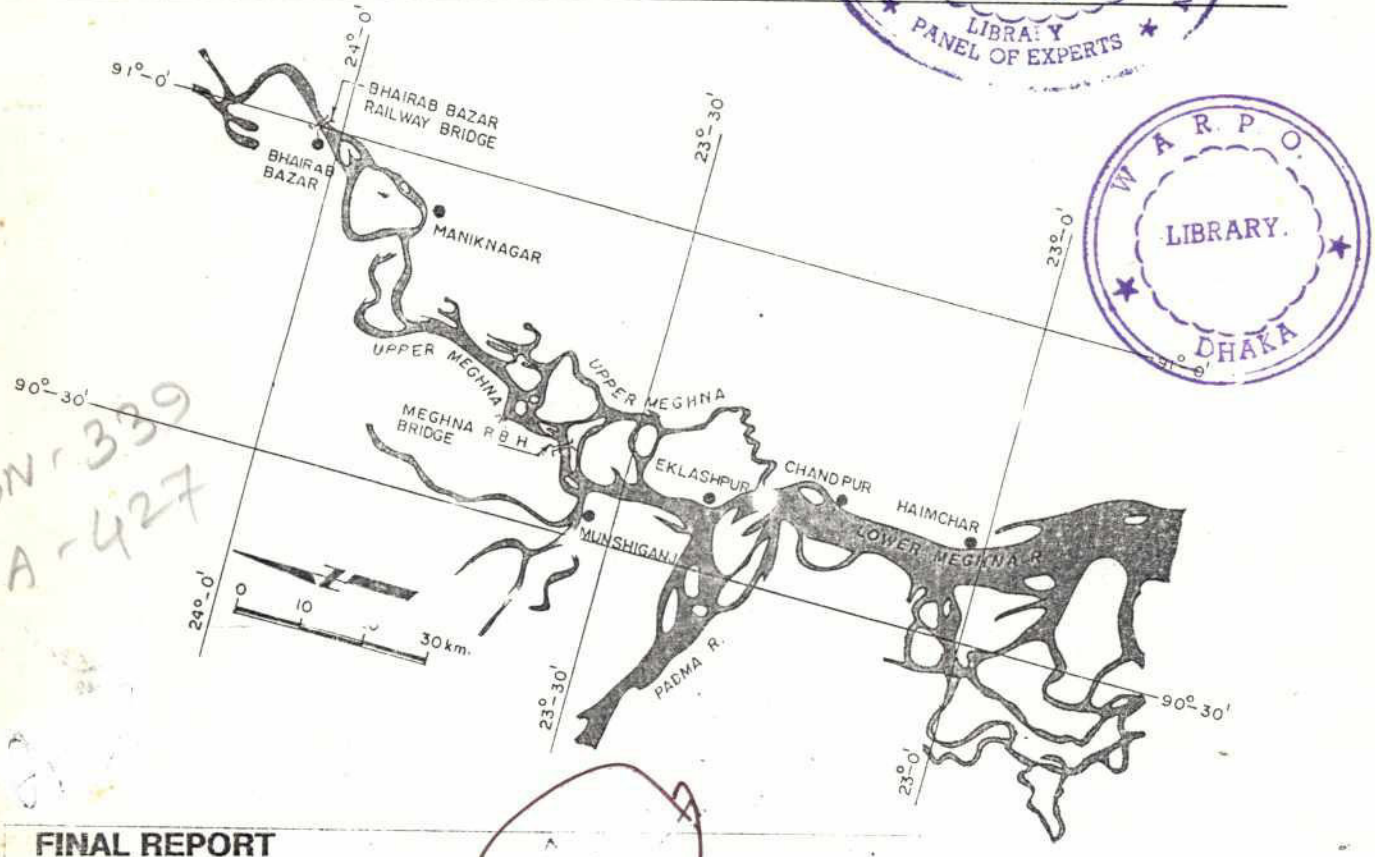
GOVERNMENT OF BANGLADESH

BANGLADESH WATER DEVELOPMENT BOARD

MEGHNA RIVER BANK PROTECTION SHORT TERM STUDY

IDA Credit 1870 BD (Part D), March 1990



FINAL REPORT

VOLUME VI

ANNEX: F ECONOMICS OF PROTECTION WORKS

February 1992

HASKONING, Royal Dutch Consulting Engineers and Architects

Delft Hydraulics

BETS, Bangladesh Engineering & Technological Services

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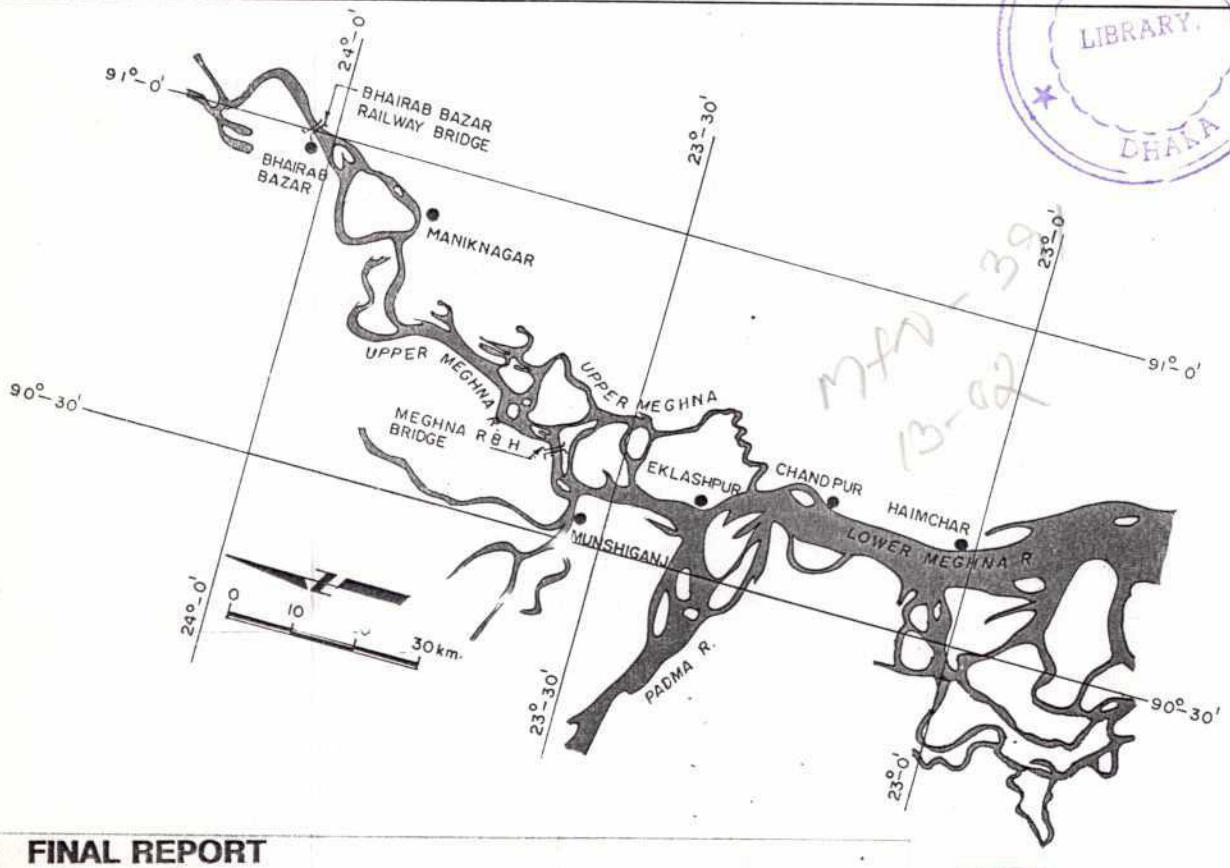

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February 1992

HASKONING, Royal Dutch Consulting
Engineers and Architects

in association with:

DELFT HYDRAULICS
BANGLADESH ENGINEERING & TECHNOLOGICAL SERVICES LTD.

PREFACE

The Meghna, one of Bangladesh' major rivers, flows through the eastern part of Bangladesh and discharges into the Bay of Bengal.

Like other rivers in Bangladesh the Meghna erodes it banks in many points and this erosion has assumed an alarming magnitude since the severe floods of 1987 and 1988. Consequently, a number of locations requires prompt attention to prevent further damage or even events of a catastrophic nature.

This Final Report describes the surveys, studies, designs, cost estimating and economic evaluation carried out during 1990-1992 as part of the Short Term Study (FAP-9B) for Meghna Bank Protection.

The Report consists of seven volumes comprising a Main Report and eight Annexes A to G and I. Some Annexes are accompanied by a series of APPENDICES containing detailed information or supporting data relevant to them.

Vol I			Main Report
Vol II	Annex	A :	Hydrology
		B :	River Morphology and Geomorphology
Vol III	Annex	C :	Geotechnical Investigations
Vol IV	Annex	D :	Scale Model Studies
		E :	Mathematical Model Studies
Vol V	Annex	G :	River Bank Protection
Vol VI	Annex	F :	Economics of Protection Works
Vol VII	Annex	H :	(not used)
		I :	Environmental Impact Assessment.

INTRODUCTION TO THE PROJECT

1. Background

There are three major rivers in Bangladesh: the Ganges, the Brahmaputra and the Meghna. Originating form Assam in India, the Meghna River flows through the eastern part of Bangladesh and discharges into the Bay of Bengal. The Meghna River drains an area of 77,000 km^2, of which about 46,500 km^2 is located in Bangladesh. The major contributors to the river upstream of Bhairab Bazar are the Boulai, the Surma and the Kushiyara rivers, covering an area of 62,960 km^2. The Ganges joins the Brahmaputra near Aricha and thereafter takes the name of the Padma. The Padma joins the Meghna at Chandpur. The Lower Meghna River conveys the melt and rain water form the Ganges and Jamuna basins, combined in the Padma River, and from the Upper Meghna basin to the sea. The total catchment area is about 1,637,000 Km^2. Maximum flows can be as high as 160,000 m^3/s. The major contribution of the discharge originates from the Jamuna River (annual average 19,642 m3/s) and the Ganges River (annual average 10,874 m^3/s).

The reach of the Meghna River from Bhairab Bazar to Haimchar is about 160 km in length. Width of the river varies from 1 km to more than 10 km. The river channel is more or less well defined upstream of its confluence with the Padma and is braided in the reach downstream of Chandpur. The river is considerably deep all along and the depth ranges to 35 m in the bends. The river bed and banks consist mainly of clayey-silt which is often loosely packed and is susceptible to liquefaction at some places. Of the three major rivers, the Meghna carries relatively less sediment. The velocity of flow of the river is high during monsoon. The river banks are also subjected to heavy wave action at some points.

Like other rivers in Bangladesh, the Meghna erodes its banks in many points. Erosion at the Meghna since the severe flood of 1988 has assumed an alarming proportion at the following locations which require prompt attention.

- The Railway bridge at Bhairab Bazar;
- Bhairab Bazar Township along the right bank;
- Maniknagar; along the left bank, falling within the proposed Gumti - Phase II Project;
- Meghna R & H Bridge;
- Eklashpur (near Meghna-Dhonagoda Project);
- Chandpur Town;
- Haimchar (adjacent to Chandpur Irrigation Project);

The Dhaleswari River, a tributary of Meghna, has been eroding its right bank at Munshiganj for quite some time and has threatened the existence of Munshiganj Town.

2. Meghna River Bank Protection -Short term Study

The study of possible bank protection works at critical locations along the Meghna river commenced officially in September 1990 when BWDB, Bangladesh Water Development Board commissioned HASKONING, Royal Dutch Consulting Engineers and Architects in association with DELFT HYDRAULICS and BETS, Bangladesh Engineering and Technological Services, to carry out the Meghna River Protection Short Term Study, financed under Credit IDA BD-1870, Part D.

The objectives of the study are:

- to provide short term measures for protection against erosion for seven locations on the Meghna river and one location on the Dhaleswari;

- to gradually implement a coherent and phased programme of works, aiming at the control of erosion on the defined stretches of the rivers Meghna and Dhaleswari. The protection of the locations indicated above should logically fit in this programme.

The Inception Phase started in November, 1990 with the mobilisation of the Expatriate Consultants. During the Inception Phase, the inter-action between this study and Flood Action Plan (FAP) Components was identified and maintained as far as possible.

The Meghna River Bank Protection Short Term Study, is now one of the **main components** of the Flood Action Plan for Bangladesh (FAP-9B. MEGHNA LB PROTECTION PROJECT), as included in the Review Report FPCO, December, 1990.

It has been recognised that during the Inception Phase, due to the internal and international situation during November 1990 to February 1991, delays were experienced, hampering the normal development of the activities planned. Therefore, activities in the critical path of the study were delayed (i.e, hydrometric surveys, geotechnical investigations, model investigations at RRI).

Furthermore, during the first phase of the project it became more and more clear that the inclusion of the flood season in the survey ... considerably improve the designs of the protection works, the Consultants were supposed to submit at the end of the Study. Moreover, strengthening of the relation with the studies of the Bangladesh Action Plan for Flood Control (FAP) would also have a positive contribution to the outcome of this project. Therefore the BWDB instructed the Consultants to review and update the work plan taking note of the flood season of 1991 and the aforementioned studies of FAP.

As part of the Study a priority ranking was established. Accordingly, it was decided:

- to carry out a feasibility study, detailed designs and tender documents for bank protection works at the following locations:

  - Bhairab Bazar Township and Railway Bridge;
  - Munshiganj Town located on the Dhaleswari River;
  - Chandpur Town;

- to carry out a full feasibility study and prepare tender documents for bank protection works in the following locations:

  - Eklashpur;
  - Haimchar;

- and only a pre-feasibility study for:

  - Meghna Roads & Highways Bridge;
  - Maniknagar, part of Gumti Phase II Project.

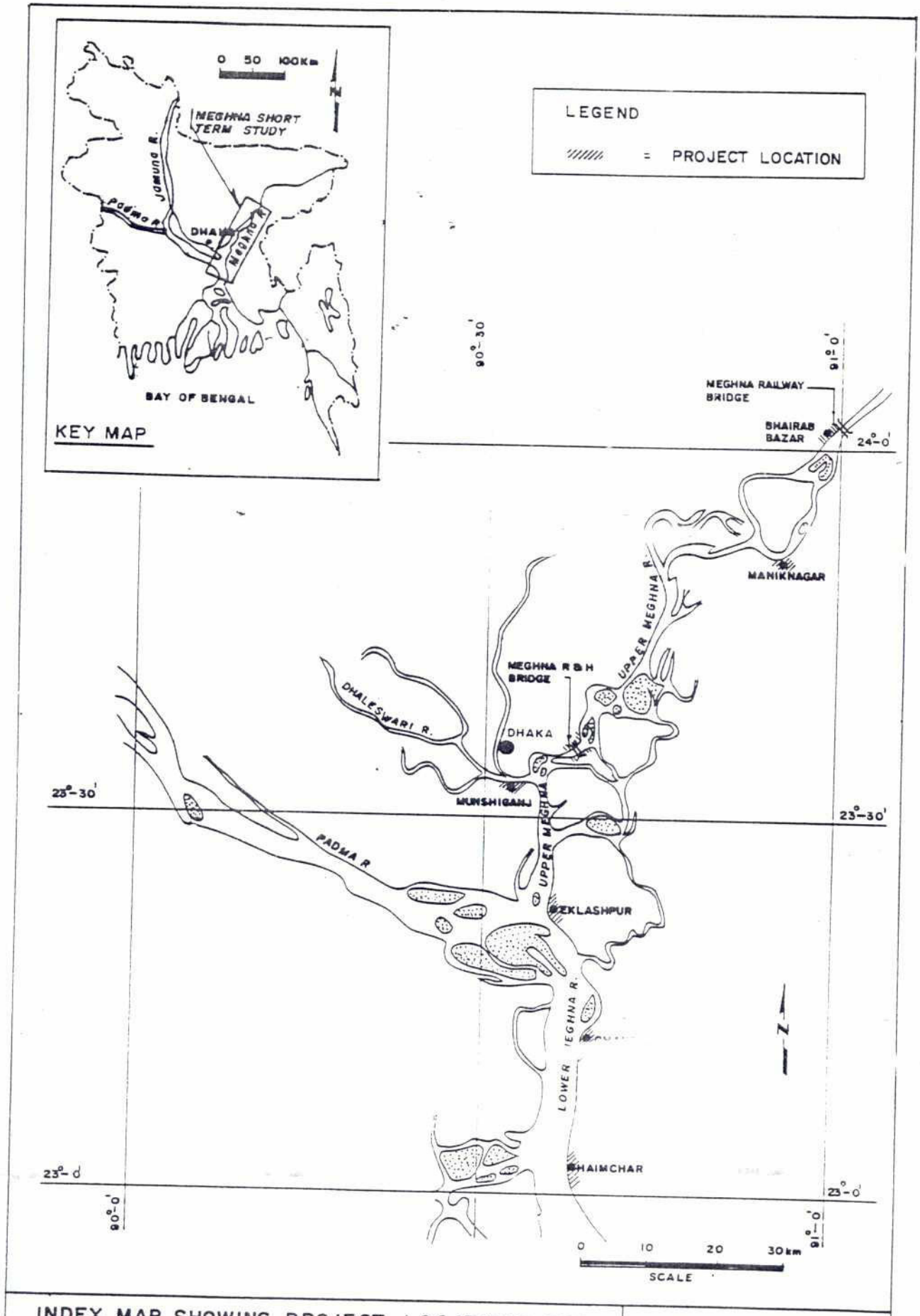
This Final Report submitted in accordance with the (Revised) Terms of Reference comprises all feasibility studies carried out as well as the detailed designs for bank protection works at the three locations mentioned above.

ABBREVIATIONS AND GLOSSARY OF TERMS

ADB	Asian Development Bank
BCSIR	Bangladesh Council for Scientific and Industrial Research
BBS	Bangladesh Bureau of Statistics
B/C	benefit cost ratio
BCL	Bangladesh Consultants Limited
BETS	Bangladesh Engineering and Technological Services Ltd
BH	Bore hole
BIWTA	Bangladesh Inland Water Transport Authority
BIWTC	Bangladesh Inland Water Transport Corporation
BOD	Biological Oxygen Demand
BR	Bangladesh Railway
BS	British Standards
BUET	Bangladesh University of Engineering and Technology
BWDB	Bangladesh Water Development Board
°C	degree Celsius
CC blocks	concrete blocks
CIF	Cost, insurance and freight
CPT	Cone Penetration Test
Crore	10,000,000
DH	Delft Hydraulics (Netherlands)
Dollar (US)	taken at an exchange rate of Tk.36 for the Study
EIA	environmental impact assessment
EIRR	economic internal rater of return
FAO	Food and Agricultural Organization (United Nations)
FAP	Flood Action Plan
F/C	foreign currency
Fig(s)	figures(s)
FML	fortnightly mean water level
FPCO	Flood Plan Coordination Organization
g	acceleration due to gravity
GL	ground level
ha	hectare(s)
hr	hour(s)
IBRD	International Bank for Reconstruction and Development
ICB	international competitive bidding
IDA	International Development Association
IRR	internal rate of return
IWTA	Inland Water Transport
JICA	Japan International Cooperation Agency

kg	kilogramme(s)
km	kilometre(s)
Km^2	square kilometre(s)
km/h	kilometre per hour
Kn	kilonewton
Lakh	100,000
L/C	local currency
LCB	local competitive bidding
LWL	Low water level
m	metre(s)
MAT	Manual and automatic tidal gauge
MCA	multi-criteria analysis
m/s	metre(s) per second
m^2	square metre(s)
m^3	cubic metre(s)
m^3/s	cubic metre(s) per second (cumecs)
MG	Metre Gauge
mm	millimetre(s)
MMSS	Mica schist silty sand
MN	meganewton
MPO	Master Plan Organization
MSL	mean sea level
N	Newton
NEDECO	Netherlands Engineering Consultants
NMC	natural moisture content
N-value	standard penetration test value
ODA	Overseas Development Agency
OECF	Overseas Economic Cooperation Fund
OMC	optimum moisture content
p.a	per annum
PDB	Power Development Board
PDF	Probability density function
PWD	Public Works Department (datum)
RC	reinforced concrete
RHD	Roads and Highways Department
RPT	Rendel, Palmer & Tritton Limited
RRI	River Research Institute
RTW	river training works
s.sec	second
SHW(L)	standard high water (level
SLW(L)	standard low water (level)
SOB	Survey of Bangladesh
SPT	standard penetration test
SWMC	Surface Water Modelling Centre
sq.km	square kilometre(s)

t(tons)	metric tons
Tk	taka
TOR	Terms of Reference
US$(or$)	US dollar(s)
USCS	Unified soil classification system
WB	World Bank



INDEX MAP SHOWING PROJECT LOCATIONS FOR THE MEGHNA SHORT TERM STUDY

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ANNEX F

Economics of protection works

F-1 Introduction

F.1 INTRODUCTION

F.1.1 General

The economic evaluation analysis presented in this annex is executed within the framework of the Meghna River Bank Protection Short Term Study. At the request of the Bangladesh Water Development Board, a team of experts has investigated the technical and economic feasibility of river bank protection works at specific sites along the Meghna River.

F.1.2 Organization of the document

This annex describes the economic analysis of the proposed river bank protection works at the selected project sites. This introductory chapter follows a general elaboration on the evaluation method applied. Specific issues related to individual sites are discussed in the respective chapters assigned to the economic feasibility analysis of these sites.

Chapter two discusses the general issues of the evaluation method applied.

The chapters three to nine deal with the economic evaluation of the bank protection works in Bhairab Bazar, Munshiganj, Chandpur, Eklashpur, Haimchar, Road and Highway Bridge and Maniknagar respectively. Chapter ten deals with the preliminary economic evaluation of a long term bank protection scheme for the whole Lower Meghna.

In appendix F/1 the results of the socio-economic survey and justification for assumptions made are summarized.

GD

ANNEX F

Economics of protection works

F-2 Evaluation method

F.2. EVALUATION METHOD

F.2.1 FPCO-guidelines for project assessment

In order to streamline techniques, bring consistency into the appraisals and facilitate comparison of potential investment opportunities, the Flood Plan Coordination Organization (FPCO) of the Ministry of Irrigation, Water Development and Flood Control has prepared standard procedures.

The standard procedures have been laid down in Guidelines for Project Assessment. These guidelines draw attention to special issues which experience indicate are of importance in Bangladesh. Their aim is to provide a sound base for decision-makers in choosing between alternative water resource strategies and investment opportunities.

The present study follows these guidelines closely. However, these procedures are focusing on flood control projects. Hence, they cannot be applied to erosion control projects without careful consideration and modification.

On the one hand, special attention must be given to information available and collected: (i) data on relevant aspects of river bank protection works are not accurate and consistent, (ii) benefits are difficult to quantify.

On the other hand, the mechanism of river bank erosion requires a deviation from the guidelines regarding the assessment of the damage probability function. Being an erosion protection, rather than a flood protection project, implies that erosion probability, unlike the flood probability, is not directly associated with high water levels in the Lower Meghna. Many other factors, e.g. geo-technical conditions, waves, sudden fall and rises of the water levels, play a decisive role in erosion of the river banks. Hence, extreme value probabilities have been determined by directly applying the extreme value theory on recorded and estimated damage rather than on weak regressions between such damages and the probability of physical phenomena such as high water levels which only partly explain the occurence of damages.

F.2.2 Scenarios to be evaluated

In agreement with the FPCO guidelines for project assessment, in the present economic feasibility analysis of the short term bank protection works a comparison is made between two future scenarios, (i) the scenario with permanent river bank protection works (with-scenario) and (ii) the scenario without such protection works (without-scenario).

In the without-scenario situation the present day practice regarding river bank repair and maintenance activities is continued. However, it must be noted that the without-scenario is not equal to the present situation, but represents an extension of the present situation into the future.
The extrapolation of the present day practice related to bank protection and repair and maintenance is sometimes difficult to predict.
The most likely future situation without the project is surely not the situation in which all interests along the river bank (urban area, irrigation districts, etc.) will be completely abandonned. If such would be the case the whole economic added value of e.g. the Bhairab Bazar Bridge, Meghna-Dhonagoda and Chandpur Irrigation Projects could be taken into account as benefits to the bank protection projects.
Experience from the past, however, indicate that the most probable future scenario without the bank protection projects considered in this study is described by continuous efforts of the authorities to protect the interests along the river banks in a non-sustainable way by either bank protection works, haphazardly designed and carried out, or by regular withdrawing of embankments.

This has, in general, the following consequences:

(i) Experience from Chandpur Town protection measures in the past decades, where expenses for repair and maintenance showed an average growth rate of over 60% over the last 10 years, and

the repair measures in Bhairab Bazar, where the annual growth rate for these expenses was over 25% in the past five years, show that expenses needed to repair and maintain the present river bank protection at isolated locations along the water front in the non-sustainable present practice are likely to increase dramatically in the future. Based on that experience it has been estimated that such expenses in the without-scenario will increase by an annual ten percent.

(ii) Experience from Chandpur Irrigation Project shows that the embankments will be retired to the extent bank erosion cannot be stopped by non-sustainable bank protection works, carried out in an ad-hoc way. For the Meghna-Dhonagoda and the Chandpur Irrigation Districts (Eklashpur and Haimchar), the without-scenario is therefore characterized by the extrapolation of this present day practice.

F.2.3 Period of analysis

The guidelines for project assessment indicate that for FAP project planning a discounting period of 30 years from the start of project construction must be used. No reason has been identified to change this period for the economic feasibility analysis of river bank protection.

F.2.4 Financial and Economic Analysis

The analysis of river bank protection is basically an economic analysis. Consequently, prices used to calculate benefits and cost are economic prices, reflecting the opportunity cost of goods and services to the economy. However, financial prices form the base for the economic prices used in the economic feasibility calculations.

The financial analysis is limited to a summary of the budgetary implication of the protection works. Such a summary is important, because it gives an indication what recurrent cost can be expected and what budget will be required in the future. In general, this budget has to be covered by national funds.

F.2.5 Unit prices and rates

F.2.5.1 Price level

All prices and cost are expressed in mid-1991 prices in Taka. This conforms to the FPCO-guidelines for project assessment.

F.2.5.2 Financial and economic costs

As it was stated before, the economic analysis is based on the financial analysis in which the financial cost and benefits are transferred into economic inputs and outputs by distinguishing between traded goods, non-traded goods and by applying the corresponding conversion factors to the different economic resources.

(i) Traded goods

Traded goods refer to all commodities that are traded on the international markets. Traded goods are valued on the basis of their international border prices, with adjustment for quality, transport cost, handling charges and marketing margins. All estimates for international prices are derived from the World Bank's Commodity Price forecasts and converted to mid-1991 constant economic prices. Hence, all internationally traded goods are expressed in Taka-values applying the official mid-1991 exchange rate.

(ii) Non-traded goods

The term non-traded goods refers to all items which cannot be valued on the basis of international border prices: e.g. local non-exported products, animals, local building materials, labour. Their economic price is

derived from the mid-1991 market price by applying a conversion factor in order to eliminate the divergence between border prices and domestic prices.

(iii) Conversion factors

The Planning Commission recommends a standard conversion factor for Bangladesh. This factor is 0.82 for non-traded goods, exclusive unskilled labour. The shadow wage rate for unskilled labour is obtained by using a conversion factor of 0.71, reflecting unemployment and under-employment in the rural economy. No reasons have been identified to deviate from the conversion factors recommended by the Planning Commission and the FPCO.

F.2.5.3 **Value of property**

In the economic appraisal of projects much attention is given to the economic value of structures. This aspect becomes important in the appraisal of river bank protection in Bhairab Bazar, Munshiganj and Chandpur, where houses, commercial enterprises and industries are at peril.

Through the socio-economic surveys reliable information was obtained on the value of houses and enterprises. The survey value for ... is the cost of materials used, without labour for construction. For the financial calculation of the cost of destroyed and damaged structures this surveyed value serve for estimating the cost of destructed and damaged structures. However, the imputed figure does not represent the construction or replacement value of structures as labour and some other cost factors are not covered.

A consistent financial appraisal requires that these costs are included in the value of the structures. The labour and non-covered components were estimated at 45% of material cost of structures. Hence, the financial cost of construction could be estimated more accurately.

In the economic appraisal of river bank protection works the economic opportunity cost of structures must be used, which may be lower than the economic replacement value. The opportunity cost of destroyed and damaged houses or commercial and industrial enterprises is the net value of production and services foregone when structures are destroyed or damaged. The following sections highlight the methods used in the economic analysis.

(i) Destruction of habitations

When property has been washed away persons cannot return to their homes and consequently economic resettlement cost must be used. However, it is unlikely that all inhabitants will be in the position to rebuilt a house somewhere else; 25% is estimated to remain homeless. Moreover, the alternative house is less expensive than the one destroyed. Hence it seems appropriate to impute for the economic cost of destroyed habitations a percentage of construction cost after correction for the foreign exchange premium. Details on this assumption are presented in the appendix.
In section F/1.5.1 of the appendix it is explained that 65% of the economic construction value is an appropriate value for shadow pricing the cost of destroyed houses.

(ii) Destruction of commercial and industrial enterprises

When commercial and industrial enterprises are destroyed by floods it is very likely that traders and industrialist will engage again in their traditional occupation in one way or another. They may possess enough savings to start trading again. Or else they could obtain a loan from a supplier, which enables them to start again.

The replacement value of the destroyed building is less appropriate as for calculation of the economic cost. One may expect that in Bangladesh considerations of investment security and prestige may have pushed land and building prices well above their economic value. Hence, their market prices is not a realistic economic estimator either. Many times the alternative will be to take the rental value: a renter is not likely to pay a premium for prestige or investment security and thus will not pay a rent higher than the

contribution the land or building can make to the economic activity he proposes to undertake. Hence, the rental value is more appropriate than the market price or replacement value.

The economic rental value is a good indicator for the annual costing purposes. However, the rent is not only used for a single year, but applies for the full period of the study. Hence, this rental value should be discounted over a range of years at an interest rate which reflects the opportunity cost of capital. The net present value thus derived can be imputed in the economic appraisal of investments.
The socio-economic surveys give indications on the rental value of commercial and industrial buildings. Details are provided in the appendix. Although, attractiveness of location, floor-space, land value may have influence on the rental value, it appears from the survey results that rents are consistent. For commercial and industrial enterprises an average rent of Tk. 57,000 per years is found. This value applies for each of the sites where town protection is evaluated. For more rural areas a lower value is used.
The rental value is discounted over a period of 30 years at an interest rate which reflects the opportunity cost of capital. In Bangladesh the assumed opportunity cost of capital is 12%. For more details reference is made to the appendix, section F/1.5.2.

(iii) Damage to houses

Houses near the river bank could be damaged by the erosion force of the river. This does not mean directly that these houses are destroyed, but merely that part of the walls are damaged or that some of the foundation works are washed away. In almost all cases it means that the owner will vacate the house and tear it down, thus saving building materials. With this materials a new home will be built elsewhere or the owner may sell materials and find other means of accommodation.
For those buildings which are torn down and rebuilt this means in economic terms that the following cost are involved:

- labour for tearing down the old building;
- transport cost for bringing materials to a new building site;
- labour cost for rebuilding the home; and
- additional material cost to replace what was lost.

Attention must be paid to the fact that a proportion of damaged houses are not rebuilt, simply because the owners do not possess the financial means to do so. This percentage is estimated at 25% (for more details reference is made to the appendix, section F/1.5.3). Based on this and the breakdown of house construction cost and what is needed to rebuild a house, it is estimated that the economic value lost as a result of house damage is 50% of the construction price. Details are provided in the appendix.

(iv) Damage to commercial and industrial enterprises

Commercial and industrial enterprises damaged by erosion are likely to be left and the owners will start operation elsewhere. In this respect damage cost are the same as cost of destruction, although with this difference that hardly any land is lost. Hence, the economic cost of damage to structures is similar to these cost when buildings are destructed; this means that the rental value is used as an indicator for the economic cost. For details reference is made to section F/1.5.2 of the appendix.
Table F.2.1 indicates which cost elements have been used for pricing the value of assets. More details are explained in section F/1.5 of the appendix.

F.2.5.4 Agricultural base rates

For the calculation of economic values of land lost due to erosion of the river banks, it has been considered appropriate to use agricultural base rates. The base rate is a combination of the following factors:

(i) Crop economics

In the agricultural areas prone to erosion the loss of irrigated crops can be averted by protection works. This aspect becomes important for protection works in Chandpur, Eklashpur, Haimchar and Maniknagar. Hence,

the economic appraisal of agriculture must give attention to the crop economics.
After reviewing cropping patterns in the selected project sites it was decided to consider only a limited number of crops. The overall importance in the cropping pattern of rice varieties (and wheat makes the analysis of other crops needless.
Because the feasibility analysis stretches over a period of 30 years it is necessary to adjust prices of inputs and commodities. In calculating the economic returns of crops mid-1991 economic prices for the year 2005 were used. The World Bank's Commodity Prices forecast served as basis for price calculation. Table F.2.2 provides a summary of economic returns per crop.

TABLE F.2.1 ELEMENTS FOR THE CALCULATION OF THE VALUE OF PROPERTY

Element	Financial appraisal (Market price)	Economic appraisal (Shadow price)
Cost of damage to habitations	50% of replacement value, excl. land value	50% of replacement value, excl. land value(after correction for foreign exchange premium)
Cost of damage to buildings of commercial and industrial enterprises	Discounted annual rent (12% and 30 years): Tk. 516,145	Discounted annual rent (12% and 30 years), after correction for foreign exchange premium: Tk. 423,239
Cost of destructed habitations	65% of replacement value of building, incl. land value	65% of replacement value, incl. land (after correction for foreign exchange premium)
Cost of destructed buildings of commercial and industrial enterprises	Discounted annual rent (12% and 30 years): Tk. 516,145	Discounted annual rent (12% and 30 years), after correction for foreign exchange premium: Tk. 423,239

TABLE F.2.2 SUMMARY OF NET ECONOMIC RETURNS PER CROP

AREA: 1 h
PRICES: mid-1991 constant economic prices
VALUES: Tk.

