent hydrological compartments, one compartment per drainage sluice. Where possible existing roads have been used to realise compartment embankments. Culverts and bridges in these roads have been closed or removed. As a result, it may be required to increase the capacity of one of the sluices, since the road plan has been designed independently.

- In each compartment, smaller or larger sections of main drains need to be re-excavated and bottlenecks need to be removed (e.g. small culverts replaced by a small bridge). In the case of compartment No. 1, an additional road cum compartment embankment has been built.

The works have been carried out on the basis of an overall water management plan and a drainage plan involving the UP, BWDB, LGED and the local population.

Additional new compartments

Figure 4.7 deals with the empoldering of new land adjacent to the existing polder. A new compartment, No. 6 has been created. Compartment No. 3 has been enlarged. The following interventions have been carried out:

- The construction of an additional primary embankment with seven surface sluices and two drainage sluices.

- The construction of a new additional section of the secondary embankment (cum compartment embankment cum main road), to connect the old secondary embankment with the new primary embankment (between compartment No. 3 and No. 6). Obviously, no structures like culverts or bridges are required here.

- Conversion of the old sluice into a bridge by removing the gates. A new, larger sluice for compartment No. 3 has been built in the new primary embankment.

- Settlement of landless in the new compartments of the polder.

- Conversion of a part of the old primary embankment into a secondary protection embankment (cum compartment embankment cum main road) between compartment 5 and 6, at no cost. Where this embankment crosses the new compartment No 3, it acts as a main road only.

- Conversion of a part of the old primary embankment into a main road, at no cost.

- Reducing the section of the former primary embankment and settlement of the excess landless people for whom no new land was available. A large number of landless people can be settled by reducing the previous river side of the old primary embankment. The slope 1:5 or 1:7 will be reduced to 1:2. The land and soil that is freed can now be used to settle landless along the old primary embankment.

Construction of subcompartments

Figure 4.8 shows the creation of subcompartments in compartment No.1. The following interventions were needed to create 11 subcompartments:

- Defining the catchment areas of surface sluices. The catchment areas will form independent hydrological subcompartments.
- Defining other hydrological units inside the compartment. Important is what the local population regards as a hydrological unit. In most cases they will correctly stress the importance to separate high areas (for example subcompartment c, i and j) from the lower areas (assumed here the areas d, f, e and g).
- Based on a local water management and drainage plan, modification of the drainage system. A (minor) number of khals will not be required for drainage and may be converted into fishing ponds by the construction of permanent cross dams. Other stretches of khals may need to be re-excavated and bottlenecks (e.g. culverts in minor roads and footpaths) may need to be removed to function properly as drains. Obstructions, like bamboo piling for fishing purposes or cross dams for water retention, are in principle no longer allowed in these drains.
- Subcompartment embankments are small (maximum one meter high) and need to be constructed where no minor road or footpaths exists. In that case, the landowner will also be the owner of the subcompartment embankment. He is entitled to use the subcompartment embankment for planting trees, cultivating vegetables etc.
- Along the toe of the embankment, a minor drain will be excavated required to facilitate drainage of fields along the embankment.
- Subcompartments d, e, f and g (here assumed to be low areas) are protected by a subcompartment embankment along the main drain. This will prevent flooding due to drainage of excess water from the higher subcompartments c and j.
- The culverts of the higher compartment c and j may have a slide gate on the inside for water retention.

Rain storms

Serious damage to the young transplanted Aman can occur in July, but also August, if a part of the polder is hit by local, but intense rain storms. Under such exceptional circumstances compartment embankments may need to be cut to drain water in adjacent compartments and to make use of the capacity of other sluices as well. Locations where compartment embankments may be cut need to be known and this should be agreed upon by the stakeholders and the water management committee (see chapter 4.3.1). In a later stage of development, regulators or fixed escape structures may be placed at such locations.

4.3 Non-physical interventions

4.3.1 Institutional aspects

Rehabilitation and modification of polders

During the planning process of empoldering or the creation of polder compartments and subcompartments, the following existing and to be created organisations should be consulted.

1) The existing Thana Development Co-ordination Committee (TDCC) or, depending on the size or boundaries of the project, the District Development Co-ordination Committee (DDCC). Possible conflicts with existing land and water use plans and practices, potential inter-agency conflicts and co-ordination will be discussed in these committees. The TDCC and DDCC should be kept informed.

