PEOPLE'S REPUBLIC OF BANGLADESH

Ministry of Irrigation, Water Development and Flood Control

Bangladesh Water Development Board

CYCLONE PROTECTION PROJECT II - FAP 7
FEASIBILITY AND DESIGN STUDIES

FINAL PROJECT PREPARATION REPORT
VOLUME 1 - MAIN REPORT

May 1992

Joint Venture of
KAMPSAX INTERNATIONAL A/S,
BCEOM
DANISH HYDRAULIC INSTITUTE
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ABBREVIATIONS AND GLOSSARY

AEZ	Agro Ecological Zone
Aman	Main monsoon season paddy crop
Aus	Late dry season/early monsoon paddy crop
BARC	Bangladesh Agricultural Research Council
B.Aman	Broadcast Aman
BBS	Bangladesh Bureau of Statistic
Beel	Low-lying area subject to flooding by rain or river water
BRDB	Bangladesh Rural Development Board
Boro	Winter (dry) season paddy crop
BWDB	Bangladesh Water Development Board
CE	Chief Engineer
CEP	Coastal Embankment Project
CFE	Cash Foreign Exchange Budget
CPP-II	Cyclone Protection Project-II .
DB	Development Budget
DOF	Department of Fisheries
EIP	Early Implementation Project (s)
FAP	Bangladesh Flood Action Plan
FCD	Flood Control and Drainage
FCDI	Flood Control Drainage and Irrigation
FFW	Food For Work
GOB	Government of Bangladesh.
HYV	High Yielding Variety.
IBRD	International Bank for Reconstruction and Development (World Bank)
IDA	International Development Agency (World Bank)
IDP	Infrastructure Development Programme (LGEB)
IOM	Improved Operation and Maintenance
IRWP	Intensive Rural Works Programme
KHARIF	Summer cropping season (May through November).
KHASLAND	Undisposed Government Land.
khalashi	Cleaner (actually guard) of regulator/sluice
lakh	Hundred thousand (100,000)
LCS	Landless Contracting Society
LGEB	Local Government Engineering Bureau
LPC	Local Project Committee
Maund(md)	37.3 kg
mouza/ mauza	Revenue village (may comprise several physical settlements)
NGO	Non-government Organisation.
O&M	Operation and Maintenance
O&MCC	Operation & Maintenance Cost Cell (CIDA/BWDB)

Parishad	Elected council (i.e. of Upazila or Union)
Rabi	Winter cropping season (November through May)
RHD	Roads and Highways Department
RMP	Rural Maintenance Programme (CARE)
RRA	Rapid Rural Appraisal
SDE	Sub-Divisional Engineer (BWDB)
SE	Superintending Engineer (BWDB)
SO	Section Officer (BWDB)
SRDI	Soil Resources Development Institutes, Ministry of Agriculture.
SRP	System Rehabilitation Project
SSDFCP	Small Scale Drainage and Flood Control Project
SSFCDIP	Second Small Scale Flood Control Drainage and Irrigation Project
Upazila	Administrative unit above Union & below Zila (460 Upazilas in Bangladesh)

EXECUTIVE SUMMARY

1. INTRODUCTION

Some 700 km of the coastline of Bangladesh from the South Eastern tip at Teknaf near Cox's Bazar to the Sundarban forest in the west are subject to the effects of cyclonic storms generated in the Bay of Bengal. As a result up to 9,000 sq km of the coastal areas and islands are inundated during cyclones affecting a population of about 4.5 millions.

During the cyclone of April 1991 about 140,000 people perished, about 50,000 heads of cattle were lost, 1.75 million houses were destroyed or damaged and standing crops covering about 280,000 acres were destroyed.

In 1989 an agreement was entered between Government of Bangladesh and the European Communities for the financing of Cyclone Protection Project II (CPP II) comprising feasibility and design studies of protection measures against cyclonic flooding.

In February 1990 the Joint Venture of Kampsax International, BCEOM and DHI was awarded a contract for the consultancy services related to the CPP II comprising both a Coastal Embankment (BWDB) component and a Road (RHD) component.

The present report deals only with the BWDB component, and the RHD component is covered in a separate report.

The objective of the consultancy services of the BWDB component is to perform

- feasibility studies of a 5 year Mid Term Programme for coastal embankment works and

- detailed design for the First Year Programme. This was changed to an Emergency Project after the Cyclone of April 1991.

The study started in February 1990 and the field studies were virtually completed when the study area was hit by the cyclone of April 1991.

After this event the highest priority was given to the preparation, engineering and tendering of a Cyclone Protection Emergency Project which eventually was invited for tenders late December 1991. Hence the completion of the feasibility study was deferred correspondingly.

2. THE PROJECT AND THE PROJECT AREA

Project Objectives

The general objectives of the sea facing embankments included in CPP II have been set as :

- to **protect** the polders against inundation by saline water due to high tide and wave overtopping during monsoon conditions and
- to provide protection against loss of life and damages caused by cyclonic storm surges by **minimizing** flooding and water flow velocities in the polder during severe cyclonic storm conditions
- to **protect** the Export Processing Zone (EPZ) area, adjoining EPZ development area and other major industrial areas in polder 62, Patenga against inundation due to storm surge and wave overtopping during severe cyclonic storms.

Project Features and Components

The Mid Term Programme project covers a total of 23 polders and it consists of the following main components.

- Repair and strengthening of existing embankments by resectioning.
- Construction of new embankments in retired alignments.
- Protective works.
- Hydraulic structures.
- Afforestation.

Resectioning means repair and strengthening of existing embankments that will be kept in their present alignment.

These are embankments on non-eroding coasts and on eroding coasts where retirement is not possible due to intensive habitation or highly valuable hinterland. A grand total of 303 km of embankments are proposed for resectioning.

New embankments in retired alignments are proposed on eroding coasts where ever possible. A grand total of 100 km of embankments are proposed for construction in retired positions.

Design criteria such as crest levels and embankment slopes were determined on the basis of hydraulic studies and embankment optimization analyses.

The embankments will generally be constructed with an outer slope 1:7 and inner slope 1:3. The crest width will be 4.3 m.

The design crest level for the sea facing embankments is varying between 6.0 m and 8.5 m (Patenga).

The embankments will be earth embankments with a clay cover layer of 1.0 m thickness on the outer slope and 0.6 m thickness on the inner slope.

Resectioned embankments on eroding coasts (Patenga, Anowara and Kutubdia) will be protected against wave erosion at the seaward toe by construction of a **revetment** consisting of stones or precast concrete blocks in random placement.

On the basis of condition surveys and field investigations the Consultants have determined the need for 48 Nos of new **hydraulic structures** (drainage sluices and surface sluices) in 14 polders and identified 28 Nos of existing sluices needing repair in 7 polders.

Time has proven that **afforestation** provides a very efficient protection to the embankments against damages by high tidal waves and cyclonic surges. Afforestation absorbs and dissipates the wave energy and reduces the level of the tidal surge and the rate of coastal erosion.

On the basis of a condition survey of all the polders under the Mid Term Programme the Consultants have prepared an afforestation programme covering about 700 km embankment with foreland.

Project Area

The polders covered by the Mid Term Programme are spread over the coastal belt of Bangladesh from Satkhira to Teknaf and they are within the jurisdiction of 9 BWDB working divisions.

The total number of inhabitants in the project area is about 3 million with about 530,000 households, 70% are farmers. About 50% of the households in the project area can be regarded as functionally landless. The projects gross area is 400,000 ha of which 312,000 ha are under cultivation. Agricultural productivity is low due to salinity and natural calamities such as cyclones, storm surges and floods.

Industrial activities are concentrated in the Chittagong area including the industries in the Bangladesh Export Processing Zone, with an annual turn over of about 11,000 million Taka.

3. PROJECT COSTS

All cost figures are given in Taka at price level of January 1992.

The total financial cost for the Mid Term Programme is estimated at:

3,694 Million Taka, out of which

2,038 million Taka is for the Emergency Project and

1,656 million Taka is for the Mid Term Programme Phase 2

The project costs consist of

- Construction and Engineering costs
- Land Acquisition Costs
- Operation and Maintenance Costs
- Afforestation Costs.

Construction costs have been estimated on the basis of unit rates and quantities involved. Unit rates were based on BWDB standard schedules of rates adjusted to January 1992 price level.

About 70% of construction costs are costs of embankment construction. Quantities of earth works have been based on engineering surveys carried out prior to the cyclone of April 1991. The effect of this cyclone has been assessed on the basis of aerial reconnaissances from helicopter.

Respectively 15% and 5% were added to the construction costs to cover physical contingencies and engineering.

The **costs of acquisition of land** was estimated as the physical quantity of land to be acquired multiplied by the net incremental production value per unit of land (FPCO Guidelines).

The estimated **maintenance costs** are of two categories :

- Routine maintenance and
- Periodic maintenance

In addition the costs for repair of cyclone damages have been estimated.

The total yearly budget for routine and periodic maintenance of embankments constructed under the Mid Term Programme is estimated at

38.3 million Taka

The yearly allocation for repair of cyclone damages is estimated at

65.0 million Taka

The grand total yearly budget of 103.3 million Taka corresponds to 2.8% of the total financial cost of the Mid Term Programme (3,694 million Taka).

The average cost per km of the recommended **afforestation programme** amounts to Taka 210,000 corresponding to a total cost of 146 million Taka for the entire afforestation programme.

4. PROJECT BENEFITS

Valued project benefits are derived from protection of

- Agriculture
- Fisheries
- Infrastructures and Property
- Industry

It is one of the main objectives of the project to save human lives from cyclone surges but no attempt has been made to put value at this saving due to the sensitive and complex nature of this subject.

The estimation of all benefits has been based on comparisons between the With Project situation and the WithOut Project situation. Two categories of benefits have been analyzed.

- yearly benefits derived from protection against yearly intrusion of saline water during monsoon storms.
- benefits derived from reduced damages from cyclone surges, converted to yearly benefits on the basis of the assumed frequency of the cyclones.

Agricultural benefits in the With Project situation are derived from

- protection against intrusion of saline water which will result in higher yields, increased cropping intensity and switching in cropping pattern.
- Protection against cyclone caused losses on crops and livestock

For fisheries the benefits are mainly accrued from reduced cyclone damages to shrimp farming.

Benefits related to property and infrastructure are derived from reduced cyclone damages to infrastructure and houses.

Industrial benefits are accrued from cyclone surge protection of the industrial areas at and near Chittagong (Patenga). A minor contribution is derived from reduction of cyclone damages to the salt production in the Cox's Bazar region.

5. ENVIRONMENTAL IMPACT ASSESSMENT

In terms of environmental impact the CPP II is not a new project as it encompasses rehabilitation, strengthening and improvement of some 500 km existing sea facing and similarly exposed coastal embankments and allied hydraulic structures.

The main objective of the CPP II is to improve the protection against damages to lives and property caused by cyclonic storm surges in the most cyclone prone coastal areas and to sustain and improve the agricultural benefits derived from the original Coastal Embankment Project.

The environmental impacts of CPP-II are therefore limited and mostly positive.

Further the CPP II includes a programme for afforestation of foreshore areas and embankment slopes in order to reduce erosion and damages by wind, waves and littoral drift and to restore a natural habitat for wildlife.

By comparison the adverse environmental impacts of the CPP II on the agriculture and the social impacts caused by land acquisition for new embankments are small and insignificant.

6. OPERATION AND MAINTENANCE

Lack of maintenance is one of the main reasons for the actual poor conditions of the present embankments.

The main problems resulting in lack of maintenance have been identified as :

- Over emphasis on construction works to the detriment of O&M.
- Insufficient funding and non-optimized use of prevailing O&M funds
- Overstaffing and lack of motivation
- Inadequate budgeting and cost control
- Lack of training specifically aimed at O&M
- Unsuitable non standard production of O&M manuals
- Lack of beneficiary participation

A basic O&m management system should be introduced and provisions should be made for future maintenance budgets for the Mid Term Programme including establishment of a separate budget for repair of cyclone damages.

Proper planning of maintenance should be introduced. Participation of Local Bodies and Beneficiaries in Maintenance should be looked further into during the construction period. This would cover such alternatives as:

- Long term leasing of embankments
- Employment of destitute women for routine maintenance
- Use of labour intensive groups or Landless Contracting Societies

Experiences drawn from other ongoing projects should be utilized in the planning and implementation of the future maintenance of the projects under the Mid Term Programme.

The merits of establishing a separate body with particular responsibility for maintenance of coastal embankments should be explored.

7. PROJECT RANKING AND JUSTIFICATION

The ranking of the projects under the Mid Term Programme has been based on economic analyses comparing project benefits with project costs.

Financial costs and prices were converted to economic costs and prices through the application of conversion factors in accordance with the guidelines issued by the Flood Plan Coordination Organization.

The following indicators of economic viability have been tested:

- Economic Internal Rate of Return (EIRR)
- Net Present Value (NPV)
- Net Present Value Ratio (NPVR)

On the basis of the economic analyses performed the project ranking list as shown in Table 7.1 has been prepared including the projects in priority order according to the EIRR.

The EIRR for the individual projects (afforestation not included) range from 50% to 4.6% with an EIRR of 18.3% for the total programme. Including afforestation will increase the average EIRR by approximately 1%.

The economic analysis has been based on direct benefits only and value of saved human lives has not been taken into account.

It is one of the main objectives of the Cyclone Protection Project II to improve the protection of human lives against cyclonic storm surges and the polders under the Mid Term Programme have been selected with a view to this objective. All of these polders have thus been selected from cyclone prone areas and the actual embankment condition make them very vulnerable to cyclonic storm surges.

The total population of the polders covered by the Mid Term Programme exceeds 1.3 million.

In view of the above the Consultant recommends that all the polders listed in Table 7.1 be included in the Mid Term Programme notwithstanding the fact that the estimated EIRR for some of the projects is below the opportunity cost of capital in Bangladesh of 12%.

Polder	Name of Polder	Length of Embankment (km)	Investment Cost ** (Million Tk)	EIRR (%)	NPV (Million Tk)	NPVR
62*	Patenga, Excl. Nav. Academy	21.5	503.9	50.3	1410.0	3.17
62*	Patenga, Incl. Nav. Academy	21.5	610.3	43.0	1343.0	2.52
73/1B	Hatia	5.0	41.4	41.9	6.1	0.15
48	Kalapara	9.0	14.1	36.2	21.0	1.35
35/1	Sarankhola	4.3	57.5	30.4	58.2	1.23
60	Sunagazi	8.0	40.4	25.7	18.9	0.42
40/2	Patherghata	9.5	59.9	24.3	5.4	0.10
72*	Sandwip I	38.5	262.3	22.2	176.7	0.63
59/2	Ramgati	14.0	78.3	20.5	13.5	0.16
59/3B	Sudharam	32.0	283.2	17.5	-63.2	-0.14
72	Sandwip	22.7	243.2	16.8	113.0	0.75
59/3C	Companyganj	16.0	246.2	15.8	-32.2	-0.07
66/1	Cox's Bazar	5.0	33.4	15.4	-10.3	-0.29
66/3*	Cox's Bazar	4.6	56.4	14.6	8.6	0.16
56/57	Bhola	62.3	317.4	14.0	38.7	0.10
64/1A*	Banskhali	26.2	266.4	13.6	24.9	0.10
68	Teknaf	17.0	107.6	13.0	-53.3	-0.46
64/2B*	Chokoria	16.4	131.8	12.4	2.7	0.02
64/1C*	Chanua	10.0	73.0	10.4	-6.0	-0.08
69*	Moheskhali	12.9	114.2	8.7	-19.4	-0.17
70	Matharbari	9.0	132.9	6.8	-30.6	-0.25
71*	Kutubdia	38.8	276.3	6.8	-72.0	-0.25
61/1*	Sitakunda	6.1	75.7	6.0	-22.4	-0.31
63/1A*	Anowara	14.5	172.0	4.6	-59.7	-0.38

Table 7.1: Ranking List for Project under the Mid Term Programme

*) Projects under the Emergency Project
**) Total financial cost including construction, engineering and land acquisition.