Crop	Type	Econ. return
HYV Boro	irr.	9 522
L Boro	non-irr.	9 824
B Aus	non-irr.	316
LT Aman	non-irr.	6 594
Wheat	non-irr.	6 755

(ii) Land use and cropping pattern

The calculation of the lost economic returns are based on actual land use and cropping patterns. For

lands outside embankments which border the river rice is the sole crop considered. With respect to Eklashpur and land upstream from Chandpur the land use and cropping pattern in the Meghna-Dhonagoda project was used. Land use and cropping pattern of the Chandpur Irrigation project apply for areas downstream of Chandpur and in Haimchar. The Gumti project land use and cropping pattern has been applied in Maniknagar.

(iii) Agricultural infra-structure

Loss of agricultural land in the three irrigation projects mentioned above would lead to the loss of irrigation infra-structure. Based on information concerning irrigation projects on the Meghna's left bank an estimated was made of replacement cost of irrigation infra-structure. The overall value on a per ha base is calculated at Tk. 1,677, based on the following assumptions (see section F/1.6 of the appendix):

- each low lift pump serves an area of 16 ha;
- economic replacement cost of that part of the irrigation structures that cannot be removed (e.g. canals, concrete structures) is evaluated at Tk. 26,835 at mid-1991 prices.

(iv) Value of land

Although it may be argued that for every hectare of arable land lost due to river bank erosion, somewhere else in the delta area a hectare of new land may become available on a char, the economic benefits of this new land has been neglected in the evaluation since it normally takes a long time before such land will give a substantial agricultural produce and the new land is even after that period not equally productive because of the absence of any irrigation infrastructure. Hence, the economic evaluation includes the value of agricultural land that is lost as a result of erosion.

One may expect that in Bangladesh considerations of investment security and prestige may have pushed land prices well above their economic value. Hence, the market price is not a realistic economic estimator. 'In these instances, we will not want to accept the market purchase price as a good estimate of the economic opportunity cost and must search for an alternative. Many times that alternative will be to take the rental value of the land', according to Price Gittinger (World Bank, 1982), when discussing the economic value of agricultural land.

The economic rental value is a good indicator for shadow pricing purposes. The annual rent as a value-indicator, however, applies to a specific single year. Hence, the annual rental value has been discounted over the 30-year study period at an interest rate of 12%, generally been taken as the economic opportunity cost of capital. The present value (PV) thus derived reflects the economic value of land lost and can be imputed in the economic appraisal of investments. Details are provided in the appendix, section F/1.6.2.

The economic value of cropped land is based on share cropping arrangements in the area. For each individual crop the rent has been calculated as the money value of production quota provided by the share cropper to the landowner. Based on the prevailing cropping pattern in the Meghna-Dhonagoda, Chandpur and Gumpti irrigation projects the average economic rental value is calculated.

For the economic analysis the avoidable losses in (i) production and (ii) land eroded are compared in the with and without project situation. Using the arrangements for share cropping, which are, like the production value, linked to the production only, as an indicator for the value of the land does not imply any double counting.

F.2.5.5 **Base rates for river works**

The cost of the river bank protection works relate to construction and engineering cost. As a result of the complexity of the river conditions (high water depths and strong current) and the high level of skill needed for river bank protection works to be carried out under such conditions, it is envisaged that qualified contractors with the required construction capacity and equipment are not available in

Bangladesh and that (i) international competitive bidding by pre-qualified contractors and (ii) supervision by a qualified engineer with experience in this type of work are conditions for their proper implementation. The costing of the works has been based on this assumption.

In addition to the construction cost more cost components have to be considered in the economic analysis, notably monitoring and maintenance cost. Monitoring cost have been based on survey cost experienced during the execution of this short term river bank study; an acceptable estimate for survey cost and other monitoring expenses is Tk. 2.0 million (mid-1991 economic prices) per site. Annual maintenance expenses of protection works have been estimated at 4% of the cost of surface protection; e.g. open stone asphalt, fascine mattress, boulders in falling apron and grouting of boulders.

Initially the unit prices and base rates for infra-structural works and river training works were based on the BWDB's Standard Schedule of Rates. The schedule of rates of river training works for the Jamuna Bridge also served as a guide. These unit rates refer to mid-1990 prices. They have been inflated by the general price index of 10% in order to adjust prices to mid-1991.

At the later stage, a contractor's approach was applied to determine the definitive cost estimate of the works designed. All cost items have been subdivided into local and foreign components.

F.2.6 Benefits from river bank protection works

When comparing the with- and without-project case, the benefits from the river bank protection project are related to (i) savings and reduction of costs associated with the present day practice of protecting the interests along the river bank and (ii) damage occurring due to the erosion of the river banks.

Theoretically the best way to identify such damages would be to assess a wide range of different scenarios of damage due to the erosion of the river banks (failure of a bank, failure of infrastructure such as bridges to the complete inundation of irrigation districts), to identify the probability of occurence and to calculate in agreement with the FPCO-guidelines the mathematical expectation of the damages. This methodology has been followed where applicable.

In relation to possible damages in irrigation districts, however, this method could not be applied, since failure probabilities and the extent of the damage of future likely events could not be easily assessed. For irrigation districts, therefore a more deterministic approach has been applied: (i) definition of a deterministic future bank protection strategy as discussed in F.2.2 in combination with an expected erosion rate derived from the geo-morphological study (Annex B).

Some of the benefits are associated with population growth or economic growth rate. They will, therefore, increase annually. The FPCO-guidelines give a 3% to 4% growth rate. For the feasibility studies a growth rate of 3% has been used, as it reflects the economic growth for Bangladesh over the period 1985 to 1990. However, no information is available for economic growth for each of the project sites individually.

The benefits thus identified are related to the following aspects:

(i) Cutbacks in maintenance and repair cost

The present and future annual expenses for repair and maintenance to the eroding river banks in the situation without appropriate bank protection works will be avoided by the well designed and constructed protection works.

(ii) Reduction of loss and damage in town areas affected by erosion

The estimated present and future annual economic loss and damage due to the bank erosion in the situation without appropriate bank protection works will also be avoided by the well designed short term

bank protection works. The loss and damage of private and public property have therefore been evaluated and an estimate of the future annual loss and damage has been made. The estimate has been based on the value of the identified assets in the area prone to erosion and the assumption that the average value of such assets is homogenously distributed over the urban area.
Referring to specific sites, specific infra-structural facilities which are likely to be affected in the situation without the permanent bank protection works, deserve special attention: the railway and IWTA terminal complexes in Chandpur, the railway bridge and oil terminal in Bhairab Bazar, etc.

(iii) Disruption of economic activities

The estimated present and future net revenues of economic activities in the commercial and industrial areas lost due to the river bank erosion in the situation without appropriate bank protection works will be avoided in the project situation with well design bank protection works. Due to the fact that commercial and industrial enterprises in the project area in the situation with appropriate bank protection works will no longer be subject to damage, economic activity will be likely to increase.

(iv) Reduced damage to the agricultural sector

Proper bank protection works will stop the annual erosion and damage to the agricultural sector and its irrigation infrastructure in the areas along the eroding river banks. The economic value of the increased production and the avoided losses to the irrigation infrastructure are benefits of the protection works.

(v) Social benefits

Employment is the major social benefit. Within the protected area either agricultural or commercial and industrial activities employ a substantial number of persons. It is obvious that permanent erosion protection works may reduce employment. Another impact of the works could be temporary increase of employment opportunities during construction. Although, these employment as such is not elaborated for the individual sites, their economic effects are already incorporated in any disruption of economic activities.

(v) Environmental benefits

In general, river bank protection works will have positive and negative environmental impacts and no cost are attached to mitigative measures for environmental protection. Where environmental monitoring may be needed, costs are included in overall monitoring.

(vi) Secondary benefits

Secondary benefits refer to land reclamation in the process of constructing river bank protection. The economic value of reclaimed land and the employment generated are, however, considered secondary benefits. Secondary benefits are not identified for the individual protection sites.

F.2.7 **Evaluation criteria feasibility study**

The economic feasibility of the river bank protection works is first evaluated by comparing the discounted values of benefits against cost. The economic internal rate of return (EIRR) is the discounting percentage at which the benefits balance cost over the 30-year evaluation period. No further discussion is needed on the calculation of the EIRR.

A common indicator for the profitability of projects is the net present value (NPV). The economic net present value for the short term bank protection works has been calculated for a discounting rate of 12%, which is generally assumed to be the opportunity cost of capital.

ANNEX F

Economics of protection works

F-3 Bhairab Bazar

F.3 BHAIRAB BAZAR

F.3.1 Present situation and previous studies

Bhairab Bazar, a major inland port in Bangladesh, is located upstream of the confluence of Meghna River and the old Brahmaputra River. The historical township is a centre of commercial and industrial activity, This may be the cause or otherwise the result, one never knows what comes first, of its strategic location at the hub of vital rail, road and water routes. Bhairab Bazar is today and will remain for many years without any doubt an important trading and industrial centre in the national economy of Bangladesh.

The present and future position of the township is nevertheless constantly threatened by the eroding force of the mighty Meghna. The river not only threatens commercial and industrial buildings along its waterfront, but also the railway bridge located on the northern fringe of the town. This bridge is vital in the network of Bangladesh Railway as it is the only means of crossing the Meghna in the railway network linking Chittagong to the eastern part of the country. The serious thread by the ever active and unpredictable river has for years now been the focus of studies and research.

The dramatic events in 1988, when not only part of the Railway property was lost, but also severe damage was caused to the river's right bank at the township, has given new momentum to the search for sustainable solutions to protect Bhairab Bazar Town and its railway bridge. In the years after the 1988 flood the river bank was damaged again despite the bank protection works carried out.

Already in October 1988, almost two month before the dramatic events that reached the national headlines, a report was presented addressing the protection of Bhairab Bazar Town. Following the loss of a considerable portion of Railway property in 1988, various specialists presented reports. In December 1990, DDC submitted a report for the protection of Meghna Railway Bridge.

These reports and studies focus mainly on technical aspects of protection works and the costs involved. The economic feasibility of the proposed works is more difficult to assess. The DDC report for instance covers only the cost of works and makes a comparison between blocks and stone revetment. The present study falls within the scope of the Flood Action Plan. Presented solutions must not only be technically sound, but equally financially, economically and environmentally sound. As such, this report is unique in that it concentrates on financial and economic feasibility analysis for river bank protection at Bhairab Bazar.

F.3.2 Specific aspects related to Bhairab Bazar

Protection works undertaken by the Meghna River bank Protection Short Term Study concentrate in Bhairab Bazar on protection of the right bank of the town and works to protect the important railway bridge. Within the boundaries of the right bank there are, apart from the commercial and industrial buildings, also two transmission towers to be considered.

The situation in Bhairab Bazar is particular as this location covers two of the eight sites under consideration, notably the township and the railway bridge. Both are combined in one single economic feasibility study as the envisaged protection works encompasses the township as well as the railway bridge. This point of view has been supported by the ADB in a meeting with the Consultants to discuss possible ideas of Bangladesh Railways to protect only the right abutment of the bridge in the coming low water season.

The area covered by the study reaches from the ferry ghat just North of the railway bridge to the confluence of the old Brahmaputra River, some three kilometres to the South. Bank protection works have been designed for the right bank of the Meghna as here the situation w becoming critical.

In the economic feasibility analysis of Bhairab Bazar for a future scenario a comparison is made between a situation with river bank protection works (with-scenario) and one without protection works (without-scenario). In the without-scenario the usual repair and maintenance activities are still carried out.

The analysis of the with-scenario concentrates on the impact of the erosion protection works designed and their associated construction and maintenance costs. As a result of the works executed it may be expected that bank erosion is completely stopped and that the risk of failure of the railway bridge's right abutment (i.e becoming outflanked) is reduced considerably to an acceptable design probability.

The without-scenario is characterized by a continuation of the present situation. It may be expected that the expenses needed to repair and maintain the present day practice of protecting the interests along the right bank and the abutment of the bridge will increase in the future.

F.3.3 Alternatives for river bank protection

Construction of durable protection works on the existing bank of the Meghna would involve the clearing of a stretch of land along the river bank, where houses and commercial enterprises are located now. Although this may prove to be an adequate and financially attractive solution for the protection of the town area and the bridge, it is likely to face strong resistance from the local authorities and population. Consequently, another protection concept has been studied as well, whereby a new, advanced, bankline is created away from the existing one.

This latter advanced[1] protection concept involves the construction of a complete new bank line, some twenty metres from the old bank line. This option has been selected for practical reasons. With this option there is no need to remove all buildings and structures over a 20 m wide strip along the water front and the alignment can be much smoother. Moreover, a proper slope can be achieved by the application of hydraulic fill.

F.3.4 Benefits of Bhairab Bazar bank protection

F.3.4.1 Reduction of repair and maintenance

From information collected on cost of maintenance and repair of erosion damage, the amounts spent in the past by the BWDB, Bangladesh Railway and the PDB were calculated. The information collected referred to accounted amounts for the financial years 1985/86 to 1990/91.

The analysis of the avoidable repair and maintenance costs as benefits from the bank protection works designed is based on the assumption that such repair and maintenance costs due to river bank erosion can be evaluated by applying the probabilistic extreme value theory to the recorded and estimated historic records. However, expenditures in one year does not always relate to the very year that damage occurred; design, decision and financing procedures form the major bottleneck for direct action after damage happens. The recorded and estimated expenses are therefore associated with the year in which the real erosion occurred.

The information collected relates to current prices, which have been deflated for conversion to mid-1991 prices. For deflation a rate of 10% is used, which is the commonly used rate of the Planning Commission in Bangladesh.

F.3.4.2 Loss and damage to properties

Past erosion damage was estimated from records on destruction and damage to property, which were supplied by the upazila and municipality. Table F.3.1 presents an overview of destruction and damage to constructions.
The average value of property could be calculated from the socio-economic survey results. However, the survey outcome only gives financial construction cost, which must be converted to economic values. These

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[1] 'Advanced' refers in principle to the position only and not necessarily to advanced techniques.

values for destructed houses and commercial buildings have been calculated as follows:

- the value of houses is estimated at 65% of its economic construction value in order to take account of the lower quality of replacement homes after destruction;
- the economic value of destroyed commercial and industrial buildings is estimated as the rental value, thus taking into account that construction cost are not a reliable indicator for shadow pricing.

TABLE F.3.1 DESTRUCTION AND DAMAGE TO STRUCTURES

DESTROYED: Year	Houses	Home-steads	Comm. enterp.	Small industr.
1985	49	9	5	0
1986	53	8	9	0
1987	65	16	11	2
1988	81	27	17	3
1989	57	19	7	1
1990	31	7	3	0

DAMAGED Year	Houses	Home-steads	Comm. enterp.	Small industr.
1985	26	5	3	1
1986	47	13	5	1
1987	93	47	18	4
1988	161	71	33	7
1989	58	35	25	1
1990	38	15	13	1

Source: Survey (1991)

As far as property is concerned, which was damaged but not destroyed, the imputed average value used is a percentage of the total value. For house and homesteads this percentage is estimated at 15%, while for commercial and industrial properties it is evaluated at 25%. For details on these estimates reference is made to Appendix F/1.

In Table F.3.2 and F.3.3 summaries are given of the economic value of houses, homesteads, commercial and industrial enterprises that were either destructed or damage during the period 1985 to 1990.

Since the data only concern loss and damage of private property a surcharge is taken into account to reflect the loss and damage of the public infrastructure of the town. Taking into account the average occupation of public and private infrastructure the total loss and damage to public infra-structure has been evaluated at 25% of the loss and damage of private property. The final result is presented in Table F.3.3. More details are provided in the appendix, section F/1.3.

F.3.4.3 Disruption of economic activities

The destruction of commercial and industrial properties leads to a loss in net profits (after payment of taxes) and employment. The first is considered in the financial and economic evaluation, while the latter is a social aspect of river bank erosion damage. The computation of losses in profitability assumes that losses as a result of destruction or damage of property are the equivalent of 12 months net economic returns (profits). Details are provided in the appendix.

TABLE F.3.2 EROSION DESTRUCTION IN THE RECENT PAST

PRICES: mid-1991 econmic prices
UNIT: Tk. x 1M

Year	Houses	Home-steads	Commerc. enterp.	Small industr.	TOTAL
1985	6.348	1.166	2.116	0.000	9.630
1986	6.866	1.036	3.809	0.000	11.712
1987	8.421	2.073	4.656	0.846	15.996
1988	10.494	3.498	7.195	1.270	22.457
1989	7.385	2.462	2.963	0.423	13.232
1990	4.016	0.907	1.270	0.000	6.193

Source: Socio-economic survey (April - May 1991)
Notes:
1) Tk. 96.5 x 1000 for average economic cost houses
2) Tk. 96.5 x 1000 for average economic cost homesteads
3) Tk. 423.2 x 1000 average shadow price commercial enterprises
4) Tk. 423.2 x 1000 average shadow price small industries
5) Tk. 33.0 x 1000 for average value housing land

TABLE F.3.3 EROSION DAMAGE IN THE RECENT PAST

PRICES: mid-1991 economic prices
UNIT: Tk. x 1M

Year	Houses	Home-steads	Commerc. enterp.	Small industr.	TOTAL
1985	3.638	0.200	2.116	0.000	5.954
1986	3.935	0.178	3.809	0.000	7.922
1987	4.825	0.356	4.656	0.148	9.986
1988	6.013	0.601	7.195	0.223	14.032
1989	4.232	0.423	2.963	0.074	7.692
1990	2.301	0.156	1.270	0.000	3.727

Source: Socio-economic survey (April - May 1991)
Notes:
1) Tk. 74.2 x 1000 for avarage economic cost houses
2) Tk. 22.3 x 1000 for avarage economic cost homesteads
3) Tk. 423.2 x 1000 for avarage economic cost commercial enterprises
4) Tk. 423.2 x 1000 for avarage economic cost economic enterprises

F.3.4.4 **Computation of avoidable repair, maintenance, loss, damage and lost profits**

In Table F.3.4 a summary is presented of the cost of repair and maintenance, losses and damage and lost net economic return for the years 1985 to 1990. River bank protection would result in a substantial decrease in losses and consequently the total amount represents avoidable losses. Hence, the benefits of erosion control works are defined as a saving in future maintenance and repair cost, loss of and damage to property and profit losses for a scenario where no protection is undertaken. A computation of these savings over the evaluation period gives the benefit flow.

In Table F.3.4 total economic repair expenses and cost of erosion damage for the recent past are computed. The annual figures are ranked in size and a frequency is assigned in agreement with their ranking. Subsequently, the cost are correlated with their frequency by fitting the Gumbel extreme value probability function. Based on this function and the procedures outlined by the FPCO-guidelines for project assessment, the expected annual economic cost due to erosion are evaluated.

TABLE F.3.4 REPAIR AND MAINTENANCE COSTS, LOSS, DAMAGE AND LOST PROFITS DUE TO BANK EROSION IN BHAIRAB BAZAR

PRICES: mid-1991 economic prices
UNIT: Tk. x 1 million

Year	REPAIR/MAINT.COST:			DAMAGE/LOSS PRIV/PUB.INFRA			LOST	GRAND
	BWDB	Bgd.Rail	TOTAL	Loss	Damage	TOTAL	PROFITS	TOTAL
1985	5.916	0.787	6.703	12.038	7.443	19.481	0.379	26.563
1986	5.378	0.716	6.094	14.640	9.902	24.542	0.635	31.271
1987	8.658	26.074	34.732	19.995	12.482	32.477	1.459	68.669
1988	15.051	29.205	44.256	28.071	17.540	45.611	2.503	92.370
1989	10.318	8.995	19.313	16.540	9.614	26.155	1.441	46.909
1990	6.264	7.036	13.300	7.741	4.659	12.400	0.721	26.420

Sources: Survey (1991), BWDB, Bangladesh Railway, Power Development Board
Notes:
1) Cost repair and maintenance BWDB includes amount paid by Power Development Board and the protection expenses of Jamuna Oil Company
2) Deflator of 10% is used to adjust expenses for repair and maintenance (value of deflacor is according to Planning Commisison)

Table F.3.5 presents the mathematical expectation of annual avoidable costs due to repair, maintenance, loss, damage and lost profits, evaluated at Tk. 50 million economically. Figure F.3.1 gives the damage-frequency curve for Bhairab Bazar.

TABLE F.3.5 MATHEMATICAL EXPECTATION OF ANNUAL AVOIDABLE COSTS IN BHAIRAB BAZAR

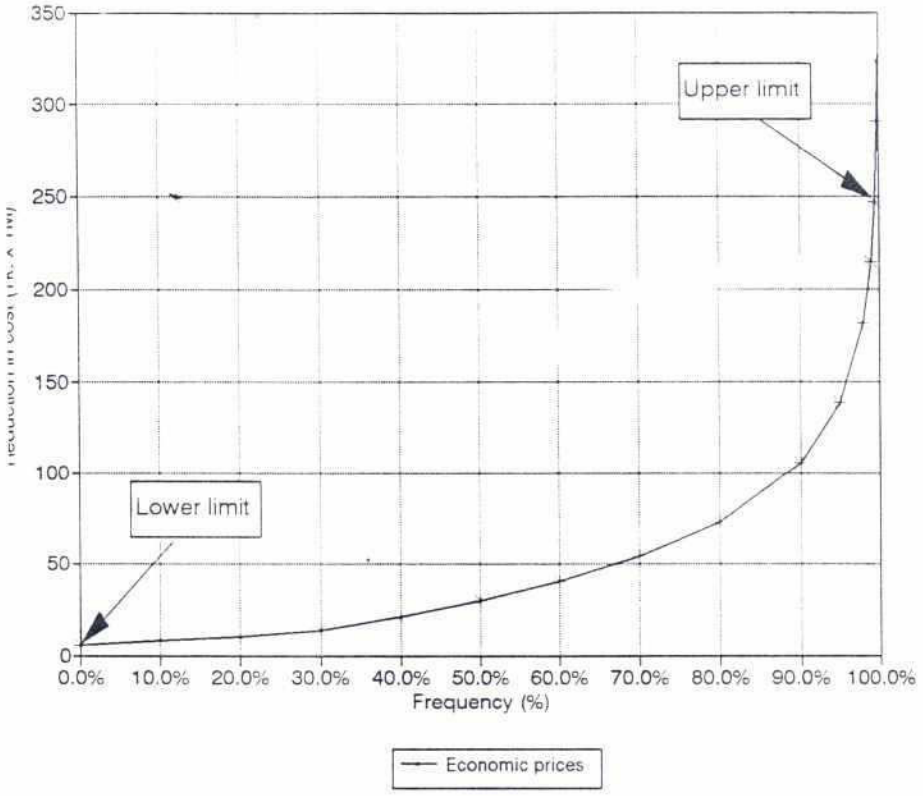
PRICES: mid-1991 economic prices
UNIT: Tk. x 1 million

Freq. (non-exc)	Return period (yrs)	REPAIR AND MAINTENACE: Total cost	C&F differ.	Cum C&F diff.	LOSSES AND DAMAGE: Total cost	C&F differ.	Cum C&F diff.	GRAND TOTAL	Covers. to US$ x 1M
0.00%		0.000		0.000	5.871		5.871	5.871	0.163
10.00%		0.000	0.000	0.000	7.994	0.693	6.564	6.564	0.182
20.00%		0.000	0.000	0.000	10.368	0.918	7.482	7.482	0.208
30.00%		0.631	0.032	0.032	13.058	1.171	8.654	8.685	0.241
40.00%		4.819	0.273	0.304	16.165	1.461	10.115	10.419	0.289
50.00%	2	9.773	0.730	1.034	19.838	1.800	11.915	12.949	0.360
60.00%		15.836	1.280	2.314	24.335	2.209	14.124	16.438	0.457
70.00%		23.652	1.974	4.289	30.132	2.723	16.847	21.136	0.587
80.00%	5	34.668	2.916	7.205	38.302	3.422	20.269	27.473	0.763
90.00%	10	53.501	4.408	11.613	52.270	4.529	24.797	36.410	1.011
95.00%	20	72.333	3.146	14.759	66.237	2.963	27.760	42.519	1.181
98.00%	50	97.229	2.543	17.302	84.701	2.264	30.024	47.326	1.315
99.00%	100	116.061	1.066	18.369	98.669	0.917	30.941	49.310	1.370
99.50%	200	134.894	0.627	18.996	112.636	0.528	31.469	50.465	1.402
99.80%	500	159.789	0.442	19.438	131.100	0.366	31.835	51.273	1.424
99.90%	1000	178.621	0.169	19.607	145.067	0.138	31.973	51.580	1.433

The steadily growing investments required to maintain the present situation is in agreement with the technical concept that the eroding forces gradually become stronger and stronger because of the protection works carried out. It can be expected that without the construction of the permanent protection works the national and regional authorities will pursue the protection of the town with all possible means. Hence, it is very likely that the expenditures in the past are a poor reflection of what may happen in the future. When extrapolating the present practice, therefore, an annual growth rate of 10% is applied to the annual expectation value of the repair and maintenance costs (Tk. 19 million) during the 30 year evaluation period. See also section F.2.2.

Concerning the loss and damage to private and public infra-structure and loss of profits (Tk. 31 million), the annual increase is 3% reflecting population growth and increase of economic activity in the affected area.

FIGURE F.3.1 DAMAGE-FREQUENCY CURVE FOR BHAIRAB BAZAR TOWN PROTECTION



F.3.4.5 **Disruption of rail transport**

(i) Methodology

Based on the results of site investigations and the geo-morphological study of the upper Meghna at Bhairab Bazar, it is expected that the railway bridge may be damaged to such an extent that railway traffic is disrupted during the coming 30 years. Consequently, a study is needed to evaluate the impact of such a disruption to the national economy. In view of the data and resources available only a limited analysis has been carried out.

Damage to the railway bridge will cause a disruption of rail traffic from and to Dhaka; passengers and cargo will either divert to other routes and modes or will have to disembark at Bhairab Bazar or Ashuganj, then cross the river by ferry and embark a train to proceed to their destination. This involves the following cost:

(a) Economic value of lost time
Depending on the length of the disruption, the total number of lost man-days can be calculated and appreciated in economic terms.

(b) Extra transport cost for passengers and cargo and/or extra cargo handling cost
Increased transport and handling cost are evaluated over the length of the disruption period. One may expect that cargo transport between Dhaka and Ashuganj will be by truck, involving extra transport cost.

(c) Repair cost of the bridge
The cost for repair of damage to the bridge is evaluated and comprises a benefit to the project.

(d) Other cost
This refers in particular to the expenses needed for upgrading the ferry ghat and assuring that enough ferries are available.

In this study the analysis is based on a review of the passenger and cargo flows presently using the bridge and their likely alternative route. The additional financial costs are estimated from financial transport, cargo handling and ferry costs for with and without protection scenarios.

The incremental failure probability of various degrees of damage to the bridge has been assessed, together with the costs and time required for the repairs. See Appendix G/5 to Anex G.
The total additional transport costs and the costs for repairs can then be evaluated as a (Gumbel extreme value) function of the failure probability.
On the basis of this damage probability function the expected annual costs have been evaluated at Tk. 17.2 million in financial term. This corresponds to Tk. 14.1 million in economic terms. The following sections provide details on the calculation of this value.

(ii) Passenger flows crossing the bridge

From data of the annual Bangladesh Rail booklets and the reported average occupation factor of 80%, a daily flow of 40,000 passengers crossing the railway bridge has been calculated. The total annual loss due to disruption of the rail transport on the bridge has been estimated at Tk. 280 million, based on the following assumptions:

- Passengers will disembark the train, cross the river by ferry and embark the train at the other side, during the period in which the bridge is in repair. Crossing the river by ferry services increases the trip time by and average 4 to 5 hours.

- Only half of the time lost can be considered an economic loss because part of the passengers are active. and be evaluated at Tk. 7.5 per hour (market prices) in agreement with the wage for unskilled labour. These additional annual (financial) cost, which are estimated at Tk. 250 million, have been taken into account in the evaluation.

- From ferry services rates and the ferry analysis in the feasibility study of the Jamuna Bridge, the financial costs of this ferry service is estimated at Tk. 2.0 (mid-1991 financial prices) per one way crossing, leading to an additional annual (financial) cost of Tk. 30 million.

- No idle ferry service capacity has been reported.

(iii) Container Transport

Annual container transport from Chittagong to Dhaka has been reported as 10,000 TEU with an average load of 20 tons. No rail transport facilities are available if the Bhairab Bazar railway bridge fails. In such an event containers should be stripped in Chittagong and the cargo can only be transported by road.

Based on information from private road transport organisations and the transport analysis carried out for the feasibility studies, the additional transport costs have been evaluated at Tk. 200 per ton, so that the annual loss due to a failure of the Bhairab Bazar railway bridge can be estimated as Tk. 40 million.

(iii) Cargo flows

From the BR booklets various estimates have been made leading to an annual cargo flow crossing the bridge of between one and two million tons of cargo. More detailed information has been obtained from an analysis of the flows of wheat, rice, fertilizer, cement, petrol and salt for three years, leading to an average cargo flow of 510,000 tons crossing the railway bridge. These substantiated flows have been further analyzed and taken into account in the economic evaluation. Since the total cargo flow crossing the bridge is probably higher, it is likely that the benefits for the bank protection works at Bhairab Bazar are underestimated. Table F.3.6 presents details.

The cargo flows identified above are schematized in agreement with the likely origin and destination, the alternative route to be followed in case of failure of the bridge and the additional financial transport and cargo handling costs per ton. These additional transport costs and cargo handling costs are based on the financial road transport costs, the tariffs for rail transport, ferry transport and cargo handling costs and evaluated at Tk. 122 million. Table F.3.7 presents details.

TABLE F.3.6 CARGO FLOWS PASSING THE RAILWAY BRIDGE

UNIT: tons x 1000

	84/85	85/86	87/88
WESTBOUND (import):			
Wheat	160	95	230
Rice	116	73	88
Fertilizer	144	164	133
Cement	39	35	26
POL	8	14	34
Salt	58	47	36
Total	525	428	547
EASTBOUND (export):			
Jute	26	20	26
Rice	8	10	7
Total	34	30	33
GRAND TOTAL	559	458	580

Source: Bangladesh Rail

TABLE F.3.7 ALTERNATIVE CARGO HANDLING AND TRANSPORT COSTS

Route	ton/year	Alternative mode	Additional costs (Tk./ton)
Chittagong-Dhaka	100,000	Road	200
Chittagong-Mymensing	250,000	Road to Dhaka and rail to Mymensing	300
Mymensing-Chittagong	30,000	Rail and ferry	200
Bhairab Bazar-Mymensing	130,000	Ferry and rail	200

(iv) Repair costs and failure probability

Five situations with a different degree of damage to the bridge have been investigated. For these situations the failure probability has been assessed. the repair costs have been estimated and the period of disruption of rail transport indicated. These situations are characterized by:

(a) Repair to the abutment
Incremental probability with respect to the improved situation is evaluated at zero.
No disruption of rail traffic.

(b) Failure of abutment
Incremental probability estimated at 5.0 E-02.
Repair costs estimated at Tk. 72 million.
Disruption of traffic for a period of six months

(c) Failure of abutment and first span
Incremental probability estimated at 1.71 E-03.
Repair costs estimated at Tk. 144 million.
Disruption of traffic for a period of one year.

(d) Failure of abutment, first span and first pillar
Incremental probability estimated at 2.47 E-05.
Repair costs estimated at Tk. 360 million.
Disruption of traffic for a period of two years.

(e) Failure of abutment, first span, first pillar and second span
Incremental probability estimated at 3.57 E-7.
Repair costs estimated at Tk. 432 million.
Disruption of traffic for a period of two years.

(v) Expected avoidable costs

Following the analysis of the above paragraphs it becomes possible to calculate the total additional financial cost related to the disruption of rail transport. By applying the Planning Commission's standard conversion factor the economic cost are calculated. Failure probabilities presented are the result of fault trees which are presented in Annex G, Appendix G/5. Estimated repair cost for the individual situations of failure are based on information from the Jamuna Bridge adjusted to the Bhairab Bazar conditions and presented in Appendix G/5 to Annex G. A summary of the avoidable cost due to interruption of rail transport on the bridge for each of the damage scenarios is presented in Table F.3.8.

For each of the five situations the total costs of repair and additional transport and cargo handling have been estimated and these values have been correlated with the incremental failure probability of the bridge by fitting the Gumbel extreme value probability function. Based on this function and following the procedures outlined in the FPCO-guidelines for project assessment, the expected annual economic costs due to disruption of rail traffic on the Bhairab Bazar Railway Bridge has been evaluated at Tk. 14.1 million. Table F.3.9 provides the mathematical expectation of annual costs due to disruption of rail transport, while Figure F.3.2 gives the damage-frequency curve.
According to what has been explained in chapter 2 and in line with the FPCO-guidelines, the expected annual cost avoided through protection grow annually with a rate of 3%. There are no arguments in support of a higher percentage than the average annually economic growth rate.