2) A to be created Project Committee (PC). The establishment of such a committee is recommended and it should be involved actively in further studies. The PC will be formed by the locally elected persons such as the Union Parishad members and Chairmen and local advisors. It is important that all stakeholders are represented by the PC and the PC should ensure that all stakeholders are heard and incorporated in need assessments. The PC will finally decide for or against a final proposal for the construction of a new polder or polder compartments. The PC may after implementation continue as a new Water Management Committee (WMC), which will be explained hereafter.

3) After the identification of stakeholders, consultation of stakeholders can take place at Parishad and Gram level. The main function is to hear the opinion of the various stakeholders organised and unorganised such as farmers, fishermen, boat owners, traders, town dwellers etc. about their needs and comments on proposed interventions.

Participatory water management in polders

An institutional framework for integrated water management is required, but not necessarily the tiers prescribed by the GPP. A more appropriate and functional set-up is necessary. Sustaining flood protection of the polder, reducing drainage congestion and optimising the control of water levels in each compartment will require an integrated approach that can overcome conflicting interests of different stakeholders and organisations.

For example, what will be considered a primary or secondary drain? What will be the policy regarding fishing in drains and near sluices? Which drainage channels should remain accessible for country boats, when should sluices be opened and closed? What are the target water levels for drains? What may be defined as a compartment or subcompartment? What will be the yearly routine and periodic maintenance programme of embankments, sluices and drains, what might be an appropriate flood protection fee (local cost recovery)? All these questions are related to water management, but can not be answered by BWDB only. The involvement of stakeholders, local Government bodies like DOF, LGED, but also NGOs are required.

New Guidelines for People's Participation

A revision of the GPP is currently under preparation. Experience with the present GPP has not been very successful. Recent national workshops on people's participation in water management revealed a number of shortcomings of the present GPP. One of the conclusions was that the present institutional framework for water management is in line with the hydraulic infrastructure of irrigation projects, but does not coincide with the infrastructure of FCD systems like polders.

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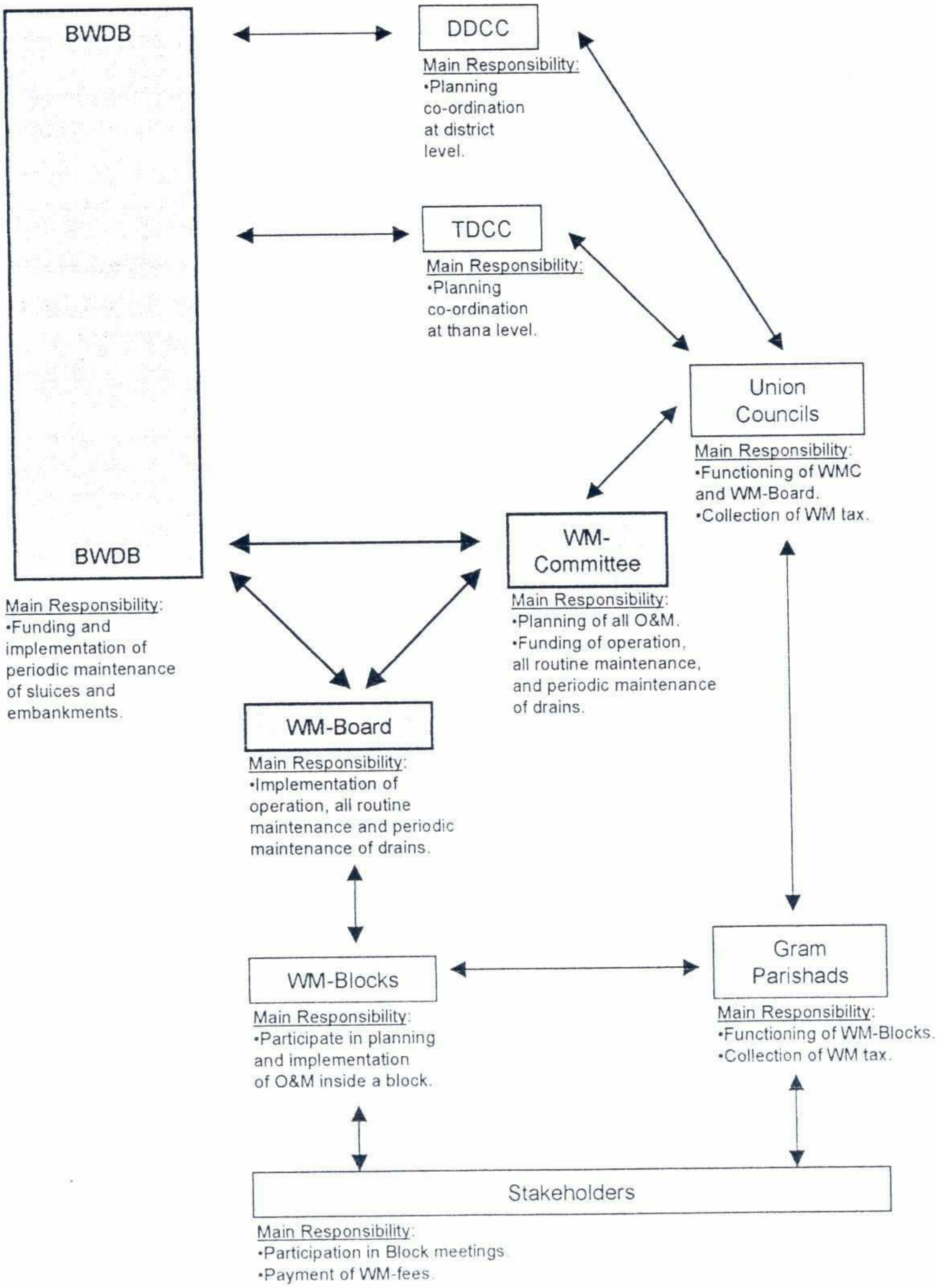
Figure 4.9: Institutional framework for water management in polders