8. IMPLEMENTATION PROGRAMME AND INVESTMENT PLAN

The Emergency Cyclone Protection Project has been divided into 8 contracts. The works are expected to commence before the rainy season 1992 and to be completed by June 1993.

The Mid Term Programme, Phase 2 may start at the beginning of the dry season 1993/94 and may be completed by the end of the dry season 1994/95.

The total investment costs for the Mid Term Programme, including costs of land acquisition are 3,694 million Taka.

	1992		1993		1994		1995		Total	
	LC	FC	LC	FC	LC	FC	LC	FC	LC	FC
EMERGENCY PROJECT										
Land Acquisition	80								80	
Construction & Engineering	490	489	490	489					979	979
PHASE 2										
Land Acquisition			51						51	
Construction & Engineering			150	150	427	427	225	226	802	803
Mid Term Programme, Total	570	489	691	639	427	427	225	226	1912	1782

Table 8.1 : Investment Plan, Mid Term Programme.

The total costs of the proposed afforestation programme are 146 million Taka corresponding to a yearly investment of 49 million Taka during the years 1993, 1994 and 1995.

9. RECOMMENDATIONS

The main recommendation are :

- The entire Mid Term Programme is recommended for implementation during 1992-1995, starting with the Emergency Project before the rainy season 1992.

- The proposed afforestation programme covering 700 km embankment and foreland is recommended for implementation during a 3-5 year period starting 1993.

- BWDB should make preparations to undertake maintenance of the

embankments and structures under the Mid Term Programme after the handing over of these works. In particular this includes management, organization, planning, budget allocations and participation of local bodies and beneficiaries.

- It is recommended that the Government take measures to arrange prompt payment for land acquisition and assist the house-and landless families in their reestablishment. Possibilities of involving these people in beneficiaries maintenance of embankments should be considered.

- Arrangements should be made for the provision of Technical Assistance in connection with beneficiaries participation in maintenance and land acquisition and the related reestablishment of house-and landless families.

- The need for Government restrictions and control of the shrimp farmers with the aim of protecting the agricultural farmers and the coastal afforestation should be further looked into.

- It is recommended to perform an integrated master plan study for protection measures against cyclones covering all aspects including coastal embankments, warning system, cyclone shelters, means of evacuation, emergency plans etc.

1. INTRODUCTION

1.1 Project Background

Natural calamities are a recurring phenomenon in Bangladesh. The most severe occur in the form of cyclonic storms which affect some 700 km of coastline from the South Eastern tip at Teknaf near Cox's Bazar to the Sundarban forest in the west. They also affect heavily populated offshore islands such as Sandwip, Kutubdia and Hatia as well as the newly accreted islands and mainlands along the coast. This zone is subject to intense cyclonic activity causing huge storm surges. As a result, upto 9,000 sq km of the coastal areas, newly accreted lands and islands in the Bay are inundated during cyclones affecting a population of about 4.5 million.

The major cyclones have been reported for centuries and have caused loss of human lives and livestock and severe devastation of crops and properties. During the last 125 years more than 42 cyclones hit the coastal belt; fifteen have occurred during the last 25 years. The most recent ones are the Cyclone of November 1970, followed by one in May 1985, one in November 1988 and then the latest one in April 1991.

In 1958, the erstwhile Government of East Pakistan started a programme for construction of coastal embankments through its Irrigation department and EPWAPDA. Subsequently, the Government of Bangladesh (GOB) through Bangladesh Water Development Board (BWDB) resumed the program and completed about 4,800 km of embankments with about 1,000 nos. of allied structures.

The sea facing works of the coastal embankment project have been in a dispersed state during the series of natural disasters since the 1970 cyclone. Rehabilitation works has been undertaken under several projects or programmes, including the IDA assisted Coastal Rehabilitation Project which commenced after the 1970 cyclone, the Food-for-Work Program (FFW) and flood rehabilitation projects supported by IDA and other donors after the 1984 floods.

But many of these works were incomplete at the time when following disasters struck (1984 floods, 1985 cyclone, and the 1987 and 1988 floods). Failure to close breaches in the embankments, temporary dwarf embankment only, which were constructed on an emergency basis to protect the aman crop and the steep country side slopes throughout most of the length of the remaining sea facing embankments, are the main reasons for the extensive damage that resulted from each disaster.

Following the 1985 cyclone, several proposals were initiated for the study of cyclones and the protection against cyclones. BWDB compiled a 'Long Term Plan for Structural Measures against Cyclonic Surges' a summary

of which was issued in a preliminary version in June, 1985. The plan consists of a Mid Term Plan for the rehabilitation and strengthening of the existing coastal embankments and a Long Term Plan for extending the system of coastal embankment to cover also newly accreted land areas. The Mid Term Plan would cover a period of 5 years.

Apart from schemes for emergency repair of the more urgent damages, the various proposals resulted in a financial agreement in 1987 between the GOB and the EEC, (ALA/87/05), on Cyclone Protection Project II-a feasibility and design study of protective measures against cyclonic flooding based on the BWDB Mid Term and Long Term Plan.

Before the agreement and terms of reference were finalized, Bangladesh was hit by the disastrous floods of 1987 and 1988, diverting the attention from protection against cyclones to relief and rehabilitation of the extensive damages caused by these floods and to measures for prevention of such damages.

In 1988 the negotiations between GOB and EEC regarding financing of the pending Cyclone Protection Project II were resumed. TOR for the project was finalized and proposals for consultant services were invited in November 1988. The financial agreement between GOB and EEC was signed in April 1989. The study was scheduled to start in mid 1989 but the initiation by GOB and the donor agencies of a coordinated 'Action Plan for Flood Control' in Bangladesh delayed the appointment of the consultant and the start of the study.

Upon finalization of the 'Action Plan for Flood Control' in November 1989 the procedures for contracting the Cyclone Protection Project II were resumed and accelerated due to the high priority of the Action Plan and the time constraints caused by the forthcoming wet season.

On January 15 1990 the selected Consultant, the Joint Venture of Kampsax International, BCEOM and DHI, were requested to start work, and on February 16, 1990 the contract was signed. The study was started on 18th February 1990.

The development during the period 1985 to 1990 covering two severe floods in 1987 and 1988 and the initiation of various rehabilitation programs has rendered the Mid Term and Long Term Plans out of date. For this purpose it was necessary for the consultants to undertake a comprehensive investigation for project identification.

The studies for the above project (CPP-II) were in progress, when a devastating cyclone hit Bangladesh on the night of April 29, 1991. The entire coastal embankment system in the northeastern and the eastern part of the Bay came under intense surge pressure and suffered heavy damage. The embankments, already in a poor state of maintenance, were

overtopped, breaches occurred at many places, revetments were dislodged and embankments were severely eroded.

During this cyclone about 140,000 people perished, over 50,000 heads of cattle were lost, more than 1.75 million homes and 6,500 schools were damaged or destroyed and standing crops covering about 278,600 acres were destroyed.

Had the coastal embankments been in a better condition to withstand the cyclonic surge, the damage would have been much less. The rehabilitation and reconstruction of these coastal embankments have therefore to be carried out urgently in order to put them in place to protect the area against future cyclones.

GOB requested EEC assistance for the Consultant to prepare plans, design and tender documents for an emergency project for the rehabilitation and reconstruction of the damaged coastal embankments. The TOR for the Consultant has been revised and the preparation of design and tender documents for the emergency project have been completed. It is estimated that the emergency project could be completed by the middle of 1993.

1.2 Cyclones and Protection Against Cyclones

1.2.1 Cyclones

Bangladesh is part of the humid tropics, with the Himalayas lying to the north and the funnel shaped coast touching the Bay of Bengal in the south. This particular geography of Bangladesh produces not only the life giving monsoons but also the catastrophic ravages of cyclones, tornadoes, thunderstorms and floods. The Bay of Bengal is thus an ideal breeding ground for tropical cyclones and other natural disasters.

The Bay of Bengal cyclones also move towards the eastern coast of India, towards Burma and occasionally into Sri Lanka. However, maximum damage occurs when the cyclone strike Bangladesh, largely due to the low flat terrain, high density of population, high level of poverty and the low level of disaster preparedness. Most of the damages occur in the coastal regions of Khulna, Patuakhali, Barisal, Noakhali and Chittagong and the off-shore islands of Bhola, Hatiya, Sandwip, Manpura, Kutubdia, Moheskhali, Nijhum Dwip, Urir Char and other newly formed chars.

Table 1.1 lists the number of deaths associated with several deadly cyclone disasters of the Bay of Bengal. It may be seen from the table that 9 out of 15 major cyclones occurred in Bangladesh.

The most severe damages to lives and property from cyclonic storms occur on the recent accreted offshore islands and sea facing coastal areas without protective foreland or afforestation, thus exposed to the combined

devastating effect of storm surge, wind and waves e.g. Bhola, Hatia and Sandwip islands and the coastal belt of Noakhali, Chittagong and Cox's Bazar divisions. See map in Figure 1.1.

Year	Location	Deaths
1970	Bangladesh	500,000
1737	India	300,000
1897	Bangladesh	175,000
1991	Bangladesh	150,000
1876	Bangladesh	100,000
1864	India	50,000
1833	India	50,000
1822	Bangladesh	40,000
1839	India	20,000
1789	India	20,000
1965	Bangladesh	19,279
1963	Bangladesh	11,520
1961	Bangladesh	11,468
1977	India	10,000
1960	Bangladesh	5,149

Table 1.1: Loss of human life by tropical cyclone disasters of the Bay of Bengal

The surges associated with many of these major cyclones occurred unexpectedly. The number of casualties would have been considerably lower if surges had been predicted.

1.2.2 Protection Against Cyclones

Cyclone protection in Bangladesh concentrates on minimizing the loss of lives and the damages to livestock, crops and property caused by the cyclonic storm surges.

The present measures for cyclone protection are briefly described in the following.

Coastal Embankments

The main purpose of the coastal embankments is to protect the low laying land in the coastal belt from inundation and intrusion of saline water during high tide and thereby increase the size of cultivable areas in the coastal region and increase the yields in already cultivated areas.

The embankments provide protection against flooding from smaller surges but have not been constructed to heights to prevent inundation of cultivated areas by severe surges as this has not been found feasible.

However, for severe surges the embankments, though being overtopped, have proved to provide protection by dissipating the energy and reducing the velocity of the surge wave, so that people, houses, roads, livestock and crops inside the embankments are not swept away by the surge wave but the area 'merely' inundated for a relative short period during and after the surge.

Early Warning System

One of the main reasons that the cyclone surges are disastrous is that they build up suddenly, within hours, and not during several days as floods caused by precipitation. Therefore the damages and especially the loss of lives can be greatly reduced by an early warning system reducing the panic.

The early warning system has two components: The meteorological prediction of the cyclone, and the communication system which can broadcast the prediction of a cyclone to all the affected areas.

Cyclone Shelters and All Weather Roads

Cyclone shelters are elevated concrete buildings in which people can seek shelter while the surrounding land is more or less inundated. For these shelters to be useful they must be connected with the surrounding areas with all weather roads, that can be used under the adverse conditions before and especially after the surge.

The cyclone shelters are normally used as schools.

1.3 Scope of Consultancy

The consultancy services include two components i.e. the BWDB component dealing with coastal protection and the RHD component dealing with feeder roads. The present report will only deal with the BWDB component, while the RHD component has been covered in a separate report. The objective of the consultancy services related to the BWDB component is to perform :

- Feasibility studies of a 5 year Mid Term Programme for coastal protection works and
- Detailed design studies for the First Year Programme. This was changed to an Emergency Project after the cyclone of April 1991.

The study report deals with the feasibility study of the Mid Term Programme and it covers the following main subjects of the feasibility

study.

- Engineering Surveys and Investigations
- Coastal Engineering Studies and Analyses
- Hydraulic Studies
- Hydrological Studies
- Economic Studies and Analyses
- Agriculture and Fishery
- Socio-Economic Studies
- Operation & Maintenance
- Afforestation
- Environmental Impact Assessment
- Cyclone Warning System.

2. THE PROJECT AND THE PROJECT AREA

2.1 Project Rationale for Protection against Cyclonic Storm Surge by Embankments

Most of the damages to life and property caused by cyclonic storm surges and tidal bores occur on low laying un-embanked off shore islands and similarly exposed areas outside coastal embankments where people, livestock, buildings, structures, crops etc. are swept away by the surge.

Areas protected by coastal embankments may be partly or wholly inundated by severe cyclonic storm surges overtopping and overflowing the embankments. However, the energy of the surge waves will partly be dispersed and reflected by properly constructed and well maintained coastal embankments. Human casualties and damages will consequently be less in areas protected by coastal embankments.

From the Consultant's studies, consultations with BWDB Superintending & Executive engineers and field damage reports it can be learned that major damages to coastal embankments occur also during the monsoon periods and are caused by wind generated waves during high tide, erosion from rain water run-off and river erosion together with general lack of maintenance.

The overall objectives of a protection system to reduce the impact of cyclones can be categorized as follows:

- protection of human lives
- protection of standing crops
- protection of cropping potential
- protection of industrial production facilities
- protection of other infrastructure - buildings, roads, communication lines etc.

Experiences from different cyclones show that, depending on the severity of the cyclone and the time of its occurrence, some of these objectives are fulfilled by the present protection set-up , whereas others are not reached at all.

The role of an embankment as a part of the cyclone protection system should be studied and clearly defined for each type of polder to be protected against the impact of cyclones.

For protection of human lives a coastal embankment that is breached during cyclonic conditions is worse than no coastal embankment. The embankment gives the residents behind it a (some times false) feeling of safety which in some cases makes them hesitate to take shelter in higher

grounds. This will evidently result in great losses if the embankment breaches - or if it is even incomplete.

This effect may partly be the reason for the many human casualties in the Patenga area and in the Banskhali polder during the April 1991 cyclone.

If a very high coastal embankment is a part of the cyclone protection system for saving lives of the polder residents, then the **entire** polder must be embanked (without any missing link) and the embankments must be designed and maintained to a standard that implies a very low probability of breaching during severe cyclonic conditions. Moderate to severe overtopping of the embankment can be accepted as long as this will not lead to breaching of the embankment or to very high flood levels in the polder.

Protection of standing crop will require embankment of the entire polder and no breaching during severe cyclone conditions. Moderate overtopping can be accepted, but good drainage of the polder is required in cases where overtopping leads to extensive flooding.

Protection of cropping potential is relevant especially for cyclones occuring in the pre-monsoon period. In case of breaching immediate actions must be taken to drain the polder and close the breaches to prevent inundation by saline water during the following monsoon period.

In the aftermath of the April 1991 cyclone actions were taken in order to locate and close breaches in embankments to secure the possibility of growing the aman crop.

Protection of Industrial Production Facilities by coastal embankments is relevant for a few polders only. In some cases individual embankments, not exposed to heavy wave attack, or construction on high ground is necessary. In cases where coastal embankments are to be preferred these should be designed and maintained to prevent breaching during severe cyclone conditions. The acceptable degree of overtopping is to be established on basis of the existing floor level for the actual industries.

Other Infrastructure, such as buildings and roads should not be considered as an objective alone for protection by coastal embankments. More valuable types of infrastructure should be designed to withstand the forces from flowing water and floor levels should be chosen high enough to avoid unacceptable inundation. Many damages to buildings are furthermore caused by winds and not by water.

In consequence of the above the objective of structural measures to be implemented under the 5 year mid term plan for cyclone protection is to strengthening, improve and extend the most exposed and vulnerable coastal embankments and protective works in the cyclone prone areas to

a standard that can sustain the normal prevailing conditions during the monsoon periods and hence be able to provide protection against loss of human life and more severe damages during cyclonic storm surges.