TABLE F.3.8 SUMMARY OF COST AS A RESULT OF DISRUPTION OF RAIL TRANSPORT

PRICES: mid-1991 economic prices
UNIT: Tk. x 1 million

Scenario	Increm. failure prob.	ADDITIONAL ECONOMIC COST: Repair cost	Pass. transp.	Container transp.	Cargo handl.	Total
Repair to abutment	0.0E+00	0.0	0.0	0.0	0.0	0.0
Failure of abutment	5.0E-02	59.0	114.8	16.4	52.1	242.3
Failure of abutment and first span	1.7E-03	118.1	229.6	32.8	104.1	484.6
Failure of abutment, first pan and first pillar	2.5E-05	324.7	459.2	65.6	208.3	1 057.8
Failure of abutment, first and second span and first pillar	3.6E-07	354.2	459.2	65.6	208.3	1 087.3

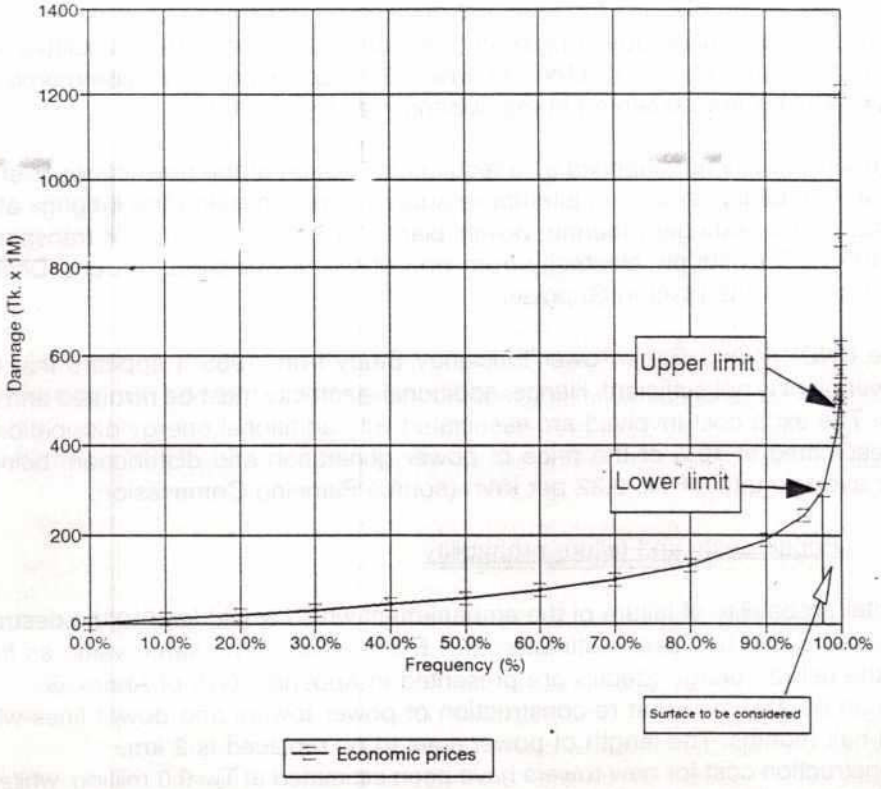
TABLE F.3.9 MATHEMATICAL EXPECTATION ANNUAL DAMAGE TO DISRUPTION OF RAIL TRANSPORT

PRICES: mid-1991 economic prices
UNIT: Tk. x 1 million

Freq. (non-exc)	Return period (yrs)	Total damage	C&F differ.	Cum. C&F diff.	Convers. to US$ x 1M
0.00%		0.000	0.000	0.000	0.000
10.00%		8.588	0.429	0.429	0.012
20.00%		18.188	1.339	1.768	0.049
30.00%		29.072	2.363	4.131	0.115
40.00%		41.637	3.535	7.667	0.213
50.00%	2	56.498	4.907	12.573	0.349
60.00%		74.686	6.559	19.133	0.531
70.00%		98.135	8.641	27.774	0.771
80.00%	5	131.184	11.466	39.240	1.090
90.00%	10	187.682	15.943	55.183	1.533
95.00%	20	244.180	10.797	65.979	1.833
97.50%		300.677	6.811	72.790	2.022
99.50%	200	431.861	7.325	80.116	2.225
99.75%	400	488.359	1.150	81.266	2.257
99.80%		506.548	0.249	81.515	2.264
99.83%		519.435	0.150	72.940	2.0[illegible]
99.90%	1000	563.045	10.365	83.1[illegible]	2.310
99.95%		619.543	0.296	83.450	2.318
100.00%		864.583	0.353	83.803	2.328
100.00%		1210.051	0.025	83.828	2.329

Notes:
1) Conversion to US$ 1 = Tk. 36
2) Annual benefits at economic prices: Tk. 14.136 million

FIGURE F.3.2 DAMAGE-FREQUENCY CURVE FOR BHAIRAB BAZAR RAILWAY BRIDGE



F.3.4.6 **Disruption of power supply**

(i) Methodology

On the basis of site investigations and the geo-morphological survey of the upper Meghna at Bhairab Bazar, it is expected that the power towers near the confluence with the old Bhramaputra could be destroyed during the coming 30 years. Consequently, there is a need to evaluate its economic impact. In view of the data available only a limited analysis has been carried out.

Destruction or heavy damage to the power towers will cause disruption of power supply to a number of industrial enterprises. However, no details are obtained on the end-users of electricity passing the Meghna at Bhairab Bazar, although it can be assumed that almost all electricity going through the power lines is used by industries. Hence the analysis can only be limited.

The possibilities of supplying power from other sources or through alternative routes are existent. However, it means additional cost for the PDB. The analysis involves the following cost:

(a) Supply of electricity foregone
Depending on the length of disruption, capacity of the line or sub-station and loads there will be a loss to the national economy as a result of disruption.

(b) Replacement cost of power towers and lines
This need not further explanation.

The analysis is based on a review of the avoidable additional cost for the supply of the amount of electricity sold normally and the repair cost of towers and lines. These cost are the loss to the national economy following the disruption of power supply.

(ii) Additional cost electricity supply

From data supplied by the PDB the total amount of electricity supplied per year can be calculated. Assuming that the period of disruption does not exceed one-and-half months, the calculated amount of electricity not supplied is estimated at 14.280 MWh, of which 76% corresponds to commercial users and 24% to domestic users. Details are presented in the appendix, section F/1.8.

The value of the electricity not supplied as a result of disruption of the power lines over the Meghna has to be evaluated at the additional cost of alternative supply. Power passing the Meghna at Bhairab Bazar has been generated at the Ashuganj thermal power plant. A disruption of power transport over the Meghna would force the PDB to supply electricity from one of the power plants around Dhaka. The most likely options would be from the plant in Ghorasal.

Based on the UNDP/World Bank Power Efficiency Study from 1985 it appears that the capacity of the Ghorasal power plant is not sufficient. Hence, additional electricity must be rerouted and supplied from other power plants. The extra cost involved are associated with additional energy dissipation in the power lines and can be estimated at 10% of the price of power generation and distribution, being Tk. 0.2 per kWh, based on the average tariff of Tk. 2.32 per kWh (source Planning Commission).

(iii) Repair costs and failure probability

The incremental probability of failure of the embankment which would lead to the destruction of the power towers in Bhairab Bazar has been estimated at 5 E-02, which is the same value as for the failure of the abutment of the railway bridge (details are presented in Appendix G/5 of Annex G).
Moreover, it can be assumed that re-construction of power towers and power lines will require not more than one-and-half months. The length of power lines to be replaced is 2 km.
Economic construction cost for new towers have been estimated at Tk. 9.0 million, while 2 km of power line would cost Tk. 16.4 million. Table F.3.10 summarizes the total cost due to disruption of power supply.
All assumptions have been made on the basis of information received from PDB.

TABLE F.3.10 SUMMARY OF COST AS A RESULT OF DISRUPTION OF POWER SUPPLY

DISRUPTION: 1.5 months
PRICES: mid-1991 economic prices
UNIT: Tk. x 1 million

Item	Estimated cost
Economic loss	2.7
Replacement cost 2 towers	9.0
Cost 2 km power line	16.4
TOTAL	28.1

Sources: Bangladesh PDB and Planning Commission
Notes:

1) Probability of failure:	5.0E-02	
2) Lost energy:	14 280	MWh
3) Additional cost for generation of electricity through alternative modes is estimated at Tk.	0.19	per kWh
3) Annual economic cost Tk.	1.3	x 1 million

The value from the table represents the total economic cost foregone when power supply is disrupted for a period of one-and-half months. The incremental probability of such a disruption is 5.0 E-2, while the incremental probability of failure in the protection works is equal to 5.0 E-3. In accordance with the FPCO-

guidelines for project assessment the annual avoidable cost as a result of protection works are the cost-frequency differential between the non-exceeding frequencies of 95 E-2 (disruption power supply) and 995 E-3 (failure protection works). The annual avoidable cost are calculated at Tk. 1.3 million.

F.3.4.7 Oil terminal

In Bhairab Bazar there are two oil terminals near the waterfront south of the railway bridge. Without adequate protection works one terminal will be engulfed within 5 years and the second within 10 years. According to engineers from Jamuna Oil Company, which were contacted on this subject, it would cost Tk. 20 million to relocate each terminal. No break-down of these cost could be provided by the oil companies. Hence, protection benefits are the avoidable cost of relocation of these terminals.
In the economic feasibility analysis an amount of Tk. 16.2 million (the economic equivalent of the financial Tk. 20 million) is imputed in 1998 and 2003 to reflect the avoidable costs as a benefit to the bank protection works.

F.3.5 Costs of the river bank protection works

F.3.5.1 Investment costs of the river bank protection works

Two alternatives for river bank protection have been considered. The first alternative is composed of a revetment of the existing bank line. The second alternative considers an advanced bank line.

The major negative effect of the river bank protection along the present bank line is caused by clearing of a strip of land along the waterfront. This implies removal of a limited number of houses and tin-shacks. The total area involved is estimated at 14,000 square meters. This is the area gained when the advanced protection works are executed.

For this reason the advanced river bank protection alternative has been proposed and further elaborated. The economic evaluation is limited to that option. The economic costs of the advanced protection concept are evaluated at Tk. 463.6 million or US$ 12.9 million. A breakdown of the economic costs is given in Table F.3.11. An estimated 53% of the total investment cost are local currency expenditures, while the foreign component amounts to 47%.

F.3.5.2 Monitoring and maintenance cost

Monitoring and maintenance of protection structures is an important component, which affects directly the long term effectiveness of protection works. Monitoring and maintenance are an integral part of river bank protection, the probability of failure of the structures may very well increase rapidly in the future if they are poor. Monitoring activities comprise sounding of bed and bank level. They are estimated at Tk. 2.0 million per annum in economic terms.

After critical judgement of protection work items it is assumed that annual maintenance is 4.0% of the investment costs of all revetment components. Consequently, annual maintenance for the protection works are evaluated at Tk. 4.8 million per annum.

F.3.5.3 Budgetary implications

Budgetary implications of the bank protection works relate in general to recurrent cost, which must be met by the national budget. The following cost are considered to be covered by this budget:

(i) Monitoring and maintenance expenses

For the advanced protection concept, initial monitoring and maintenance cost are Tk. 8.2 million per year in financial terms. After five years the amount becomes Tk. 13 million, while the amount needed in the year 2008 is Tk. 35 million.

(ii) Environmental monitoring

Costs of the required environmental monitoring are low and could easily be covered by the reservations made for other cost. Details on environmental monitoring are presented in Annex I.

Table F.3.11 ECONOMIC INVESTMENT COSTS FOR THE BHAIRAB BAZAR BANK PROTECTION WORKS

PRICES: mid-1991 economic prices
UNIT: US $ x 1,000

No.	Summary	TOTAL	LOCAL LABOUR	EXPAT. LABOUR	IMPORTED MATERIALS	LOCAL MATERIAL	PLANT & FUEL
1	Dredging	5 088.3				3 381.3	1 707.0
2	Working/material area	102.2	24.7			35.9	
3	Earthworks above SLW	258.1	86.5				171.6
4	Clear site and reinstate	17.7	6.2				11.5
5	Open stone asphalt	664.4	50.3		122.7	332.9	158.5
6	Fascine matress	1 425.5	42.2		438.2	613.8	331.4
7	Boulders in falling apron	1 148.2	53.2			684.2	410.9
8	Grounting of boulders	86.7	3.6			78.9	4.2
9	Containment bunds	0.0					
10	Construction cost and supervision	525.6		378.0	127.9	19.7	
11	Mobilization/demobilization	49.2			49.2		
	COST OF MATERIALS AND WORKS	9 366.0	266.6	378.0	738.0	5 146.5	2 836.9
	Physical contingencies (10%)	936.6					
	TOTAL COST OF MATERIALS AND WORK	10 302.6					
	Contractors margins and fees (20%)	1 873.2					
	TOTAL CONSTRUCTION COST	12 175.8					
	Engineering and supervision (7.5%)	702.4					
	TOTAL INVESTMENT COST	12 878.2					
	Total (Tk x 1M)	463.6					

Notes:
1) Overall lokal cost component is 53.5%
   Overall foreign cost component is 46.5%
2) Annual maintenance is estimated as %-age of surface protection: open stone asphalt, fascine matress, boulders in falling apron and grounting of boulders. Percentage 4%
   So, annual maintenance cost are estimated at T 4.8 million
3) Conversion: 1 US$ = Tk. 36

F.3.6 Economic feasibility analysis

F.3.6.1 Cash flow

The cash flow computation for river bank protection in Bhairab Bazar makes a comparison of benefits and cost over the 30-year evaluation period. The investment costs have been discussed in detail in the previous section. Project benefits were discussed in Section F.3.4.

In Table F.3.12 the economic cash flow is given. The table makes use of estimated avoidable cost for town protection, rail transport disruption and failure of power supply. In the table the imputed figure has been increase by the annual percentage retained and discussed before. Furthermore, the lay-out of cash flow table requires no further discussion.

TABLE F.3.12 ECONOMIC CASH FLOW FOR THE BHAIRAB BAZAR BANK PROTECTION

PRICES: mid-1991 economic prices
UNIT: Tk. x 1 million
STARTI 1993
CONST 1 years

EIRR: 20.62% NPV: 446.4 NPVR1: 0.75

	WITH-PROJECT SITUATION COST:				PROJECT BENEFITS:					CASH	Cash F.
Year	Invest.	M&M	Other	Total	T.prot.	Prot.Rb.	Pw.Sup	Oil term.	Total	FLOW	(US$x1M)
1993	463.6	6.8	2.3	472.7						-472.7	-13.1
1994	0.0	6.8	2.3	9.1	59.7	15.4	1.4		76.5	67.4	1.9
1995		6.8	2.3	9.1	63.2	15.9	1.4		80.6	71.5	2.0
1996		6.8	2.3	9.1	67.1	16.4	1.5		84.9	75.8	2.1
1997		6.8	2.3	9.1	71.2	16.9	1.5		89.6	80.5	2.2
1998		6.8	2.3	9.1	75.7	17.4	1.6	16.4	111.1	102.0	2.8
1999		6.8	2.3	9.1	80.6	17.9	1.6		100.1	91.0	2.5
2000		6.8	2.3	9.1	85.9	18.4	1.7		105.9	96.8	2.7
2001		6.8	2.3	9.1	91.6	19.0	1.7		112.3	103.2	2.9
2002		6.8	2.3	9.1	97.8	19.6	1.8		119.1	110.0	3.1
2003		6.8	2.3	9.1	104.5	20.2	1.8		126.4	117.3	3.3
2004		6.8	2.3	9.1	111.8	20.8	1.9		134.4	125.3	3.5
2005		6.8	2.3	9.1	119.7	21.4	1.9		143.0	133.9	3.7
2006		6.8	2.3	9.1	128.4	22.0	2.0		152.4	143.3	4.0
2007		6.8	2.3	9.1	137.8	22.7	2.0		162.5	153.4	4.3
2008		6.8	2.3	9.1	148.0	23.4	2.1	16.4	189.9	180.8	5.0
2009		6.8	2.3	9.1	159.2	24.1	2.2		185.4	176.3	4.9
2010		6.8	2.3	9.1	171.4	24.8	2.2		198.4	189.3	5.3
2011		6.8	2.3	9.1	184.6	25.5	2.3		212.5	203.3	5.6
2012		6.8	2.3	9.1	199.1	26.3	2.4		227.8	218.7	6.1
2013		6.8	2.3	9.1	214.9	27.1	2.4		244.4	235.3	6.5
2014		6.8	2.3	9.1	232.2	27.9	2.5		262.6	253.5	7.0
2015		6.8	2.3	9.1	251.1	28.7	2.6		282.4	273.3	7.6
2016		6.8	2.3	9.1	271.7	29.6	2.7		304.0	294.9	8.2
2017		6.8	2.3	9.1	294.3	30.5	2.7		327.5	318.4	8.8
2018		6.8	2.3	9.1	318.9	31.4	2.8		353.2	344.0	9.6
2019		6.8	2.3	9.1	345.9	32.3	2.9		381.2	372.1	10.3
2020		6.8	2.3	9.1	375.5	33.3	3.0		411.8	402.7	11.2
2021		6.8	2.3	9.1	407.9	34.3	3.1		445.2	436.1	12.1
2022		6.8	2.3	9.1	443.3	35.3	3.2		481.8	472.7	13.1
SUM	463.6	203.6	69.5	736.8	5312.9	698.5	62.6	32.8	6106.8	5370.0	149.2

Notes:

1) INVESTMENT COST:
   Tk. x 1M 463.6

2) O&M COST (Tk. x 1M):
   Maintenance 4.8
   Survey cost 2.0

3) OTHER COST:
   Tk. x 1M 2.3

4) BENEFITS (Tk. x 1M):
   Savings damage/loss 31.5
   Annual increase 3%
   Savings repair/maint 19.0
   Annual increase 10%
   Damage ...way bridge 14.1
   Annual increase 3%
   Damage power supply 1.3
   Annual increase 3%
   Re-loaction oil terminal 16.4 (in 1998)

PV (12%) benefits:
MTk. 933.7

F.3.6.2 Economic Internal Rate of Return

The economic feasibility of the river bank protection works is first evaluated by comparing the discounted values of benefits against cost. The economic internal rate of return (EIRR) is the discounting percentage at which the benefits balance cost over the 30-year evaluation period.
The short term bank protection works give an economic internal rate of return of 21%, which is considerably above the assumed opportunity cost of capital in Bangladesh (12%). The economic internal rate of return indicates that the interests to be protected, especially those related to the railway bridge, fully justify the investments in the bank protection works in economic terms.

F.3.6.3 Net Present Value

The economic net present value for the short term bank protection works in Bhairab Bazar, evaluated at a discount rate of 12%, is equal to Tk. 446 million. The NPVR, being the ratio between the net present value and the present value of public capital and operation and maintenance cost at financial prices is evaluated at 0.75.

The conclusions drawn from this chapter comprise the following:

(a) The bank protection works show an EIRR of about 21% and are fully justified in economic terms.
(b) The rate realized is well above the interest rate normally required by (international) development banks. In this respect, interest obligations and repayment can easily be guaranteed.
(c) The NPV at 12% is positive, which indicates that the rate of return is above this discount rate. In view of a scarcity of development resources, this project may very well obtain the priority of the Government.

F.3.7 Sensitivity analysis

F.3.7.1 General

The economic analysis of the bank protection works is based on uncertain future events and imperfect data. Because of this, it is important that sensitivity analyses be undertaken. This implies an analysis of the economic internal rate of return as function of changes in investment cost, monitoring and maintenance expenditure and estimated value of benefits.

F.3.7.2 Reduction in the value of benefits

The influence of a reduction of the value of benefits on the economic internal rate of return of the proposed river bank protection works is presented in Table F.3.13. and Figure F.3.3.

F.3.7.3 Increase in investment cost

Details on changes in investment cost of the river bank protection works can also be found in Table F.3.13 and Figure F.3.4.

Cost estimates are considered rather accurate. However, due to the fact that an international tender procedure will precede the awarding of the construction contract, some difference in total price must be expected. Experience has learned that international tendering results in offers that vary over a band of plus or minus 10% as compared with the estimated investment cost.

F.3.7.4 Increase of monitoring and maintenance cost

A critical issue in the economic feasibility analysis of river bank protection in Bhairab Bazar remains the estimate of likely future monitoring and maintenance cost. Consequently, it is very important to analyze the sensitivity to any change in these cost, although this may cause a difference in failure probability. This

difference may be to such an extent that accepted failure probability is not any longer achieved. This matter is touched upon later in this annex.

Concerning the sensitivity of the EIRR for variation of the annual monitoring and maintenance costs, it is demonstrated that:

(a) 30% more monitoring and maintenance services leads to a lowering of the EIRR by 0.4%;
(b) decreasing the cost by 30% gives a gain of also 0.4%.

F.3.7.5 Delays in construction

An increase of the construction period envisaged means that the estimated benefits come into effect on a later date. This leads, in general, to a lower economic internal rate of return. With respect to the standard and improved protection concepts the estimated construction period is one year. Doubling of the construction period leads to a negligible reduction in the economic internal rate of return of the project. No arguments can be found to increase the construction period even more. Within one year and at most two years the work can be carried out.

TABLE F.3.13 RESULTS OF THE SENSITIVITY ANALYSIS FOR BHAIRAB BAZAR

VALUE Economic Internal Rate of Return (EIRR)
UNIT: perc

Change investm.	CHANGE IN BENEFITS: -30%	-20%	-10%	0%	10%	20%	30%
-30%	20.08%	22.43%	24.75%	27.04%	29.33%	31.61%	33.89%
-20%	18.19%	20.30%	22.37%	24.41%	26.43%	28.44%	30.45%
-10%	16.67%	18.60%	20.48%	22.32%	24.14%	25.95%	27.75%
0%	15.41%	17.20%	18.93%	20.62%	22.29%	23.93%	25.56%
10%	14.34%	16.02%	17.63%	19.20%	20.74%	22.26%	23.76%
20%	13.42%	15.00%	16.52%	17.99%	19.43%	20.84%	22.23%
30%	12.61%	14.12%	15.55%	16.94%	18.29%	19.62%	20.92%

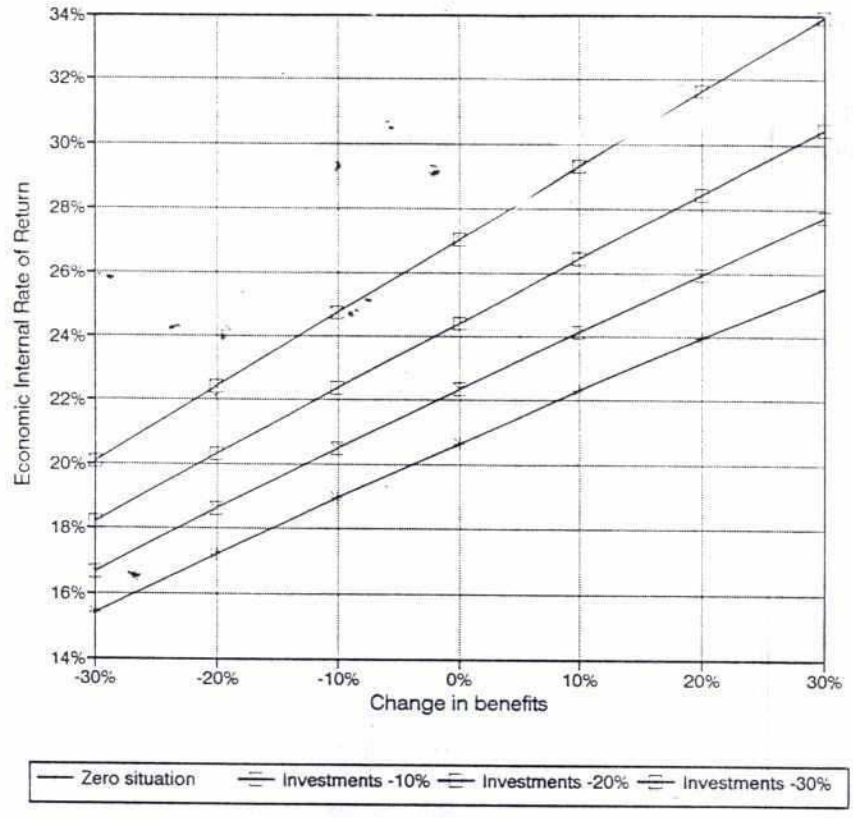
Change M&M	CHANGE IN BENEFITS: -30%	-20%	-10%	0%	10%	20%	30%
-30%	15.78%	17.57%	19.31%	21.01%	22.68%	24.34%	25.98%
-20%	15.66%	17.45%	19.18%	20.88%	22.55%	24.20%	25.84%
-10%	15.53%	17.32%	19.06%	20.75%	22.42%	24.07%	25.70%
0%	15.41%	17.20%	18.93%	20.62%	22.29%	23.93%	25.56%
10%	15.29%	17.08%	18.81%	20.49%	22.15%	23.80%	25.43%
20%	15.17%	16.96%	18.68%	20.37%	22.02%	23.66%	25.29%
30%	15.05%	16.84%	18.56%	20.24%	21.89%	23.53%	25.15%

F.3.8 Feasibility analysis without railway bridge

F.3.8.1 Investment cost

To investigate the economic feasibility of the protection of the town area of Bhairab Bazar alone, independent of the protection of the railway bridge, a partial analysis has been made, taking into account the costs and benefits associated with the town protection only. Assuming that the bridge abutment and the upstream part will be protected separately, the investment costs somewhat decrease to Tk. 404.1 million. A cost break-down is presented in table F.3.14.

FIGURE F.3.3 AND F.3.4 RESULTS SENSITIVITY ANALYSIS



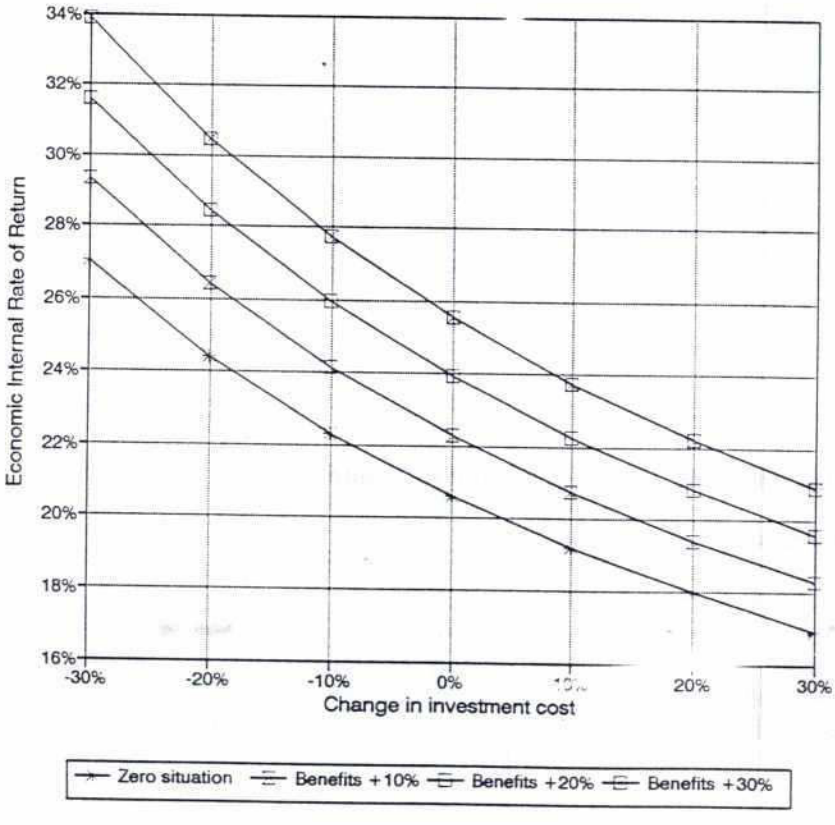
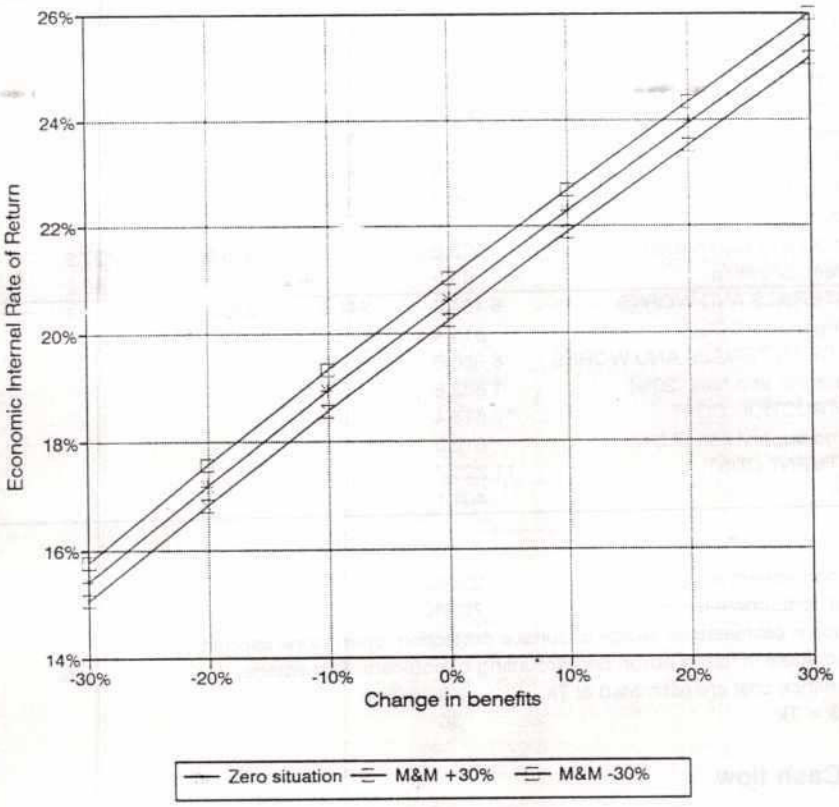


FIGURE F.3.5 AND F.3.6 RESULTS SENSITIVITY ANALYSIS



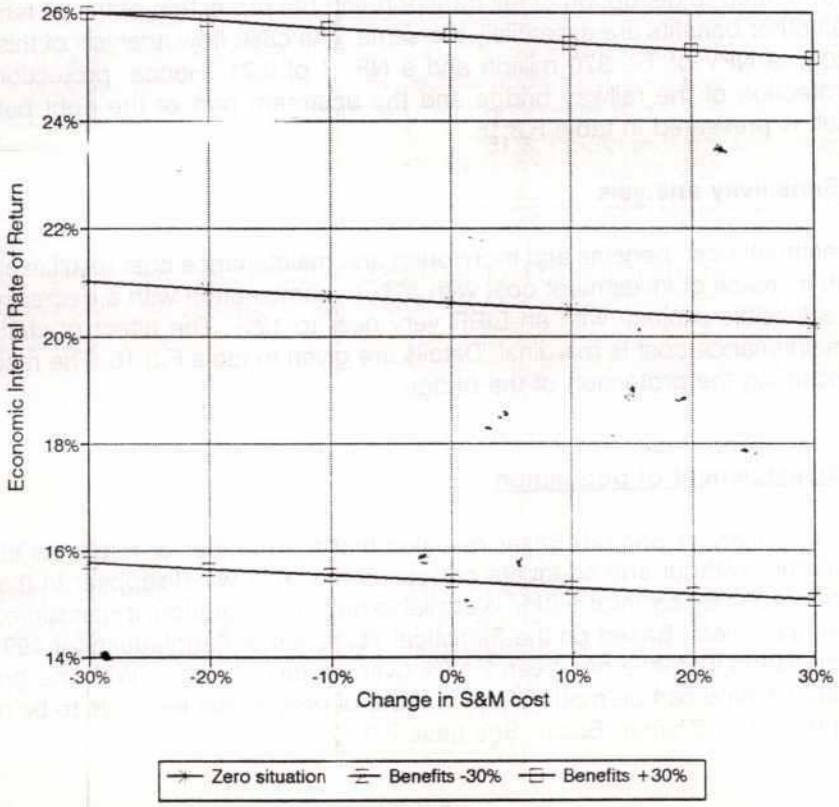


TABLE F.3.14 INVESTMENT COST FOR TOWN PROTECTION WORKS ONLY

PRICES: mid-1991 economic prices
UNIT: US $ x 1.000

No.	Summary	TOTAL	LOCAL LABOUR	EXPAT. LABOUR	IMPORTED MATERIALS	LOCAL MATERIAL	PLANT & FUEL
1	Dredging	4 523.0			3 015.3		1 507.7
2	Working/material area	96.7	20.4			35.9	40.4
3	Earthworks above SLW	258.1	86.5				171.6
4	Clear site and reinstate	31.4	10.5				20.9
5	Open stone asphalt	560.1	45.7		101.1	274.1	139.2
6	Fascine matress	1 174.8	34.7		360.9	466.1	313.1
7	Boulders in falling apron	879.0	40.7			524.1	314.2
8	Grounting of boulders	66.3	2.8			60.4	3.2
9	Containment bunds	0.0					
10	Construction cost and supervision	525.6		378.0	127.9	19.7	
11	Mobilization/demobilization	49.2			49.2		
	COST OF MATERIALS AND WORKS	8 164.2	241.3	378.0	3 654.4	1 380.2	2 510.3
	Physical contingencies (10%)	816.4					
	TOTAL COST OF MATERIALS AND WORKS	8 980.6					
	Contractors margins and fees (20%)	1 632.8					
	TOTAL CONSTRUCTION COST	10 613.4					
	Engineering and supervision (7.5%)	612.3					
	TOTAL INVESTMENT COST	11 225.7					
	Total (Tk x 1M)	404.1					

Notes:

1) Overall lokal cost component is 23.2%
   Overall foreign cost component is 76.8%
2) Annual maintenance is estimated as %-age of surface protection: open stone asphalt, fascine matress, boulders in falling apron and grounting of boulders. Percentage: 4%
   So, annual maintenance cost are estimated at Tk. 3.9 million
3) Conversion: 1 US$ = Tk. 36

F.3.8.2 Cash flow

When considering the economic feasibility without the railway bridge, benefits are also lower due to the fact that the benefits attributed to disruption of rail transport and the protection of the oil terminal can no longer be considered. All other benefits are essentially the same. The cash flow analysis of this situation shows an EIRR of about 20%, a NPV of Tk. 370 million and a NPVR of 0.71. Hence, protection of Bhairab Bazar, excluding the protection of the railway bridge and the upstream part of the right bank, is economically feasible. The result is presented in table F.3.15.

F.3.8.3 Sensitivity analysis

Changing the investment cost, benefits and monitoring and maintenance cost result in changes in the EIRR. However, even an increase of investment cost with 30% in combination with a decrease of the benefits by 30% would give a feasible project, with an EIRR very near to 12%. The effect of changes in the level of monitoring and maintenance cost is marginal. Details are given in table F.3.16. The results are very similar to the situation including the protection of the bridge.