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Anticipating expected changes, it is envisaged that there should be three important parties involved in water management: BWDB, the so-called Water Management Committee and the stakeholders' organisation. Figure 4.9 shows an institutional framework for water management, which makes maximum use of already existing local organisations. The newly proposed institutional framework for FCD systems differs from the present GPP framework, which was meant for all FCD and Irrigation Systems (see Figure 2.7). This new set-up (or similar) is at present being discussed by BWDB and is subject to approval of a new more elaborated and more functional GPP for FCD systems by MOWR.

Role of BWDB

The role of BWDB will remain limited to planning and implementation of periodic maintenance of primary embankments and sluices. BWDB will ensure participation of stakeholders and local Government Representatives in these tasks. BWDB must participate in a thana and district level co-ordination committee to discuss issues related to periodic and emergency maintenance. The BWDB's role under the current GPP, which is regarded as the motor of people's participation in water management, is too far from their traditional engineering role. The Local Government seems to be a more appropriate organisation to stimulate participatory water management. Technical training of members of Gram, Union and (if existing) Upazila Parishad can be provided by BWDB or other professional training institutes.

Water Management Committee

The new Water Management Committee (WMC) comprises local politicians and advisers. Depending on the administrative boundaries, a WMC will have members from more than one union council. The union council chairmen may appoint additional advisers of the WMC.

The role of the WMC is mainly that of planning and decision making in operation and maintenance. Also arbitration in water management conflicts, cost recovery, formulation of an annual and seasonal water management plan for the polder and defining the function of infrastructure in the context of a land and water use plan will be handled by the WMC.

Besides, WMC will have the means to implement a water management plan. A local budget can be raised through the collection of a local flood protection and drainage fee, a polder fee. This fee will be fixed and collected by the Union Council. The Union Council has the legal right to collect local taxes.

Stakeholders

To involve stakeholders and to ensure representation of interest groups, the organisation of stakeholders, such as farmers, fishermen, boat owners, traders etc. is needed. The stakeholders will be organised along their main interest or profession. As much as possible use will be made of already existing groups. Organisation on a geographical basis will be done at (potential) compartment level, the catchment area of a drainage sluice. The organisation may be named Water Management Block, WM-Block. This WM-Block will be responsible for the day-to-day operations of hydraulic infrastructure inside their compartment, like drainage and surface sluices, cross dams in drains, cutting or closing of embankments, monitoring of water levels etc.

In addition it is proposed to have a Water Management Board (WM-Board) for the entire polder. The members of this board are proposed by the Blocks, but are subject to approval and appointment by the WMC. Since the WMC members are occupied by their principle tasks in the Union Councils and other bodies, the members of the WM-Board should be regarded as an extension of the WMC. The WMC are the supervising directors, whereas the WM-Board are the chief executives of water management policies and plans. The WM-Boards should therefore receive some remuneration for their efforts and time and possibly some (modest) office facility from the Local Government.