The general objectives for the sea facing embankments included in CPP II have been set as:

- to **protect** the polder against inundation by saline water due to high tide and wave overtopping during monsoon conditions and

- to provide protection against loss of life and damages caused by cyclonic storm surges by **minimizing** flooding and water flow velocities in the polder during severe cyclonic storm conditions

For Polder 62, Patenga, which is characterized by the presence of the Export Processing Zone (EPZ) and other industrial areas, the following additional objective has been set:

- to **protect** the EPZ area, adjoining EPZ development area and other major industrial areas against inundation by saline water due to storm surge and wave overtopping during severe cyclonic storms.

Raising the present design crest levels of the coastal embankments to further reduce or prevent flooding by cyclonic storm surges should be part of a long term master plan for flood protection in the coastal belt.

2.2 Situation Before And After The April 1991 Cyclone

2.2.1 Situation Before the April 1991 Cyclone

The embankments and allied structures constructed earlier, though not fully designed to withstand severe cyclones, were originally very useful in containing the storm surges and thereby reducing their damage potentials. Their effectiveness was of great importance as damage to lives, property and environment would be of greater magnitude if the embankments failed or there were no embankments at all.

Since the 1970 cyclone rehabilitation works has been undertaken under several projects or programs including the IDA assisted Coastal Rehabilitation Project, the Food For Works Programme (FFW) and flood rehabilitation projects supported by IDA and other donors agencies. However, many of these works were incomplete prior to the April 1991 cyclone.

In recent years, due to lack of proper maintenance the strength of embankments has been considerably reduced. At many places erosion and settlements have taken place. In sub-sequent years the slopes of the embankments have been steepened by erosion.

Poor maintenance could be singled out as one of the main reasons for the disappearance of embankment at several locations and very poor condition of the embankment at some other areas. Failure to close breaches in the embankment by other means than temporary dwarf embankment sections contributed to the extensive damage that resulted from each cyclone.

Sub-standard compaction has been one of the other main reasons for the inherited weakness in the embankments. Damage to the embankments would have been considerably reduced if all sections had been maintained to design profile between each of the successive exposures to cyclonic surges.

The damage to the embankment has further aggravated in many polders due to cuts made to bring in saline water for shrimp cultivation.

During the reconnaissance and condition survey prior to the April 1991 cyclone the Consultant has monitored the status of the existing embankments and hydraulics structures at different polders.

The cross sectional areas and crest levels of the embankments have been compared to those of the original design and the result can be found in Appendix B to the present study report.

2.2.2 Situation After the April 1991 Cyclone

The devastating cyclone and tidal surge hitting Bangladesh on 29 April 1992 caused considerable damages and destructions to the infrastructures of almost all the polders in South-Eastern Region.

The death figure according to Government source is 138,000. More than 10 million people of 102 upazillas of Chittagong, Cox's Bazar and Noakhali areas were badly affected.

The cyclone caused massive damage to the already weakened coastal embankments in Chittagong and Cox's Bazar districts. Some 470 Km of embankments were destroyed or seriously damaged, exposing about 72,000 ha aman paddy land to salt water intrusion. The industries at Patenga and salt and shrimp producing fields in Cox's Bazar were severely damaged too.

Immediately after the cyclone struck it was decided to advance the first year construction program for CPP-II to 1991/92 instead of 1992/93 as planned originally. The Consultant was directed to immediately prepare a plan and engineering documentation for an emergency reconstruction programme.

The Mid Term Programme therefore now comprises of two elements - the Emergency Cyclone Protection Project and the Mid Term Programme - Phase 2.

2.3 Project Features and Components

The final delineation of the study area has been established through a screening process comprising :

- Field reconnaissances of sea facing embankments and polders to assess their exposure to waves and cyclonic surges.
- Review of BWDB damage reports on seafacing polders.
- Consultations with senior engineers of the BWDB.
- Consultation with other project organizations with a view of excluding polders covered by other studies and projects.

On this basis a number of polders has been identified for inclusion in the study of the Mid Term Programme.

2.3.1 Main Components

The project consists of the following main components

- Repair and strengthening of existing embankments by resectioning.
- Construction of new embankments in retired alignments.
- Protective works.
- Hydraulic structures.
- Afforestation.

2.3.2 Resectioning of Existing Embankments

Resectioning means repair and strengthening of existing embankments that will be kept in their present alignment.
These are embankments on non-eroding coasts and on eroding coasts where retirement is not possible due to intensive habitation or highly valuable hinterland.

A grand total of 303 km of embankments are proposed for resectioning. Out of this 135 km are to be resectioned under the Emergency Cyclone Protection Project and 168 km are to be resectioned under Phase 2 of the Mid Term Programme. The total volume of earth involved is estimated to 12.9 million m^3.

The location of the individual sections is shown in Table 2.1 and Table 2.2 below. Reference is furthermore given to the polder maps included in Annex XII.

The sea facing embankments will generally be resectioned to an outer slope 1:7 and inner slope 1:3. The crest width will be 4.3 m as in the original CEP design.

The design crest level for the sea facing embankments is varying between 6.0 m and 8.5 m (Patenga). During the construction 0.1 m overheight will be provided to cover for long term settlements in the sub-soil.

A typical cross section is included in Annex II.

The embankments will be earth embankments with a clay cover layer of 1.0 m thickness on the outer slope and 0.6 m thickness on the inner slope. This layer will be compacted to minimum 90% Standard Proctor. Core materials will be compacted to minimum 80 % Standard Proctor.

2.3.3 New Embankments in Retired Alignments

New embankments in retired alignments are proposed on eroding coasts where ever possible.

A grand total of 100 km of embankments are proposed for construction in retired positions. Out of this 54 km are to be constructed under the Emergency Cyclone Protection Project and 46 km are to be constructed under Phase 2 of the Mid Term Programme. The total volume of earth involved is estimated to 7.8 million m^3.

The location of the individual sections is shown in Table 2.1 and Table 2.2 below and reference is furthermore given to the polder maps included in Annex XII.

The sea facing embankments will generally be constructed with an outer slope 1:7 and inner slope 1:3. The crest width will be 4.3 m.

The design crest level for the sea facing embankments is varying between 6.0 m and 8.5 m (Patenga). During the construction 0.2 m overheight will be provided to cover for long term settlements in the sub-soil.

A typical cross section is included in Annex II.

The embankments will be earth embankments with a clay cover layer of 1.0 m thickness on the outer slope and 0.6 m thickness on the inner slope. This layer will be compacted to minimum 90% Standard Proctor. Core materials will be compacted to minimum 80 % Standard Proctor.

Further details can be found in Annex II to the present report and in Appendix C.

2.3.4 Protective Works

Resectioned embankments on eroding coasts (Patenga, Anowara, Sandwip and Kutubdia) will be protected against wave erosion at the seaward toe by construction of an revetment consisting of stones or precast concrete blocks in random placement.

A total of 5.9 km embankment under the Emergency Cyclone Protection Project is proposed for protection by this type of revetment.

A typical cross section is included in Annex II to the present report.

It is further proposed that the river side slope on 4.3 km of the river embankment of polder 35/1 Sharankhola (under the Phase 2 of the Mid Term Programme) be protected by hollow concrete blocks serving as an reinforcement of the grass cover.

A concrete sea-wall has been designed to protect the Naval Academy against flooding. The sea-wall has a total length of 1,400 m.

Further details can be found in Annex II to the present report and in Appendix C.

2.3.5 Hydraulic Structures

On the basis of condition surveys and field investigations the Consultants have determined the need for 48 Nos of new hydraulic structures (drainage sluices and surface sluices) in 14 polders and identified 28 Nos of existing sluices needing repair in 7 polders. The number of structures proposed in the individual polders is shown in Tables 2.1 and 2.2 below. Location and ventages of these structures are presented in Annex II.

Analyses of hydrological and topographical data and simulation for ventage requirement of each new drainage structure are described in Volume 2, Annex II.

2.3.6 Afforestation

Time has proven that in the Coastal Embankment Project area, afforestation provides a very efficient protection to the embankments against damages by high tidal waves and cyclonic surges. Afforestation absorbs and dissipates the wave energy and reduces the level of the tidal surge.

Realizing the importance of coastal afforestation for the consolidation of newly accereted land, Bangladesh Forestry Department has undertaken afforestation projects with mangrove species for some coastal areas of Bangladesh. There are, however, many other areas in the coastal region where afforestation could be established to protect the embankments and reduce erosion from waves.

The Consultant has made a survey of all the polders under the Mid Term Programme to study the existing afforestation and determine the need for further afforestation. On this basis an afforestation programme covering about 700 Km embankment with foreland has been proposed, refer Annex VI and Appendix H - Afforestation.

Implementation of afforestation schemes would require close co-ordination and cooperation between the Forestry Department and the Water Development Board.

POLDER NO	CHAINAGE	EMBANKMENT WORKS		PROTECTIVE WORKS		STRUCTURES	
		RESECTION (KM)	NEW RETIRED (KM)	REPAIR (KM)	NEW (KM)	NEW (NO.)	REPAIR (NO.)
61/1 SITAKUNDA	1-2.6 0.5E-2.11E R2.11E-R4.98E	1.6 1.6	2.9			2	1
62 PATENGA	0-1.3 Nav. Academy R1.98-R5.485 5.55-22.2	1.3 16.7	3.6	1.4	3.6	9	
63/1A ANOWARA	28.5-33.98 R33.98-R37.04 36.8-38.1 R38.31-R42.02 41.8-43.0	5.5 1.3 1.2	3.0 3.7		1.6		1
64/1A BANSKHALI	81.0-83.25 R83.25-R90.11 90.7-100.5 R100.4-R107.82	2.2 9.8	6.8 7.4			1	1
64/1C CHANUA	11.0-21.0	10.0					
64/2B CHOKORIA	10.8-14.2 116.8-126.8 104.0-107.0	3.4 10.0 3.0					
66/3 COX'S BAZAR	R44.3-R45.9 46.3-49.3	 3.0	1.6			1	
69 MOHESKHALI	0-12.9	12.9				4	
71 KUTUBDIA	0-11.7 R11.7-R23.8 R23.8-R24.6 R24.6-R25.1 R25.1-28.5 "28.5-41.0" 41.0-50.0	11.7 0.8 3.4 1.3 9.0	12.1 0.5		0.80	5	3
72 SANDWIP	R8.4-R21.25 20.9-46.5	 25.6	12.5			5	18
	TOTAL	135.1	54.4	1.4	5.90	27	24

Table 2.1 : Emergency Cyclone Protection Project, Summary of Works.

POLDER NO.	CHAINAGE	EMBANKMENT WORKS		PROTECTIVE WORKS		STRUCTURES (NO.)	
		RESECTION (KM)	NEW RE-TIRED (KM)	REPAIR (KM)	NEW (KM)	NEW	REPAIR
35/1 SHARANKHOLA	1.6-4.1 6.3-8.1	2.5 1.8		1.8	2.5	1	
40/2 PATHERGATA	10.0-15.0 & 18.5-23	9.5					
48 KALAPARA	26.0-35.0	9.0					
56/57 BHOLA	63.7-67.5 67.5-76.0 76.0-80.5 80.5-126	3.8 45.5	8.5 4.5			1	
59/2 RAMGATI	121-124.0 124-126.5 126.5-135.0	3.0 8.5	2.5			2	
59/3B SUDHARAM	19.5-42.0 60.8-69.8	22.5 9.0	0.5			9	
59/3C COMPANIGANJ	11.0-14.0 14.0-21.0 21.0-27.0	7.0	3.0 6.0			5	
60 SONAGAZI	15.0-21.0 & 25.0-27.0	8.0					3
66/1 COX'S BAZAR	0-5.0	5.0					1
68 TEKNAF	11.4-16.4 16.4-18.3 18.3-23.5 23.5-28.4	5.0 5.2	1.9 4.9			1	
70 MATHERBARI	0-6.5 "6.5-26.0"	6.5	2.5			2	
72 SANDWIP	0-3.0 3.0-8.5 46.0-51.0 51.0-52.5 52.5-57.5 57.5-58.7 58.7-59.5 59.5-60.2	5.5 5.0 5.0 0.7	3.0 1.5 1.2 0.8		0.8 0.7		
73/1B HATIA	51.5-56.5		5.0				
TOTAL		168.0	45.8	1.8	4.0	21	4

Table 2.2 : Mid Term Programme, Phase 2, Summary of Works.

2.4 Project Area

The present study covers the coastal area of Bangladesh which is directly exposed to the cyclones and storm surges generated in the Bay of Bengal.

The area under Cyclone Protection Project-II is shown on the base map (Figure 2.1).

2.4.1 Location

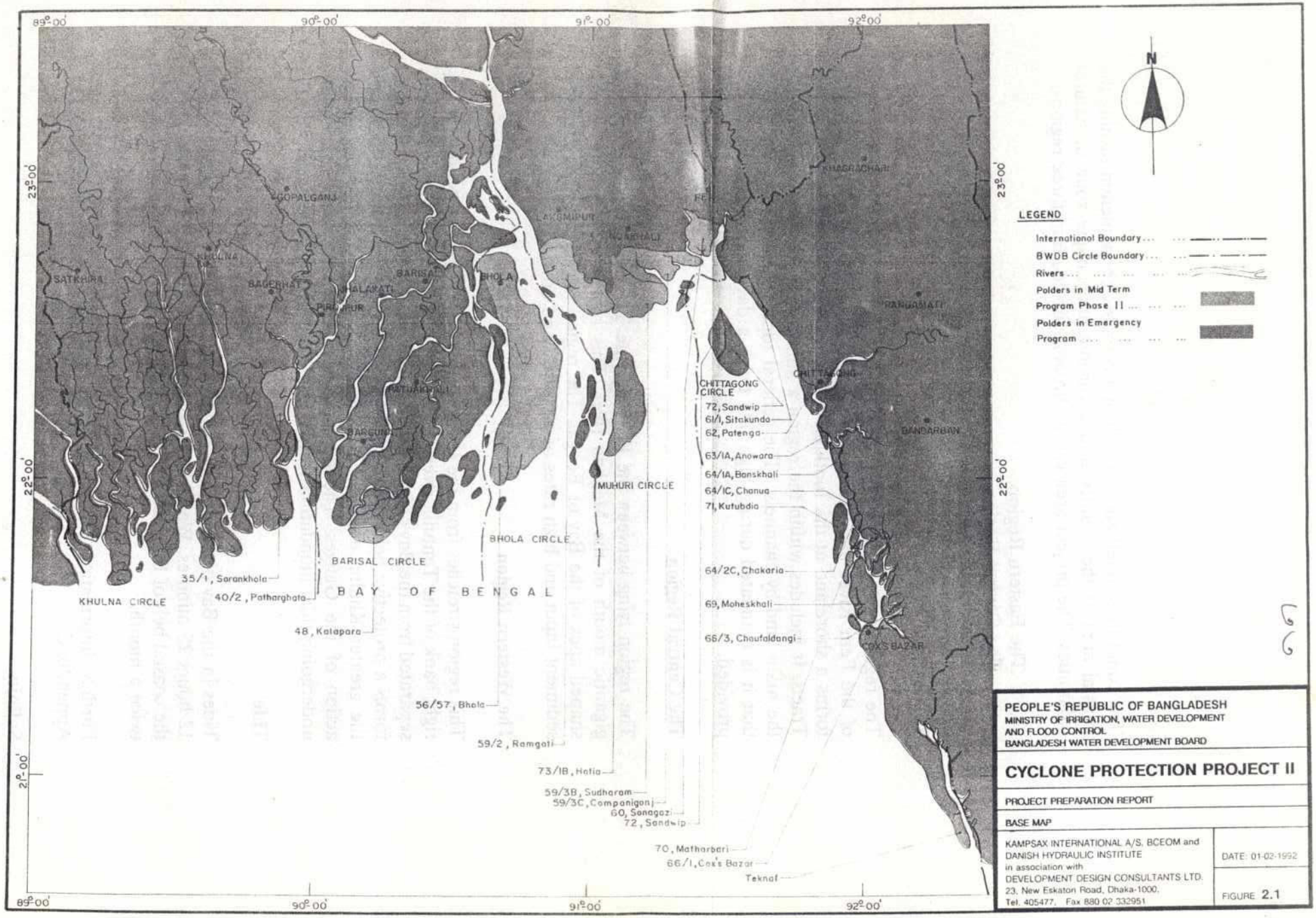
The project area is located between the east longitudes 89°-0′ and 92°-30′ and between the North latitudes of 21°-0′ and 22°-30′. The Polders covered by this study are spread over the coastal belt of Bangladesh from Satkhira to Teknaf. These polders are within the jurisdiction of 9 BWDB working divisions and are presented below:

Polder - 35/1	(Bagerhat O&M Division)
Polder - 40/2	(Barguna O&M Division)
Polder - 48	(Patuakhali O&M Division)
Polder - 56/57	(Bhola O&M Division-I)
Polder - 59/2	(Laximpur O&M Division)
Polder - 59/3B,59/3C,60 and 73/1B	(Noakhali O&M Division)
Polder - 61/1 and 62	(Chittagong O&M Division-I)
Polder - 63/1A,64/1A,64/1C and 72	(Chittagong O&M Division-II)
Polder - 64/2B,66/1,66/3,68,69,70 and 71	(Cox's Bazar O&M Division)

2.4.2 Physical Characteristics

The area under CPP-II representing the coastal belt of Bangladesh is on the outfall of the Ganges, Brahmaputra and Meghna rivers which constitute one of the largest river-systems in the world. The majority of the area lies within the delta of this river system and has been formed by sedimentary deposits in recent geological time. The system annually carries a sediment load of 1.5 to 2.4 billion Ton. This sediment load being interacted by wave and tide leads to regular accretion and erosion in the coastal area. The morphology of the coastal area is characterized by the following:

- A vast network of rivers.
- High discharge flow-condition.
- Heavy load of sediment both as suspension and as bed transport.
- Very active process of accretion and erosion on islands between the channels.
- The depth, configuration and situation of the Bay of Bengal altogether forming a funnel between the Indian Ocean and Bangladesh.
- Strong tidal and wind actions.
- Tropical cyclones being quite frequent.



PEOPLE'S REPUBLIC OF BANGLADESH
MINISTRY OF IRRIGATION, WATER DEVELOPMENT AND FLOOD CONTROL
BANGLADESH WATER DEVELOPMENT BOARD

CYCLONE PROTECTION PROJECT II

PROJECT PREPARATION REPORT

BASE MAP

KAMPSAX INTERNATIONAL A/S, BCEOM and DANISH HYDRAULIC INSTITUTE
in association with
DEVELOPMENT DESIGN CONSULTANTS LTD.
23, New Eskaton Road, Dhaka-1000.
Tel. 405477, Fax 880 02 332951

DATE: 01-02-1992

FIGURE 2.1

The conditions stated above result in a complex phenomenon turning the coastal area of the country into a chronic and unique zone of natural calamities. The project area can be broadly divided into three regions:

- The Eastern Region.
- The Central Region.
- The Western Region.

The Eastern Region

The region having a coastline of 250 km length starts from the left bank of the Feni River and extends upto the Badar Mokam at the south. It forms a shoreland at the foothills of Chittagong and North Arakan Hill Tracts. It includes within the region a number of islands separated from the main land by channels. The general topography of the area is such that it is inundated during high tide twice a day where no protection is provided.

The Central Region

The region lying between the Feni and the Tentulia rivers includes the gigantic mouth of the Meghna river. This region includes the funnel-shaped apex of the Bay of Bengal. The region is characterized by heavy sediment input and high rates of accretion and erosion.

The Western Region

This region stretches from the Indian border river, the Haribhanga to the right bank of the Tentulia river. Most of the coastal area in this region is separated from the Bay of Bengal by "Sundarbans" (Swamp forests) which forms a protective belt from 40 to 60 km wide along the southern part of the greater Khulna district. The area is entirely formed by the deltaic action of the Ganges. The topography of the area is alluvium plain undergoing tidal inundation twice a day, where it is unprotected.

Tide

Tides in the Bay of Bengal are semi-diurnal and the normal tide cycle is 12 hours 25 minutes. Water levels rise and fall with the tides throughout the coastal belt of Bangladesh. Spring tide and neap tide occur alternately twice a month.

Further information on water levels are included in Annex II and Appendix C.

Salinity

Saline water from the Bay of Bengal is transported throughout the project area by tidal flows following a fairly uniform pattern. The incursion is

influenced principally by the extent to which flows of the Ganges, Brahmaputra and Meghna rivers enter a particular channel.

2.4.3 Climatic Conditions

The Cyclone Protection Project II area is within the tropical zone. There are distinct seasonal weather patterns that are governed by the monsoons. These may be generally categorized as follows:

Dry season from November to April. Rainfall is infrequent under the influence of the dry air carried in from the northwest. Temperatures may rise above 38°C in April. Humidity gradually decreases during this season, reaching a minimum of 60 to 70 per cent in March and April.

Wet season from June to September. This season is characterized by heavy rainfall under the influence of the southeast monsoon with 75 per cent of the annual total occurring in this period. Storms are usually of several days duration and rainfall is steady at moderate rates. Mean temperature is 27°C and humidity averages about 85 per cent.

Transition periods during May and October. The months of May and October are characterized by violent, short-duration thunderstorms over the land masses and severe cyclonic storms generated in the Bay of Bengal. Nearly 80 per cent of the cyclonic storms that strike the coastal area occur during these two months.

Climatological factors of the representative stations of the area are included in Annex II.

2.4.4 Population

Literacy and Education

Literacy rates for population of 5 years and above in the study upazilas are generally lower than Bangladesh average. Literacy rates for male, female and both sexes range higher in the South-West compared to the other two regions. Highest literacy rates are in Patharghata having 39.3%, 44.5% and 33.1% for both sexes, male and females respectively against the Bangladesh average of 23.8%, 31.0% and 16.0%. The lowest literacy rates are in Teknaf with 8.8% 13.9% and 3.3% respectively.

Structure of Land Holdings

The proportion of area operated by small farms is lowest in the South-West region and highest in the South-East region.

In Noakhali and Patuakhali Regions 37% of all rural households are entirely without arable land. Another 27.6% own up to merely 0.5 acres of land, an area by far too insufficient to generate enough income for a family.

Generally speaking 50% of the households in the project area can be regarded as functionally landless as they own less than 0.5 acres each.

Land Tenurial Aspects

There is an active land leasing market in the project area of Patuakhali.

Land lease takes place in two forms: Share-cropping and cash leasing. The share-cropping in Patuakhali is in kind like elsewhere in Bangladesh, but share varies between cropping seasons. One season (aus) the landowners receive two thirds of the produce and tenants receive one third. For the aman harvest landowners receive three fourths and the tenant one fourth. Input costs are normally borne by the tenants.

Cash leasing takes two forms: leasing for one year and leasing for several years. For one year leases the normal rate is Tk. 2,500-3,000 per acre and seven years leases vary from Tk. 9,000-12,000 per acre.

Labour Market

Labour is hired on a permanent basis (one year contracts) or on daily basis in Patuakhali. Permanent labourers receive 20 maunds of paddy or the equivalent in money per year and new clothes yearly. Old and young/child labourers receive less. All permanent labourers receive 3 meals daily. Day labourers also receive food, 2 meals and about twenty-five take during the peak season, and 15 taka during the slack season.

During the peak season of the harvest, workers in the project area may get as much as 50 takas per day, because work has to be completed within a very limited time, before fields get flooded again. Some go to work in the low lying areas where there are no permanent settlements and get paid in kind according to the amount of work they do. After four weeks of work they may bring home 8-10 maunds of rice, which is equivalent to Tk. 1,600-2,000.

2.4.5 Agricultural and Socio-economic Characteristics

The study polders are located in three major agro-ecological zones roughly corresponding to 3 study regions: South-West, Central and South-East. These regions have by the large distinct agricultural, physical and socio-economical characteristics.

The study polders are inhabited by an estimated number of 3 million people having 528,900 households. Of these, about 30% are non-farmers and 70% are farmers.The portion of non-farm holdings is generally lower in the South-West region compared to the other two regions.

Agriculture is an important sector in the Bangladeshi national economy, providing half of the nations GDP and 40% of its export earnings as well as providing employment to 60% of the population. However, agricultural productivity is low in the coastal belt. This is due to salinity problems, poor communication, service and credit facilities. These constraints are

compounded by natural calamities, such as cyclones, storm surges and floods, which can cause devastating damage to property, crops, livestock as well as human lives.

Coastal embankments have been constructed in the endeavour to protect the low lying land along the coastal belt from intrusion and inundation by saline waters and thereby increase cultivable land, cropping intensity and yields.

Land Use

Of the total gross area of 4.01 lakh ha., 3.12 lakh ha. (78% of the gross area) is cultivated. The rest is utilized for homesteads, markets, schools roads, embankments, water bodies etc.

The main crop for the area is the Aman rice of which the local variety of transplanted Aman is by far the most dominant. Lack of sufficient irrigation water and high salt contents in the soils inhibits the utilisation of the soils during the dry season. Where cutivation is possible, due to sufficient residual moisture or irrigation facilities, vegetables, pulses chillis and to some extent wheat are grown.

Farming Practices

The Agricultural calender is divided into two principal seasons : the Kharif or pre-monsoon (Kharif I) and monsoon (Kharif II) period from March to November and the Rabi season which is the dry and cold period from November to March.

Aman rice varieties are the predominant crops during the Kharif season. Aus rice is planted in the premonsoon period and harvested in July. This crop is then immediately followed by the transplanted Aman rice.

Of the cultivated area 70% is single cropped, 27% is double cropped and only 0.3% is triple cropped. This means that the cropping intensity is 134% in the project area as compared to the national average of 150%.

Not only is the cropping intensity in the project area lower than the national average, but so are the average yeilds from the different crops grown. There are a wide range of reasons for the low productivity level of which the most important are listed below:

- High salinity levels in the soils, which inhibits plant growth
- Limited water resourses and inadequate management of the potential resources.
- Large land ownership, which leads to the lack of interest from the shareholder to invest in land improvement due to the shareholding system.

- Poor communication facilities hampering services such as extension, credit and marketing.
- Limited knowledge of improved technology by the farmers.
- Poor quality draught power due to poor management and lack of fodder.

Livestock Rearing

Rearing of livestock is undertaken by farm and non-farm households in varying degrees to provide nutritious animal products, augment family income and provide traction power.

Bovine animals are primarily for draught power, milk and meat purposes. Availability of bovine animals per 100 ha decreased with increase in farm sizes. Small farmers rear more of these animals mainly to supplement their meagre farm income as animals are less susceptible to damages/losses due to climatic hazards than crops.

The average number of bovine animal per 1000 population is 300. this figure reflects big differences varying from 464 in Kalapara and 145 in Sitakundu.

2.4.6 Industry and Infrastructure in Polder 62, Patenga

Major industrial activities

Chittagong has always been the principal port of Bangladesh. Therefore the major industrial activities have been located in this area.

Among the major industries should be mentioned Chittagong Steel Mill, General Electrical Manufacturing, Eastern Cable, Chittagong Cement Factory, Eastern Refinery and the Triple Super Phosphate Complex.

The annual turnover and value added for the major industries have been computed by a CIDA funded study in 1985. The study found that the annual turn over amounted to 10,835 million Taka and the value added to 3,600 million Taka, including the industries in EPZ. It is assumed that only minor changes in industrial production outside the EPZ have taken place since 1985.

The Bangladesh Export Processing Zone (EPZ)

The Export Processing Zone was established in 1983. The aim is to attract foreign investment and to create employment opportunities.

The Zone has been established in accordance with international well known principles such as tax holidays for 10 years, exemption of income taxes on borrowed capital, duty free import of machinery, duty free export of goods etc.

The export processing zone is competing with similar zones in other countries on conditions regarding local labour costs, stability etc.

The zone covers an area of 412 acres(167 ha) which is divided into plots of ½ an acre. The land is developed and the zone authority is leasing the land to the industries on a 30 years term with possibility for extension.

The industries are covering 3 different groups:

- Category A With 100% foreign investment,
- Category B Joint ventures and
- Category C 100% national owned.

As of October 1991 74 industries have been approved, out of which 39 are in operation in October 1991. The remaining ones are expected to commence production within 1992. There are presently employed 9,600 in the factories.

Due to the low labour cost industrial production of garments is a dominating activity. But other production which requires a relatively high labour input are also established in the Export Processing Zone.

When all the aforesaid industries are established the total value of the investment is expected to reach 473 million USD.

3. PROJECT COSTS

All cost figures are given in Bangladesh Taka - price level January 1992.

The total financial cost for the Mid Term programme is estimated to:

3,694 Million Taka, out of which

2,038 million Taka is for the Emergency Project and

1,656 million Taka is for the Mid Term Programme Phase 2

3.1 Construction and Engineering Costs

The costs of *construction* works have been estimated on basis of unit rates and quantities of work involved.

Unit rates have been based on BWDB's Standard Schedule of Rates 1989 adjusted to January 1992.

A major part of the construction costs are costs of earth works for embankment construction (approximately 70%) and a break down of the average unit rate is included in Annex II, section 2.5.

The quantities of earthwork is estimated on basis of engineering surveys carried out in 1990, i.e. prior to the April 1991 cyclone. Supplementary surveys after the cyclone has only been carried out in polder 62, Patenga. The effect of the cyclone on the embankments has been assessed on basis of aerial reconnaissance from helicopter.

The actual earth volume will be determined on basis of surveys to be carried out immediately prior to execution.

Physical contingencies has been included in the estimate by 15% of the total construction cost.

The *engineering* costs have been estimated as 5% of the total construction cost incl. physical contingencies. The engineering costs cover supervision during construction and detailed engineering of Phase 2 projects. The detailed engineering of the Emergency Projects has been part of the present study and the cost involved is not included in the economic analyses.

3.1.1 Emergency Cyclone Protection Project

The cost estimate for the Emergency Cyclone Protection Project has been based on Bill of Quantities prepared for tendering purposes.

	FINANCIAL COSTS IN MILLION TAKA							
	EM-BANK-MENT	PRO-TEC-TIVE WORKS	STRUC-TURES	SUB-TOTAL	CON-TIN-GEN-CIES 15%	TO-TAL CONS-TR.	ENG. COST 5%	TOT. CON + ENG
62 PATENGA	172.9	144.1	97.2	414.2	62.1	476.3	23.8	500.1
62 NAV. ACADEMY		88.1		88.1	13.2	101.3	5.1	106.4
61/1 SITAKUNDA	40.9		19.2	60.1	9.0	69.1	3.5	72.6
63/1A ANOWARA	86.5	48.3	0.6	135.4	20.3	155.7	7.8	163.5
64/1A BANSKHALI	192.6		13.2	205.8	30.9	236.7	11.8	248.5
64/1C CHANUA	60.4			60.4	9.1	69.5	3.5	73.0
64/2B CHOKORIA	109.1			109.1	16.4	125.5	6.3	131.8
66/3 COX'S B.	34.7		6.8	41.5	6.2	47.7	2.4	50.1
69 MOHESKHALI	69.6		25.0	94.6	14.2	108.8	5.4	114.2
71 KUTUBDIA	146.7	30.0	32.0	208.7	31.3	240.0	12.0	252.0
72 SANDWIP	131.5		72.2	203.8	30.6	234.4	11.7	246.1
TOTAL	1,045.0	310.5	266.2	1,621.7	243.3	1,865.0	93.3	1,958.3

Table 3.1: Cost Estimate Emergency Project. Construction and Engineering.