F.3.9 Displacement of population

The socio-economic survey in Bhairab Bazar revealed that the number of habitants in the area prone to erosion is 760 persons. Without any adequate protection this area will disappear in the coming 30 years. As no detailed geo-morphological information is available on bank-migration, it is assumed that the migration will be the same for each year. Based on the Statistical Yearbook of Bangladesh for 1991 (table 2.08, page 45), the annual population increase has been 2.17% over the last 10 years. With this growth factor for the coming 30 years an estimate can be made of the number of people that will have to be resettled due to the ongoing erosion process at Bhairab Bazar. See table F.3.17.

TABLE F.3.15 ECONOMIC CASH FLOW FOR THE BHAIRAB BAZAR BANK PROTECTION WITHOUT RAILWAY BRIDGE PROTECTION

PRICES: mid-1991 economic prices
UNIT: Tk. x 1 million
STARTI 199?
CONST 1 years

EIRR: 19.89% NPV: 369.7 NPVR1: 0.71

	WITH-PROJECT SITUATION COST:				PROJECT BENEFITS:				CASH	Cash F.
Year	Invest.	S&M	Other	Total	T.prot.	Pw.Sup	Oil term	Total	FLOW	(US$x1
1993	404.1	5.9	2.0	412.0					-412.0	-11.4
1994	0.0	5.9	2.0	7.9	59.7	1.4		61.1	53.2	1.5
1995		5.9	2.0	7.9	63.2	1.4		64.7	56.8	1.6
1996		5.9	2.0	7.9	67.1	1.5		68.5	60.7	1.7
1997		5.9	2.0	7.9	71.2	1.5		72.7	64.9	1.8
1998		5.9	2.0	7.9	75.7	1.6	16.4	93.7	85.8	2.4
1999		5.9	2.0	7.9	80.6	1.6		82.2	74.3	2.1
2000		5.9	2.0	7.9	85.9	1.7		87.5	79.6	2.2
2001		5.9	2.0	7.9	91.6	1.7		93.3	85.4	2.4
2002		5.9	2.0	7.9	97.8	1.8		99.5	91.6	2.5
2003		5.9	2.0	7.9	104.5	1.8		106.3	98.4	2.7
2004		5.9	2.0	7.9	111.8	1.9		113.7	105.8	2.9
2005		5.9	2.0	7.9	119.7	1.9		121.7	113.8	3.2
2006		5.9	2.0	7.9	128.4	2.0		130.4	122.5	3.4
2007		5.9	2.0	7.9	137.8	2.0		139.8	131.9	3.7
2008		5.9	2.0	.9	148.0	2.1	16.4	166.5	158.6	4.4
2009		5.9	2.0	7.9	159.2	2.2		161.3	153.5	4.3
2010		5.9	.0	7.9	171.4	2.2		173.6	165.7	4.6
2011		5.9	2.0	7.9	184.6	2.3		186.9	179.0	5.0
2012		5.9	2.0	7.9	199.1	2.4		201.5	193.6	5.4
2013		5.9	2.0	7.9	214.9	2.4		217.4	209.5	5.8
2014		5.9	2.0	7.9	232.2	2.5		234.7	226.8	6.3
2015		5.9	2.0	7.9	251.1	2.6		253.7	245.8	6.8
2016		5.9	2.0	7.9	271.7	2.7		274.4	266.5	7.4
2017		5.9	2.0	7.9	294.3	2.7		297.0	289.1	8.0
2018		5.9	2.0	7.9	318.9	2.8		321.8	313.9	8.7
2019		5.9	2.0	7.9	345.9	2.9		348.8	341.0	9.5
2020		5.9	2.0	7.9	375.5	3.0		378.5	370.6	10.3
2021		5.9	2.0	7.9	407.9	3.1		410.9	403.0	11.2
2022		5.9	2.0	7.9	443.3	3.2		446.5	438.6	12.2
SUM	404.1	175.8	60.6	640.5	5312.9	62.6	32.8	5408.3	4767.7	132.4

Notes:

1) INVESTMENT COST:
   Tk. x 1M 404.1

2) O&M COST (Tk. x 1M):
   Maintenance 3.9
   Survey cost 2.0

3) OTHER COST:
   Tk. x 1M ?.0

4) BENEFITS (Tk. x 1M):
   Savings damage/loss 31.5
   Annual incre... 3%
   Savings repair/maint 19.0
   Annual increase 10%
   Damage power supply 1.3
   Annual increase 3%
   Re-loaction oil terminal 16.4 (in 1998)
   Re-location oil terminal 16.4 (in 2003)

5) Conversion US$ 1 = Tk. 36

PV (12%) benefits	
MTk.	794.0

TABLE F.3.16 RESULT OF SENSITIVITY ANALYSIS IN THE SITUATION WITHOUT PROTECTION OF RAILWAY BRIDGE

VALUES: Economic Internal Rate of Return (EIRR)
UNIT: percent

Change i	CHANGE IN BENEFITS:						
investm.	-30%	-20%	-10%	0%	10%	20%	30%
-30%	19.80%	21.87%	23.88%	25.84%	27.76%	29.66%	31.53%
-20%	17.97%	19.84%	21.65%	23.41%	25.13%	26.82%	28.49%
-10%	16.49%	18.21%	19.87%	21.48%	23.04%	24.58%	26.09%
0%	15.26%	16.87%	18.41%	19.89%	21.34%	22.75%	24.14%
10%	14.22%	15.73%	17.18%	18.57%	19.91%	21.22%	22.51%
20%	13.32%	14.76%	16.12%	17.43%	18.70%	19.93%	21.13%
30%	12.53%	13.90%	15.20%	16.45%	17.64%	18.81%	19.94%

Change i	CHANGE IN BENEFITS:						
M&M	-30%	-20%	-10%	0%	10%	20%	30%
-30%	15.62%	17.23%	18.77%	20.26%	21.71%	23.13%	24.52%
-20%	15.50%	17.11%	18.65%	20.14%	21.59%	23.00%	24.39%
-10%	15.38%	16.99%	18.53%	20.01%	21.46%	22.88%	24.26%
0%	15.26%	16.87%	18.41%	19.89%	21.34%	22.75%	24.14%
10%	15.15%	16.75%	18.29%	19.77%	21.21%	22.62%	24.01%
20%	15.03%	16.63%	18.17%	19.65%	21.09%	22.50%	23.88%
30%	14.91%	16.52%	18.05%	19.53%	20.97%	22.37%	23.75%

TABLE F.3.17 DISPLACEMENT OF POPULATION IN BHAIRAB BAZAR

Period	Number of persons displaced
1993-1998	140
1998-2003	155
2003-2008	175
2008-2013	195
2013-2018	215
2018-2013	240
Total	1,120

Source: Socio-economic survey 1991

F.3.10 Multi-criteria analysis

F.3.10.1 Economic criteria

The economic criteria of the river bank protection works at Bhairab Bazar and the railway bridge have already been discussed in detail in the previous chapters. This paragraphs just summarizes the results:

- EIRR 21%
- NPV(12%) MTk. 446
- NPVR 0.75

One additional economic criterion has been calculated, notably the PV(12%) of the cash flow of the benefits. The calculated value of Tk. 934 million gives an indication of to what extent investments can be sustained at a discount rate of 12%.

F.3.10.2 **Probability of failure**

For design purposes the accepted failure probability of the protection works has been evaluated. Under the assumption that maintenance works are realized for 80%, the accepted failure probability for the protection works designed becomes five times in one thousand years (5.0 E-03).
Based on an alternative assumption whereby virtually no maintenance is carried out, the failure probability of the protection works increases almost to eighty-five times in one thousand years (8.5 E-02).

F.3.10.3 **Budgetary implications**

Reference is made to section F.3.5.3.

F.3.10.4 **Displacement of population**

Reference is made to section F.3.9.

F.3.10.5 **Summary of results**

Table F.3.18 summarizes the results of the multi-criteria analysis.

TABLE F.3.18 RESULTS OF THE MULTI-CRITERIA ANALYSIS FOR BHAIRAB BAZAR PROTECTION WORKS

Data type	Variable	Advanced protection, with railway bridge	Advanced protection, without railway bridge
1. Economic profitability	- EIRR (%) - NPV (12%) - NPVR - PV (12%) benefits	21% MTk. 446 0.75 MTk. 934	20% MTk. 370 0.71 Mtk. 794
2. Probability of failure	Design criteria Low maintenance	5.0 E-03 8.5 E-02	5.0 E-03 8.5 E-02
3. Budgetary implications	Monitoring and maintenance: 1993: 1998: 2008:	Current prices: MTk. 8.2 MTk. 13.0 MTk. 35.0	Current prices: MTk. 7.2 MTk. 11.6 MTk. 30
4. Displacement of population	Total number of persons over 30 year evaluation period	1,120	1,120

ANNEX F

Economics of protection works

F-4 Munshiganj

F.4 MUNSHIGANJ

F.4.1 Present situation and previous efforts for protection

Munshiganj, the centre of potato growing in Bangladesh is located on the Dhaleswari River. As a result of the importance of potato growing in the region, the town harbours a large number of cold storage units where the product is kept in store. In addition to this cold storage, industrial activity, comprising many twining and spinning plants, is important in Munshiganj.
The present and future position of the township is nevertheless constantly threatened by the eroding force of the Dhaleswari River. The river not only threatens commercial and industrial buildings along its waterfront, but also the road along the river bank and the ferry ghat upstream. Until this moment actions taken to counteract the erosion of the river bank have been few. Some efforts were made to protect the ferry ghat by the Roads and Highway Department, while the Municipality and private firms undertook some actions to protect the waterfront.

F.4.2 Specific aspects related to Munshiganj

Protection works undertaken by the Meghna River bank Protection Short Term Study concentrate in Munshiganj on protection of the right bank of the town. Within the boundaries of the right bank there are mainly habitations, commercial and industrial buildings which need protection.

The area covered by the study zones from the ferry ghat West of the town to the wharf some three kilometres to the East. Bank protection works have been designed for the right bank of the Dhaleswari River as the situation there is becoming critical.

F.4.3 Alternatives for river bank protection

Construction of durable protection works on the existing bank of the Dhaleswari proves to be an adequate and financially attractive solution for the protection of the town area. Consequently no other protection concept has been considered.

F.4.4 Benefits of Munshiganj bank protection

F.4.4.1 Reduction of repair and maintenance

From information collected on cost of maintenance, damage and repair, the amounts spent in the past by the Road and Highway Department and the Municipality on these aspects were calculated. The information collected referred to accounted amounts for the financial years 1985/86 to 1990/91.

The analysis of benefits that can be attributed to the permanent river bank protection works to be designed in this project is based on the general assumption that the repair and maintenance expenses are directly related to the bank erosion.

By using the data of the past five years, future benefits of permanent bank protection works have been estimated as the avoidable annual costs of the non-permanent and non-sustainable bank protection works being carried out in the future in the without-scenario.

F.4.4.2 Loss and damage to properties

To be able to assess the historic losses, damage and economic revenue lost due to bank erosion a socio-economic sample survey was carried out and data were collected from the upazila and municipality. Table F.4.1 provides details on the destruction and damage of structures during the past years.

TABLE F.4.1 DESTRUCTION AND DAMAGE TO STRUCTURES

DESTROYED: Year	Houses	Homestea	Comm. enterp.	Small industr.
1985	21	7	5	2
1986	29	13	12	0
1987	43	21	21	3
1988	83	28	38	2
1989	67	28	48	2
1990	69	31	31	0
DAMAGED Year	**Houses**	**Homestea**	**Comm. enterp.**	**Small industr.**
1985	42	13	19	6
1986	75	23	29	8
1987	89	41	36	15
1988	131	60	52	22
1989	117	66	63	10
1990	132	84	46	4

Source: Survey (1991)

The average value of property is calculated from the socio-economic survey results. However, the survey outcome only give financial construction cost, which must be converted to economic prices. The economic value for destructed houses and commercial buildings has been calculated as follows:

- the value of houses is estimated at 65% of its economic construction value in order to take account of the lower quality of replacement homes after destruction;
- the economic value of destroyed commercial and industrial buildings is estimated as the rental value, thus taking into account that construction cost are not a reliable indicator for shadow pricing.

As far as damaged property is concerned the imputed average value of repairs used is a percentage of the total construction value. For houses and homesteads this percentage is estimated at 15%, while for commercial and industrial properties it is evaluated at 25%. For details reference is made to the Appendix F/1.

In Table F.4.2 and F.4.3 summaries are given of the economic value of houses, homesteads, commercial and industrial enterprises that were either destructed or damaged during the period 1985 to 1990.

Since the data only concern loss and damage of private property a surcharge is taken into account to reflect the loss and damage of public infra-structure of the town. Taking into account the average occupation of public and private infra-structure the total loss and damage to public infra-structure has been evaluated at 25% of the loss and damage of private property. Reference is made to Appendix F/1.

F.4.4.3 Disruption of economic activities

The destruction of commercial and industrial properties leads to a loss in profits (after payment of taxes) and employment. The first must be accounted for in the economic evaluation, while the latter is a social aspect of flood damage. The computation of losses in profitability assumes that losses due to the destruction or damage to property are the equivalent to 12 months' net economic returns.

TABLE F.4.2 EROSION DESTRUCTION IN THE RECENT PAST

PRICES: mid-1991 econmic prices
UNIT: Tk. x 1M

Year	Houses	Home-steads	Commerc. enterp.	Small industr.	TOTAL
1985	0.644	0.215	2.116	0.846	3.822
1986	0.890	0.399	5.079	0.000	6.368
1987	1.320	0.644	8.888	1.270	12.122
1988	2.547	0.859	16.083	0.846	20.336
1989	2.056	0.859	20.315	0.846	24.077
1990	2.117	0.951	13.120	0.000	16.189

Source: Socio-economic survey (April - May 1991)
Notes:
1) Tk. 12.9 x 1000 for average economic cost houses
2) Tk. 12.9 x 1000 for average economic cost homesteads
3) Tk. 423.2 x 1000 average shadow price commercial enterprises
4) Tk. 423.2 x 1000 average shadow price small industries
5) Tk. 17.8 x 1000 for average value housing land

TABLE F.4.3 EROSION DAMAGE IN THE RECENT PAST

PRICES: mid-1991 economic prices
UNIT: Tk. x 1M

Year	Houses	Home-steads	Commerc. enterp.	Small industr.	TOTAL
1985	0.209	0.070	2.116	0.020	2.414
1986	0.288	0.129	5.079	0.000	5.496
1987	0.427	0.209	8.888	0.030	9.554
1988	0.825	0.278	16.083	0.020	17.206
1989	0.666	0.276	20.315	0.020	21.280
1990	0.686	0.308	13.120	0.000	14.114

Source: Socio-economic survey (April - May 1991)
Notes:
1) Tk. 9.9 x 1000 for average economic cost houses
2) Tk. 9.9 x 1000 for average economic cost homesteads
3) Tk. 423.2 x 1000 for average economic cost commercial enterprises
4) Tk. 423.2 x 1000 for average economic cost industrial enterprises

F.4.4.4 Computation of avoidable repair, maintenance, loss, damage and lost profits

In Table F.4.4 a summary is presented of the cost of repair and maintenance, losses and damage and lost net economic return for the years 1985 to 1990. River bank protection would result in a substantial decrease in losses and consequently the total amount represents avoidable losses. Hence, the benefits of erosion

control works are defined as a saving in future maintenance and repair cost, loss of and damage to property and profit losses for a scenario where no protection is undertaken. A computation of these savings over the evaluation period provides the cash flow of benefits.

TABLE F.4.4 REPAIR AND MAINTENANCE COSTS, LOSS, DAMAGE AND LOST PROFITS DUE TO BANK EROSION IN MUNSHIGANJ

PRICES: mid-1991 economic prices
UNIT: Tk. x 1 million

Year	REPAIR	DAMAGE/LOSS PRIV/PUB.INFR			LOST	GRAND
	COST	Loss	Damage	TOTAL	PROFITS	TOTAL
1985	0.000	4.777	3.018	7.795	0.811	8.607
1986	0.000	7.960	6.870	14.830	1.055	15.885
1987	1.240	15.152	11.942	27.095	1.868	30.202
1988	0.598	25.420	21.508	46.928	[illegible]	50.217
1989	0.000	30.097	26.599	56.696	2.293	58.989
1990	1.093	20.236	17.643	37.879	1.339	40.311

Sources: Field survey
Notes:
1) Deflator of 10% is used to adjust expenses for repair and maintenance (value of deflacor is according to Planning Commisison)

In Table F.4.4 total economic repair expenses and cost of erosion damage for the recent past are computed. It is assumed that the total figures have an extreme value distribution. They have been correlated with their frequency by fitting the Gumbel extreme value probability function. Based on this function and the procedures outlined in the FPCO-guidelines for project assessment, the expected annual cost due to erosion is evaluated.

Table F.4.5 presents the mathematical expectation of annual avoidable costs due to repair, maintenance, loss, damage and lost profits, evaluated at Tk. 30 million economically. Figure F.4.1 gives the damage-frequency curve for Munshiganj.

As a result of an ongoing erosion over the years the expected value of the annual avoidable costs identified above are assumed to increase.
With respect to damage, destruction and loss in profits, it is expected that the annual increase will be 3%. This reflects the expected economic growth for Bangladesh and is not related to changes in the prices of commodities.

Concerning repair and maintenance expenses, the annual increase of these is evaluated at 10%, because in the present-day practice of the without-scenario repair and maintenance expenses are expected to increase sharply in the future.

F.4.5 Costs of the river bank protection works

F.4.5.1 Investment costs of the river bank protection works

Only one alternative for river bank protection in Munshiganj has been considered, notably construction of protection works on the existing bankline. The economic costs of protection works are evaluated at Tk 215 million or US$ 6.0 million. A breakdown of the economic costs is given in Table F.4.7. An estimated 31% of the total investment cost are local currency expenditures, while the foreign component amounts to 69%.

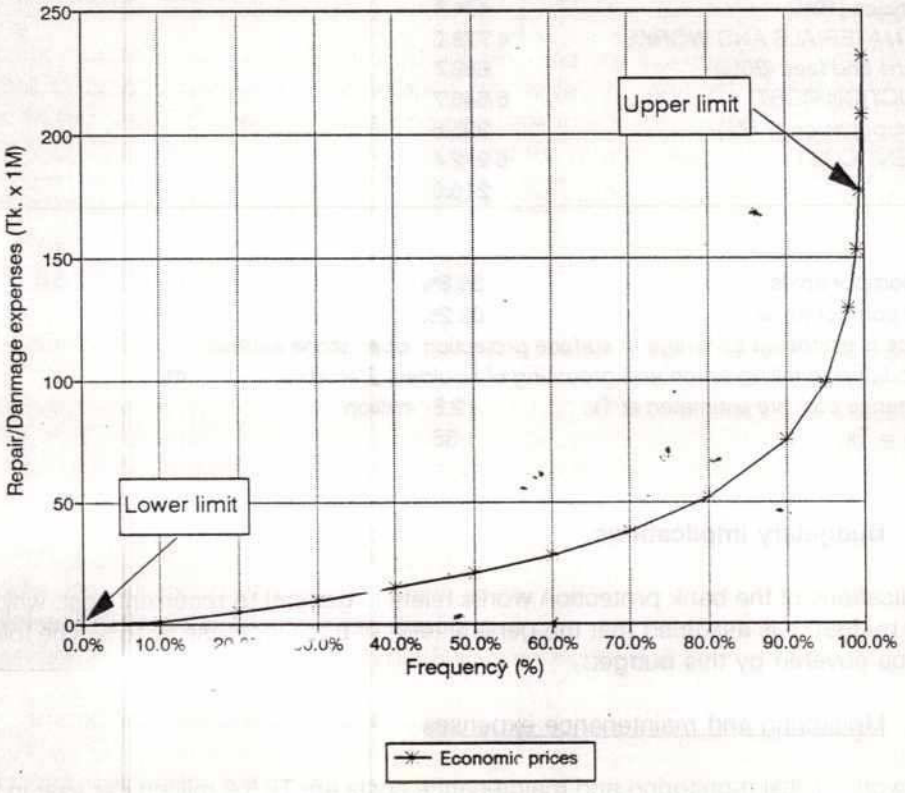
TABLE F.4.5 MATHEMATICAL EXPECTATION OF ANNUAL AVOIDABLE COSTS IN MUNSHIGANJ

PRICES: mid-1991 economic prices
UNIT: Tk. x 1 million

Freq. (non-exc)	Return period (yrs)	REAPAIR AND MAINTENACE: Total cost	C&F differ.	Cum C&F diff.	LOSSES AND DAMAGE: Total cost	C&F differ.	Cum C&F diff.	GRAND TOTAL	Covers. to US$ x 1M
0.00%		0.000		0.000	0.000		0.000	0.000	0.000
10.00%		0.000	0.000	0.000	0.851	0.043	0.043	0.043	0.001
20.00%		0.000	0.000	0.000	4.736	0.279	0.322	0.322	0.009
30.00%		0.000	0.000	0.000	9.141	0.694	1.016	1.016	0.028
40.00%		0.000	0.000	0.000	14.226	1.168	2.184	2.184	0.061
50.00%	2	0.069	0.003	0.003	20.240	1.723	3.907	3.911	0.109
60.00%		0.301	0.019	0.022	27.601	2.392	6.299	6.321	0.176
70.00%		0.600	0.045	0.067	37.091	3.235	9.534	9.601	0.267
80.00%	5	1.021	0.081	0.148	50.466	4.378	13.912	14.060	0.391
90.00%	10	1.741	0.138	0.286	73.331	6.190	20.102	20.388	0.566
95.00%	20	2.461	0.105	0.391	96.195	4.238	24.340	24.731	0.687
98.00%	50	3.413	0.088	0.479	126.421	3.339	27.679	28.159	0.782
99.00%	100	4.133	0.038	0.517	149.286	1.379	29.058	29.575	0.822
99.50%	200	4.853	0.022	0.540	172.151	0.804	29.861	30.401	0.844
99.80%	500	5.805	0.016	0.556	202.376	0.562	30.423	30.979	0.861
99.90%	1000	6.525	0.006	0.562	225.241	0.214	30.637	31.199	0.867

Notes:
1) Coversion to US$ 1 = Tk. 36

FIGURE F.4.1 DAMAGE FREQUENCY CURVE FOR MUNSHIGANJ TOWN PROTECTION



F.4.5.2 Monitoring and maintenance cost

Monitoring and maintenance of protection structures is an important component, which affects directly the long term effectiveness of protection works. Monitoring and maintenance are an integral part of river bank protection, the probability of failure of the structures may very well increase rapidly in the future if they are poor.

Monitoring activities comprise sounding of bed and bank level. They are estimated at Tk 2.0 million per annum in economic terms. After critical judgement of the protection works it is further assumed that annual maintenance of 4.0% of the investment costs of all revetment components is required. Consequently, annual maintenance for the protection works are evaluated at Tk 2.8 million per annum.

TABLE F.4.7 ECONOMIC INVESTMENT COSTS FOR THE MUNSHIGANJ BANK PROTECTION WORKS

PRICES: mid-1991 economic prices
UNIT: US $ x 1,000

No	Summary	TOTAL	LOCAL LABOUR	EXPAT. LABOUR	IMPORTE MATERIAL	LOCAL MATERIAL	PLANT & FUEL
1	Dredging	1 207.6			805.1		402.5
2	Working/material area	116.9	31.3			7.8	77.8
3	Temporary access, diversion and culverts	99.9	10.4		55.4	8.2	25.9
4	Earthworks	399.9	114.8				285.1
5	Open stone asphalt	575.4	43.4		106.0	287.5	138.5
6	Fascine matress	1 093.3	31.9		331.0	480.1	250.4
7	Boulders in falling apron	161.3	7.5			96.1	57.7
8	Grounting of boulders	95.6	4.0			87.0	4.6
9	Clear site and reinstate	36.4	10.4				25.9
10	Construction cost and supervision	491.7	42.6	399.9	32.8	16.4	
11	Mobilization/demobilization	65.6			65.6		
	COST OF MATERIALS AND WORKS	4 343.6	296.3	399.9	1 395.8	983.0	1 268.5
	Physical contingencies (10%)	434.4					
	TOTAL COST OF MATERIALS AND WORKS	4 778.0					
	Contractors margins and fees (20%)	868.7					
	TOTAL CONSTRUCTION COST	5 646.7					
	Engineering and supervision (7.5%)	325.8					
	TOTAL INVESTMENT COST	5 972.4					
	Total (Tk x 1M)	215.0					

Notes:

1) Overall lokal cost component is 30.8%
   Overall foreign cost component is 69.2%
2) Annual maintenance is estimated as %-age of surface protection: open stone asphalt, fascine matress, boulders in falling apron and grounting of boulders. Percenta 4%
   So, annual maintenance cost are estimated at Tk. 2.8 million
3) Conversion: 1 US$ = Tk. 36

F.4.5.3 Budgetary implications

Budgetary implications of the bank protection works relate in general to recurrent cost, which must be met by the national budget. It is assumed that the general level of price increase is 10%. The following cost are considered to be covered by this budget:

(i) Monitoring and maintenance expenses

For protection works, initial monitoring and maintenance costs are Tk 5.8 million per year in financial terms. After five years the amount becomes Tk 9.4 million, while in 2008 they equal Tk 24 million.

(ii) Environmental monitoring

Costs of the required environmental monitoring are low and could easily be covered by the reservations made for other cost. Details on environmental monitoring are presented in Annex I.

F.4.6 Economic feasibility analysis

F.4.6.1 Cash flow

The cash flow computation for river bank protection in Munshiganj makes a comparison of benefits and cost over the 30-year evaluation period. The investment costs have been discussed in detail in the previous section. Project benefits were discussed in Section F.4.4.
In Table F.4.8 the economic cash flow is given. The table requires no further discussion.

F.4.6.2 Economic Internal Rate of Return

The bank protection works yield an economic internal rate of return of 16%, which is above the generally accepted opportunity cost of capital. The economic internal rate of return indicates that the interests to be protected, fully justify the investments in the bank protection works in economic terms.

F.4.6.3 Net Present Value

The economic net present value for the short term bank protection works in Munshiganj has been calculated for a discount rate of 12% and amounts to Tk 76 million.
The ratio between the net present value and the value of public capital and operation and maintenance costs at financial prices (NPVR) as required by the Guidelines for Project Assessment has been evaluated at 0.27.

The following conclusions can be drawn:

(i) The bank protection works show an EIRR of 16% and are fully justified in economic terms.
(ii) The rate realized is well above the interest rate normally required by international development banks. In this respect, interest obligations and repayment can easily be guaranteed.
(iii) The NPV at 12% is positive, which indicates that the rate of return is higher. In view of a scarcity of development resources, this project may very well obtain the priority of the Government.

F.4.7 Sensitivity analysis

F.4.7.1 General

The economic analysis of bank erosion protection is based on uncertain future events and imperfect data. Because of this, it is important that sensitivity analyses be undertaken. This implies an analysis of the economic internal rate of return as function of changes in investment cost, monitoring and maintenance expenditure and estimated value of benefits.

F.4.7.2 Reduction in the value of benefits

The impact of a reduction of the value of benefits on the economic internal rate of return of the proposed river bank protection works is presented in Table F.4.9 and Figure F.4.2.

F.4.7.3 Increase in investment cost

Cost estimates are considered rather accurate. However, due to the fact that an international tender procedure will precede the awarding of the construction contract, some difference in total price must be

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expected. Experience has learned that international tendering results in offers that vary over a band of plus or minus 10% as compared with the estimated investment cost.
Details on changes in investment cost of the river protection works can also be found in Table F.4.9 and Figure F.4.3.

TABLE F.4.8 ECONOMIC CASH FLOW FOR THE MUNSHIGANJ BANK PROTECTION

PRICES: mid-1991 economic prices
UNIT: Tk. x 1 million
STARTING: 1993
CONSTR: 1 years

EIRR: 16.11% NPV: 76.1 NPVR1: 0.27

	WITH-PROJECT SITUATION COST:				BENEFITS:			CASH	Cash F.
Year	Invest.	M&M	Other	Total	Town pro.	Rep/main	Total	FLOW	(US$x1M)
1993	215.0	4.8	0.2	220.0				-220.0	-6.1
1994	0.0	4.8	0.2	5.0	32.6	0.7	33.3	28.4	0.8
1995	0.0	4.8	0.2	5.0	33.6	0.8	34.4	29.4	0.8
1996		4.8	0.2	5.0	34.6	0.9	35.5	30.5	0.8
1997		4.8	0.2	5.0	35.7	1.0	36.6	31.6	0.9
1998		4.8	0.2	5.0	36.7	1.1	37.8	32.8	0.9
1999		4.8	0.2	5.0	37.8	1.2	39.0	34.0	0.9
2000		4.8	0.2	5.0	39.0	1.3	40.2	35.2	1.0
2001		4.8	0.2	5.0	40.1	1.4	41.5	36.5	1.0
2002		4.8	0.2	5.0	41.3	1.5	42.9	37.9	1.1
2003		4.8	0.2	5.0	42.6	1.7	44.3	39.3	1.1
2004		4.8	0.2	5.0	43.9	1.9	45.7	40.7	1.1
2005		4.8	0.2	5.0	45.2	2.0	47.2	42.2	1.2
2006		4.8	0.2	5.0	46.5	2.3	48.8	43.8	1.2
2007		4.8	0.2	5.0	47.9	2.5	50.4	45.4	1.3
2008		4.8	0.2	5.0	49.4	2.7	52.1	47.1	1.3
2009		4.8	0.2	5.0	50.8	3.0	53.8	48.8	1.4
2010		4.8	0.2	5.0	52.4	3.3	55.7	50.7	1.4
2011		4.8	0.2	5.0	53.9	3.6	57.6	52.6	1.5
2012		4.8	0.2	5.0	55.6	4.0	59.5	54.6	1.5
2013		4.8	0.2	5.0	57.2	4.4	61.6	56.6	1.6
2014		4.8	0.2	5.0	58.9	4.8	63.8	58.8	1.6
2015		4.8	0.2	5.0	60.7	5.3	66.0	61.0	1.7
2016		4.8	0.2	5.0	62.5	5.8	68.4	63.4	1.8
2017		4.8	0.2	5.0	64.4	6.4	70.8	65.8	1.8
2018		4.8	0.2	5.0	66.3	7.1	73.4	68.4	1.9
2019		4.8	0.2	5.0	68.3	7.8	76.1	71.1	2.0
2020		4.8	0.2	5.0	70.4	8.6	78.9	73.9	2.1
2021		4.8	0.2	5.0	72.5	9.4	81.9	76.9	2.1
2022		4.8	0.2	5.0	74.7	10.4	85.0	80.0	2.2
SUM	215.0	143.2	6.5	364.6	1475.5	106.8	1582.2	1217.6	33.8

Notes:
1) INVESTMENT COST:
Tk. x 1M 215.0
2) M&M COST (Tk. x 1M):
Maintenance 2.8
Survey cost 2.0
3) OTHER COST:
Tk. x 1M 0.2
4) BENEFITS (Tk. x 1M):
Town protection 29.9
Annual increase 3%
Reduction rep/main 0.5
Annual increase 10%
5) Conversion US$ 1 = Tk. 36

PV (12%) benefits:
MTk. 345.2

F.4.7.4 Increase of monitoring and maintenance cost

A critical issue in the economic feasibility analysis of river bank protection in Munshiganj remains the estimate of likely future monitoring and maintenance cost. Consequently, it is very important to analyze the sensitivity to any change in these cost, although this may cause a difference in failure probability. This

TABLE F.4.9 RESULTS OF THE SENSITIVITY ANALYSIS FOR MUNSHIGANJ

VALUES: Economic Internal Rate of Return (EIRR)
UNIT: percent

Change investm.	CHANGE IN BENEFITS: -30%	-20%	-10%	0%	10%	20%	30%
-30%	15.18%	17.43%	19.63%	21.81%	23.96%	26.10%	28.24%
-20%	13.53%	15.56%	17.54%	19.48%	21.40%	23.30%	25.18%
-10%	12.19%	14.06%	15.86%	17.63%	19.36%	21.07%	22.77%
0%	11.06%	12.81%	14.48%	16.11%	17.70%	19.26%	20.81%
10%	10.11%	11.75%	13.31%	14.83%	16.30%	17.75%	19.18%
20%	9.28%	10.83%	12.31%	13.73%	15.12%	16.47%	17.80%
30%	8.54%	10.03%	11.43%	12.78%	14.09%	15.36%	16.61%

Change M&M	CHANGE IN BENEFITS: -30%	-20%	-10%	0%	10%	20%	30%
-30%	11.72%	13.46%	15.14%	16.77%	18.36%	19.94%	21.50%
-20%	11.50%	13.24%	14.92%	16.54%	18.14%	19.71%	21.27%
-10%	11.28%	13.02%	14.70%	16.32%	17.92%	19.49%	21.04%
0%	11.06%	12.81%	14.48%	16.11%	17.70%	19.26%	20.81%
10%	10.85%	12.59%	14.26%	15.89%	17.48%	19.04%	20.59%
20%	10.63%	12.38%	14.05%	15.67%	17.26%	18.82%	20.36%
30%	10.41%	12.16%	13.84%	15.46%	17.04%	18.60%	20.14%

difference may be to such an extent that accepted failure probability is not any longer achieved. This matter is touched upon later in this annex. The results of the sensitivity analysis are presented in Table F.4.9 and Figure F.4.4.