The WMC, BWDB, WM-Blocks and the WM-Board will meet at least twice, seasonally (pre-monsoon) and annually (post-monsoon). O&M plans and budgets will be prepared and finalised by the WMC and BWDB with participation of the stakeholders (WM-Blocks). Implementation of O&M plans is carried out by the BWDB (periodical and emergency maintenance) and the local WM-Board (operation and preventive maintenance as well as periodical maintenance of drains).

It is expected that the present GPP idea of the "project council" or "polder council" will be discontinued under the new GPP. The already existing TDCC is the most appropriate platform to co-ordinate activities of BWDB, LGED, DOF and DAE and other GOs and NGOs. In the TDCC, an integrated water management plan may be presented by the WMC. Based on an integrated water management plan, a drainage plan can be derived followed by a plan of action of BWDB and the WMC.

4.3.2 Improved O&M concepts

Management, operation & maintenance

The WMC, assisted by the WM-Board, will formulate an operation plan involving the various WM-Blocks, that prescribes water level targets to be met in drainage channels on a monthly basis and a set of instructions and regulations for the operation of sluices. The WM-Block will appoint a sluice operator and ensure the daily operation of sluices and monitor the water levels in the drainage channels through gauge readers.

BWDB will continue to built-up skills and experience in preparing a sound periodic maintenance plan for its infrastructure (Embankments and sluices) as formulated in improved O&M concepts formulated under SRP. Based on an inventory of the hydraulic infrastructure and maintenance criteria, a periodic maintenance plan can be prepared and implemented. Periodic maintenance plans are based on actual field inspections, surveys and needs expressed by the WM-Blocks and WM-Board. The periodic maintenance plan of BWDB requires approval from the WMC. The WMC, via the WM-Board and WM-Blocks, will monitor the works implemented by BWDB and will sign for completion of periodic maintenance works.

Operation, preventive and periodic maintenance (of drains) will be implemented by the WM-Board. These activities and works, which are funded by the Union Councils, will also be monitored by persons appointed by the Union Councils.

Based on the operation plan and formulated targets, financial and physical performance indicators need to be identified. Values for these indicators (data) will be collected and used to evaluate the yearly performance of the polder and each compartment. This will be a task of the WMC. Actual implementation of data collection will be the responsibility of WM-Board, WM-Blocks and BWDB.

The implementation of an O&M programme requires the regular presence of a Sub-Divisional Engineer of BWDB, trained in periodic maintenance planning, budgeting, implementation and monitoring.

Water management and O&M budget

One of the conditions for successful implementation is the availability of sufficient periodic maintenance funds under the heading "works" of the revenue budget allocated to BWDB. The height of the O&M budget will depend on the maintenance standards applied, but will be at least near to one to two per cent of the present value of the infrastructure. BWDB must provide the funds required for periodic and emergency maintenance of embankments and sluices as well as their own establishment.

In planning and raising sufficient fund, BWDB will make use of Needs Based Budget (NBB). The NBB is based on an inventory and operation and fixed maintenance criteria. The NBB represents an average O&M budget over a period of say, 20 years. The NBB can also be used as a reference to evaluate the financial performance of a polder, e.g. budget spent on O&M compared to average budget, detailed for categories such as establishment and operation, O&M facilities and O&M preventive, periodic and emergency works.

Cost recovery

Stakeholders such as landowners, farmers, fishermen, house owners, shopkeepers and traders will pay a local polder tax. Polder tax revenue should cover the budget requirement for the implementation of a routine maintenance plan for sluices and embankments, but also the routine and periodic maintenance plan for drains. It should also cover establishment costs such as the remuneration of the local WM-Board members and their employees such as sluice operators and gauge readers. The Union Council through their local tax system will be entitled to collect the polder tax.

Involvement of landless and destitute women

Preventive maintenance should be carried out by Embankment Maintenance Groups (EMG) and Channel Maintenance Groups (CMG) consisting of destitute women and the landless, eventually supported by NGOs. Funds will be provided by the Union Council.

For periodic maintenance of embankments, BWDB will employ local Labour Contracting Societies (LCS) for earth works (status of D-Class contractor), who, if properly supervised, provide a better quality of earthwork than regular contractors. Both groups will consist of landless and destitute women and will be trained by BWDB. Periodic maintenance of sluices will be carried out by local contractors.

There is no guarantee that with the above described institutional set-up O&M will improve. However, transparency and accountability are clearly increased. Moreover, the physical safety of lives and property has now become a shared responsibility of WMC/Union Councils and BWDB.

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