The average foreign currency component is estimated at 50 %. Break down is given in Annex II to the present report.

3.1.2 Mid Term Programme - Phase 2

The cost estimate for the Mid Term Programme Phase 2 has been based on preliminary design as prepared as part of the present study.

POLDER NO	FINANCIAL COST IN MILLION TAKA							
	EM-BANK-MENT	PRO-TEC-TIVE WORKS	STRUC-TURES	SUB-TOTAL	CON-TIN GEN. 15%	TOTAL CON-STR.	ENG. COST 5%	TOT. CON. + ENG.
35/1 SHARANKHOLA	10.0	25.0	12.0	47.0	7.1	54.1	2.7	56.8
40/2 PATHERGATA	48.3	0.0	0.0	48.3	7.2	55.5	2.8	58.3
48 KALAPARA	10.8	0.0	0.0	10.8	1.6	12.4	0.6	13.0
56/57 BHOLA	242.3	0.0	9.9	252.2	37.8	290.0	14.5	304.5
59/2 RAMGATI	50.8	0.0	11.7	62.5	9.4	71.9	3.6	75.5
59/3B SUDHARAM	125.1	0.0	104.5	229.6	34.4	264.0	13.2	277.2
59/3C COMPANIGANJ	109.8	0.0	85.8	195.6	29.3	224.9	11.2	236.1
60 SONAGAZI	31.7	0.0	0.6	32.3	4.8	37.1	1.9	39.0
66/1 COX'S BAZAR	26.6	0.0	0.3	26.9	4.0	30.9	1.5	32.4
68 TEKNAF	76.5	0.0	8.5	85.0	12.8	97.8	4.9	102.7
70 MATHERBARI	92.4	0.0	14.5	106.9	16.0	122.9	6.1	129.0
72 SANDWIP	113.6	84.0	0.0	197.6	29.6	227.2	11.4	238.6
73/1B HATIA	34.2	0.0	0.0	34.2	5.1	39.3	2.0	41.3
TOTAL	972.1	109.0	247.8	1,328.9	214.1	1,528.0	76.4	1,604.4

Table 3.2: Cost Estimate, Mid Term Programme - Phase 2 Construction and Engineering.

The average foreign currency component is estimated at 50 %. Break down is given in Annex II to the present report.

3.2 Land Acquisition Costs

The costs for acquisition of land is estimated as the physical quantity of land to be acquired multiplied by the net incremental production value per unit of land (FPCO Guidelines).

The area of land to be acquired for the embankments is the length of the embankment multiplied by the construction width at the toe plus 4.5 m (right of way). Land to be acquired for establishment of afforestation or for provision of borrow material has not been included.

The estimate for land acquisition includes 15% physical contingencies.

3.2.1 Emergency Cyclone Protection Project

POLDER	FINANCIAL COSTS IN MILLION TAKA				
	LAND ACQUISITION COST	CONTIN-GENCIES 15%	TOTAL L. A. COST	CONSTR. AND ENG. COST	TOTAL FINANCIAL COST
62 PATENGA	3.25	0.5	3.8	500.1	503.9
62 NAV. ACADEMY	0.0	0.0	0.0	106.4	106.4
61/1 SITAKUNDA	2.7	0.4	3.1	72.6	75.7
63/1A ANOWARA	7.4	1.1	8.5	163.5	172.0
64/1A BANSKHALI	15.6	2.3	17.9	248.5	266.4
64/1C CHANUA	0.0	0.0	0.0	73.0	73.0
64/2B CHOKORIA	0.0	0.0	0.0	131.8	131.8
66/3 COX'S B.	5.5	0.8	6.3	50.1	56.4
69 MOHESKHALI	0.0	0.0	0.0	114.2	114.2
71 KUTUBDIA	21.1	3.2	24.3	252.0	276.3
72 SANDWIP	14.1	2.1	16.2	246.1	262.3
TOTAL	69.7	25.4	80.1	1,958.3	2,038.4

Table 3.3: Cost Estimate Emergency Project. Land Acquisition and Total Costs

3.2.1 Mid Term Programme - Phase 2

POLDER NO	FINANCIAL COST IN MILLION TAKA				
	LAND ACQUISI-TION COST	CONTINGENCIES 15%	TOTAL L. A. COSTS	CONSTRUC-TION AND ENGINEERING	TOTAL FINANCIAL COST
35/1 SHARANKHOLA	0.63	0.1	0.7	56.8	57.5
40/2 PATHERGATA	1.40	0.2	1.6	58.3	59.9
48 KALAPARA	0.96	0.1	1.1	13.0	14.1
56/57 BHOLA	11.16	1.7	12.9	304.5	317.4
59/2 RAMGATI	2.36	0.4	2.8	75.5	78.3
59/3B SUDHARAM	5.20	0.8	6.0	277.2	283.2
59/3C COMPANIGANJ	8.84	1.3	10.1	236.1	246.2
60 SONAGAZI	1.19	0.2	1.4	39.0	40.4
66/1 COX'S BAZAR	0.88	0.1	1.0	32.4	33.4
68 TEKNAF	4.33	0.6	4.9	102.7	107.6
70 MATHERBARI	3.39	0.5	3.9	129.0	132.9
72 SANDWIP	4.04	0.6	4.6	238.6	243.2
73/1B HATIA	0.12	0.0	0.1	41.3	41.4
TOTAL	44.5	~~21.6~~ 6·6	51.1	1,604.4	1,655.5

Table 3.4: Cost Estimate Mid Term Programme Phase 2. Land Acquisition and Total Costs

3.3 Operation and Maintenance Costs

The estimated maintenance costs are of two types as defined in Appendix F to the present report:

- Routine maintenance and
- Periodic maintenance

In addition the costs for repair of cyclone damages have been estimated.

The costs have been estimated on basis of an evaluation of the average yearly damages to the embankments and the maintenance requirements for hydraulic structures - see Appendix C to the present report. Establishment costs are included by 25% of the subtotal.

The total yearly budget for *routine and periodic maintenance* of embankments constructed under the Mid Term Programme is estimated to

38.3 million Taka

The yearly allocation for *repair of cyclone damages* is estimated to

65.0 million Taka

The grand total yearly budget of 103.3 million Taka corresponds to 2.9% of the total financial cost of the Mid Term Programme (3,592 million Taka).

The following average yearly maintenance costs per unit are estimated :

	EMBANKMENTS (Tk per km)	PROTECTIVE WORKS (Tk per km)	STRUCTURES (Tk per unit)
Routine and Periodic Maintenance	(403.3 km) 75,000	(10.2 km) 120,000	(79 nos.) 85,900
Repair of Cyclone Damages	(380.5 km) 150,000	(10.2 km) 580,000	(79 nos.) 25,000
Total	225,000	700,000	110,900

Table 3.5: Maintenance Costs, Average Unit Costs

3.4 Afforestation Costs

The cost estimate for establishing of afforestation on embankments and foreshores has been prepared on basis of unit costs and quantities as described in Appendix H to the present report.

The investment covers plantation and re-plantation up to two times plus maintenance during 3-5 years.

The cost includes physical contingencies 15% and establishment cost 15% of the subtotal.

The following total is arrived at for a total of 700 km afforestation:

145.8 million Taka

corresponding to Tk 210,000 per km.

4. PROJECT BENEFITS

4.1 Introduction

The project is by its nature a protective measure accruing benefits from several sources. The main source of valued benefits is agriculture. However, for certain polders the protective effect on infrastructure may also give a substantial contribution to the benefits.

The project will also contribute to saving of human lives, but no attempt will be made to put value at this saving due to the sensitive and complex nature of this subject.

4.2 Protection and Improvement of Agricultural Production

The agricultural sector contributes to 50% of GNP in Bangladesh. The development strategy has emphasized on encouraging agricultural production with the aim of Bangladesh becoming self sufficient in food supply.

Construction of new embankments or improvement of the existing ones has a recognized impact on agricultural production. The agricultural benefits come mainly from three sources:

- higher yield per ha due to protection against intrusion of saline water,
- increased cropping intensity,
- switching in cropping pattern towards a more extensive use of high yield varieties (HYV) of grains.

The embankments will protect the low lying land in the coastal area from intrusion of saline water during periods with high water levels caused by monsoon storms.

The embankments will also provide some protection against flooding caused by cyclone created surges. However, these benefits are of minor importance due to return periods of 10 and 20 years.

The intrusion of saline water has a serious impact on agricultural production. Not only does it decrease the yield for crops which are more or less tolerant to salinity but it also prevent farmers from cultivating higher yield varieties of rice because these crops are more vulnerable to salinity. In addition the salt content in the soil does prevent the farmers from cultivating crops during the dry season.

The benefits in terms of increased yield are based on farm budget analyses comparing the WithOut Project situation (WO) to the With Project situation (WP).

Since the project covers a widespread area with different agricultural conditions a categorization of the polders has been necessary. The polder have been divided into 6 categories according to agricultural characteristics such as soil salinity, cropping intensity and cropping pattern. For each category cropping pattern, cropping intensity and yield per ha have been determined both in the pre-project situation (WO) as well as the in post-project (WP) situation. For further details see Appendix D Agriculture and Fisheries.

Higher Yield. In general it is anticipated that in the WO situation agricultural production will decrease by 2% per year for 5 years due to intrusion of saline water.

For the polders which have irrigation systems a decrease of 4% per year for 5 years has been anticipated. It has further been assumed in the WP situation that yield for existing kind of crops will raise due to increased utilization of farm inputs like fertilizers and pesticides. This increase is estimated to be in the range of 5-10% depending on crop and region.

Increased Cropping Intensity. The average cropping intensity for all 7 categories is expected to increase from 134% to 152%. These figures cover very big variations between the areas.

Changed Cropping Pattern. In certain areas high yield varieties are already common due to the agricultural conditions. However, in the project polders high yield varieties are not grown because of the prevailing soil conditions of lowlands which are not protected from intrusion of sea water.

Protection against Cyclone Caused Losses. The above mentioned agricultural benefits will be achieved on a yearly basis. Apart from that damages caused by cyclones surges corresponding to return periods of 10 and 20 years have also been taking into account.

Other Agricultural Benefits. The embankments also provide protection of livestock in connection with cyclone surges. During the April 1991 cyclone approximately 30-40 percent of the livestock was lost. Official figures for e.g. Sandwip show that over 40 per cent of the livestock was lost. On the basis of this figure and other estimates the Consultant has assessed that a loss ratio of 30 per cent in a WO situation would be realistic.

4.3 Protection of Cultural Fisheries

Cultural fisheries comprises fish ponds as well as shrimp farming. During the last decade shrimp farming has been a major activity in the South East area. Fish rearing in ponds has also increased in recent years. In the absence of embankment the ponds and shrimp farms are subject the overflow during cyclonic surges.

Improving embankment and sluices will decrease losses in connection with cyclones. This was clearly demonstrated during the April 1991 cyclone in

absence of embankment the ponds and shrimp farms are subject the overflow during cyclonic surges.

Improving embankment and sluices will decrease losses in connection with cyclones. This was clearly demonstrated during the April 1991 cyclone in the Chittagong area.

On the basis of official damage reports it has been estimated that the loss is close to 130 million Taka. This amount has been taken into account when assessing the benefits corresponding to cyclones with a return period of 40 years. Effect in terms of increased shrimp farming activity has not been considered.

Regarding ponds fishery the losses caused by the 1991 cyclone have been difficult to assess due to lack of information regarding area with ponds on the specific polders.

Apart from the above, the destructive forces of the cyclone also affect regulators and other infrastructure components in connection with the shrimp farms.

Although a part of the devastation should be ascribed to the wind speed, the embankment will obviously contribute to save investment in shrimp farms. This is in particular applicable for cyclones with a return period of less than 40 years.

Taking the above into consideration it is clear that the benefits counted from cultural fisheries is estimated on the conservative side.

4.4 Protection of Property and Infrastructure

The benefits from improved protection against cyclone caused damages to houses and infrastructure are difficult to assess. However, on the basis of an official damage report prepared after the April 1991 cyclone some estimates have been made with regard to damages to property.

Houses. When assessing the damages to houses and cottages the damages caused by high wind speed should be excluded.

As a rough estimate it is anticipated that half of the damages to houses have been caused by the wind and not by the intrusion of water. The value of totally damaged houses has been assessed at 15,000 Taka per house. This low figure reflects the fact that it is mainly the poorest constructed houses which are subject to total damage by cyclones.

Infrastructure. Information regarding infrastructure has been difficult to analyze. Firstly damages to infrastructure are mainly registered upazilawise. Secondly, the records covers both roads, bridges, telephones and power supply jointly.

The Consultant considers that damages to telephones and power supply would mainly be caused by the high wind speed.

Regarding roads and bridges it has been difficult to identify damages which are geographical strictly related to the polders.

However, on the basis of maps and information from Local Government Engineering Bureau (LGEB) for some selected polders average damage costs for roads and culverts have been estimated. These estimates are fairly rough and should be considered as reasonable approximations in order to provide a figure for the damage cost of roads.

4.5 Protection of Salt Production

Salt production in Bangladesh takes place in the South Eastern part in the district of Chittagong. Salt production is vulnerable to intrusion of sea water mainly at the end of the production period, which coincides with the pre-monsoon period where cyclones occurs. This means that cyclones might destroy the production. This happened during the 1991 cyclone. The benefits from improved protection of salt production has been considered for the polders with salt production (66/3, 69, 70). The losses counted has been adjusted according to the seasonal risk.

4.6 Protection of Human Lives

When dealing with cyclones the question of saving human lives is a very important subject and it is one of the main objectives of the present project to protect human lives. However, valuing the saving of human lives is for obvious reason a rather sensitive and complex issue and no attempt has been made to evaluate savings of human lives in economic terms.

Thirty four (34) cyclones have been recorded since 1960. These cyclones have resulted in a total of more than 600,000 deaths and caused damage to agricultural production and physical infrastructure. The cyclones appear with different severity and many of them cause rather limited damages. The few severe cyclonic storms of hurricane intensity are accounting for 95 per cent of the deaths. Six (6) cyclones have each caused more than 10,000 deaths since 1960.

During the April 1991 cyclone over 100,000 people were killed in the project area. In table 4.1 is shown the number of people killed recorded polder by polder. It will be noted from table 4.1 that the polders of the project area were not equally exposed to cyclone damages. The South Eastern area was most exposed.

Construction of the embankment means a major contribution to protection of human lives. Although overtopping still can happen after construction of the new embankments the flooding of the polders will be delayed and reduced. The massive and sudden flooding which happened in connection with the April 1991 cyclone due to missing sections of the embankment or

breaches will not happen in a WP situation. In a similar WP situation a substantial part of the polder will be flooded for a period but the delay in the flooding will give time for the inhabitants to escape and move to more safe areas or cyclone shelters.

Polder		Gross Protected Area ha	Direct Protected Area ha	Net agricult Area ha	Population 1990	People Killed by 1991 Cyclone
61/1	Sitakunda	730	730	600	15,000	400
63/1A	Anowara	5,450	1,500	1,250	20,000	9,500
64/1A	Banskhali	12,700	4,700	4,300	55,000	34,000
66/3	Cox's Bazar	3,000	3,000	900	25,000	1,100
69	Moheskhali	2,800	2,800	1,400	15,000	2,000
70	Moheskhali	2,850	2,850	400	23,000	10,000
71	Kutubdia	5,450	5,450	4,400	80,000	19,100
72	Sandwip	18,700	18,700	15,000	295,000	23,100
73/2B	Hatia	1,600	1,600	1,400	10,000	500
64/1C	Chanua	3,000	1,500	1,200	13,500	8,000
64/2B	Chokoria	7,000	4,100	3,250	46,000	10,000
	Total	63,280	46,930	34,100	597,500	117,700

Table 4.1 : Registered losses of human lives due to the April 1991 cyclone.