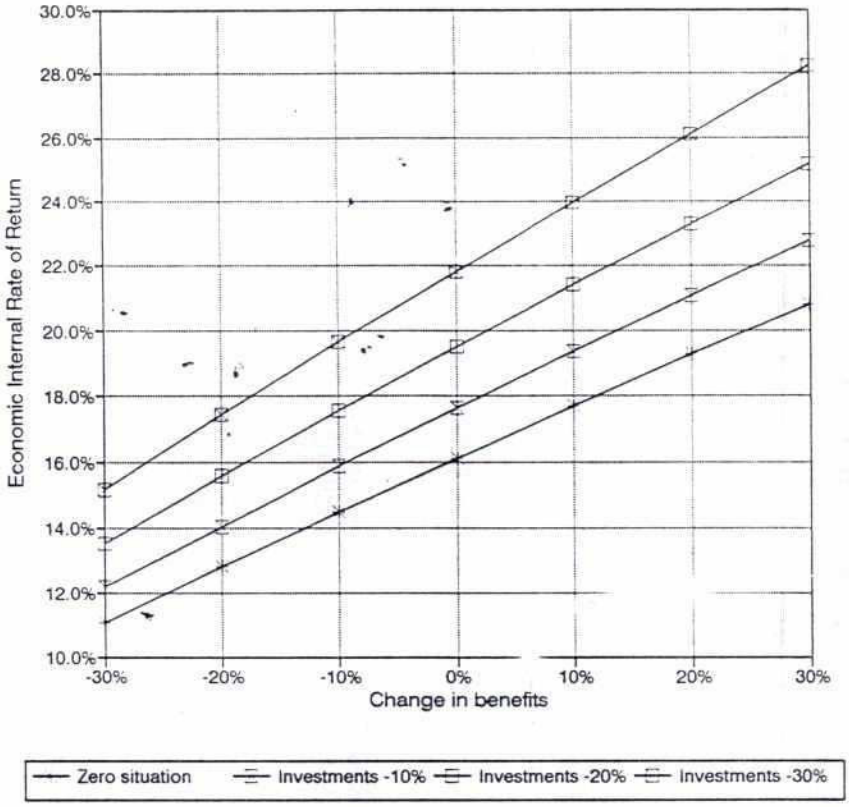
F.4.7.5 Delays in construction

Doubling of the construction period leads to a reduction in the economic internal rate of return of the project of 0.5%. No arguments can be found to increase the construction period even more. Within one year and at most two years the work can be carried out.

F.4.8 Displacement of population

From the socio-economic survey of Munshiganj follows that in the area prone to erosion live 4,260 persons. These persons would be displaced in the coming 30 years if no protection works are built. As no detailed geo-morphological information is available on bank-migration per five-year period, we assume that migration will be the same for each five-year period.
Based on the Statistical Yearbook of Bangladesh for 1991 (table 2.08, page 45), the annual population increase was 2.17% over the last 10 years. Using this factor for the coming 30 years would give total numbers for each five-year period, see table F4.10.

FIGURE F.4.2 AND F.4.3 RESULTS OF THE SENSITIVITY ANALYSIS



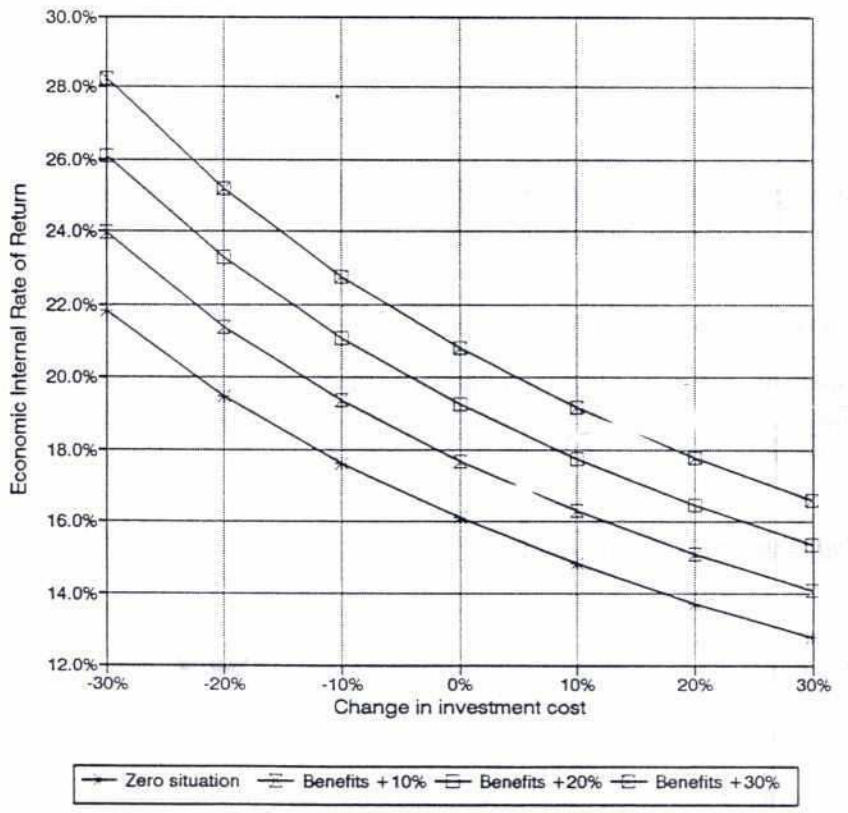
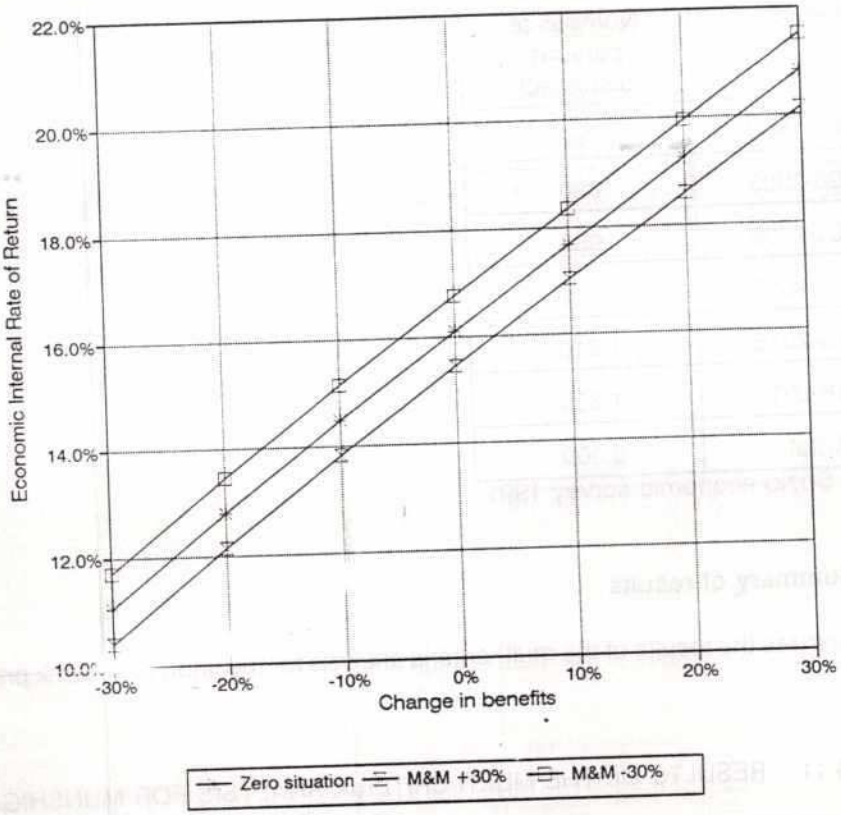


FIGURE F.4.4 RESULTS OF THE SENSITIVITY ANALYSIS



F.4.9 Multi-criteria analysis

F.4.9.1 Economic criteria

The economic criteria have already been discussed in detail in the previous chapters. This paragraph just summarizes the results:

- EIRR 16%
- NPV MTk. 76
- NPVR 0.27

F.4.9.2 Probability of failure

For design purposes the accepted failure probability of the protection works have been evaluated. Under the assumption that maintenance works will be implemented for 80%, the accepted failure probability for the protection works designed becomes five times in one thousand years (5.0 E-03).
Based on an alternative assumption whereby virtually no maintenance is carried out, the failure probability of the protection works increases almost to eighty-five times in one thousand years (8.5 E-02).

F.4.9.3 Budgetary implications

Reference is made to section F.4.5.4.

F.4.9.4 Displacement of population

Reference is made to section F.4.8.

TABLE F.4.10 DISPLACEMENT OF POPULATION IN MUNSHIGANJ

Period	Number of persons displaced
1993-1998	790
1998-2003	880
2003-2008	980
2008-2013	1,090
2013-2018	1,210
2018-2013	1,350
Total	6,300

Source: Socio-economic survey 1991

F.4.9.5 **Summary of results**

Table F.4.11 summarizes the results of the multi-criteria analysis for the short term bank protection works at Munshiganj.

TABLE F.4.11 RESULTS OF THE MULTI-CRITERIA ANALYSIS FOR MUNSHIGANJ

Data type	Variable	Protection works
1. Economic profitability	- EIRR (%) - NPV (12%) - NPVR - PV (12%) benefits	16% MTk. 75 0.27 MTk. 345
2. Probability of failure	Design criteria No maintenance	5.0 E-3 8.5 E-02
3. Budgetary implications	Monitoring and maintenance: 1993: 1998: 2008:	Current prices: MTk. 5.8 MTk. 9.4 MTk. 24
4. Displacement of population	Total number of persons displaced over 30 year evaluation period	6,300

ANNEX F

Economics of protection works

F-5 Chandpur

F.5 CHANDPUR

F.5.1 Present situation and previous efforts for protection

The Lower Meghna is the most important river in this part of the world, discharging the waters of the Brahmaputra, Jamuna and Meghna into the Bengal Estuary. River bank protection under the Meghna River Bank Protection Short Term Study evaluates the options for erosion control works in Chandpur.

Chandpur is an important inland harbour on the Lower Meghna. Its location on one of the waterways leading to Dhaka and India has made Chandpur a centre of commercial and industrial activity. In the old days the town played an important role as the point where railway and river transport met. Although the importance of railway transport has declined, Chandpur is at present, and will remain so in the future, beyond any doubt an important trading and industrial centre in the national economy of Bangladesh.

The present and future position of the township is nevertheless constantly threatened by the eroding force of the Lower Meghna River. The river not only threatens public assets and private commercial and industrial buildings along its waterfront, but could make Chandpur into an isolated island, completely surrounded by the waters of the Meghna. The serious threat by the ever active and unpredictable river has been for years the focus of studies and research.

Events since 1988, when part of the township disappeared in the river, have given new momentum to the search for sustainable solutions to protect Chandpur. In the period after the 1988 cyclone the river caused almost every year damage to the old town, in spite of erosion control works carried out.

During the past seasons embankments downstream of Chandpur have been severely damaged, threatening the Chandpur Irrigation project. Upstream of the town the river banks are eroded causing the loss of irrigated agricultural lands in the Meghna-Dhonagoda Irrigation District. The migration of the river bank towards the east has progressed every year and for the foreseeable future erosion will continue.

Much efforts have been made to protect Chandpur against the waters of the Meghna. Before BWDB embarked on measures for protection of Chandpur town, Bangladesh Railway had already tried to protect the railway station at Nutan Bazar by dumping large quantities of boulders on the river bank. From the early seventies onwards protective works started under the umbrella of BWDB.

As a result of the protection works executed by the Bangladesh Railway and later by the BWDB, the rate of migration of the river bank has considerably been reduced, contributing also in the protection to the Meghna-Dhonagoda and Chandpur Irrigation Districts, north and south of the town. However, in spite of all the (temporary and emergency) bank protection works carried out so far, the left bank of the Meghna, both upstream and downstream of Chandpur town has shown considerable migration. Without proper action and permanent river bank protection works, this will eventually lead to the outflanking of the town.

In the economic feasibility analysis of Chandpur for a future scenario a comparison is made between a situation with river bank protection works (with-scenario) and one without protection works (without-scenario). In the without-scenario usual repair and maintenance activities are still carried out. However, it must be pointed out that the without-scenario is not equal to the present situation, but represents an extension of the present situation into the future.

The analysis of the with-scenario concentrates on benefits and cost that can be related to the erosion protection works. As a result of the works executed one may expect that bank erosion is completely stopped and that the risk of the town being outflanked as a whole is reduced considerably.

The without-scenario is characterized by a continuation of the present situation as described above. One may expect that the expenses needed to repair and maintain the present protection along the town will increase in the future, when continuing the present-day practice. Although, it may be possible to foresee the process of bank migration rather well as a result of the geo-morphological study, anticipating the

reaction of the authorities remains more difficult. Hence, it becomes a complex task to predict future expenditures in repair and maintenance of protection.

F.5.2 Area affected

The river bank protection works aim at protecting the area of the town and its associated costs and benefits. As a result of the works executed it is expected that bank erosion at Chandpur town will be stopped completely. Moreover, there will be mitigating effects of the bank erosion immediately upstream and downstream of the town, increasing the protection of parts of the Meghna-Dhonagoda and Chandpur Irrigation Districts.

The area covered by the feasibility analysis consists therefore of the town area and the area of influence upstream and downstream of the town. It can be divided in three parts, notably:

- town area of Chandpur;
- river bank of the Lower Meghna upstream of the town; and
- river bank downstream of Chandpur.

F.5.3 Alternative river bank protection works

Construction of durable protection works on the existing bank of the Lower Meghna at Chandpur is not a feasible option. It would involve the destruction of houses to create a work space while the river bank line has become so erratic, that construction of an acceptable slope is difficult.

The option under review is based on an advanced protection concept which involves the construction of a complete new bank line, at some distance from the old bank line. A characteristic in this type of constructions are containment bunds with fill, which facilitate construction of smooth slopes. Moreover, a proper slope can be achieved by the application of hydraulic fill.

F.5.4 Benefits of Chandpur town protection

F.5.4.1 Reduction in maintenance and repair expenses

Expenditures on erosion protection works in Chandpur have been collected from BWDB for the period 1981-1990. The information collected refers to real financial expenditures which have been deflated by an annual 10% to reflect the mid-1991 price level.

The analysis of benefits is based on the general assumption that the repair and damage expenses are directly related to the bank erosion. However, expenditure in one year does not always relate to the very year that damage occurred; design, decision on allocation of funds form the major bottleneck for direct action after damage happens. The recorded and estimated expenses on repair and maintenance have therefore been incurred to the year the erosion damage occurred.

By using the data of the past ten years, future benefits of the permanent bank protection works can be estimated as the avoidable annual costs of the non-permanent and non-sustainable bank protection works being carried out in the future. The approach has been based on the assumption that damage and repair expenses are a associated with a series of extreme conditions, referring not only to the recorded high water levels, but also regarding extreme geo-technical conditions, wave attack etc. The erosion mechanism is a complicated mechanism and erosion is not always the result of the same combination of effects. Therefore, the probabilistic extreme value theory is directly applied to the repair and recorded and estimated in relation to bank erosion. This regression appeared to be more reliable than any other regression relating the recorded and estimated repair, maintenance, loss and damage to the probabilities of physical phenomena such as high water levels or high water duration frequencies.

The amounts spent in the past twenty years on the protection of Chandpur show an annual growth rate of between 25 and 40%. The steadily growing investments required to maintain the present situation is in agreement with the technical concept that the eroding forces gradually become stronger and stronger because of the protection works carried out. It can be expected that without the construction of the permanent protection works the national and regional authorities will pursue the protection of the town with all possible means. Hence, it is very likely that the expenditures in the past are a poor reflection of what may happen in the future. When extrapolating the present practice, therefore, an annual growth rate of 10% is applied to the annual expectation value of the repair and maintenance costs during the 30 year evaluation period.

F.5.4.2 Loss and damage to properties

To be able to assess the historic losses, damage and economic revenue lost due to bank erosion a socio-economic sample survey was carried out and data were collected from the upazila and municipality. Past erosion damage was estimated from records on destruction and damage to property, which were supplied by the upazila and municipality. Table F.5.1 presents an overview of destruction and damage to construction.

TABLE F.5.1 DESTRUCTION AND DAMAGE TO STRUCTURES

DESTROYED: Year	Houses	Homestea	Comm. enterp.	Small industr.
1985	41	14	6	3
1986	65	31	11	2
1987	181	116	26	5
1988	250	200	40	10
1989	112	98	32	3
1990	100	39	98	2
DAMAGED Year	**Houses**	**Homestea**	**Comm. enterp.**	**Small industr.**
1985	31	7	5	2
1986	57	18	7	2
1987	113	68	25	7
1988	[illegible]	100	46	12
1989	72	51	35	3
1990	50	20	17	2

Source: Survey (1991)

The average value of property could be calculated from the socio-economic survey results. However, the survey outcome only give financial construction cost, which must be converted to shadow prices. The economic value for destructed houses and economic buildings has been calculated as follows:

- the value of houses is estimated at 65% of its economic construction value in order to take account of the lower quality of replacement homes after destruction;
- the economic value of destroyed commercial and industrial buildings is estimated as the rental value, thus taking into account that construction cost are not a reliable indicator for shadow pricing.

As far as property is concerned which was damaged but not destroyed, the imputed average value used is a percentage of the total value. For houses and homesteads this percentage is estimated at 50%, while for commercial and industrial the rental value is used. Reference is made to section F/1.3 of the appendix for more details.

In Table F.5.2 and F.5.3 summaries are given of the economic value of houses, homesteads, commercial and industrial enterprises that were either destructed or damage during the period 1985 to 1990.

TABLE F.5.2 EROSION DESTRUCTION IN THE RECENT PAST

PRICES: mid-1991 econmic prices
UNIT: Tk. x 1M

Year	Houses	Home-steads	Commerc. enterp.	Small industr.	TOTAL
1985	7.792	2.661	2.539	1.270	14.262
1986	12.354	5.892	4.656	0.846	23.748
1987	34.400	22.047	11.004	2.116	69.567
1988	47.514	38.011	16.930	4.232	106.688
1989	21.286	18.626	13.544	1.270	54.725
1990	19.006	7.412	41.477	0.846	68.742

Source: Socio-economic survey (April - May 1991)
Notes:
1) Tk. 113.7 x 1000 for average economic cost houses
2) Tk. 113.7 x 1000 for average economic cost homesteads
3) Tk. 423.2 x 1000 average shadow price commercial enterprises
4) Tk. 423.2 x 1000 average shadow price small industries
5) Tk. 76.4 x 1000 for average value housing land

TABLE F.5.3 EROSION DAMAGE IN THE RECENT PAST

PRICES: mid-1991 economic prices
UNIT: Tk. x 1M

Year	Houses	Home-steads	Commerc. enterp.	Small industr.	TOTAL
1985	3.585	1.224	2.539	0.262	7.610
1986	5.683	2.710	4.656	0.175	13.224
1987	15.825	10.142	11.004	0.437	37.409
1988	21.858	17.486	16.930	0.874	57.148
1989	9.792	8.568	13.544	0.262	32.167
1990	8.743	3.410	41.477	0.175	53.805

Source: Socio-economic survey (April - May 1991)
Notes:
1) Tk. 87.4 x 1000 for average economic cost houses
2) Tk. 87.4 x 1000 for average economic cost homesteads
3) Tk. 423.2 x 1000 for average economic cost commercial enterprises
4) Tk. 423.2 x 1000 for average economic cost industrial enterprises

Since the data only concern loss and damage of private property a surcharge is taken into account to reflect the loss and damage of the public infrastructure of the town. In the analysis on loss and damage of the private and public infrastructure a number of public facilities have not yet been taken into account. These assets refer to the railway complex and the IWTA terminals, the fish market, the Chandpur water works and treatment plants, schools, power lines, etc. The railway complex and IWTA terminal are discussed in detail later. Taking into account the average occupation of public and private infrastructure and the value thereof the total loss and damage to public and urban infra-structure has been evaluated at 25% of the loss and damage of private property. Appendix F/1 provides more details.

F.5.4.3 Disruption of economic activities

The destruction of commercial and industrial properties leads to a loss in net profits (after payment of taxes) and employment. The first is considered in the financial and economic evaluation, while the latter is a social aspect of river bank erosion damage. The computation of losses in profitability assumes that losses are the equivalent of 12 months net economic returns (profits). Results are summarized in Table F.5.3

F.5.4.4 Computation of avoidable repair, maintenance, loss, damage and lost profits

In Table F.5.4 a summary is presented of the cost of repair and maintenance, losses and damage and lost net economic return for the years 1981 to 1990. The figures for loss and damage to property and lost profits have been interpolated to the years 1952, when there was no bank erosion. River bank protection would result in a substantial decrease in losses and consequently the total amount represents avoidable losses. Hence, the benefits of erosion control works are defined as a saving in future maintenance and repair cost, loss of and damage to property and profit losses for a scenario where no protection is undertaken. A computation of these savings over the evaluation period gives the cashflow of benefits.

TABLE F.5.4 REPAIR AND MAINTENANCE COSTS, LOSS, DAMAGE AND LOST PROFITS DUE TO BANK EROSION IN CHANDPUR

PRICES: mid-1991 economic prices
UNIT: Tk. x 1 million

Year	REPAIR/ MAIN.CST	DAMAGE/LOSS PRIV/PUB.INFRA: Loss	Damage	TOTAL	LOST PROFITS	GRAND TOTAL
1981	3.433			24.175	10.278	37.885
1982	4.144			24.930	10.632	39.705
1983	3.849			25.709	10.986	43.544
1984	3.782			26.512	11.341	41.635
1985	5.920	17.828	9.513	27.341	11.695	44.956
1986	11.134	29.685	16.530	46.214	19.473	76.822
1987	15.963	86.959	46.761	133.720	57.045	206.729
1988	65.640	133.360	71.435	204.795	87.484	357.918
1989	52.844	68.407	40.208	108.615	44.875	206.333
1990	3.526	85.927	67.257	153.184	56.368	213.078

Notes:
1) Total loss/damage to property and lost profits for the years 1981-1984 were estimated by dicreasing the 1985 damage lineair

In Table F.5.4 total economic repair expenses and cost of erosion damage for the recent past are computed. It is assumed that the totals have an extreme value distribution. The annual figures are subsequently ranked in size and a frequency is assigned in agreement with their ranking. The expenses are then correlated with their frequency by fitting the Gumbel extreme value probability function. This equation forms the basis for the calculation of the mathematical expectation values of loss and damage due to erosion.

Table F.5.5 presents the mathematical expectation of annual avoidable costs due to repair, maintenance, loss, damage and lost profits, evaluated at Tk. 86 million economically. Figure F.5.1 gives the damage-frequency curve for Chandpur.

As a result of an ongoing erosion over the years the expected value of the annual avoidable costs identified above are assumed to increase. In section F.5.4.1 the increase in the annual cost for repair and maintenance has already been discussed. Concerning, the loss and damage to private and public infra-structure and loss of profits, the annual increase is 3% per. This increase is not related to changes in the prices of commodities, but reflects merely aspects related to population growth and increase of economic activity in the affected area as was discussed in chapter 2.

TABLE F.5.5 MATHEMATICAL EXPECTATION OF ANNUAL AVOIDABLE COSTS IN CHANDPUR

PRICES: mid-1991 economic prices
UNIT: Tk. x 1 million

Freq. (non-exc)	Return period (yrs)	REPAIR AND MAINTENACE: Total cost	C&F differ.	Cum C&F diff.	LOSSES AND DAMAGE: Total cost	C&F differ.	Cum C&F diff.	GRAND TOTAL	Covers. to US$ x 1M
0.00%		0.000		0.000	0.000		0.000	0.000	0.000
10.00%		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20.00%		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30.00%		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
40.00%		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
50.00%	2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
60.00%		0.000	0.000	0.000	7.941	0.397	0.397	0.397	0.011
70.00%		2.367	0.118	0.118	57.133	3.254	3.651	3.769	0.105
80.00%	5	22.155	1.226	1.344	126.465	9.180	12.831	14.175	0.394
90.00%	10	55.982	3.907	5.251	244.989	18.573	31.403	36.655	1.018
95.00%	20	89.810	3.645	8.896	363.513	15.213	46.616	55.512	1.542
98.00%	50	134.527	3.365	12.261	520.194	13.256	59.872	72.133	2.004
99.00%	100	168.354	1.514	13.776	638.718	5.795	65.666	79.442	2.207
99.50%	200	202.182	0.926	14.702	757.242	3.490	69.156	83.858	2.329
99.75%	400	236.009	0.548	15.250	875.766	2.041	71.197	86.447	2.401
99.80%	500	246.899	0.121	15.370	913.923	0.447	71.645	87.015	2.417
99.90%	1000	280.727	0.264	15.634	1032.447	0.973	72.618	88.252	2.451

Notes:
1) Coversion to US$ 1 = Tk. 36

F.5.4.5 **Computation of avoidable losses to railway complex and IWTA terminal**

The railway complex in Chandpur is a very large compound with harbours schools, a hospital and mosque as well as accommodation for railway personnel. The total surface of the complex is 72 ha, according to information collected in Chandpur with BR and the Municipality. The total value is estimated at Tk. 500 million. This amount is in financial prices, which must be converted to economic prices with the help of the overall conversion factor of 0.82. Hence, the economic value of the complex is Tk. 410 million. For details reference is made to the appendix, section F/1.9.

Information of the IWTA terminal has been collected with the association in Dhaka and in Chandpur. It has been possible to evaluate the value of the terminal in economic prices. The terminal and its buildings cover and area of 36 thousand m^2. Relocation of the terminal would cost Tk. 43 million, as has been calculated in the appendix, see table F/1.24.

The railway complex lays between Station Road and Dakatia River in Nutan Bazar. Within this stretch of land the terminal of IWTA is also located. Without any protection works year after year part of the complex and the terminal would be eroded. However, within 30 years not the whole complex will vanish. Over the 30 year evaluation period a total of 120 thousand m^2 will be eroded according to the geomorphologic investigations.

For an estimation of the avoidable losses to railway complex and IWTA terminal we have made use of a deterministic approach. Based on the map of bank migration of Chandpur waterfront, see figure F/1.1, the areas of the railway complex and the IWTA terminal that will erode in the coming 30 years are measured. By multiplying these areas with the average value per area unit, it becomes possible to calculate the avoidable losses. These losses are imputed in the cash flow for their respective year. Table F.5.6 summarizes the results. Erosion losses are assumed to be evenly distributed over the years.

FIGURE F.5.1 DAMAGE-FREQUENCY CURVE FOR CHANDPUR TOWN PROTECTION

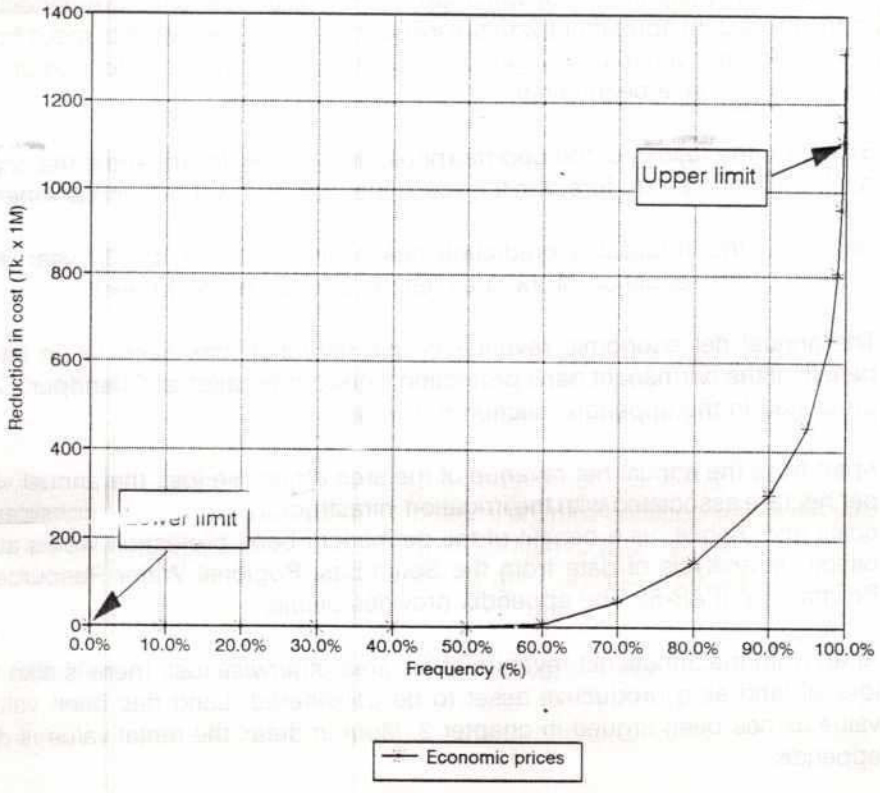


TABLE F.5.6 EROSION OF RAILWAY COMPLEX AND IWTA TERMINAL

PRICES: mid-1991 economic prices
UNIT: Tk. x 1,000

Period	BR COMPLEX: Area eroded (m2)	Unit value (Tk/m2)	Economic loss	IWTRA TERMINAL: Area eroded (m2)	Unit value (Tk/m2)	Economic loss	TOTAL ECONOMI LOSS
1993-1998	11 260	574	6 463	10 530	1 193	12 565	19 028
1998-2003	15 310	574	8 788	12 390	1 193	14 784	23 572
2003-2008	34 990	574	20 084	0	1 193	0	20 084
2008-2013	12 960	574	7 439	0	1 193	0	7 439
2013-2018	12 560	574	7 209	0	1 193	0	7 209
2018-2023	18 310	574	10 510	0	1 193	0	10 510
TOTAL	105 390		60 494	22 920		27 349	87 843

Source: Annex B and socio-economic survey 1991
Note:
1) Before 1993 it is expecred that part of the railway complex and the IWTA terminal will already have been eroded

F.5.4.6 **Agricultural benefits**

The agricultural benefits are associated with the protection of arable land of the Meghna-Dhonagoda and Chandpur Irrigation projects upstream and downstream of Chandpur due to the permanent bank protection works proposed in the project. In agreement with the FPCO-guidelines the benefits result from the reduction of net agricultural revenues lost and loss of irrigation infra-structure or land due to erosion. To evaluate this reduction the following steps have been taken:

(i) Based on the results of the geo-morphological survey for the area, the change of the river bank position can be forecast for scenarios with and without embankment protection.

(ii) Based on this forecast a prediction has been [illegible] for the 30 year evaluation of th project, of the reduction of the area lost as a result of the project.

(iii) The annual net economic revenue of this reduction has been taken into account as a benefit of the permanent bank protection works undertaken at Chandpur. Crop budgets are presented in the appendix, section F/1.6.

(iv) Apart from the annual net revenue of the area otherwise lost, the annual value of Tk 1,677 per hectare associated with the irrigation infrastructure can also be considered as avoidable costs and, hence, as a benefit of the permanent bank protection works at Chandpur. It is based on analysis of data from the South-East Regional Water Resources Development Programme (FAP-5). The appendix provides details.

(v) Apart from the annual net revenue of the area otherwise lost, there is also the reduction in loss of land as a productive asset to be considered. Land has been valued at its rental value as has been argued in chapter 2. More in detail the rental value is discussed in the appendix.

The net annual economic revenue of the Meghna-Dhonagoda and Chandpur Irrigation Districts have been evaluated at Tk 11,920 per ha and Tk 9,263 per ha, adapted from Thompson (1990). The computation of the figures is presented in Tables F.5.7 and F.5.8. The rental value has been evaluated at Tk. 73,244 per ha per year for the Meghna-Dhonagoda project and at Tk. 49,896 per ha per year for the Chandpur Irrigation project. Reference is made to the appendix for further explanation

Table F.5.9 and F.5.10 provides details of agricultural benefits over the 30-year period of the feasibility study for the zones of influence upstream and downstream of Chandpur. In the table with and without-project scenarios are compared. Benefits of river training works are given by the balance, which represents the reduction in losses to cropping. It is noted that erosion is not a linear process; the geo-morphological process that applies for the Meghna is a cyclic process. For more details reference is made to Annex B.

F.5.5 **Costs of the river bank protection works**

F.5.5.1 **River bank protection works at Chandpur**

The estimated quantities of work for the construction of protection works are based on the design drawings. Estimated cost for the individual items of works are calculated for each affected location of the project site by multiplying quantities by the unit rates. Cost of the advanced protection concept are evaluated at Tk. 2,076 million or US$ 58 million (mid-1991 economic prices). A breakdown of the costs is given in Table F.5.11. An estimated 33% of the total investment cost are local currency expenditures, while the foreign component amounts to 67%.

The above investment cost comprise works executed in 1993. However, for a sustainable protection of Chandpur, it is eminent that additional protection works have to be executed. The works envisaged prevent the short term works from being outflanked and the additional investments required amount to Tk. 221 million in economic terms and should be incurred in the year 2003.

TABLE F.5.7 MEGHNA-DHONAGODA IRRIGATION PROJECT, COMPUTATION OF NET ECONOMIC RETURNS

PRICES: constant mid-1991 economic prices
UNIT: Tk.

Item	Unit	Unit return	Fraction in area	Annual return
Culivation:				
Rabi crops 1)	ha	6 755	82.3%	5 557
HYV Boro	ha	9 522	4.7%	447
B A	ha	316	81.3%	257
TL Aman	ha	6 594	85.5%	5 639
Sub-total	ha		90.3%	11 899
Fish-ponds 2)	yr	20 736	0.1%	21
Orchards 2)	yr	218	0.0%	0
Other areas			9.6%	
TOTAL				11 920
Rental value	yr			73 244

Notes:
1) Rabi crop considered is wheat
2) Adapted from Thompson (1990)
3) Rental value is adapted from crop budgets

TABLE F.5.8 CHANDPUR IRRIGATION PROJECT, COMPUTATION OF NET ECONOMIC RETURNS

PRICES: constant mid-1991 economic prices
UNIT: Tk./ha

Item	Unit	Unit return	Fraction in area	Annual return
Culivation:				
Rabi crops 1)	ha	6 755	10.4%	706
HYV Boro	ha	9 522	43.2%	4 116
B Aus	ha	316	8.5%	27
TL Aman	ha	6 594	57.7%	3 806
Sub-total	ha		62.2%	8 655
Fish-ponds 2)	yr	5 660	5.4%	306
Orchards 2)	yr	2 206	13.7%	302
Other areas			18.7%	
TOTAL				9 263
Rental value	yr			49 896

Notes:
1) Rabi crop considered is wheat
2) Adapted from Thompson (1990)
3) Rental value is adapted from crop budgets

F.5.5.2 Monitoring and maintenance

Monitoring and maintenance of the river bank protection works is an important component, which affects directly the long term effectiveness of the protection works. They form an integral part of the river bank protection works and the rate of failure of the structures may increase rapidly in the future if monitoring and maintenance are carried out poorly.

The monitoring activities are limited to regular inspection and both topographic and bathymetrical measurements. The annual costs for monitoring and maintenance have been determined at Tk. 2.0 million per annum in economic terms. Annual maintenance is estimated at 4% of surface components, e.g. open stone asphalt, fascine mattress, boulders in falling apron and grouting of boulders.

TABLE F.5.9 AGRICULTURAL BENEFITS UPSTREAM OF CHANDPUR

PRICES: constant mid-1991 economic prices
UNIT: Tk x 1000

Year	SITUATION [W]:			SITUATION [WO]:			Protection
	Lost area(ha)	Production losses	Land+Infra value	Lost area(ha)	Production losses	Land+Infra value	benefits [W]-[WO]
1993	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1994	7.7	91.8	610.4	7.7	91.8	610.4	0.0
1995	7.7	183.6	610.4	7.7	183.6	610.4	0.0
1996	7.7	275.3	610.4	7.7	275.3	610.4	0.0
1997	7.7	367.1	610.4	7.7	367.1	610.4	0.0
1998	7.7	458.9	610.4	7.7	458.9	610.4	0.0
1999	5.5	524.5	436.0	8.4	558.6	662.7	34.1
2000	5.5	590.0	436.0	8.4	658.2	662.7	294.9
2001	5.5	655.6	436.0	8.4	757.9	662.7	329.0
2002	5.5	721.2	436.0	8.4	857.5	662.7	363.1
2003	5.5	786.7	436.0	8.4	957.2	662.7	397.2
2004	3.3	826.0	261.6	8.8	1062.1	697.6	462.7
2005	3.3	865.4	261.6	8.8	1167.0	697.6	737.6
2006	3.3	904.7	261.6	8.8	1271.9	697.6	803.1
2007	3.3	944.1	261.6	8.8	1376.7	697.6	868.7
2008	3.3	983.4	261.6	8.8	1481.6	697.6	934.3
2009	2.2	1009.6	174.4	18.7	1704.5	1 482.4	1 130.9
2010	2.2	1035.8	174.4	18.7	1927.4	1 482.4	2 199.6
2011	2.2	1062.1	174.4	18.7	2150.4	1 482.4	2 396.3
2012	2.2	1088.3	174.4	18.7	2373.3	1 482.4	2 593.0
2013	2.2	1114.5	174.4	18.7	2596.2	1 482.4	2 789.7
2014	2.2	1140.7	174.4	22.0	2858.4	1 744.0	3 025.7
2015	2.2	1167.0	174.4	22.0	3120.6	1 744.0	3 523.3
2016	2.2	1193.2	174.4	22.0	3382.9	1 744.0	3 759.3
2017	2.2	1219.4	174.4	22.0	3645.1	1 744.0	3 995.3
2018	2.2	1245.6	174.4	22.0	3907.3	1 744.0	4 231.4
2019	1.5	1264.0	122.1	29.0	4253.5	2 302.1	4 559.2
2020	1.5	1282.3	122.1	29.0	4599.7	2 302.1	5 497.4
2021	1.5	1300.7	122.1	29.0	4945.8	2 302.1	5 825.2
2022	1.5	1319.1	122.1	29.0	5292.0	2 302.1	6 153.0
SUM	110.7	25 620.7	8 772.6	444.0	58 282.4	35 194.9	56 904.0

Notes:
1) Tk. 6 031 per ha is the value of irrigation infra-structure based on an analysis of data from SERWRDP (FAP5)

F.5.5.3 Budgetary implications

The monitoring and maintenance requirements have a direct impact on the future annual budget requirements. Monitoring and maintenance expenditure for river training works must normally be met by the national budget. Assuming a general level of price increase of 10% per annum, means that the cost met by the budget increase substantially over the years. Moreover, expenses for environmental monitoring and, if such is necessary, mitigative measure must equally be met by the national budget. The following cost are considered to be covered by this budget:

(i) Monitoring and maintenance expenses

These expenses amount per annum to Tk 25.6 million in mid-1991 financial prices just after completion of the works. Assuming an annual inflation rate of 10%, it means the operation and maintenance cost become Tk 41.2 million after five years and Tk. 119 million after fifteen years.

(ii) Environmental monitoring

Cost of required environmental monitoring are considered small. Annex I provides details on work to be carried out. It is expected that these cost are largely covered by the imputed amount in other costs.

TABLE F.5.10 AGRICULTURAL BENEFITS DOWNSTREAM OF CHANDPUR

PRICES: constant mid-1991 economic prices
UNIT: Tk x 1000

Year	SITUATION [W]:			SITUATION [WO]:			Protection benefits [W]-[WO]
	Lost area(ha)	Production losses	Land+Infra value	Lost area(ha)	Production losses	Land+Infra value	
1993	11.0	101.9	615.2	11.0	101.9	615.2	0.0
1994	6.6	106.1	369.1	9.5	189.5	529.1	243.3
1995	6.6	146.0	369.1	9.5	277.1	529.1	291.1
1996	6.6	185.8	369.1	9.5	364.8	529.1	339.0
1997	6.6	225.6	369.1	9.5	452.4	529.1	386.8
1998	6.6	265.4	369.1	9.5	540.0	529.1	434.6
1999	0.0	265.4	0.0	8.4	617.4	467.5	819.6
2000	0.0	[illegible]	0.0	8.4	694.9	467.5	897.1
2001	0.0	265.4	0.0	8.4	772.3	467.5	974.5
2002	0.0	265.4	0.0	8.4	849.7	467.5	1 051.9
2003	0.0	265.4	0.0	8.4	927.2	467.5	1 129.4
2004	0.0	265.4	0.0	17.6	1 090.2	984.3	1 809.1
2005	0.0	265.4	0.0	17.6	1 253.2	984.3	1 972.2
2006	0.0	265.4	0.0	17.6	1 416.2	984.3	2 135.2
2007	0.0	265.4	0.0	17.6	1 579.3	984.3	2 298.2
2008	0.0	265.4	0.0	17.6	1 742.3	984.3	2 461.2
2009	0.0	265.4	0.0	24.9	1 972.5	1 390.3	3 097.5
2010	0.0	265.4	0.0	24.9	2 202.8	1 390.3	3 327.8
2011	0.0	265.4	0.0	24.9	2 433.1	1 390.3	3 558.1
2012	0.0	265.4	0.0	24.9	2 663.3	1 390.3	3 788.3
2013	0.0	265.4	0.0	24.9	2 893.6	1 390.3	4 018.6
2014	0.0	265.4	0.0	29.3	3 164.6	1 636.4	4 535.7
2015	0.0	265.4	0.0	29.3	3 435.7	1 636.4	4 806.7
2016	0.0	265.4	0.0	29.3	3 706.7	1 636.4	5 077.7
2017	0.0	265.4	0.0	29.3	3 977.7	1 636.4	5 348.8
2018	0.0	265.4	0.0	29.3	4 248.7	1 636.4	5 619.8
2019	0.0	265.4	0.0	35.9	4 580.9	2 005.5	6 321.1
2020	0.0	265.4	0.0	35.9	4 913.0	2 005.5	6 653.2
2021	0.0	265.4	0.0	35.9	5 245.2	2 005.5	6 985.4
2022	0.0	265.4	0.0	35.9	5 577.3	2 005.5	7 317.5
SUM	44.0	7 399.4	2 460.8	602.1	63 883.7	33 675.8	87 699.3

Notes:
1) Tk. 6 031 per ha is the value of irrigation infra-structure based on an analysis of data from SERWRDP (FAP5)

TABLE F.5.11 ECONOMIC INVESTMENT COSTS FOR THE CHANDPUR SHORT PROTECTION WORKS

PRICES: mid-1991 econ... prices
UNIT: US $ x 1.000

No	Summary	TOTAL	LOCAL LABOUR	EXPAT. LABOUR	IMPORTE MATERIA	LOCAL MATERIA	PLANT & FUEL
1	Dredging	13 793.3	0.0		9 195.5		4 597.8
2	Working/material area	264.2	61.8			79.8	122.6
3	Earthworks above SLW	368.8	123.5				245.2
4	Clear site and reinstate	184.4	61.8				122.6
5	Open stone asphalt	1 044.9	91.4		142.3	519.2	291.9
6	Fascine matress	6 411.1	126.2		5 694.9	94.4	495.7
7	Rock in falling apron	5 562.5	143.9			4 306.1	1 112.5
8	Grounting of boulders	95.1	4.0			86.5	4.6
9	Containment bunds	10 423.9	2 511.2			5 012.4	2 900.3
10	Constractors cost and supervision	1 347.7		1 108.2	190.2	49.2	
11	Mobilization/demobilization	72.2			72.2		
12	Fascine matress boulders	329.3	5.7		293.9	3.3	26.4
	COST OF MATERIALS AND WORKS	39 897.2	3 129.5	1 108.2	15 589.0	10 151.0	9 919.5
	Physical contingencies (15%)	5 984.6					
	TOTAL COST OF MATERIALS AND WORKS	45 881.8					
	Contractors margins and fees (22%)	8 777.4					
	TOTAL CONSTRUCTION COST	54 659.2					
	Engineering and supervision (7.5%)	2 992.3					
	TOTAL INVESTMENT COST	57 651.4					
	Total (Tk x 1M)	2 075.5					

Notes:
1) Overall lokal cost component is 33.0%
Overall foreign cost component is 67.0%
2) Annual maintenance is estimated as %-age of surface protection: open stone asphalt, fascine matress, boulders in falling apron and grounting of b...ulders. Pe 4%
So, annual maintenance cost are estimated at Tk. 19.0 million
3) Conversion: 1 US$ = Tk. 36

F.5.6 Economic feasibility analysis

F.5.6.1 Cash flow

The cash flow computation for river bank protection for Chandpur makes a comparison of benefits and cost over the period of the study. The investment cost have been discussed in detail in the previous section. Project benefits were discussed in Section F.5.4. In Table F.5.12 the economic cash flow of river bank protection works at Chandpur town is given.

F.5.6.2 Economic Internal Rate of Return

The economic internal rate of return (EIRR), the discount rate at which the benefits balance cost over the period of the study, has been evaluated at 6% and depends very much on the estimate of the future annual repair and maintenance of the river bank in the situation without permanent bank protection works.

F.5.6.3 Net Present Value

The net present value for the erosion control in Chandpur has been calculated for a discount rate of 12%, The net present value in economic terms for the short term protection works in Chandpur at a 12% discount rate is evaluated at Tk. - 983 million, which means that the internal rate of return is below that discount rate. When considering infra-structural projects like bank protection, it is, however, doubtful whether a rate of 12% is the appropriate criterion for an investment decision.

TABLE F.5.12 ECONOMIC CASH FLOW OF THE CHANDPUR BANK PROTECTION WORKS

PRICES: mid-1991 economic prices
UNIT: Tk. x 1 million
STARTI 1993
CONST 1 years

EIRR: 6.07% NPV: -983 N /R1: -0.38

	WITH-PROJECT SIT	N COST:			PROJECT BENEFITS:				CASH	Cash F.
Year	Invest.	O&M	Other	Total	T.prot	BR/IWT	Agric.	Total	FLOW	(US$x1M)
1993	2075.5	21.0	2.1	2098.5				0.0	-2098.5	-58.3
1994	0.0	21.0	2.1	23.1	98.1	3.8	0.3	102.2	79.1	2.2
1995	0.0	21.0	2.1	23.1	102.5	3.8	0.3	106.6	83.5	2.3
1996		21.0	2.1	23.1	107.1	3.8	0.4	111.3	88.2	2.5
1997		21.0	2.1	23.1	112.0	3.8	0.5	116.3	93.2	2.6
1998		21.0	2.1	23.1	117.3	4.7	0.5	122.5	99.4	2.8
1999		21.0	2.1	23.1	122.9	4.7	1.4	129.0	105.9	2.9
2000		21.0	2.1	23.1	128.9	4.7	1.6	135.1	112.0	3.1
2001		21.0	2.1	23.1	135.2	4.7	1.8	141.7	118.6	3.3
2002		21.0	2.1	23.1	142.1	4.7	2.0	148.7	125.6	3.5
2003	221.4	23.3	2.1	246.7	149.4	4.0	2.2	155.6	-91.2	-2.5
2004		23.3	2.1	25.3	157.2	4.0	3.6	164.9	139.5	3.9
2005		23.3	2.1	25.3	165.6	4.0	4.1	173.7	148.4	4.1
2006		23.3	2.1	25.3	174.6	4.0	4.6	183.2	157.9	4.4
2007		23.3	2.1	25.3	184.3	4.0	5.1	193.4	168.1	4.7
2008		23.3	2.1	25.3	194.8	1.5	5.6	201.9	176.5	4.9
2009		23.3	2.1	25.3	206.0	1.5	8.7	216.2	190.8	5.3
2010		23.3	2.1	25.3	218.1	1.5	9.7	229.3	204.0	5.7
2011		23.3	2.1	25.3	231.2	1.5	10.8	243.4	218.1	6.1
2012		23.3	2.1	25.3	245.3	1.5	11.9	258.7	233.3	6.5
2013		23.3	2.1	25.3	260.6	1.4	13.0	275.0	249.7	6.9
2014		23.3	2.1	25.3	277.1	1.4	15.4	293.9	268.6	7.5
2015		23.3	2.1	25.3	294.9	1.4	16.9	313.3	288.0	8.0
2016		23.3	2.1	25.3	314.3	1.4	18.5	334.2	308.9	8.6
2017		23.3	2.1	25.3	335.3	1.4	20.2	356.9	331.6	9.2
2018	0.0	23.3	2.1	25.3	358.1	2.1	21.9	382.1	356.7	9.9
2019		23.3	2.1	25.3	382.8	2.1	26.3	411.2	385.9	10.7
2020		23.3	2.1	25.3	409.7	2.1	28.6	440.4	415.1	11.5
2021		23.3	2.1	25.3	438.9	2.1	31.1	472.1	446.8	12.4
2022		23.3	2.1	25.3	470.7	2.1	33.7	506.5	481.2	13.4
SUM	2296.9	675.2	62.3	3034.3	6534.8	84.0	300.5	6919.3	3885.0	107.9

Notes:

1) INVESTMENT COST:
   Tk. x 1M 2075.5

2) O&M COST (Tk. x 1M):
   Maintenance 19.0
   Survey cost 2.0

3) OTHER COST:
   Tk. x 1M 2.1

4) BENEFITS (Tk. x 1M):
   Savings damage/loss 71.2
   Annual increase 3%
   Savings repair/maint. 15.2
   Annual increase 10%
   Annual increase savings agricultural loss 3%

5) Conversion US$ 1 = Tk 36

PV (12%) benefits:
MTk. 1,125

Next to the traditional net present value calculations, the FPCO-guidelines for project assessment require to evaluate NPVR, the ratio between the net present value of the project and the present value of public capital and operation and maintenance cost at financial prices. This ratio has been calculated at -0.38.

The conclusions drawn from this section are summarized below:

(i) The economic internal rate of return is higher than the interest rate normally charged for soft loans from (international) development banks and may be considered acceptable for this type of infrastructural projects.

(ii) The NPV at 12% is negative, which indicates that rate of return is below 12%. In view of a scarcity of development resources, it could therefore be possible that priority may be given to other projects with a higher NPV.

F.5.7 Sensitivity analysis

F.5.7.1 General

The economic analysis of bank erosion protection is based on uncertain future events and imperfect data. Because of this, it is important that sensitivity analyses be undertaken. This implies an analysis of the economic internal rate of return as a function of changes in investment cost, operation and maintenance expenditure and value of benefits.

F.5.7.2 Value of benefits

The influence of changes in the value of benefits on the economic internal rate of return of the proposed river bank protection works is presented in Table F.5.11 and Figure F.5.2. As it is demonstrated, the economic internal rate of return increases when benefits are increased by 10% to 50%.

F.5.7.3 Increase in investment cost

When the investment cost decrease and/or benefits increase considerably, the analysis is to give a positive effect on the economic internal rate of return. Details are presented in Table F.5.11 and Figure F.5.3.

F.5.7.4 Increase of monitoring and maintenance costs

A critical issue in the economic feasibility analysis of river bank protection for the lower Meghna remains the estimate of likely future monitoring and maintenance cost. Consequently, it is very important to analyze the sensitivity to any change in these cost. For a summary see Table F.5.11 and Figure F.5.4.

F.5.7.5 Delays during construction

A delay of the implementation envisaged means that the estimated benefits come into effect on a later date. This leads, in general, to a lower economic internal rate of return. A one-year delay in implementation of the initial protection works would lead to a decrease in EIRR of 0.1% point.

F.5.8 Displacement of population

Based on the result of the socio-economic survey and the migration of the bankline in the town area of Chandpur, it has been possible to estimate the number of persons affected by erosion. More details are presented in the appendix. The gross area covered by the survey was measured on the street map and covered 293,200 m^2. The number of persons living in this area has been surveyed, there were 2,620 residents.
Hence, the population density is 8,940 persons per km^2. The same population density applies for the area prone to erosion. Based on the Statistical Yearbook of Bangladesh for 1991 (table 2.08, page 45), the annual

population increase was 2.17% over the last 10 years. Using this factor and the area lost for the coming 30 years would give total numbers for each five-year period.

TABLE F.5.13 RESULTS OF THE SENSITIVITY ANALYSIS FOR CHANDPUR

VALUES: Economic Internal Rate of Return (EIRR)
UNIT: percent

Change investm.	CHANGE IN BENEFITS: -10%	0%	10%	20%	30%	40%	50%
-30%	7.83%	8.82%	9.75%	10.65%	11.51%	12.35%	13.16%
-20%	6.81%	7.74%	8.62%	9.46%	10.26%	11.03%	11.78%
-10%	5.96%	6.84%	7.68%	8.47%	9.22%	9.95%	10.65%
0%	5.22%	6.07%	6.87%	7.62%	8.34%	9.03%	9.69%
10%	4.58%	5.40%	6.17%	6.89%	7.58%	8.24%	8.87%
20%	4.01%	4.81%	5.55%	6.25%	6.91%	7.54%	8.15%
30%	3.50%	4.27%	4.99%	5.67%	6.31%	6.92%	7.51%

Change M&M	CHANGE IN BENEFITS: -10%	0%	10%	20%	30%	40%	50%
-30%	5.56%	6.40%	7.18%	7.93%	8.64%	9.32%	9.98%
-20%	5.45%	6.29%	7.08%	7.83%	8.54%	9.22%	9.88%
-10%	5.34%	6.18%	6.98%	7.73%	8.44%	9.13%	9.79%
0%	5.22%	6.07%	6.87%	7.62%	8.34%	9.03%	9.69%
10%	5.11%	5.96%	6.76%	7.52%	8.24%	8.93%	9.59%
20%	4.99%	5.85%	6.65%	7.41%	8.14%	8.83%	9.49%
30%	4.87%	5.73%	6.54%	7.31%	8.03%	8.73%	9.40%

F.5.9 Multi-criteria analysis

F.5.9.1 Economic criteria

The economic criteria can be summarized as follows:

- EIRR: 6%
- NPV: MTk. (983)
- NPVR: (0.38)

F.5.9.2 Probability of failure

For design purposes the accepted failure probability of protection works and advanced protection concept have been evaluated in-depth. Under the base assumption that maintenance works are realized for 80%, the design failure probability amounts to two-and-half times in one thousand years (2.5 E-03).
If virtually no maintenance is carried out, it is concluded from the risk analysis that the failure probability increases by a factor 17 to about 4.25 E-02.

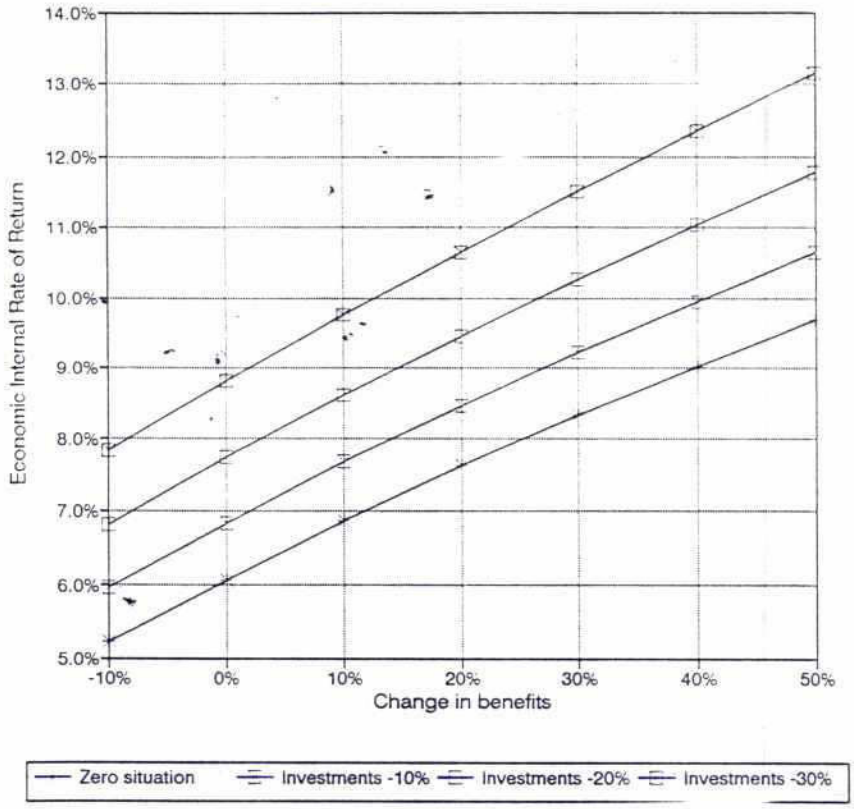
F.5.9.3 Budgetary implications

Reference is made to section F.5.5.3

F.5.9.4 Displacement of population

Reference is made to section F.5.8.

FIGURE F.5.2 AND F.5.3 RESULTS SENSITIVITY ANALYSIS



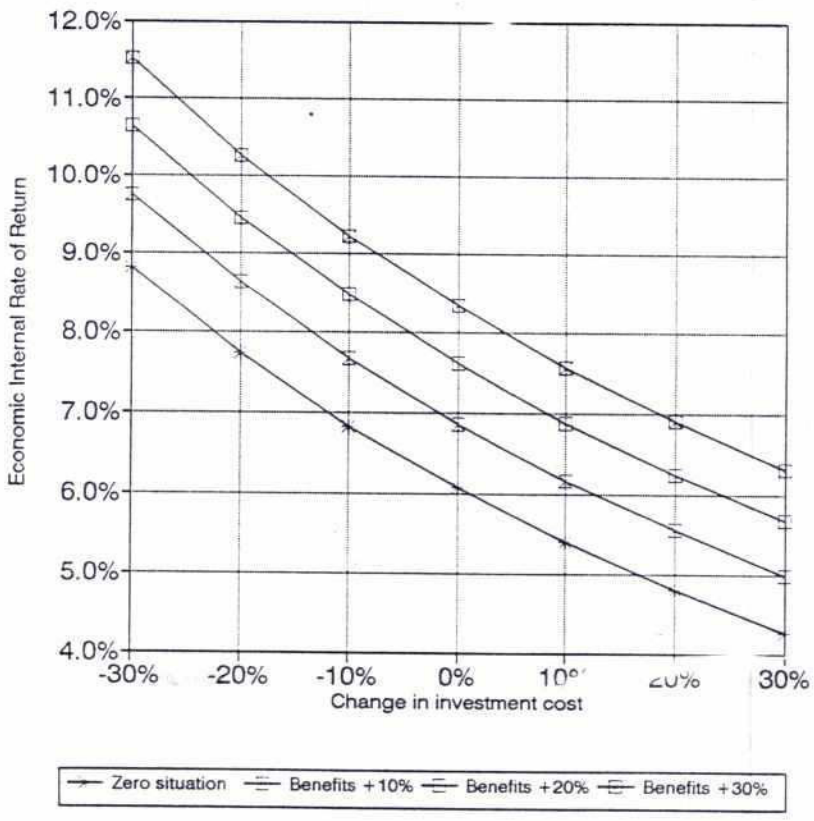


FIGURE F.5.4 RESULTS SENSITIVITY ANALYSIS

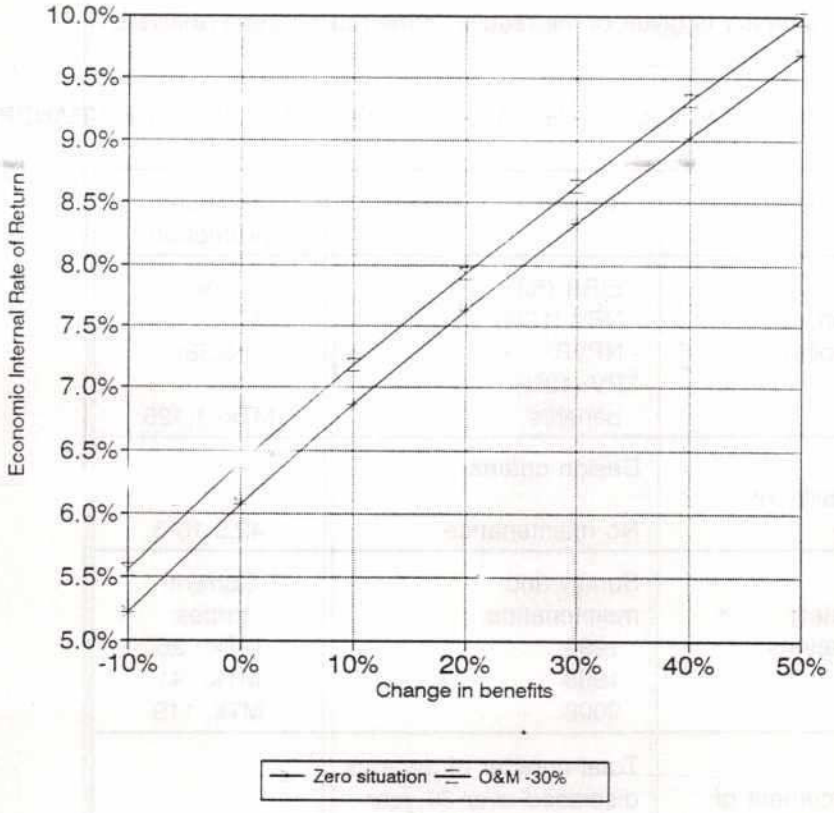


TABLE F.5.14 DISPLACEMENT OF POPULATION IN CHANDPUR

Period	Area lost in Puran B. and Nutan B. (North Station Rd.)	Number of persons displaced
1993-1998	182,250 - 42,040 m^2	2,230
1998-2003	198,450 + 33,130 m^2	2,560
2003-2008	207,520 + 63,340 m^2	3,340
2008-2013	75,650 + 52,890 m^2	1,760
2013-2018	66,260 + 133,730 m^2	3,060
2018-2013	81,000 + 143,050 m^2	3,810
Total	1,279,310 m^2	16,760

Source: Annex B and socio-economic survey 1991

F.5.9.5 **Summary of results**

In Table F.5.15 a summary is given of the results of the multi-criteria analysis.

TABLE F.5.15 RESULTS OF THE MULTI-CRITERIA ANALYSIS FOR CHANDPUR

Data type	Variable	Advanced protection
1. Economic profitability	- EIRR (%) - NPV (12%) - NPVR - PV (12%) benefits	6% MTk. (0.38) MTk. 1,125
2. Probability of failure	Design criteria No maintenance	2.5 10-3 42.5 10-3
3. Budgetary implications	Survey and maintenance: 1993 1998 2008	Current prices: MTk. 26 MTk. 41 MTk. 119
4. Displacement of population	Total number of persons displaced over 30 year evaluation period	16,760

ANNEX F

Economics of protection works

F-6 Eklashpur

F.6 EKLASHPUR

F.6.1 Present situation and previous studies

Eklashpur is situated on the left bank of the Lower Meghna, near the confluence of the Padma and the Meghna. Erosion has attacked the river bank for more than a decade and is the result of both current and wave action. Agriculture is the main economic activity in the area. However, erosion threatens the embankment around the Meghna-Dhonagoda irrigation project.
Rehabilitation of the Meghna-Dhonagoda irrigation project is being studied at present by the FAP5. The FAP project is mainly concerned with agricultural production, irrigation and drainage. Hence the scope is not on river training works to avert erosion of the existing embankment.
The FAP12's rapid rural appraisal (1990) carried out a post-evaluation of the Meghna-Dhonagoda irrigation project four years after its completion. Data on economic indicators for this project can also be found in Thompson's study on the impact of flood control on agriculture (1990).
If the embankment of the Meghna-Dhonagoda project is breached, the whole benefit of flood control for the area would be lost. The project's pump station is located very near to the border of the river. Without any river training works or any other sort of bank protection this will be destroyed. Hence, the embankments would have to be retired some 700 m and the pump station relocated, in order to be out of the reach of the river until well in the next century.

F.6.2 Specific aspects related to Eklashpur

Design of river training and bank protection works are undertaken by the Meghna River Bank Short Term Study, which envisages the protection of the river bank and the embankment in Eklashpur. The existing embankment and the irrigation pump station almost reach the river in this location and need to be protected. Moreover, along the shore of the Lower Meghna there are a number of habitations and small commercial enterprises, which would be protected.

Embankments at Eklashpur protect the Meghna-Dhonagoda irrigation project. The irrigation system was officially completed in June 1988 but during its implementation the original embankment from Mohanpur to Eklashpur was engulfed by the river and retired in 1980. The embankment between Eklashpur and Amirabad was engulfed in 1986/87. In 1987 the flood embankment on Dhonagoda River was breached and it was again breached the next year.

The area of influence of the proposed works reaches from the point where the Padma and the Meghna join the Dhonagoda River and end some two kilometres south of it. The area protected covers lands outside the existing embankment bordering the river and parts of the Meghna-Dhonagoda irrigation project located inside the embankment.

The economic feasibility analysis covers three alternatives, notably (a) protection through a groyne; (b) bank protection works on the existing bank line in Eklashpur and (c) guide protection. It makes a comparison between a future scenario with river training or protection works (with-scenario) and without any works being done (without-scenario). In the without-scenario situation one may expect that the existing embankment must be retired and the irrigation pump station relocated more inland. Moreover, it is likely that repair and maintenance to those parts of the embankment that remain in place will increase.
It is more than likely, that the river bank will advance considerably in the coming 30 years. Hence, the embankment will be retired time and again. With respect to the pumping station, it is expected that the advancement of the bank line will necessitate its relocation already in 1998. Table F.6.1 gives the actions needed in this scenario.
It is emphasized that the complete loss of the Meghna-Dhonagoda Irrigation Project has not been taken as the without-scenario, since that is not considered the most likely scenario to develop in the future. When comparing the bank protection works with such scenario an economic rate of return as high as 20% would be obtained.

The progress of bank erosion in the without-scenario situation can be estimated from the results of the geo-morphological study (see Annex B). This progress is expected to be important in the coming 30 years; without any protection works large parts of the existing embankment and land of the irrigation project will disappear. Hence, it is more than likely that new retired embankments will be constructed at regular intervals of time.

History has shown that where the river damages or destroys embankments, the authorities have taken action to protect villages and agricultural land that lay behind it. In almost all cases this resulted in the construction of new and more retired embankments. However, continuing bank erosion also threatened newly constructed embankments, thus leading to again a new retirement. Hence, it is more than likely, that in the without-scenario situation new stretches of embankment will be constructed at regular time intervals to replace destructed parts, while in between much money will be allocated on protection measures to stop further erosion.

Concerning the pump station the results of the geo-morphological study show that by 1998 it would be destroyed by river erosion unless protected sufficiently. As one may label past actions to stop erosion as insufficient and no-sustainable, destruction of the pump station will be difficult to avoid. Hence, a new pump station must be constructed in that year to replace the old one.

TABLE F.6.1 EXPECTED WITHOUT-PROJECT SCENARIO

Year	Construction of new embankment	Construction of pump station
1993	0 km	
1998	2.5 km	1 station
2003	4.0 km	
2008	4.5 km	
2013	5.5 km	
2018	7.8 km	

As a result of the implementation of the short term bank protection works one can expect that less agricultural land will disappear and fewer structures will be damaged. Hence, the associated investments give benefits which relate to a reduction of embankment construction, loss of agricultural land and destruction of structures.

F.6.3 Alternatives for protection

Three types of river bank protection have been investigated, notably (a) a groyne just north of Eklashpur reaching out for some 600 m into the river, (b) protection of the existing bank and (c) guide protection along the existing embankment.

The groyne option is the most expensive, but it will lead to sedimentation and create additional land, though it may take many years before a substantial area will become available and productive. Moreover, high investment cost vis-a-vis benefits are affecting the rate of return.

The second option, bank protection works, has an important economic advantage: investments are much lower and not concentrated at the start of the 30 year study period, but staggered.

The third option consists of guide bunds at Eklashpur and at the confluence of the Meghna and Dhonagoda. Guide bunds are river training works and as such a good alternative for a groyne. However, they are far more expensive than bank protection works and slightly more expensive than the groyne alternative.

F.6.4 Benefits of Eklashpur protection works

Benefits related to river training or bank protection works are considered the same. Hence, no distinction in benefits is made between the alternatives.

F.6.4.1 Reduction in repair and maintenance expenses

Maintenance and repair of the embankments of the Meghna-Dhonagoda irrigation project is carried out each year by the BWDB. So far the amount allocated has been small. BWDB spends about Tk. 500 thousand per year. Expenditures required in the coming years, however, will increase rapidly; in 1990/91 a total of Tk. 104 million has been spent on CC blocks to repair embankments.
A retirement of the embankment is foreseen every five years from 1998 onwards. Because only small sections of the embankment are renewed, emergency protection cannot be neglected altogether. Based on the considerable amount spent in 1990/91, it has been assumed that annual maintenance required will initially be about 2% of the amount spent in 1990/1991. Together with the regular maintenance Tk. 2.6 million per year is assumed the present-day repair and maintenance budget. This amount is expected to increase rapidly by an estimated 10% per year and has to be considered as additional to the costs incurred for regular retirement of embankments.
These costs in repair and maintenance can be saved and can be considered as benefits from adequate sustainable river training works.