4.7 Other Benefits

The benefits from several sources have been quantified in the paragraph above. Although not quantified in the present report, benefits from other sources should also be mentioned such as saving on emergency relief.

Emergency relief is usually launched with the aim of assisting the victims of the calamity. The need for relief can basically be split into two categories : Needs arising from damage due to the high wind speed and needs created by damage inflicted by the cyclonic surge. Embankments will afford little protection from high winds, however the construction of embankments will provide protection against cyclonic surge and will have a perceptable impact on the magnitude of the relief effort required for the population adversely affected by the surge. Although difficult to accurately quantity, such benefits should not be neglected.

5. ENVIRONMENTAL IMPACT ASSESSMENT

5.1 Introduction

In terms of environmental impact the Cyclone Protection Project II (CPP-II) is not a new project as it encompasses rehabilitation, strengthening and improvement of some 500 Km existing sea facing and similarly exposed coastal embankments and allied hydraulic structures.

These were originally planned and constructed in the 1960's and early 70's as part of the Coastal Embankment Project (CEP). The main purpose of CEP was the protection of approximately 14,000 Km^2 potentially fertile land against high tide intrusion of saline water and monsoon flooding in order to increase the agricultural production through increased crop yields.

The CEP embankments, of total length approximately 5,000 Km, with approximately 1,000 allied flood control and drainage structures, were constructed by GOB under USAID to rehabilitate and replace small seasonal dikes and embankments constructed since the 17th century by local effort around individual land separated by numerous tidal creeks and inlets under the Zamindari system until its abolishment in 1947.

5.2 Environmental Impacts of CEP

Although the general concept of embankments in the coastal tidal zone is old the environmental impacts experienced after the construction of the much bigger and more permanent CEP embankments have been numerous, complex and in some aspects negative.

Some of the most significant adverse environmental impacts of CEP have been increased siltation of rivers and channels leading to drainage congestion and reduction of natural fishing grounds, reduction of sediment deposit on protected land and subsequent long term reduction of soil fertility and lack of fresh water flooding during the monsoon season.

Among the subsequent adverse social impacts of CEP are increased social tensions due to conflicts of interests between agricultural farmers and shrimp farmers and inequitable distribution of benefits, hindrance to navigation and water borne transport due to closure of channels and loss of open freshwater capture fishery.

A closer study and assessment of most of these and other environmental impacts of the original Coastal Embankment Project is outside the scope of the present study and is largely covered by FAP 18 and other studies on the environmental impact of FCD/I projects in Bangladesh.

Besides increase of agricultural yields the single most significant benefit of CEP has been the reduction of the areas flooded and the depth of flooding caused by cyclone storm waves and surges and subsequent reduction of loss of lives and damages in the project area as experienced and reported after

a number of cyclones since construction of the CEP embankments.

5.3 Environmental Impacts of CPP-II

The main objective of CPP-II in to improve the protection against damages to lives and property caused by cyclonic storm surges in the most cyclone prone coastal areas and to sustain and improve the agricultural benefits derived from the original Coastal Embankment Project.

The environmental impacts of CPP-II are therefore limited and mostly positive.

The general environmental impacts of CPP-II are summarized in section 5.4 below.

The assessment of other environmental impacts of the project are presented in Annex VII under the following main headings:

- Impact on Agricultural Production
- Impact on Fishery
- Impact on Forestry
- Social Impact

5.4 General Environmental Impact of CPP-II

The rehabilitation, reconstruction and improvement of approximately 500 Km of the most exposed and vulnerable coastal embankments under CPP-II will have major beneficial effect by providing protection against future loss of lives and damages by cyclone storm surges and intrusion of saline water for:

- A total population of approximately 3.0 million
- More than 300,000 ha of cultivated land with an annual production of approximately 800 tons paddy
- Approximately 500,000 homesteads
- Approximately 800,000 livestocks
- Shrimp farms and fish ponds of the project area
- Infrastructures and industry of the area.

The protection will be provided by construction of continuous well compacted earthen embankments without any missing links or weak portions which may threaten the integrity of the embankments.

Further the CPP-II include a programme for afforestation of foreshore areas and embankment slopes in order to reduce erosion and damages by wind, waves and littoral drift and to restore a natural habitat for wildlife.

By comparison the adverse environmental impacts of CPP-II on the agriculture and the social impacts caused by land acquisition for new embankments are small and insignificant.

6. OPERATION AND MAINTENANCE

6.1 Introduction

The study being on feasibility study of coastal embankments has not been directly involved in polder operation and its O&M. This O&M report has to rely considerably on those studies aimed at improving O&M within the BWDB, and the prevailing BWDB O&M organisation and management.

This O&M report , as a consequence, should be considered as a contribution to the maintenance component of O&M in any future reviews of BWDB O&M.

For further details reference is made to Appendix F to the present report.

6.2 The Bangladesh Water Development Board (BWDB)

The Bangladesh Water Development Board is a semi-autonomous public agency under the administrative control of the Ministry of Irrigation, Water Development and Food Control (MIWDFC) and established in 1972. It employs about 18,000 staff, is managed by an appointed Chairman and five Board Members, and is responsible for planning, execution and O&M of FDC/I projects, along with river erosion control and town protection.

At present, BWDB maintains ownership of all FCD/I project assets through all phases of the project including operation. BWDB also has responsibility for O&M on FCD/FCDI projects.

6.2.1 BWDB O&M Organisation

An O&M organisational structure was established by the BWDB during the early 1980's, and an O&M member was appointed to the Board in 1983. This was followed in 1985 by the BWDB zones, headed by Chief Engineers, being placed under the control of the Member O&M, thus the field offices of BWDB because responsible formally for O&M, in addition Mechanical, Engineering Dredging and Food-For-Work are under the O&M Member.

Figure 6.1 shows the structure formed in 1985.

The basic zonal organisation consists of the following categories of personnel.

-	Zone	Chief Engineer	(SZ)
-	Circles	Superintending Engineers	(SE)
-	Divisions	Executive Engineers	(XEN)
-	Sub-divisions	Sub-divisional Engineers	(SDE)
		Section Officers	(SO)
		Works Assistants	(WA)

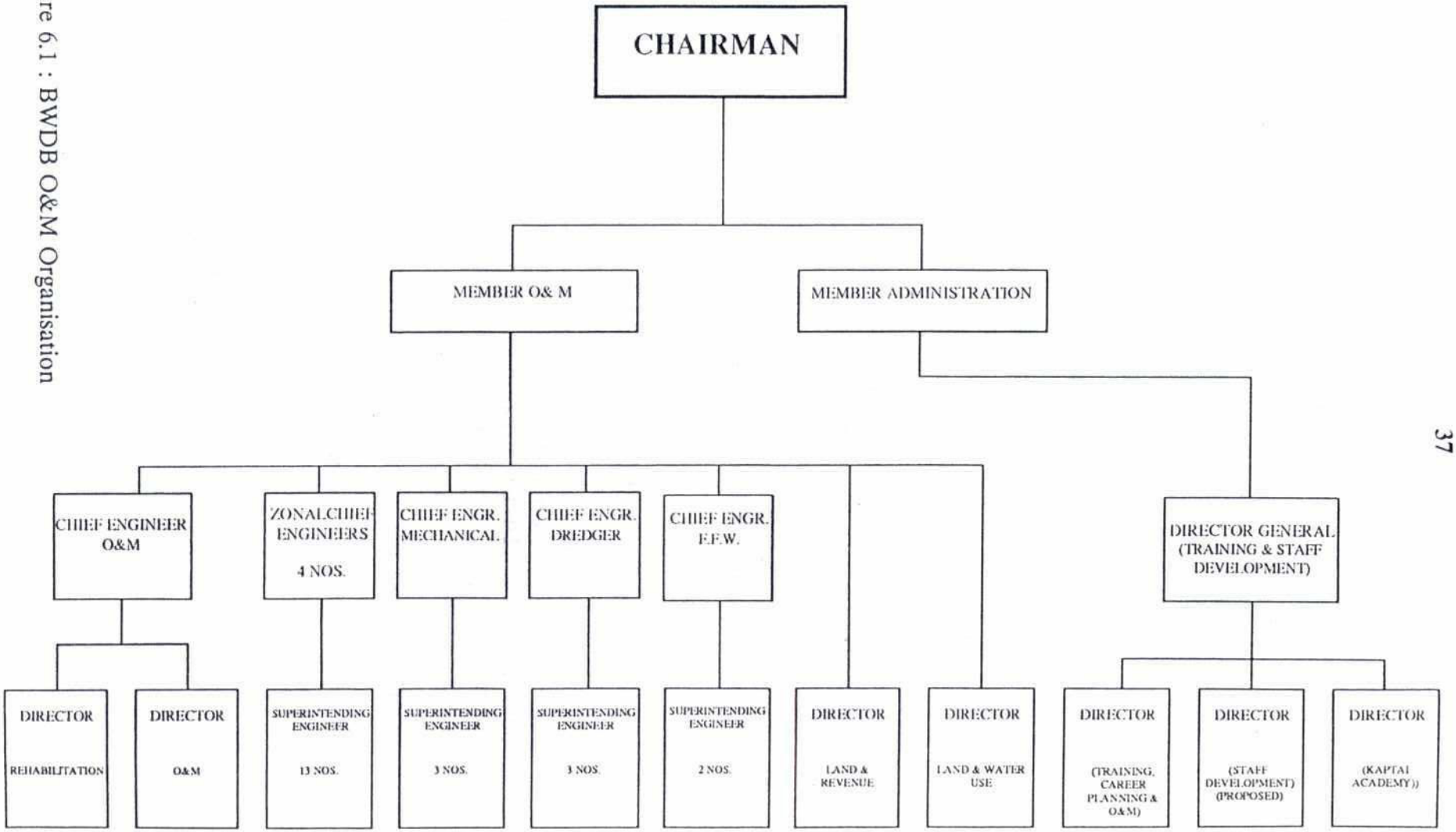
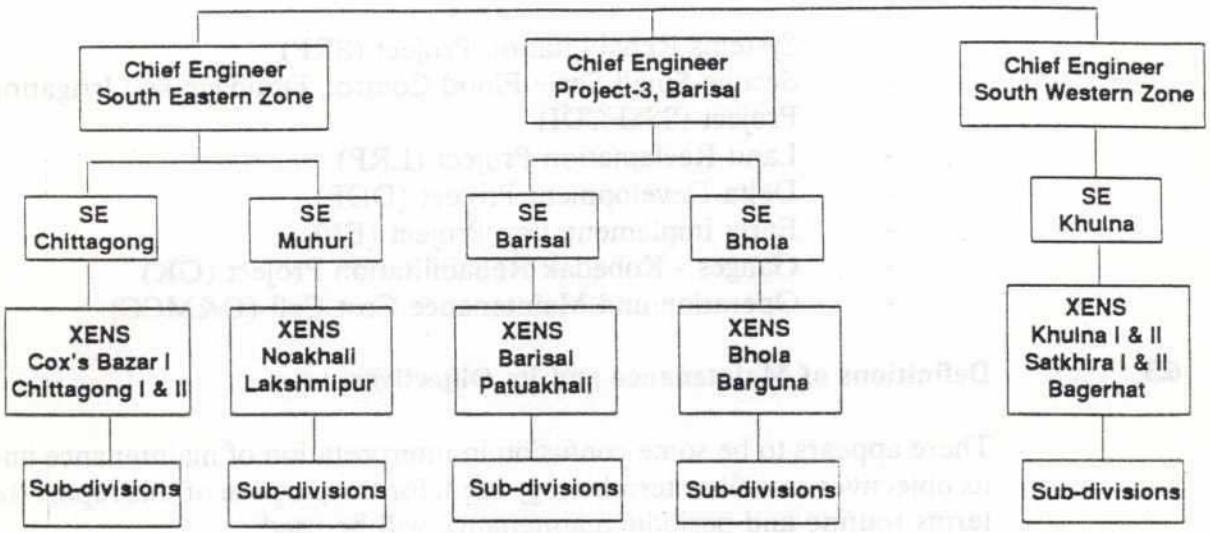


Figure 6.1 : BWDB O&M Organisation

The BWDB O&M organisation directly involved within the project area consists of :



6.2.2 O&M Problems

Review studies into the benefits achieved by FCD/I projects identified lack of O&M as a major constraint, the problems being identified as :

- Over emphasis on construction works to the detriment of O&M.
- Insufficient funding and non-optimized use of prevailing O&M funds
- Overstaffing and lack of motivation
- Inadequate budgeting and cost control
- Lack of training specifically aimed at O&M
- Unsuitable non standard production of O&M manuals
- Lack of beneficiary participation

This problem has caused such concern that O&M components have been included in a number of sub-projects within some externally aided projects or programmes. Furthermore, there are, projects, for example FCD/I rehabilitation systems which are specifically aimed at improving O&M and remedying the constraints on benefit achievement.

6.2.3 Projects Directed at Improving BWDB O&M are:

- Systems Rehabilitation Project (SRP)
- Second Small Scale Flood Control, Drainage and Irrigation Project (SSSFCDI)
- Land Reclamation Project (LRP)
- Delta Development Project (DDP)
- Early Implementation Project (EIP)
- Ganges - Kobadak Rehabilitation Project (GK)
- Operation and Maintenance Cost Cell (O&MCC)

6.3 Definitions of Maintenance and its Objectives

There appears to be some confusion in interpretation of maintenance and its objectives as well as terminology used, for the purpose of this report the terms routine and periodic maintenance will be used .

Definitions :

Maintenance (General)

The work required to maintain a structure in, as near as possible to, its original as constructed condition.

Routine Maintenance

The year round day to day work to repair defects caused by ordinary wear and tear.

Periodic Maintenance

The work required to repair defects which can be carried out only when climatic or physical conditions allow, or when routine maintenance alone is no longer sufficient to preserve the structures (embankments, protective works, water control structures, plantation, buildings and equipment).

Flood and Cyclone Damage

Major damage caused by floods and cyclones is not considered within the scope of normal maintenance resources (labour, materials, equipment and finance).

Maintenance Objectives

The objectives of maintenance are :

- To maintain the embankment and hydraulic structures in such a manner that polders can operate productively and safely.
- To protect the capital investment provided for the construction of the polders.

6.4 Participation by Local Bodies and Beneficiaries in Maintenance

Routine maintenance of embankments and hydraulic structures require labour intensive operations with little need for equipment. This type of work is very suitable for destitute women, landless or the needy.

The Consultant considers that the following alternatives require further consideration for routine maintenance; i). long term leasing of embankments to destitute women and landless ii) employment of destitute women for maintenance of embankments and iii). either long term leasing or honorarium for khalashi

i. Long term leasing would enable participants to become "beneficiaries" with a vested interest in preserving the condition of the embankment. However, participants must be instructed on the work activities required and given on the job training, also methods of cultivation and planting allowed should be specified in the terms of the lease. This method of maintenance would be at no cost to the BWDB with a resulting saving of O&M funds.

ii. Employment of destitute womens' groups on embankment routine maintenance would provide continuity of employment for the groups, with vested interest in preserving the condition of the embankment. Allocation of 0.5 km of embankment per woman has been proposed with a 6 hour 6 days working week at Tk. 25 per day including equipment amounting to Tk. 9125 per women for year round work or Tk. 18,250 per km embankment.

iii. Leasing of embankment plus hut in the immediate vicinity of hydraulic structures to a khalashi would provide similar benefits as described in i) or alternatively paying an honorarium to the khalashi would reduce present costs.