F.6.4.2 Relocation of irrigation pump station

The actual pump station is located at a spot which could be eroded by the river in the year 1998, according to the results of the geomorphological survey. A relocation of this pump station to a site more inland is needed. It is assumed that one relocation only will take place during the period of the study. Hence, the new location of the pump station must be somewhere near to the expected bank line in year 2020, which marks the end of the study period.

The cost of relocation of the pump stations are based on earlier cost estimates for construction of similar stations. These data have been inflated by the Planning Commission's inflator (10%) in order to give mid-1991 prices. The estimated economic cost for relocation of the pump station are Tk. 32.4 million. Consequently, the construction of river training works is expected to prevent the relocation of the pump station and yields a saving of Tk. 32.4 million in 1998.

F.6.4.3 New retired embankments

As the river bank shifts towards the east, it will destroy the existing embankment. From the results of the geo-morphological study (see Annex B) it could be estimated how far the bank line will recede. The without-project scenario foresees that, every five years, a new stretch of embankment must be constructed in order to protect the Meghna-Dhonagoda Irrigation Project. Table F.6.1 gives details, which are based on expected progress of erosion.
From data of earlier embankment constructions, the actual price for this type of works has been estimated. Per kilometre-length embankment construction cost is Tk. 7.83 million. Table F.6.2 provides details on the cost needed for the construction of new retired embankments. Because, no new retired embankment construction is required if the proposed river training works are implemented, the cost figures from the table are savings. Hence, they represent expected benefits.

TABLE F.6.2 COST OF NEW EMBANKMENT CONSTRUCTION AND RELOCATION OF PUMP STATION

PRICES: mid-1991 economic prices
UNIT: Tk. x 1M

	INFRA-STRUCTURAL WORKS:				
Year	Embankm (km)	Constr. cost	Pump station	Constr. cost	Total
1993	0.0		0		0.000
1998	2.5	19.575	1	32.400	51.975
2003	4.0	31.320	0		31.320
2008	4.5	35.235	0		35.235
2013	5.5	43.065	0		43.065
2018	7.8	61.074	0		61.074
2023	8.5	66.555	0		66.555

Source: cost data from FAP5
Notes:
1) Tk. 7.830 x 1M are the construction cost per km embankment
2) Tk. 32.400 x 1M are the estimated construction cost for the irrigation pump station
3) At 0.75 is estimated the compounded conversion factor of SWR and Planning Commissions's SCF that relates to construction works

F.6.4.4 **Destruction of buildings and urban infra-structure**

River bank erosion will cause loss of buildings and damage to existing structures. Some inhabitants have already moved their homes more inland to protect them from the water of the Meghna. However, a considerable number of houses and commercial buildings in the area remain prone to erosion.
Many houses are simple one-storey kutcha structures which have a marginal value and can be moved at low cost, mainly labour. However, also structures of a more permanent nature and a market area exist. Moreover, from field observations, it has been estimated that about 10% of the area in Eklashpur is used for non-agricultural purposes, being either commercial enterprises or homes. This percentage also includes public infra-structure.

From the results of the geo-morphological study the progress of bank erosion could be estimated as well as how much land is likely to disappear. Based on the socio-economic surveys in Bhairab Bazar, Munshiganj and Chandpur an estimate could be made of the average price of houses and other buildings. In the three towns surveyed, we have estimated that social and town infra-structure covers 25% of the built-on area. The calculated average economic price per square meter land area is Tk. 1,065. In view of the type of structures observed in Eklashpur in comparison to those in the three sites surveyed, it has been assumed that structures in Eklashpur have a 25% lower value. Consequently, the economic price of structures is estimated at Tk. 799 per square meter land area. In Table F.6.3 the estimated economic value of destruction of buildings and urban infra-structure are presented.

Apart from the infra-structural losses as a result of bank erosion, also loss of land is to be considered. The fact that it washes away and is lost means that it must be considered in the economic evaluation. However, all land has already been accounted for in the analysis of agricultural production, assuming that agriculture is the nearest-best economic activity. Moreover, double-counting has thus been avoided.

In the table the balance of destructions for the with- and without-project scenarios is presented. Although, the proposed works protect the existing embankment, there remains some erosion in the area between the river and the embankment. This has been accounted for in calculating the value of

destructed village infra-struct... The benefits of protection works are consequently evaluated as the reduction in destruction between both scenarios.

No account was taken of losses in revenues of commercial enterprises. The nature of commerce in Eklashpur is such that one may expect that stocks and equipment are removed well before erosion will wash them away. Setting up a new commercial venture on higher land is only a matter of hours. Hence, no loss in trading profits can be expected in the without-project scenario.

TABLE F.6.3 VALUE OF DESTRUCTED OF BUILDINGS AND URBAN INFRA-STRUCTURE

PRICES: constant mid-1991 economic prices
UNIT: Tk x 1M

Year	SITUATION [W]: Area lost (ha)	Urban assets	SITUATION [WO]: Area lost (ha)	Urban assets	Protection benefits [W]-[WO]
1993	40.1	32.038	41.8	33.445	1.407
1994	42.9	34.260	45.5	36.353	2.093
1995	42.9	34.260	45.5	36.353	2.093
1996	42.9	34.260	45.5	36.353	2.093
1997	42.9	34.260	45.5	36.353	2.093
1998	42.9	34.260	45.5	36.353	2.093
1999	34.5	27.612	63.8	51.020	23.408
2000	34.5	27.612	63.8	51.020	23.408
2001	34.5	27.612	63.8	51.020	23.408
2002	34.5	27.612	63.8	51.020	23.408
2003	34.5	27.612	63.8	51.020	23.408
2004	28.2	22.564	73.2	58.512	35.948
2005	28.2	22.564	73.2	58.512	35.948
2006	28.2	22.564	73.2	58.512	35.948
2007	28.2	22.564	73.2	58.512	35.948
2008	28.2	22.564	73.2	58.512	35.948
2009	15.7	12.540	39.2	31.340	18.801
2010	15.7	12.540	39.2	31.340	18.801
2011	15.7	12.540	39.2	31.340	18.801
2012	15.7	12.540	39.2	31.340	18.801
2013	15.7	12.540	39.2	31.340	18.801
2014	19.3	15.459	57.0	45.568	30.109
2015	19.3	15.459	57.0	45.568	30.109
2016	19.3	15.459	57.0	45.568	30.109
2017	19.3	15.459	57.0	45.568	30.109
2018	19.3	15.459	57.0	45.568	30.109
2019	15.2	12.135	76.3	61.027	48.892
2020	15.2	12.135	76.3	61.027	48.892
2021	15.2	12.135	76.3	61.027	48.892
2022	15.2	12.135	76.3	61.027	48.892
SUM	804.0	642.749	1740.7	1391.520	748.770

Notes:
1) Tk. 0.799 x 1000 per sq.m is the estimated average value of urban infra-structure and buildings
2) At 10% is estimated the urbanised area

F.6.4.5 **Agriculture**

Agricultural benefits are associated with protection of arable land which would otherwise be lost as a result of bank migration. Behind the embankment one finds mainly irrigated lands, while outside the embankment non-irrigated cropping takes place. Hence, for economic feasibility analysis purposes it has been assumed that irrigated agriculture takes place inside the embankment and non-irrigated agriculture outside it.

In agreement with the FPCO-guidelines the agricultural benefits of river training and bank protection works result from reduction of net agricultural revenues lost due to erosion of arable land. Based on the results of the geo-morphological survey for the area, the change of the river bank position could be forecast for scenarios with and without investments. Hence, a prediction could be made of reduction in the area lost as a result of river training works, covering the evaluation period.

The cropping pattern in the Meghna-Dhonagoda irrigation project and the net economic return of irrigated agriculture were adapted from Thompson (1990) and results of work done by FAP5. An assumption was made for the cropping pattern of lands outside the irrigation scheme: only one crop per year is cultivated, notably L.Boro. The annual net economic revenues of reduced losses in agricultural area are taken into account as benefit of works undertaken at Eklashpur.

Apart from the annual net revenue of the area inside the embankment otherwise lost, a value of Tk. 1,677 per hectare associated with the irrigation infra-structure can also be considered as avoidable costs and, hence, as benefit of protection works in Eklashpur. This figure was derived from data supplied by FAP5 and details are given in the appendix.

The net annual economic revenues of the Meghna Dhonagoda irrigation project have been evaluated at Tk. 11,920 per ha. Details are reported in Table 6.4 and in the appendix. For cropping outside the embankment net annual economic revenues are estimated at Tk. 8,842 per ha, assuming that 90% of the land is cropped once per year.

TABLE F.6.4 ANNUAL NET REVENUES PER HECTARE IN THE MEGHNA-DHONAGODA IRRIGATION PROJECT

PRICES: constant mid-1991 economic prices
UNIT: Tk.

Item	Unit	Unit return	Fraction in area	Annual return
Culivation:				
Rabi crops 1)	ha	6 755	82.3%	5 557
HYV Boro	ha	9 522	4.7%	447
B Aus	ha	316	81.3%	257
TL Aman	ha	6 594	85.5%	5 639
Sub-total	ha		90.3%	11 899
Fish-ponds 2)	yr	20 736	0.1%	21
Orchards 2)	yr	218	0.0%	0
Other areas			9.6%	
TOTAL				11 920
Rental value	yr			73 244

Notes:
1) Rabi crop considered is wheat
2) Adapted from Thompson (1990)
3) Rental value is adapted from crop budgets

Apart from the loss of agricultural production as a result of bank erosion, there is also the reduction in loss of land as a productive asset to be considered. The fact that land washes away and is directly lost for cropping means that it must be considered in the economic evaluation. Hence, the value of this asset must be estimated, while the reduction of lost agricultural land is considered as a benefit of river training works or bank protection. As already explained in F.2.5.4 the present value of the economic rental value has been taken into account to reflect the economic value of the land lost due to erosion.
The economic value of cropped land is based on share cropping arrangement in the area. For each individual crop the rent has been calculated as the money value of production quota provided by the share cropper to the landowner. Based on the prevailing cropping pattern in the Meghna-Dhonagoda irrigation project and lands outside the embankment, the average economic rental value is calculated. For irrigated land inside the embankment the rental value is Tk. 73,244 per ha. The rental value for non-irrigated land is calculated as Tk. 40,686 per ha. For more details reference can be made to the appendix.
Table F.6.5 provides details of total agricultural benefits over the 30-year period of the feasibility study. In the table with and without project scenarios are compared. Benefits of river training works are given by the balance, which represents the reduction in losses to cropping.

TABLE F.6.5 AGRICULTURAL BENEFITS

PRICES: constant mid-1991 economic prices
UNIT: Tk x 1000

Year	SITUATION [W]: Areas lost (ha): in.emb.	out.emb.	Production loss(CUM)	Land+Infra value	SITUATION [WO]: Areas lost (ha): in.emb.	out.emb.	Production loss(CUM)	Land+Infra value	Protection benefits [W]-[WO]
1993	0.0	21.8	192.6	886.1	0.0	21.8	192.6	886.1	0.0
1994	0.0	30.8	465.3	1 254.9	0.0	30.8	465.3	1 254.9	0.0
1995	0.0	30.8	738.0	1 254.9	0.0	30.8	738.0	1 254.9	0.0
1996	0.0	30.8	1 010.7	1 254.9	0.0	30.8	1 010.7	1 254.9	0.0
1997	0.0	30.8	1 283.4	1 254.9	0.0	30.8	1 283.4	1 254.9	0.0
1998	0.0	30.8	1 556.1	1 254.9	0.0	30.8	1 556.1	1 254.9	0.0
1999	0.0	28.8	1 810.4	1 169.9	0.0	34.0	1 856.7	1 382.9	259.3
2000	0.0	28.8	2 064.6	1 169.9	0.0	34.0	2 157.2	1 382.9	305.6
2001	0.0	28.8	2 318.8	1 169.9	0.0	34.0	2 457.7	1 382.9	351.9
2002	0.0	28.8	2 573.1	1 169.9	0.0	34.0	2 758.2	1 382.9	398.2
2003	0.0	28.8	2 827.3	1 169.9	0.0	34.0	3 058.8	1 382.9	444.5
2004	0.0	16.7	2 975.3	681.2	15.2	22.5	3 398.0	1 696.5	1 438.0
2005	0.0	16.7	3 123.3	681.2	15.2	22.5	3 737.2	1 696.5	1 629.2
2006	0.0	16.7	3 271.4	681.2	15.2	22.5	4 076.4	1 696.5	1 820.3
2007	0.0	16.7	3 419.4	681.2	15.2	22.5	4 415.6	1 696.5	2 011.5
2008	0.0	16.7	3 567.4	681.2	15.2	22.5	4 754.8	1 696.5	2 202.7
2009	0.0	[illegible]	3 664.5	446.7	11.0	18.7	5 021.8	1 327.0	2 237.6
2010	0.0	11.0	3 761.6	446.7	11.0	18.7	5 288.8	1 327.0	2 407.6
2011	0.0	11.0	3 858.6	446.7	11.0	18.7	5 555.8	1 327.0	2 577.5
2012	0.0	11.0	3 955.7	446.7	11.0	18.7	5 822.8	1 327.0	2 747.5
2013	0.0	11.0	4 052.7	446.7	11.0	18.7	6 089.9	1 327.0	2 917.5
2014	0.0	13.1	4 168.3	531.7	19.3	24.6	6 486.3	1 997.1	3 783.4
2015	0.0	13.1	4 283.8	531.7	19.3	24.6	6 882.7	1 997.1	4 064.3
2016	0.0	13.1	4 399.4	531.7	19.3	24.6	7 279.0	1 997.1	4 345.1
2017	0.0	13.1	4 514.9	531.7	19.3	24.6	7 675.4	1 997.1	4 626.0
2018	0.0	13.1	4 630.5	531.7	19.3	24.6	8 071.8	1 997.1	4 906.8
2019	0.0	17.8	4 787.6	723.2	23.0	36.1	8 604.0	2 654.7	5 747.9
2020	0.0	17.8	4 944.8	723.2	23.0	36.1	9 136.1	2 654.7	6 122.9
2021	0.0	17.8	5 102.0	723.2	23.0	36.1	9 668.3	2 654.7	6 497.9
2022	0.0	17.8	5 259.1	723.2	23.0	36.1	10 200.5	2 654.7	6 872.8
SUM	0.0	594.8	94 580.6	24 200.6	319.4	819.1	139 699.7	49 797.6	70 716.1

Notes:
1) Tk. 1 677 per ha is the value of irrigation infra-structure based on an analysis of data from SERWRDP (FAP5)
2) Inside the existing embankment land is irrigated, outside the embankment land is not irrigated
3) Tk. 9 263 is the economic unit value of land in the Chandpur irrigation project
Tk. 8 842 is the economic value of land outside embankments, assuming 90% use for cropping
4) Tk. 40 686 per ha is the rental value of land outside embankments

F.6.5 Cost of alternative protection options

F.6.5.1 Investment cost

Estimated cost for river training works are based on design drawings. The cost of individual items of work has been calculated by multiplying used quantities by unit rates. Economic investment cost for a large groyne at Eklashpur is estimated to cost US$ 31.37 million, which equals to Tk. 1,129.5 million. An estimated 35% of the investment cost are local currency expenditure and the foreign component amounts to 65%.

A second design for protection has been made, notably protection of the existing bank. This type of protection is less expensive at the beginning of the 30-year study period. However, in later years additional works must be carried out. Initial investment cost are evaluated at US$ 7.90 million or Tk 260.8 million, while in 1998 an additional Tk. 264.4 million must be invested. A final investment is needed in 2005, requiring also Tk. 264.4 million. Local currency expenditure is 45% and the foreign component totals 55%.

The third option comprises of guide bunds. This type of investment is more expensive than any of the previous options. Total economic investment costs are estimated at US$ 34.24 million or Tk. 1,232.6 million. An estimated 26 % of investment cost are local currency expenditure and the foreign component is 74%. Table F.6.6 provides a summary of investment cost for all three options.

TABLE F.6.6 SUMMARY OF ECONOMIC INVESTMENT COST FOR WORKS AT EKLASHPUR

Type	Investment cost and year	Local/foreign currency
Large groyne	1993: MTk. 1,129.5	Local: 35% Foreign: 65%
Protection of existing bank	1993: MTk. 284.5 1998: MTk. 264.4 2005: MTk. 264.4	Local: 45% Foreign: 55%
Guide bunds	1993: MTk. 1,232.6	Local: 26% Foreign: 74%

F.6.5.2 Monitoring and maintenance

Monitoring and maintenance of river training works is an important component, which affects directly the long term effectiveness of protection against bank erosion. They form an integral part of protection works and the rate of failure of structures may increase rapidly in the future if maintenance works are carried out poorly.
Monitoring comprises regular inspection of structures as well as topographic and bathymetrical measurements. The annual cost of monitoring is estimated at Tk. 2.0 million per year (mid-1991 economic prices). Annual maintenance is estimated at 4% of surface components, e.g. open stone asphalt, fascine mattress, boulders in falling apron and grouting of boulders. Details of monitoring and maintenance expenditure are provided in Table F.6.7.

F.6.5.3 Budgetary implications

Monitoring and maintenance expenditure for river training works must normally be met by the national budget. Assuming a general level of price increase of 10% per annum, means that the cost met by the

TABLE F.6.7 SUMMARY OF ANNUAL MONITORING AND MAINTENANCE AT EKLASHPUR

Type	Maintenance expenditure	Monitoring cost
Large groyne	1993: MTk. 16.9	MTk. 2.0
Protection of existing bank	1993: MTk. 6.9 1998: MTk. 11.3 2005: MTk. 15.7	MTk. 2.0
Guide bunds	1993: MTk. 21.2	MTk. 2.0

budget increase substantially over the years. Moreover, expenses for environmental monitoring and, if such is necessary, mitigative measure must equally be met by the national budget.

(i) Monitoring and maintenance expenses

In Table F.6.8 a summary is presented of current expenditure for monitoring and maintenance operations at the start of the project, after five years and in the year 2008.

TABLE F.6.8 MONITORING AND MAINTENANCE IN CURRENT PRICES

Type	Expenditure in 1993	Expenditure in 1998	Expenditure in 2008
Large groyne	MTk. 25.0	MTk. 41.6	MTk. 108
Protection of existing bank	MTK 10.8	MTk. 25.3	MTk. 90
Guide bunds	MTk. 20.6	MTk. 33.2	MTk. 86

(ii) Environmental monitoring

Cost of required environmental monitoring are considered small. Annex I provides details on work to be carried out. It is expected that these cost are largely covered by the imputed amount in other costs.

F.6.6 Economic feasibility study

F.6.6.1 Cash flow

The cash flow computation for river training works at Eklashpur compares benefits and cost over the 30-year evaluation period. The investment costs have been discussed in detail in the previous section. Project benefits were discussed in section F.6.4.
Table F.6.9 provides the cash flow calculation for protection of the existing bank, the option which economically is most attractive. The cash flow table requires no further discussion.

F.6.6.2 Economic Internal Rate of Return

The economic feasibility of the river bank protection works is first evaluated by comparing the discounted values of benefits against cost. The economic internal rate of return (EIRR) is the discounting percentage at which the present value of benefits and cost over the 30-year evaluation period are in balance.

The construction of a groyne gives an EIRR of less than 1% This means that the economic value of the interest to be protected are more or less equal to the cost to be made. The EIRR, however, is low.

TABLE F.6.9 ECONOMIC CASH FLOW EKLASHPUR PROTECTION OF THE EXISTING BANK

PRICES: mid-1991 economic prices
UNIT: Tk. x 1 million
START: 1993
CONSTR: 1 years

EIRR: 2.83% NPV: -293.0 NPVR1: -0.45

	WITH-PROJECT SITUATION COST:				BENEFITS:					CASH	Cash F.
Year	Invest.	M&M	Other	Total	Repair c.	Nw.emb.	Urban pr.	Agric.	Total	FLOW	(US$x1M)
1993	284.5	8.9	0.3	293.7	0.0	0.0	0.0	0.0	0.0	-293.7	-8.16
1994	0.0	8.9	0.3	9.2	3.4		2.1	0.1	5.7	-3.5	-0.10
1995	0.0	8.9	0.3	9.2	3.8		2.1	0.2	6.0	-3.1	-0.09
1996		8.9	0.3	9.2	4.2		2.1	0.2	6.4	-2.7	-0.08
1997		8.9	0.3	9.2	4.6		2.1	0.2	6.9	-2.3	-0.06
1998	246.4	13.3	0.3	260.0	5.0	52.0	2.1	0.2	59.3	-200.7	-5.57
1999		13.3	0.3	13.6	5.5		23.4	2.0	30.9	17.3	0.48
2000		13.3	0.3	13.6	6.1		23.4	2.2	31.7	18.2	0.50
2001		13.3	0.3	13.6	6.7		23.4	2.5	32.6	19	0.53
2002		13.3	0.3	13.6	7.4		[illegible]	2.8	33.6	20.0	0.56
2003		13.3	0.3	13.6	8.1	31.3	23.4	3.1	65.9	52.4	1.45
2004		13.3	0.3	13.6	8.9		35.9	4.2	49.1	35.5	0.99
2005	246.4	17.7	0.3	264.4	9.8		35.9	4.6	50.4	-214.0	-5.95
2006		17.7	0.3	18.0	10.8		35.9	5.0	51.8	33.8	0.94
2007		17.7	0.3	18.0	11.9		35.9	5.5	53.3	35.3	0.98
2008		17.7	0.3	18.0	13.1	35.2	35.9	5.9	90.1	72.1	2.00
2009		17.7	0.3	18.0	14.4		18.8	5.0	38.2	20.2	0.56
2010		17.7	0.3	18.0	15.8		18.8	5.2	39.8	21.9	0.61
2011		17.7	0.3	18.0	17.4		18.8	5.5	41.6	23.7	0.66
2012		17.7	0.3	18.0	19.1		18.8	5.7	43.6	25.6	0.71
2013		17.7	0.3	18.0	21.0	43.1	18.8	5.9	88.8	70.8	1.97
2014		17.7	0.3	18.0	23.1		30.1	7.1	60.3	42.3	1.18
2015		17.7	0.3	18.0	25.4		30.1	7.4	63.0	45.0	1.25
2016		17.7	0.3	18.0	28.0		30.1	7.8	65.9	47.9	1.33
2017		17.7	0.3	18.0	30.8		30.1	8.2	69.1	51.1	1.42
2018		17.7	0.3	18.0	33.9	61.1	30.1	8.5	133.6	115.6	3.21
2019		17.7	0.3	18.0	37.3		48.9	10.2	96.3	78.3	2.18
2020		17.7	0.3	18.0	41.0		48.9	10.7	100.6	82.6	2.30
2021		17.7	0.3	18.0	45.1		48.9	11.3	105.3	87.3	2.43
2022		17.7	0.3	18.0	49.6		48.9	11.9	110.4	92.4	2.57
SUM	777.3	456.2	8.5	1242.0	511.1	222.7	747.4	149.1	1630.3	388.3	10.79

Notes:

1) INVESTMENT COST (Tk. x 1M):

Year	1993	284.5
	1998	246.4
	2005	246.4

2) M&M COST (Tk. x 1M):

Maintenance:	1993	6.9
	1998	4.4
	2005	4.4
Monitoring		2.0

3) OTHER COST:

Tk. x 1M	0.3

4) BENEFITS (Tk. x 1M):

Savings repair	2.1
Annual mainten.	0.5
Annual increase	10%

5) Conversion US$ 1 = Tk. 36

PV(12%) of benefits:	
Tk. x 1M	244.1
US$ x 1M	6.8

The mere protection of the existing bank requires less investment at the start of the 30-year period, although later on additional investment are needed. From Table 6.8 it can be concluded that the EIRR for this option is about 3%. The benefits just offset the costs needed for protection.
The third protection option comprises protection through guide bunds. The EIRR of this protection concept is also under 1%. Only the river bank protection option is presented in the following sections.

F.6.6.3 Net Present Value

The economic NPV for the bank protection works at Eklashpur, at a discount rate of 12%, has been evaluated at Tk. -293 million. The NPVR ratio as required by the FPCO-guidelines yields -0.45.

The conclusions from this chapter comprise:

(i) Bank protection at Eklashpur to protect the existing interests has a low economic rate of return when compared to the present-day practice of gradually shifting the embankment to the extent erosion progresses.
(ii) In spite of the low return, it may be worthwile to consider such bank protection schemes in a long term strategic planning for the Lower Meghna

F.6.7 Sensitivity Analysis

F.6.7.1 Changes in benefits and cost

The economic analysis of bank protection is based on uncertain future events and imperfect data. Because of this, it is important that sensitivity analyses be undertaken. This implies an analysis of the economic internal rate of return as function of changes in investment cost, monitoring and maintenance expenditure and estimated value of benefits. The results of the sensitivity analysis are presented in Table F.6.10 and Figures F.6.1 to F.6.3.

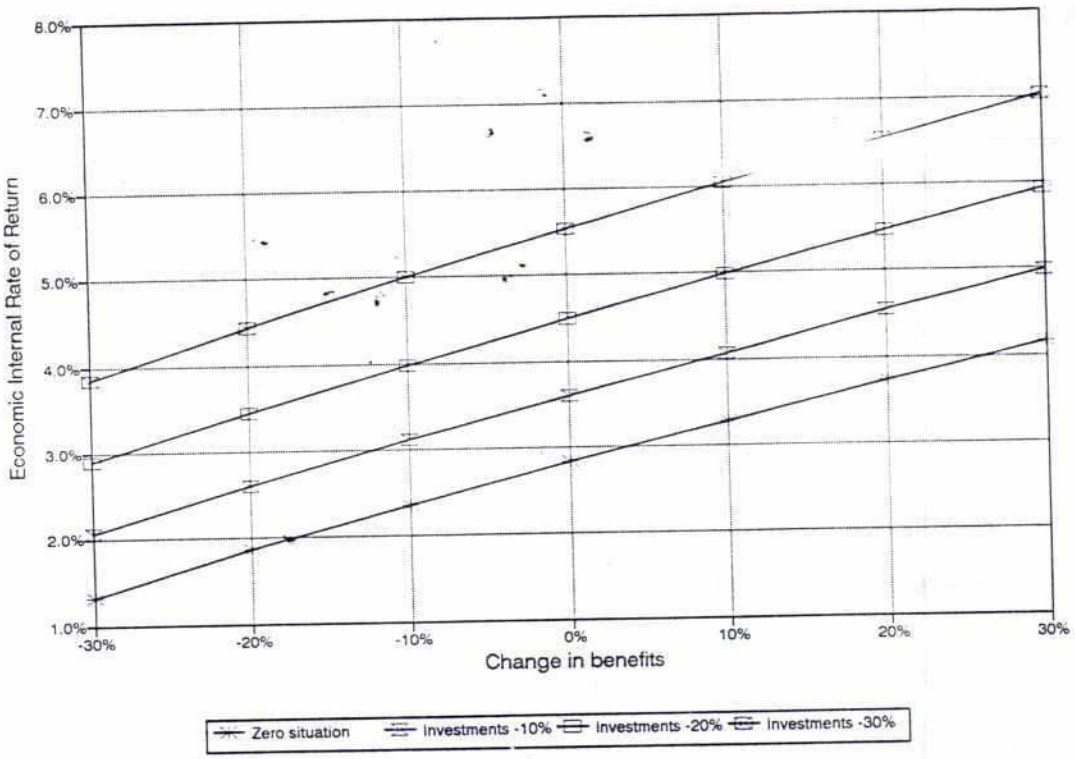
TABLE F.6.10 RESULTS OF THE SENSITIVITY ANALYSIS FOR EKLASHPUR

VALUES: Economic Internal Rate of Return (EIRR)
UNIT: percent

Change in	CHANGE IN BENEFITS:						
investm.	-30%	-20%	-10%	0%	10%	20%	30%
-30%	3.86%	4.44%	5.00%	5.54%	6.05%	6.56%	7.04%
-20%	2.89%	3.45%	3.98%	4.50%	4.99%	5.47%	5.93%
-10%	2.05%	2.60%	3.11%	3.61%	4.08%	4.54%	4.99%
0%	1.32%	1.85%	2.35%	2.83%	3.29%	3.73%	4.16%
10%	0.67%	1.18%	1.67%	2.14%	2.59%	3.02%	3.44%
20%	0.08%	0.58%	1.06%	1.52%	1.96%	2.38%	2.78%
30%	0.00%	0.04%	0.51%	0.96%	1.39%	1.80%	2.20%

Change in	CHANGE IN BENEFITS:						
Mon&Mai	-30%	-20%	-10%	0%	10%	20%	30%
-30%	2.35%	2.85%	3.32%	3.78%	4.22%	4.65%	5.06%
-20%	2.01%	2.52%	3.00%	3.47%	3.91%	4.34%	4.76%
-10%	1.67%	2.18%	2.68%	3.15%	3.60%	4.04%	4.46%
0%	1.32%	1.85%	2.35%	2.83%	3.29%	3.73%	4.16%
10%	0.97%	1.51%	2.02%	2.51%	2.98%	3.43%	3.86%
20%	0.61%	1.16%	1.68%	2.18%	2.66%	3.12%	3.56%
30%	0.25%	0.81%	1.35%	1.86%	2.34%	2.81%	3.26%

FIGURES F.6.1 AND F.6.2 SENSITIVITY ANALYSIS FOR PROTECTION OF THE EXISTING BANK.



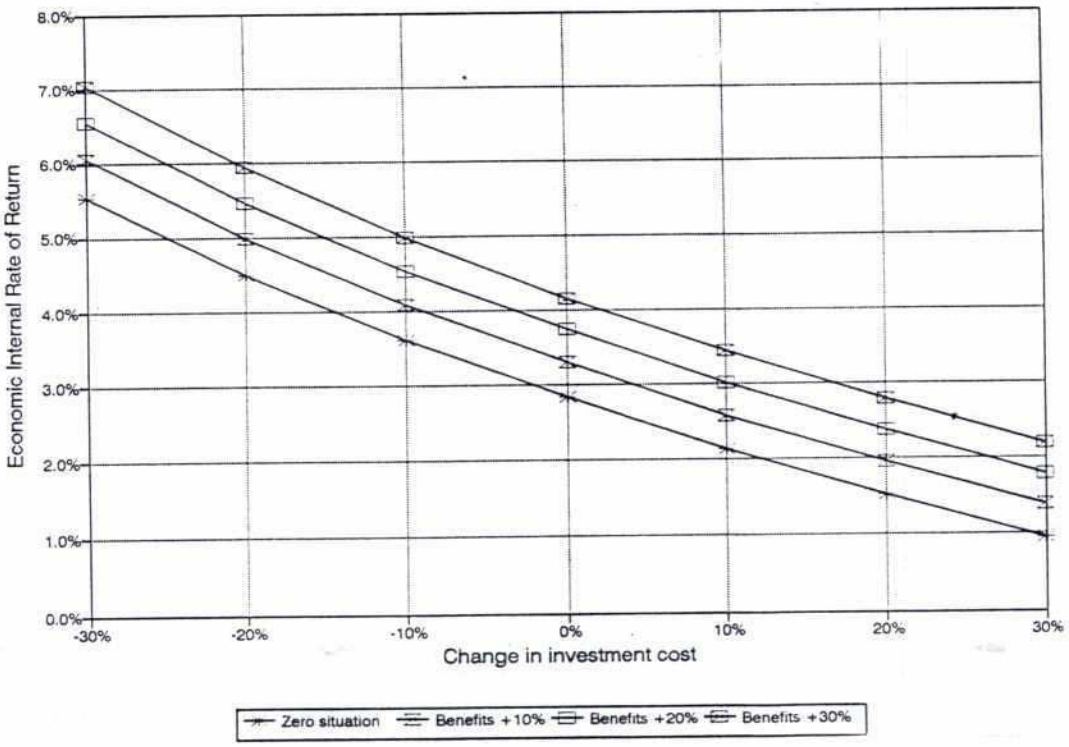
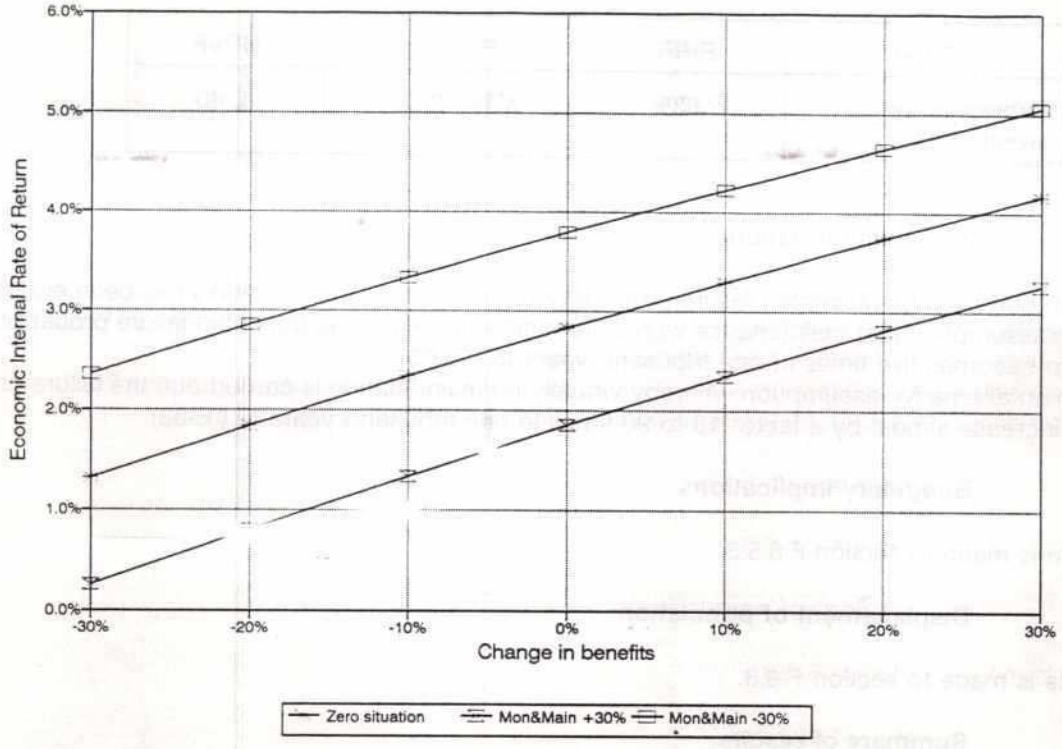


FIGURE F.6.3 SENSITIVITY ANALYSIS FOR PROTECTION OF THE EXISTING BANK.