Periodic maintenance will require a mixture of i) labour intensive groups (e.g. repair of embankment slopes) and ii) specific skills groups which require skilled manpower, special materials and equipment and are not labour intensive.

The following alternatives should be given further consideration :

i. Labour Intensive Groups

Labour intensive groups, as in routine maintenance, could consist of destitute women or landless paid either on a daily rate or a negotiated lump sum basis. However groups already being used on routine maintenance should not be allocated to this work to the detriment of routine maintenance, rather other groups should be used. Alternatively the use of Landless Contracting Societies (LCS) as developed by EIP could be considered for this type of work.

ii. Specific Skills Groups

The groups require specialist tools and equipment but will only be required for relatively short periods of time, and the use of LCS should be considered for this type of work.

6.5 Basic O&M Maintenance System

Procedures for a basic O&M management system have been included in the O&M report refer Appendix F and could be considered as a contribution to any reviews of the BWDB O&M organisation & management. The basic elements of an O&M management system should consist of:

- A location reference system
- An inventory of O&M facilities
- An identification of work activities
- A system of inspection to identify defects
- Quantification of defects
- Preparation of a Annual Work Programme (based on need)
- Preparation of work activity methods and assessment of productivity
- An assessment of resources (manpower, plant/equipment and materials,) to complete the Annual Work Programme (need)
- Preparation of the Annual Work Schedule (need)
- Preparation of the Annual Work Budget (need)
- Review of Annual Work Programmes, schedules and budgets to comply with actual budget allocation
- Finalise Annual Work Programme, schedules and budgets related to actual allocated O&M funds
- Monitor work implementation
- Annual review.

6.6 O&M Planning

The present absence of clear definitions of O&M (in particular maintenance) and its objectives provides a severe restraint on the current planning of annual and long term O&M works.

Planning of annual maintenance work requires :

- A clear definition of maintenance and its objectives
- Description of the work activities involved
- Inspection to identify, locate and quantify the repair works necessary.
- Determination of work importance in priority order.
- Definition of work standards and output
- An assessment of the resources (manpower, materials & equipment) required to carry out the repair works.
- Preparation of work programmes and schedules.

The work programmes and schedules will form the basis for the preparation of the annual work budget in a logical and systematic manner.

6.7 Training

The establishment of an O&M Technical Unit (HQ), divided from new construction works, should provide the basis for the creation of a new career structure specifically or personnel who will be involved solely in O&M. This career structures will enable the BWDB to build up progressing an O&M organisation staffed by personnel experienced in O&M and motivated to attain the required objectives. Care of personnel for O&M is essential, poor quality staffing can result in the system failing or falling into disrepute.

The formation of a new O&M organisation should be accompanied by a planned training programme for the tasks required of each category of personnel from management through to work implementation. Planning of training should involve close co-operation between the O&M Technical Unit (HQ) and BWDB's Training Director.

6.8 Future Maintenance of Coastal Embankments and Structures

It is considered imperative that the future maintenance of the embankments and structures under the Mid Term Programme is started at the handing over of the completed works. During the construction period a detailed maintenance programme should be prepared with due consideration to experiences gained from ongoing projects, refer section 6.2.3 of this Chapter.

It is recommended that participation by local bodies and beneficiaries be further studied with a view to making such participation an integrated part of the future maintenance. The merits of establishing a separate body with particular responsibility for maintenance of coastal embankments and allied structures should be explored.

7. PROJECT RANKING AND JUSTIFICATION

7.1 Economic Analyses

The project period has been fixed at 30 years, which is in line with the guidelines issued by Flood Plan Coordination Organization (FPCO Guidelines).

The economic analyses are based on construction and maintenance costs as described in Chapter 3 and benefits derived from agriculture and other sources as described in Chapter 4 and Annex X. All costs and benefits used in the analyses are economic costs and prices.

The tables in the present chapter show financial costs only, covering construction, engineering and land acquisition.

The financial costs/prices have been converted to economic costs/prices in accordance with FPCO Guidelines. The following factors have been applied for the conversion:

i. Investment cost and Operation and Mainteance cost for embankments and hydraulic structures. Conversion factor 0.75 has been applied both for investment and maintenance on basis of a breakdown of the various costs.

ii. For Non-agricultural benefits, which mainly are related to houses and infrastructure, a conversion factor of 0.78 has been applied.

iii. For Agriculture Products a detailed estimation of economic prices has been conducted for each product, based on import prices.

For estimation of the annual costs of cyclone damages a 40 year return period has been assumed for a major cyclone of severity as the April 1991 cyclone. The cost of the damages related to this cyclone has been assessed on basis of official damage reports combined with the Consultant's own estimates as described in Chapter 4.

The average annual loss due to all cyclones throughout the project period has been computed on basis of the model 'Annual Cumulated Benefits' according to the FPCO Guidelines. An example is shown in Annex X.

The following indicators of economic viability has been tested:

- Economic Internal Rate of Return (EIRR)
- Net Present Value (NPV)
- Net Present Value Ratio (NPVR)

The Net Present Values have been discounted on basis of a rate of 12%, which reflects the opportunity cost of capital in Bangladesh.

The NPVR provides a measure of the relative utilisation of public investment in different projects.

7.2 Project Ranking List

On basis of the economic analyses performed as described above a project ranking list has been prepared including the projects in priority order according to the EIRR.

Polder	Name of Polder	Length of Embankment (km)	Investment Cost ** (Million Tk)	EIRR (%)	NPV (Million Tk)	NPVR
62*	Patenga, Excl. Nav. Academy	21.5	503.9	50.3	1410.0	3.17
62*	Patenga, Incl. Nav. Academy	21.5	610.3	43.0	1343.0	2.52
73/1B	Hatia	5.0	41.4	41.9	6.1	0.15
48	Kalapara	9.0	14.1	36.2	21.0	1.35
35/1	Sarankhola	4.3	57.5	30.4	58.2	1.23
60	Sunagazi	8.0	40.4	25.7	18.9	0.42
40/2	Patherghata	9.5	59.9	24.3	5.4	0.10
72*	Sandwip I	38.5	262.3	22.2	176.7	0.63
59/2	Ramgati	14.0	78.3	20.5	13.5	0.16
59/3B	Sudharam	32.0	283.2	17.5	-63.2	-0.14
72	Sandwip	22.7	243.2	16.8	113.0	0.75
59/3C	Companyganj	16.0	246.2	15.8	-32.2	-0.07
66/1	Cox's Bazar	5.0	33.4	15.4	-10.3	-0.29
66/3*	Cox's Bazar	4.6	56.4	14.6	8.6	0.16
56/57	Bhola	62.3	317.4	14.0	38.7	0.10
64/1A*	Banskhali	26.2	266.4	13.6	24.9	0.10
68	Teknaf	17.0	107.6	13.0	-53.3	-0.46
64/2B*	Chokoria	16.4	131.8	12.4	2.7	0.02
64/1C*	Chanua	10.0	73.0	10.4	-6.0	-0.08
69*	Moheskhali	12.9	114.2	8.7	-19.4	-0.17
70	Matharbari	9.0	132.9	6.8	-30.6	-0.25
71*	Kutubdia	38.8	276.3	6.8	-72.0	-0.25
61/1*	Sitakunda	6.1	75.7	6.0	-22.4	-0.31
63/1A*	Anowara	14.5	172.0	4.6	-59.7	-0.38

Table 7.1: Ranking List for Project under the Mid Term Programme

*) Projects under the Emergency Project
**) Total financial cost including construction, engineering and land acquisition.

7.3 Emergency Cyclone Protection Project

After the April 1991 cyclone the Consultant was requested to prepare an emergency project comprising those polders hit by the cyclone and that were left the most vulnerable to subsequent flooding from monsoon and cyclone surges.

The polders included in the emergency project are ranked in Table 7.2.

The EIRR for the complete Emergency Cyclone Project is 14.2 %.

However, a substantial part of the benefits are related to polder 62, Patenga. Excluding this polder from the calculation will lower the EIRR for the remaining part of the Emergency Programme to 11.0%.

It should be noted that protection of the Naval Academy in polder 62, Patenga was included in the list of projects under the emergency project at a very late stage and therefore no separate analysis has been made for this project. However, as a part of the protection of polder 62 Patenga it will be economically justified.

Polder	Name of Polder	Length of Embankment (km)	Investment Cost (Million Tk)	EIRR (%)	NPV (Million Tk)	NPV/K
62	Patenga, Excl. Nav. Academy	21.5	503.9	50.3	1410.0	3.17
62	Patenga, Incl. Nav. Academy	21.5	610.3	43.0	1343.0	2.52
72	Sandwip I	38.5	262.3	22.2	176.7	0.63
66/3	Cox's Bazar	4.6	56.4	14.6	8.6	0.16
64/1A	Banskhali	26.2	266.4	13.6	24.9	0.10
64/2B	Chokoria	16.4	131.8	12.4	2.7	0.02
64/1C	Chanua	10.0	73.0	10.4	-6.0	-0.08
69	Moheskhali	12.9	114.2	8.7	-19.4	-0.17
71	Kutubdia	38.8	276.3	6.8	-72.0	-0.25
61/1	Sitakunda	6.1	75.7	6.0	-22.4	-0.31
63/1A	Anowara	14.5	172.0	4.6	-59.7	-0.38

Table 7.2: Ranking of projects in Emergency Programme

7.4 Mid Term Programme - Phase 2

The remaining polders studied and analysed under the Mid Term Programme Phase 2 are presented in priority order in Table 7.3.

The EIRR for the complete Phase 2 of the Mid Term Programme is 21.4%.

Polder	Name of Polder	Length of Embankment (km)	Investment Cost (Million Tk)	EIRR (%)	NPV (Million Tk)	NPVR
73/1B	Hatia	5.0	41.4	41.9	105.8	2.54
48	Kalapara	9.0	14.1	36.2	46.0	2.91
35/1	Sarankhola	4.3	57.5	30.4	89.1	1.33
60	Sunagazi	8.0	40.4	25.7	62.0	1.35
40/2	Patherghata	9.5	59.9	24.3	68.4	1.27
59/2	Ramgati	14.0	78.3	20.5	43.4	0.50
59/3B	Sudharam	32.0	283.2	17.5	97.9	0.34
72	Sandwip	22.7	243.2	16.8	72.3	0.31
59/3C	Companyganj	16.0	246.2	15.8	56.4	0.24
66/1	Cox's Bazar	5.0	33.4	15.4	9.5	0.27
56/57	Bhola	62.3	317.4	14.0	38.7	0.10
68	Teknaf	17.0	107.6	13.0	6.2	0.05
70	Matharbari	9.0	132.9	6.8	-34.6	-0.28

Table 7.3: Ranking List for Project under The Mid-Term Programme Phase 2.

7.5 Sensitivity and Risks

Sensitivity

The sensitivity of the EIRR to possible changes in the key parameters has been tested by :

- Increase of Investment Cost and O&M
- Reduction of total Project Benefits
- Reduction of Agricultural Benefits
- Reduction of Non-agricultural Benefits

The test based on switching value shows the required percentage change in order to reach an EIRR of 12%.

The results are shown in Table 7.4.

Polder	Name of Polder	EIRR (%)	Increase Invest. + O & M Cost (%)	Reducti-on of Benefits (%)	Reduction of Agricult. Benefits (%)	Reducti-on of Non-Agricult. Benefits (%)
62*	Patenga, Excl. Nav. Acade-my	50.3	446	81		82
62*	Patenga, Incl. Nav. Academy	43.0	351	77		78
73/1B	Hatia	41.9	254	77	88	
48	Kalapara	29.5	265	73	>100	
35/1	Sarankhola	30.8	178	64	80	
60	Sunagazi	25.7	109	52	76	
40/2	Patherghata	24.3	102	50	62	
72*	Sandwip I	22.2	78	44	52	
59/2	Ramgati	20.9	25	20	30	
59/3B	Sudharam	17.5	9	8	9	
72	Sandwip	16.8	31	29	35	
59/3C	Company-ganj	15.8	-1	1		
66/1	Cox's Bazar	15.4	27	26	38	
66/3*	Cox's Bazar	14.6	21	12	34	
56/57	Bhola	14.0	15	13	16	
64/1A*	Banskhali	13.6	13	11	19	
68	Teknaf	13.0	6	7	9	
64/2B*	Chokoria	12.4	3	3	3	
64/1C*	Chanua	10.4	-11			
69*	Moheskhali	8.7	-22			
70	Matharbari	6.8	-28			
71*	Kutubdia	6.8	-33			
61/1*	Sitakunda	6.0	-27			
63/1A*	Anowara	4.6	-47			

Table 7.4 : Sensitivity Analysis Non-applicable

Risks

Lack of proper maintenance represents the major risk to the project.

It is essential that minor damages be repaired on a regular basis in order to secure that the embankments are in good shape when a cyclone hits.

The history of the CEP embankments show that that lack of funding hampers the maintenance procedures. Repair of cyclone damages cannot be done on a regular basis and it is of vital importance for the future embankment management that the funds also are reserved for this purpose, as suggested by the Consultant.

Delays in implementation of the project, owing to delays in the preparation activities, will result in further damage to the embankments and will result in increased construction costs.

7.6 Project Justification

The economic analysis has been carried out on the basis of the direct economic benefits only and, value of saved human lives has not been taken into account. The economic benefits included in the analyses therefore only represent a part of the total benefits.

It is one of the main objectives of the Cyclone Protection Project II to improve the protection of human lives against cyclonic storm surges and the polders under the Mid Term Programme have been selected with a view to this objective. All of these polders have thus been selected from cyclone prone areas and the actual embankment condition make them very vulnerable to cyclonic storm surges.

It can be seen that 17 of the 23 projects covered by the Mid Term Programme show an EIRR above 12%. The cost of these projects amounts to 4.850 million Taka representing 77% of the proposed investment programme.

For the Mid-Term Programme Phase 2, the average EIRR is 21.4 percent. Some 12 projects out of 13 yield an EIRR of 12 percent or more.

The total population of the polders covered by the Mid Term Programme exceeds 1.3 million.

Table 7.5 shows the polders in ranking order by EIRR with total population and investment per inhabitant. It can be noted that the ranking by EIRR and by investment per inhabitant do not fully correspond.

Polder	Name of Polder	Investment Cost (Million Tk)	EIRR (%)	Population (Nos.)	Investment per inhabitant (Taka)
62	Patenga, Excl. Nav. Academy	503.9	50.3	47,000	10,700
62	Patenga, Incl. Nav. Academy	610.3	43.0	47,000	13,000
72	Sandwip I	262.3	22.2	174,000	1,500
66/3	Cox's Bazar	56.4	14.6	20,400	2,800
64/1A	Banskhali	266.4	13.6	86,800	3,100
64/2B	Chokoria	131.8	12.4	44,900	2,900
64/1C	Chanua	73.0	10.4	17,300	4,200
69	Moheskhali	114.2	8.7	65,400	1,700
71	Kutubdia	276.3	6.8	73,500	3,800
61/1	Sitakunda	75.7	6.0	25,500	3,000
63/1A	Anowara	172.0	4.6	32,700	5,300

Table 7.5: Ranking of projects in Emergency Programme Investment per Inhabitant

Table 7.6 shows the polders of the Mid Term Programme-Phase 2 in ranking order by investment per inhabitants. The ranking list of Table 7.6 might be used for prioritization of projects in the Phase 2 programme in order to aim at protection of the highest number of inhabitants at any time within the constraints of the available funds.

Polder	Name of Polder	Investment Cost (Million Tk)	EIRR (%)	Population (Nos.)	Investment per inhabitant (Taka)
73/1B	Hatia	41.4	41.9	22,400	1,800
48	Kalapara	14.1	36.2	25,500	600
35/1	Sarankhola	57.5	30.4	47,000	1,200
60	Sunagazi	25.7	25.7	62,300	600
40/2	Patherghata	24.3	24.3	39,800	1,500
59/2	Ramgati	20.5	20.5	76,600	1,000
59/3B	Sudharam	283.2	17.5	90,900	3,100
72	Sandwip	243.2	16.8	95,000	2,560
59/3C	Companyganj	246.2	15.8	56,200	4,400
66/1	Cox's Bazar	33.4	15.4	22,400	1,500
56/57	Bhola	317.4	14.0	155,300	2,000
68	Teknaf	107.6	13.0	26,500	4,100
70	Matharbari	132.9	6.8	10,200	13,000

Table 7.6: Ranking List for Project under The Mid-Term Programme Phase 2. Investment per inhabitant.

In view of the above the Consultant recommends that all the polders listed the Table 7.1 be included in the Mid Term Programme notwithstanding the fact that the estimated EIRR for some of the projects is below the opportunity cost of capital in Bangladesh of 12%.

7.7 **Polders not justified for inclusion in the Mid Term Programme.**

At an early stage of the project the polders 5, 7/1, 7/2, 10-12, 14/1, 14/2 and 15 in the Khulna district were proposed for the Mid Term Plan.

However, the Consultant has reviewed the projects and found that the above should not be included in the Mid Term Plan. The reasons are as follows :

i) The existing embankments, although not maintained to design condition, do protect against intrusion of saline water. (no breaches)

ii) The geographical location is up-river with a distance to the sea of about 60 km which make them less exposed to cyclonic surges.

iii) Food For Work is carrying out periodic maintenance on the embankments.

iv) In view of i) and iii) the Consultant finds that no regular (yearly) agricultural benefits should be counted. The absence of these major benefits makes the projects doubtful from an economic point of view. It is further considered that cyclone caused damages to agricultural produce as well as infrastructure and houses might be difficult to justify in view of the existing embankment and the geographical location up-river. There might be some minor benefits which should be counted owing to the fact that breaches are more likely to occur in the existing embankment that in a new one.

v) In view of the above the investment should mainly be justified through a reduction in the maintenance costs. The consultant has compared the present maintenance cost (Food For Work) with the future costs after construction of new embankments.

The Food For Work programme make repairs every 4-5 years on average. The quantities applied amounts to 10 to 15 cubic meter of earth per meter embankment. The unit cost is estimated to 15 Tk per cubic meter. This cost has been compared to cost of routine and periodic maintenance for embankment under the present project as reflected in Annex F, page 23. Calculations show benefit/cost ratios varying between 0.09 and 0.25 - see Annex X.

Consequently the above projects cannot yield even small annual benefits.

8. IMPLEMENTATION PROGRAMME AND INVESTMENT PLAN

8.1 Implementation Programme

The Mid Term Programme is divided into the following two projects :

- Emergency Cyclone Protection Project with total investment cost 2038 million Tk.
- Mid Term Programme -Phase 2 with total investment cost 1656 million Tk.

It is proposed that the two projects are implemented in consecutive order starting with the Emergency Project. The implementation should be based on international tendering with participation also of qualified local contractors. The projects should be divided into suitable contracts.

The proposed implementation programme is presented in Figure 8.1.

8.1.1 Emergency Cyclone Protection Project

In view of the urgency of the Emergency Project the implementation of this project has already been initiated during the second half of 1991.

Prequalification of international and local contractors was completed early December 1991 and tenders invited late December 91. Tender opening will take place on 16th February 1992. Contracts are expected to be awarded during July 1992 and field works would commence before the rainy season. Construction is planned to be completed by the end June 1993.

The project has been divided into 8 contracts.

8.1.2 Mid Term Programme, Phase 2

Final Engineering and tender documents for this project should be prepared during 1992. The field surveys should therefore be started in February 1992 so they may be completed during the remaining dry season 1991-92.

Tendering should take place early 1993 with award of contract around May 1993 to provide ample mobilization time for start of construction works at beginning of the dry season 1993/94.

Construction works to be completed by the end of the dry season 1994/95.

8.1.3 Construction Supervision

It is recommended that the supervision of the construction works be undertaken by a suitable consulting engineering company.

The proposed Term of Reference for these services are presented in Annex XIII.

8.2 Investment Plan

The total investment costs for the Mid Term Programme are:

	Construct cost plus Engineering Million Taka	Land Acquisition Million Taka	Total Million Taka
Emergency Project	1,958	80	2,038
Mid Term Programme, Phase 2	1,605	51	1,656
Total	3,563	131	3,694

Table 8.1 : Investment Costs, Mid Term Programme.

The below investment plan has been prepared on the basis of the implementation programme shown on Figure 8.1 and the following assumptions.

- Land acquisition costs to be paid at the start of each project.
- Construction and Engineering costs for the Emergency Project broken down by years : 50% in 1992 and 50% in 1993.
- Construction and Engineering costs for Phase 2 broken down by years : 20% in 1993, 50% in 1994 and 30% in 1995.

Cost of Construction and Engineering consists, of 50% Foreign Currency and 50% Local Currency, refer Chapter 3.

Investment Plan Mid Term Programme - Million Taka

	1992		1993		1994		1995		Total	
	LC	FC	LC	FC	LC	FC	LC	FC	LC	FC
EMERGENCY PROJECT										
Land Acquisition	80								80	
Construction & Engineering	490	489	490	489					979	979
PHASE 2										
Land Acquisition			51						51	
Construction & Engineering			150	150	427	427	225	226	802	803
Mid Term Programme, Total	570	489	691	639	427	427	225	226	1912	1782

Table 8.2 : Investment Plan, Mid Term Programme.

8.3 Afforestation

A programme for afforestation of about 700 km foreland and embankments at a total cost of 700 x 210,000 = 147 million Taka has been recommended.

This programme could start at the beginning of 1993 and would take 3 years to implement corresponding to a yearly investment of 49 million Taka during the years 1993, 1994 and 1995.

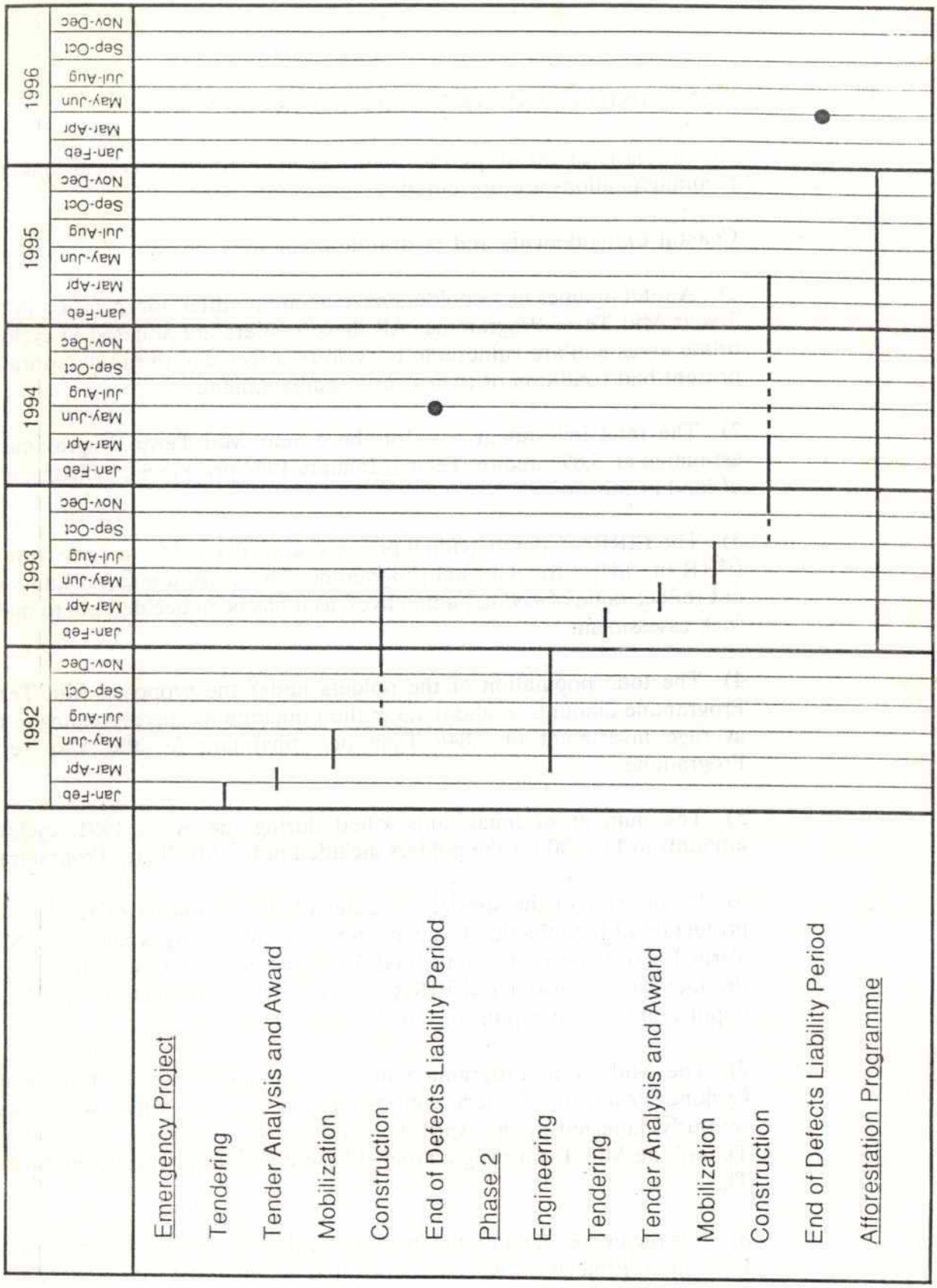


Figure 8.1 : Implementation of Mid Term Programme.

9. CONCLUSIONS AND RECOMMENDATIONS

On the basis of the study the following main findings, conclusions and recommendations are presented.

Coastal Embankments and Hydraulic Structures

1) A total number of 23 polders have been identified for inclusion in the 5 year Mid Term Programme. All these polders are situated in cyclone prone areas and are vulnerable to cyclone surges due to the deteriorated present bad condition of their coastal embankments.

2) The total investment cost for the 5 year Mid Term Programme is estimated at 3,694 million Taka at January 1992 price level, including cost of land acquisition.

3) The EIRR for the individual projects range from 50% to 4.6% with an EIRR of 18.3% for the total programme. These economic indicators do not reflect value of saving human lives, as it has been decided not to make such assessment.

4) The total population of the polders under the proposed Mid Term Programme amounts to about 1.3 million inhabitants corresponding to an average investment of 2,846 Taka per inhabitant for the Mid Term Programme.

5) The number of inhabitants killed during the April 1991, cyclone amounts to 117,000 for the polders included in the Mid Term Programme.

6) In the view of the special character of these projects related to the protection of the inhabitants against future cyclonic surges the entire Mid Term Programme is recommended for implementation, notwithstanding the fact that the estimated EIRR for some of the projects is below the opportunity cost of capital in Bangladesh.

7) The Mid Term Programme has been divided into an Emergency Cyclone Protection Project comprising the polders which were most seriously damaged by the April 91 cyclone, with total costs 2,038 million Tk and the Mid Term Programme - Phase 2 with total cost 1,656 million Tk.

8) It is recommended that the implementation of the Emergency Cyclone Protection Projects proceeds as planned with tender opening in mid February 1992 and award of contracts as soon as possible there after.

9) It is further recommended that tender documents for Phase 2 of the Mid Term Programme be made ready for tendering of this project early 1993 with the aim of starting field works at the beginning of the dry season 1993/94.

Operation & Maintenance

10) The embankments are subject to yearly erosion from high tides and monsoon storm. Lack of maintenance at such damages is one of the main reasons for the bad condition of many of the existing embankments.

11) There are a number of reasons for the lack of maintenance such as:

- Over emphasis on construction works
- Insufficient funding and non-optimized use of funds
- Lack of staff motivation
- Inadequate planning
- Inadequate budgeting and cost control
- Lack of training
- Lack of beneficiary participation.

12) Operation and Maintenance components have been included in a number of on-going projects with the aim of improving the O&M. Experiences drawn from such projects should be utilized in the planning and implementation of the future maintenance of the projects under the Mid Term Programme. The merits of establishing a separate body with particular responsibility for maintenance of **coastal** embankments and allied structures should be explored.

13) It is recommended that provision be made for future maintenance budgets for the Mid Term Programme including establishment of a separate budget for repair at cyclone damages.

14) Beneficiary participation in maintenance of embankments should be introduced and it is recommended that a plan be prepared for beneficiary participation and subsequently implemented during the construction period for the Mid Term Programme.

15) Technical assistance will be required for the planning and implementation of beneficiary participation. It is recommended that steps are taken to provide such assistance soonest possible.

Afforestation

16) Both previous experience with afforestation as well as the Consultant's observation during field reconnaissances indicate that afforestation of the foreland and the embankment provides an effective protection of the embankment against wave action and erosion from rain. It also absorbs wave energy during storm surges thus delaying and reducing the overtopping effect from storm surges and the eroding effect of the waves on the coast.

17) There are large coastal sections under the Mid Term Programme left without afforestation the protection of which could be substantially improved by establishment of afforestation on the foreland and the

embankment.

18) Afforestation is relatively cheap, with the cost in the range of 200,000 Taka per km and apart from its protective effects it creates employment, generates wood for many purposes and has a positive effect on the environment.

19) Private landownership is a hindrance for the establishment of afforestation on many coast sections, and it is recommended, that the Government takes action to solve this problem including establishment of cooperative and acquisition of the land where necessary.

20) Including afforestation in the project will increase the average EIRR by approximately 1% and it is recommended to implement an afforestation programme under the Mid Term Programme at a total estimated cost of 147 million Taka not including possible cost of land acquisition.

21) The afforestation programme should be implemented in close collaboration between the BWDB and the Department of Forestry.

22) Beneficiaries should be involved in establishing and maintenance of the afforestation.

Fisheries

23) The affect of the Mid Term Programme will be negligible for fresh water and salt water fisheries while it may have a positive effect on shrimp farming due to the improved protection against storm surges.

24) Shrimp farmers have been found to cause intrusion of saline water on the agricultural farmland and to perform uncontrolled pruning and cutting of mangrove afforestation.

25) It is recommended that the Government introduce restrictions and control of the shrimp farmers with the aim of protecting the agricultural farmers and the coastal afforestation.

Environment

26) The Mid Term Programme will have a positive effect on the environment as it will generate higher agricultural production and protect human lives.

27) The adverse effects of the programme on the physical environment are negligible.

28) The programme will have an adverse effect on the social environment through the creation of a number of house and landless families due to the acquisition of their land for new embankments.

29) It is recommended that the Government take measures to arrange prompt payment for land acquisition and assist the house and landless families in their reestablishment. Possibilities of involving these people in beneficiaries maintenance of embankments should be considered.

30) It is recommended that the Technical Assistance proposed for planning and implementation of beneficiaries participation also include assistance in land acquisition and reestablishment of the house and landless families.

Other Protective Measures Against Cyclones

31) The proposed Mid Term Programme will reduce and delay the effects of a cyclone surge but it will not completely prevent overtopping and subsequent flooding from a severe cyclone surge.

32) The existing early warning system is both inadequate and complicated and therefore of little use for the general public.

33) The early warning system should make full use of available space meteorology in order to improve reliability of weather bulletins. Cyclone warnings should be more specific for different areas.

34) Other protective measure should be introduced in addition to the Mid Term Programme such as additional and possibly other types of cyclone shelters, suitable evacuation roads, improvements of the early warning system etc.

35) A number of studies regarding cyclone shelters are ongoing.

36) It is recommended to perform an integrated master plan study for protection measures against cyclones covering all aspects including coastal embankments, warning system, cyclone shelters, means of evacuation, emergency plans etc.