F.6.7.2 **Delays in construction time**

When assuming that construction costs will not increase when the implementation of the works is postponed, it can be concluded from the cashflow that deferring construction until 1998 is beneficial, since hardly any benefits are generated till this year. The EIRR will increase to about 4%.

F.6.8 Displacement of population

For the rural areas along the Lower Meghna no surveys were executed. Hence, there are no data for the number of persons displaced as a result of likely bank migration. Moreover, the 1991 Statistical Yearbook for Bangladesh is inconclusive with respect to population densities in the aforementioned rural areas. The overall population density for the country is about 750 persons per km^2 in 1991 (Statistical Yearbook 1991). Present day rural population counts for about 70% and is expected to reduce to about 50% over the project period ('Developing the Infrastructure, Volume Three of the Report of the Task Forces on Bangladesh Development Strategies for the 1990's' 1991). The averaged rural population density is therefore estimated at 400 people per square-kilometer. Since the total rural area likely to be lost to erosion in the coming 30 years without the erosion protection works being carried out is estimated at some 1000 ha, about 4,000 persons will be affected.

F.6.9 Multi-criteria analysis

F.6.9.1 **Economic criteria**

The economic criteria have already been discussed in detail in the previous chapters. Table F.6.11 just summarizes the results:

TABLE F.6.11 SUMMARY OF RESULTS OF THE FEASIBILITY ANALYSIS

Type	EIRR	NPV(12%)	NPVR
Protection of existing bank	2.83%	MTk. -293	-0.45

F.6.9.2 **Probability of failure**

For design purposes the accepted failure probability of the bank protection works has been evaluated. Under the assumption that maintenance works are realized for 80%, the accepted failure probability for the design becomes five times in one thousand years (5.0 E-03).
Based on an alternative assumption whereby virtually no maintenance is carried out, the failure probability will increase almost by a factor 18 to 90 times in one thousand years (90 E-03).

F.6.9.3 **Budgetary implications**

Reference is made to section F.6.5.3.

F.6.9.4 **Displacement of population**

Reference is made to section F.6.8.

F.6.9.5 **Summary of results**

Table F.6.12 summarizes the results.

TABLE F.6.12 RESULTS OF MULTI-CRITERIA ANALYSIS FOR EKLASHPUR

Data type	Variable	Protection of existing bank
1. Economic profitability	- EIRR (%) - NPV (12%) - NPVR - PV (12%) benefits	2.83% MTk. -293 -0.45 MTk. 244
2. Probability of failure	Design criteria Low maintenance	5.0 E-03 90 E-03
3. Budgetary implications	Monitoring and maintenance: in 1993 in 1998 in 2008	Current prices: MTk. 10.8 MTk. 26.1 MTk. 40
4. Displacement of population	Total number of persons displaced over 30 year evaluation period	4,000

ANNEX F

Economics of protection works

F-7 Haimchar

F.7 HAIMCHAR

F.7.1 Present situation and previous studies

Haimchar is situated on the left bank of the Lower Meghna, south of the town of Chandpur. Erosion has attacked the river bank for more than a decade and is the result of both current and wave action. In 1989 the village was retired more inland after the floods. Agriculture is the main economic activity in the area. However, erosion threatens the embankment around the Chandpur irrigation project.

Rehabilitation of the Chandpur irrigation project is being studied at present by the FAP5. The FAP project is mainly concerned with agricultural prc uction, irrigation and drainage. Hence the scope is not on protection works to avert erosion of the existing embankment. Data on economic indicators for this project can also be found in Thompso ..udy on the impact of flood control on agriculture (1990) and missing information was kindly provided by FAP5.

If the embankment of the Chandpur project is breached, the whole benefit of flood control for the area would be lost. Without any river training works or any other form of protection, the embankment is likely to be engulfed and irrigation infra-structure will be destroyed. Hence, the embankments would have to be protected or regularly retired in order to safeguard the project until well into the next century.

F.7.2 Specific aspects related to Haimchar

Design of river training and bank protection works are undertaken by the Meghna River Bank Short Term Study, which envisages the protection of the river bank and the embankment in Haimchar. The existing embankment almost reaches the river at this location and need to be protected. Moreover, along the shore of the Lower Meghna there are a number of habitations and small commercial enterprises, which would be protected.

Embankments at Haimchar protect the Chandpur irrigation project. Flood protection commenced in 1976/77, while the project started effective irrigation in 1978/79. Drainage is a major problem in the project, while flooding from the waters of the Meghna has sofar only been a minor obstacle to production. However, from the geo-morphological study (see Annex B) one can forecast that bank erosion could become more important in the future.

The area of influence of the proposed works reaches from a point some 3 km north of Haimchar and goes as far as 7 km south of the village. The area to be protected covers land outside the existing embankment bordering the river as well as parts of the Chandpur irrigation project located inside the embankment.

The economic feasibility analysis covers three alternatives, notably (a) protection through a groyne; (b) bank protection works on the existing bank line and (c) guide bund protection. It makes a comparison between a future scenario with river training or bank protection works (with-scenario) and without any works being executed (without-scenario). In the without-scenario situation one may expect that the existing embankment must be retired. Moreover, it is likely that repair and maintenance to these parts of the embankment that remain in place will increase considerably.

It is more than likely, that the river bank will be eroded considerably in the coming 30 years. Hence, the embankment will have to be retired time and again. Table F.7.1 gives the result of river bank migration and the anticipated construction scheme of new embankments required.

The progress of bank erosion in the without-scenario situation can be estimated from the results of the geo-morphological study (see Annex B). This progress is expected to be important in the coming 30 years; without any protection works large parts of the existing embankment and land of the irrigation project will disappear. Hence, it is more than likely that retired embankments will be constructed at regular intervals.

Such as is the case in Eklashpur, it is emphasized that the complete loss of the Chandpur Irrigation Project has not been taken as the without-scenario, since that is not likely to occurr.
History has shown that where the river damages or destroys embankments, the authorities have taken action to protect villages and agricultural land that lay behind it. In almost all cases this resulted in the construction of new and more retired embankments. However, continuing bank erosion also threatens this newly constructed embankment, thus leading to again a new retirement.
When comparing the bank protection works with the scenario that Chandpur Irrigation Project will be completely abandonned because of erosion problems at Haimchar, an economic internal rate of return of about 15% will be evaluated.
It is, however, more likely, that in the without-scenario new stretches of embankment will be constructed at regular time intervals to replace destructed parts, while in between much money will be allocated to protection measures to stop further erosion.

TABLE F.7.1 EXPECTED WITHOUT-PROJECT SCENARIO

Year	Construction of new embankment
1993	1.2 km
1998	1.8 km
2003	2.3 km
2008	3.1 km
2013	5.6 km
2018	7.2 km

As a result of the bank protection works executed, less agricultural land will disappear, fewer structures lost and agricultural produce higher.

F.7.3 Alternatives for protection

Three types of river bank protection have been investigated, notably (a) a groyne just north of Haimchar reaching out for some 500 m into the river, (b) protection of the existing bank and (c) guide bund protection along the existing embankment.

The first option is the most costly, but it generates additional land, although it may take many years before a substantial area becomes available. Moreover, high investment cost vis-a-vis benefits are affecting the rate of return. Hence, the economic feasibility of the second and third options is also considered.

The second option consists of protection of the existing bank at Haimchar. However, this option does not aim at training the river; it simply provides protection. Initial costs are lower than those of a groyne, but additional costs have to be incurred in 2008.

The third option, guide bunds, has an important economic advantage: investments are lower and not concentrated in the beginning of the 30 year evaluation period, but staggered. Guide bunds are river training works and as such a good alternative for a groyne. Of the third solution different construction scenarios are considered: (a) all construction done at once in 1993, (b) construction spread over the years 1993 and 2008 and (c) staggered construction, notably in 1993, 1998 and 2008.

F.7.4 Benefits of Haimchar bank protection works

Benefits related to river [illegible] protection works are considered the same. Hence, no distinction in benefits is made between the alternatives.

F.7.4.1 Reduction in repair and maintenance expenses

Maintenance and repair of the embankments of the Chandpur irrigation project is carried out each year by the BWDB. In the past the allocated amount has been very small, with the exception of years when major works were carried out. In 1989/90 a total of Tk. 10 million has been spent on retirement of embankments and in 1973/77 Tk. 14.3 million were spent on new embankments. Expressed in mid-1991 prices these investments correspond to an average Tk. 5 million per year. Moreover, BWDB spends annually Tk. 300 thousand on maintenance of the embankments.

Based on the results of the geomorphological study (Annex B) a retirement of part of the embankment will be required every five years from 1993 onwards. Because only small sections of the embankment are renewed, emergency protection and repair cannot be neglected altogether. In view of the similarity of the situation it is expected that in Haimchar repair expenses will be of the same magnitude as estimated for Eklashpur. From the experience at Chandpur, a rapid increase of such repair and maintenance expenditures may be expected if Haimchar will continue to be protected by the non-sustainable present-day approach. These expenses are therefore expected to increase annually by 10%.
This amount is additional to the costs incurred for the regular retirement of embankments.
These annual costs of repair and maintenance can be saved if adequate sustainable bank protection works are carried out and, hence, can be considered as benefits originating from such works.

F.7.4.2 New retired embankments

As the river bank shifts towards the east, it will destroy the existing embankment. From the results of the geo-morphological study it could be estimated how far the bank line will progress. The without-project scenario foresees that every five years a new stretch of embankment must be constructed in order to protect the Chandpur irrigation project. Table F.7.1 gives details, which are based on expected progress of erosion.
From data of earlier embankment constructions, the actual price for this type of works has been estimated. Per kilometre-length embankment construction cost is Tk. 7.83 million. Table F.7.2 provides details on the cost needed for the construction of new retired embankments. Because, no new retired embankment construction is required if the proposed river training or protection works are implemented, the cost figures from the table are savings due to the project. Hence, they represent expected benefits.

F.7.4.3 Destruction of buildings and urban infra-structure

River bank erosion has caused loss of buildings and damage to existing structures in the recent past. Some inhabitants have already moved their homes more inland to protect them from the water of the Meghna. However, a considerable number of houses and commercial buildings in the area are still prone to erosion.

Many houses are simple one-storey kutcha structures which have a marginal value and can be moved at low cost, mainly involving just labour. However, there are also structures of a more permanent nature, especially in the irrigation project. It is estimated from field observations that about 10% of the area of influence is used for non-agricultural purposes, being either commercial enterprises or homes. This percentage also includes social and town infra-structure.

From Annex B it could be estimated how far the bank line will progress and how much land surface is likely to disappear. Based on the socio-economic surveys in Bhairab Bazar, Munshiganj and Chandpur an estimate could be made of the average price of houses and other buildings. In the three towns surveyed, we have estimated that social and town infra-structure covers 25% of the built-on area. The average economic price calculated per square meter land area is Tk. 1,065.

TABLE F.7.2 COST OF NEW EMBANKMENT CONSTRUCTION

PRICES: mid-1991 economic prices
UNIT: Tk. x 1M

Year	INFRA-STR. WORKS: Embankm (km)	Constr. cost
1993	1.2	9.396
1998	1.8	14.094
2003	2.3	18.009
2008	3.1	24.273
2013	5.6	43.848
2018	7.2	56.376

Source: cost data from FAP5
Notes:
1) Tk. 7.830 x 1M are the construction cost per km embankment
3) At 0.75 is estimated the compounded conversion factor of SWR and Planning Commissions's SCF that relates to construction works

As observed for Eklashpur, it can be assumed that structures in Haimchar have a 25% lower value than in the surveyed townships. Consequently, the economic price of structures is estimated at Tk. 799 per square meter of land area. In Table F.7.3 the estimated economic value of destruction of buildings and urban infra-structure has been presented.

Apart from the infra-structural losses as a result of bank erosion, also loss of land is to be considered. The fact that it washes away and is lost means that it must be c[illegible]ered in the economic evaluation. However, all land was accounted for in the analysis of agricultural production, assuming that agriculture is the nearest-best economic activity. Moreover, double-[illegible]ounting has thus been avoided.

In Table F.7.3 the balance of destructions for the with and without protection scenarios is presented. Although the proposed works protect the existing embankment, there remains some erosion in the area between the river and the embankment. This has been accounted for in calculating the value of destructed village infra-structure. The benefits of protection works are consequently evaluated as the reduction in destruction between both scenarios.

No account was taken of losses in revenues of commercial enterprises. The nature of commerce in Haimchar is such that one may expect that stocks and equipment are removed well before the water strikes. Setting up a new commercial venture on higher land is only a matter of hours. Hence, no loss in trading profits can be expected in the without-project scenario.

F.7.4.4 Agriculture

Agricultural benefits are associated with protection of arable land which would otherwise be lost as a result of bank migration. Behind the embankment one finds mainly irrigated lands, while outside the embankment non-irrigated cropping takes place. Hence, for economic feasibility analysis purposes it has been assumed that irrigated agriculture takes place inside the embankment and non-irrigated agriculture outside it.
In agreement with the FPCO-guidelines the agricultural benefits of river [illegible]ing and bank protection works result from reduction of net agricultural revenues lost due to erosion of arable land. Based on the results of the geo-morphological survey for the area, the change of the river bank position could be forecast for scenarios with and without investments. Hence, a prediction could be made of reduction in the area lost as a result of river training or protection works.

TABLE F.7.3 VALUE OF DESTRUCTION OF BUILDINGS AND URBAN INFRA-STRUCTURE

PRICES: constant mid-1991 economic prices
UNIT: Tk x 1M

Year	SITUATION [W]: Area lost (ha)	Urban assets	SITUATION [WO]: Area lost (ha)	Urban assets	Protection benefits [W]-[WO]
1993	21.8	17.411	21.8	17.411	0.000
1994	30.8	24.657	30.8	24.657	0.000
1995	30.8	24.657	30.8	24.657	0.000
1996	30.8	24.657	30.8	24.657	0.000
1997	30.8	24.657	30.8	24.657	0.000
1998	[illegible]	24.657	30.8	24.657	0.000
1999	28.8	22.986	34.0	27.172	4.186
2000	28.8	22.986	34.0	27.172	4.186
2001	28.8	22.986	34.0	27.172	4.186
2002	28.8	22.986	34.0	27.172	4.186
2003	28.8	22.986	34.0	27.172	4.186
2004	16.7	13.384	37.6	30.092	16.708
2005	16.7	13.384	37.6	30.092	16.708
2006	16.7	13.384	37.6	30.092	16.708
2007	16.7	13.384	37.6	30.092	16.708
2008	16.7	13.384	37.6	30.092	16.708
2009	11.0	8.776	29.7	23.725	14.949
2010	11.0	8.776	29.7	23.725	14.949
2011	11.0	8.776	29.7	23.725	14.949
2012	11.0	8.776	29.7	23.725	14.949
2013	11.0	8.776	29.7	23.725	14.949
2014	13.1	10.447	43.9	35.104	24.657
2015	13.1	10.447	43.9	35.104	24.657
2016	13.1	10.447	43.9	35.104	24.657
2017	13.1	10.447	43.9	35.104	24.657
2018	13.1	10.447	43.9	35.104	24.657
2019	17.8	14.210	59.1	47.239	33.029
2020	[illegible]	14.210	59.1	47.239	33.029
2021	17.8	14.210	59.1	47.239	33.029
2022	17.8	14.210	59.1	47.239	33.029
SUM	594.8	475.502	1138.5	910.114	434.612

Notes:
1) Tk. 0.799 x 1000 per sq.m is the estimated average value of urban infra-structure and buildings
2) At 10% is estimated the urbanised area

The cropping pattern in the Chandpur irrigation project and the net economic return of irrigated agriculture were adapted from Thompson (1990) and results of work done by FAP5. An assumption was made for the cropping pattern of lands outside the irrigation scheme; only one crop per year is cultivated, notably L.Boro. The annual net economic revenues of reduced losses in agricultural area are taken into account as benefit of works undertaken at Haimchar.

Apart from the annual net revenue of the area inside the embankment otherwise lost, a value of Tk. 1,677 per hectare associated with the irrigation infra-structure can also be considered as avoidable costs and, hence, as benefit of protection works in Haimchar. This figure was derived from data supplied by FAP5.

The net annual economic revenues of the Chandpur irrigation project have been evaluated at Tk. 9,263 per ha. Details are reported in Table 7.4. For cropping outside the embankment net annual economic revenues are estimated at Tk. 8,842 per ha, assuming that 90% of the land is cropped once per year.

TABLE F.7.4 ANNUAL NET REVENUES PER HECTARE CHANDPUR IRRIGATION PROJECT

PRICES: constant mid-1991 economic prices
UNIT: Tk./ha

Item	Unit	Unit return	Fraction in area	Annual return
Culivation:				
Rabi crops 1)	ha	6 755	10.4%	706
HYV Boro	ha	9 522	43.2%	4 116
B Aus	ha	316	8.5%	27
TL Aman	ha	6 594	57.7%	3 806
Sub-total	ha		62.2%	8 655
Fish-ponds 2)	yr	5 660	5.4%	306
Orchards 2)	yr	2 206	13.7%	[illegible]
Other areas			18.7%	
TOTAL				9 263
Rental value	yr			49 896

Notes:
1) Rabi crop considered is wheat
2) Adapted from Thompson (1990)
3) Rental value is adapted from crop budgets

Apart from the loss of agricultural production as a result of bank erosion, there is also the reduction in loss of land as a productive asset to be considered. The fact that land washes away and is directly lost for cropping means that it must be considered in the economic evaluation. Hence, the value of this asset must be estimated, while avoiding loss of agricultural land is considered as a benefit of river training or bank protection works.
As already indicated in F.2.4 the present value of the economic annual rental value has been taken into account in the economic assessment of the river training and bank protection works.

The economic value of cropped land is based on share cropping arrangement in the area. For each individual crop the rent has been calculated as the money value of production quota provided by the share cropper to the landowner. Based on the prevailing cropping pattern in the Chandpur irrigation project and lands outside the embankment, the average economic rental value is calculated. For irrigated land inside the embankment the rental value is Tk. 49,896 per ha. The rental value for non-irrigated land is calculated as Tk. 40,686 per ha. For details reference is made to the appendix.

Table F.7.5 provides details of total agricultural benefits on lands prone to erosion covering the 30-year period of the feasibility study. In the table with and without-project scenarios are compared. Benefits of river training works are given by the balance, which represents the reduction in losses to cropping.

F.7.5 Cost of alternative protection options

F.7.5.1 Investment cost

The economic investment cost for a large groyne at Haimchar is estimated at US$ 18.5 million, which equals to Tk. 667.9 million. An estimated 36% of investment cost are local currency expenditure and the foreign component amounts to 64%.

The initial investment costs for the second option which merely provides protection of the existing bank are less, evaluated at US$ 10.6 million or Tk 381.7 million, although and additional amount of Tk. 1,381.7 million is spent in 2008. Local currency expenditure is 31% and foreign component totals 69%.

TABLE F.7.5 AGRICULTURAL BENEFITS

PRICES: constant mid-1991 economic prices
UNIT: Tk x 1000

Year	SITUATION [W]: Areas lost (ha): in.emb.	out.emb.	Production loss(CUM)	Land + Infra value	SITUATION [WO]: Areas lost (ha): in.emb.	out.emb.	Production loss(CUM)	Land + Infra value	Protection benefits [W]-[WO]
1993	0.0	21.8	192.6	886.1	0.0	21.8	192.6	886.1	0.0
1994	0.0	30.8	465.3	1 254.9	0.0	30.8	465.3	1 254.9	0.0
1995	0.0	30.8	738.0	1 254.9	0.0	30.8	738.0	1 254.9	0.0
1996	0.0	30.8	1 010.7	1 254.9	0.0	30.8	1 010.7	1 254.9	0.0
1997	0.0	30.8	1 283.4	1 254.9	0.0	30.8	1 283.4	1 254.9	0.0
1998	0.0	30.8	1 556.1	1 254.9	0.0	30.8	1 556.1	1 254.9	0.0
1999	0.0	28.8	1 810.4	1 169.9	0.0	34.0	1 856.7	1 382.9	259.3
2000	0.0	28.8	2 064.6	1 169.9	0.0	34.0	2 157.2	1 382.9	305.6
2001	0.0	28.8	2 318.8	1 169.9	0.0	34.0	2 457.7	1 382.9	351.9
2002	0.0	28.8	2 573.1	1 169.9	0.0	34.0	2 758.2	1 382.9	398.2
2003	0.0	28.8	2 827.3	1 169.9	0.0	34.0	3 058.8	1 382.9	444.5
2004	0.0	16.7	2 975.3	681.2	15.2	22.5	3 398.0	1 696.5	1 438.0
2005	0.0	16.7	3 123.3	681.2	15.2	22.5	3 737.2	1 696.5	1 629.2
2006	0.0	16.7	3 271.4	681.2	15.2	22.5	4 076.4	1 696.5	1 820.3
2007	0.0	16.7	3 419.4	681.2	15.2	22.5	4 415.6	1 696.5	2 011.5
2008	0.0	16.7	3 567.4	681.2	15.2	22.5	4 754.8	1 696.5	2 202.7
2009	0.0	11.0	3 664.5	446.7	11.0	18.7	5 021.8	1 327.0	2 237.6
2010	0.0	11.0	3 761.6	446.7	11.0	18.7	5 288.8	1 327.0	2 407.6
2011	0.0	11.0	3 858.6	446.7	11.0	18.7	5 555.8	1 327.0	2 577.5
2012	0.0	11.0	3 955.7	446.7	11.0	18.7	5 822.8	1 327.0	2 747.5
2013	0.0	11.0	4 052.7	446.7	11.0	18.7	6 089.9	1 327.0	2 917.5
2014	0.0	13.1	4 168.3	531.7	19.3	24.6	6 486.3	1 997.1	3 783.4
2015	0.0	13.1	4 283.8	531.7	19.3	24.6	6 882.7	1 997.1	4 064.3
2016	0.0	13.1	4 399.4	531.7	19.3	24.6	7 279.0	1 997.1	4 345.1
2017	0.0	13.1	4 514.9	531.7	19.3	24.6	7 675.4	1 997.1	4 626.0
2018	0.0	13.1	4 630.5	531.7	19.3	24.6	8 071.8	1 997.1	4 906.8
2019	0.0	17.8	4 787.6	723.2	23.0	36.1	8 604.0	2 654.7	5 747.9
2020	0.0	17.8	4 944.8	723.2	23.0	36.1	9 136.1	2 654.7	6 122.9
2021	0.0	17.8	5 102.0	723.2	23.0	36.1	9 668.3	2 654.7	6 497.9
2022	0.0	17.8	5 259.1	723.2	23.0	36.1	10 200.5	2 654.7	6 872.8
SUM	0.0	594.8	94 580.6	24 200.6	319.4	819.1	139 699.7	49 797.6	70 716.1

Notes:
1) Tk. 1 677 per ha is the value of irrigation infra-structure based on an analysis of data from SERWRDP (FAP5)
2) Inside the existing embankment land is irrigated outside the embankment land is not irrigated
3) Tk. 9 263 is the economic unit value of land in the Chandpur irrigation project
Tk. 8 842 is the economic value of land outside embankments, assuming 90% use for cropping
4) Tk. 40 686 per ha is the economic value of land outside embankments

The third option comprises guide bunds. Although this alternative may be more expensive than the previous options, investment scenarios have been evaluated whereby costs are staggered over more years. For the scenario where construction is broken up in three parts, initial economic investment cost are estimated at US$ 4.5 million or Tk. 163.7 million. In later years additional investments of Tk 199.5 million and Tk. 264.1 million are needed. An estimated 37% of total investment cost are local currency expenditure and the foreign component is 63%. Table F.7.6 provides a summary of investment cost for all three options.

TABLE F.7.6 SUMMARY OF ECONOMIC INVESTMENT COST FOR WORKS AT HAIMCHAR

Type	Investment cost and year	Local/foreign currency
Large groyne	1993: MTk. 667.9	Local: 36% Foreign: 64%
Protection of existing bank	1993: MTk. 381.7 1998: MTk.1381.7	Local: 31% Foreign: 69%
Guide bunds: - Scenario 1	1993: MTk. 632.7	Local: 40% Foreign: 60%
Guide bunds: - Scenario 2	1993: MTk. 381.7 2008: MTk. 264.1	Local: 39% Foreign: 61%
Guide bunds: - Scenario 3	1993: MTk. 163.7 1998: MTk. 199.5 2008: Mtk. 264.1	Local: 37% Foreign: 63%

F.7.5.2 **Monitoring and maintenance**

Monitoring and maintenance of river training works is an important component, which affects directly the long term effectiveness of protection against bank erosion. They form an integral part of protection works and the rate of failure of structures may increase rapidly in the future if maintenance works are carried out poorly.
Monitoring comprises regular inspection of structures as well as topographic and bathymetrical measurements. The annual cost of monitoring is estimated at Tk. 2.0 million per year (mid-1991 economic prices). Annual maintenance is estimated at 4% of surface components, e.g. open stone asphalt, fascine mattress, boulders in falling apron and grouting of boulders. Details of monitoring and maintenance expenditure are provided in Table F.7.7.

F.7.5.3 **Budgetary implications**

Monitoring and maintenance expenditure for river training works must normally be met by the national budget. Assuming a general level of price increase of 10% per annum, means that the cost met by the budget increase substantially over the years. Moreover, expenses for environmental monitoring and, if such is necessary, mitigative measure must equally be met by the national budget.

(i) Monitoring and maintenance expenses

In Table F.7.8 a summary is presented of current expenditure for monitoring and maintenance operations at the start of the project, after five years and in the year 2008.

(ii) Environmental monitoring

Cost of required environmental monitoring are expected to be very small. A proposed for works to be undertake is presented in Annex I. However, cost could easily be met by the factor retained for other cost in the feasibility analysis.

TABLE F.7.7 ANNUAL MONITORING AND MAINTENANCE FOR WORKS AT HAIMCHAR

Type	Maintenance expenditure	Monitoring cost
Large groyne	1993: MTk. 5.9	MTk. 2.0
Protection of existing bank	1993: MTk. 5.4 2008: MTk. 10.8	MTk. 2.0
Guide bunds: - Scenario 1	1993: MTk. 7.2	MTk. 2.0
Guide bunds: - Scenario 2	1993: MTk. 5.4 2008: MTk. 9.1	MTk. 2.0
Guide bunds: - Scenario 3	1993: MTk. 3.0 1998: MTk. 6.6 2008: MTk. 10.0	MTk. 2.0

TABLE F.7.8 EXPENDITURES FOR MONITORING AND MAINTENANCE IN CURRENT PRICES

Type	Expenditure in 1993	Expenditure in 1998	Expenditure in 2008
Large groyne	MTk. 9.6	MTk. 15.5	MTk. 40
Protection of existing bank	MTK. 9.0	MTk. 14.5	MTk. 65
Guide bunds: - Scenario 1	MTk. 11.2	MTk. 18.1	MTk. 47
Guide bunds: - Scenario 2	MTk. 9.0	MTk. 14.5	MTk. 57
Guide bunds: - Scenario 3	MTk. 6.1	MTk. 16.9	MTk. 63

F.7.6 Economic feasibility study

F.7.6.1 Cash flow

The cash flow computation for river training works at Haimchar makes a comparison of benefits and cost over the 30-year evaluation period. The investment costs have been discussed in detail in the previous section. Project benefits were discussed in section F.7.4.
Table F.7.9 provides the cash flow calculation of the guide bund protection scenario 3 option. The table requires no further discussion.

F.7.6.2 Economic Internal Rate of Return

The economic feasibility of the river bank protection works is first evaluated by comparing the discounted values of benefits against cost. The economic internal rate of return (EIRR) is the discounting percentage at which the present values of benefits and costs over the 30-year evaluation period are in balance.

TABLE F.7.9 ECONOMIC CASH FLOW HAIMCHAR GUIDE PROTECTION SCENARIO-3

PRICES: mid-1991 economic prices
UNIT: Tk. x 1 million
START: 1993
CONSTR: 1 years

EIRR: 1.65% NPV: -215.9 NPVR1: -0.50

	WITH-PROJECT SITUATION COST:				BENEFITS:					CASH	Cash F.
Year	Invest.	M&M	Other	Total	Repair c.	Nw.emb.	Urban pr.	Agric.	Total	FLOW	(US$x1M)
1993	163.7	5.0	0.2	168.8	0.0	9.4	0.0	0.0	9.4	-159.4	-4.43
1994	0.0	5.0	0.2	5.1	2.8		0.0		2.8	-2.3	-0.06
1995	0.0	5.0	0.2	5.1	3.1			0.0	3.1	-2.0	-0.05
1996		5.0	0.2	5.1	3.4		0.0	0.0	3.4	-1.7	-0.05
1997		5.0	0.2	5.1	3.7		0.0	0.0	3.7	-1.4	-0.04
1998	199.5	8.6	0.2	208.3	4.1	14.1	0.0	0.0	18.2	-190.0	-5.28
1999		8.6	0.2	8.8	4.5		4.2	0.3	9.0	0.2	0.01
2000		8.6	0.2	8.8	5.0		4.2	0.3	9.5	0.7	0.02
2001		8.6	0.2	8.8	5.5		4.2	0.4	10.0	1.3	0.03
2002		8.6	0.2	8.8	6.0		4.2	0.4	10.6	1.9	0.05
2003		8.6	0.2	8.8	6.6	18.0	4.2	0.4	29.3	20.5	0.57
2004		8.6	0.2	8.8	7.3		16.7	1.5	25.5	16.7	0.47
2005		8.6	0.2	8.8	8.0		16.7	1.7	26.4	17.7	0.49
2006		8.6	0.2	8.8	8.8		16.7	1.9	27.4	18.7	0.52
2007		8.6	0.2	8.8	9.7		16.7	2.1	28.5	19.7	0.55
2008	264.1	12.3	0.2	276.6	10.7	24.3	16.7	2.3	53.9	-222.7	-6.19
2009		12.3	0.2	12.5	11.8		14.9	2.3	29.0	16.5	0.46
2010		12.3	0.2	12.5	12.9		14.9	2.5	30.3	17.8	0.50
2011		12.3	0.2	12.5	14.2		14.9	2.6	31.8	19.3	0.54
2012		12.3	0.2	12.5	15.6		14.9	2.8	33.4	20.9	0.58
2013		12.3	0.2	12.5	17.2	43.8	14.9	3.0	79.0	66.5	1.85
2014		12.3	0.2	12.5	18.9		24.7	3.9	47.5	35.0	0.97
2015		12.3	0.2	12.5	20.8		24.7	4.1	49.6	37.1	1.03
2016		12.3	0.2	12.5	22.9		24.7	4.4	52.0	39.5	1.10
2017		12.3	0.2	12.5	25.2		24.7	4.7	54.6	42.1	1.17
2018		12.3	0.2	12.5	27.7	56.4	24.7	5.0	113.7	101.2	2.81
2019		12.3	0.2	12.5	30.5		33.0	5.8	69.4	56.9	1.58
2020		12.3	0.2	12.5	33.5		33.0	6.2	72.8	60.3	1.67
2021		12.3	0.2	12.5	36.9		33.0	6.4	76.5	64.0	1.78
2022		12.3	0.2	12.5	40.6			7.0	80.6	68.1	1.89
SUM	627.2	295.9	4.9	928.0	418.2	166.0	434.6	72.1	1090.9	162.9	4.52

Notes:

1) INVESTMENT COST (Tk. x 1M):

			SC1	SC2	SC3
Year	1993	163.7	532.7	381.7	163.7
	1998	199.5	0.0	0.0	199.5
	2008	264.1	0.0	264.1	264.1

2) O&M COST (Tk. x 1M):

Maintenance:	1993	3.0	7.2	5.4	3.0
	1998	3.6	0.0	0.0	3.6
	2008	3.7	0.0	3.7	3.7
Monitoring		2.0	2.0	2.0	2.0

3) OTHER COST:

Tk. x 1M		0.2	EIRR:	1.82%	1.35%	1.65%

4) BENEFITS (Tk. x 1M):

			NPV:	-417.4	-314.6	-215.9
Savings repair cost		2.1	NPVR1:	-0.62	-0.57	-0.50
Annual mainten.		0.03				
Annual increase		10%				

5) Conversion US$ 1 = Tk. 36

PV(12%) of benefits:	
Tk. x 1M	136.6
US$ x 1M	3.8

The third protection option, which provides protection through guide bunds, yields an economic internal rate of return just below 2%. The other options show even a slightly negative internal rate of return. It means that bank protection works via guide bunds is, from the economic point of view, marginally better than the extrapolated present-day practice of non-sustainable repair and maintenance together with retirement of embankments to the extent bank erosion progresses.

F.7.6.3 **Net Present Value**

The economic net present value for the guide bund bank protection at Haimchar has been evaluated at Tk. -216 million for a discount rate of 12%. The NPVR ratio required by the FPCO-guidelines can be calculated at -0.50.

The following conclusions can be drawn:

(i) Guide bund bank protection works at Haimchar to protect the existing interests along the river bank show a low economic internal rate of return, when compared to the present-day practice of gradually shifting the embankments to the extent bank erosion progresses.

(ii) In spite of the low return on investments, it may be worthwile to consider such bank protection schemes in a long term strategic planning for the Lower Meghna.

F.7.7 **Sensitivity Analysis**

F.7.7.1 **Changes in benefits and cost**

The economic analysis of bank erosion protection is based on uncertain future events and imperfect data. Because of this, it is important that sensitivity analyses be undertaken. This implies an analysis of the economic internal rate of return as function of changes in investment cost, monitoring and maintenance expenditure and estimated value of benefits. The results are presented in Table 7.10 and Figures 7.1 to 7.3.

TABLE F.7.10 RESULTS SENSITIVITY ANALYSIS HAIMCHAR

VALUES: Economic Internal Rate of Return (EIRR)
UNIT: percent

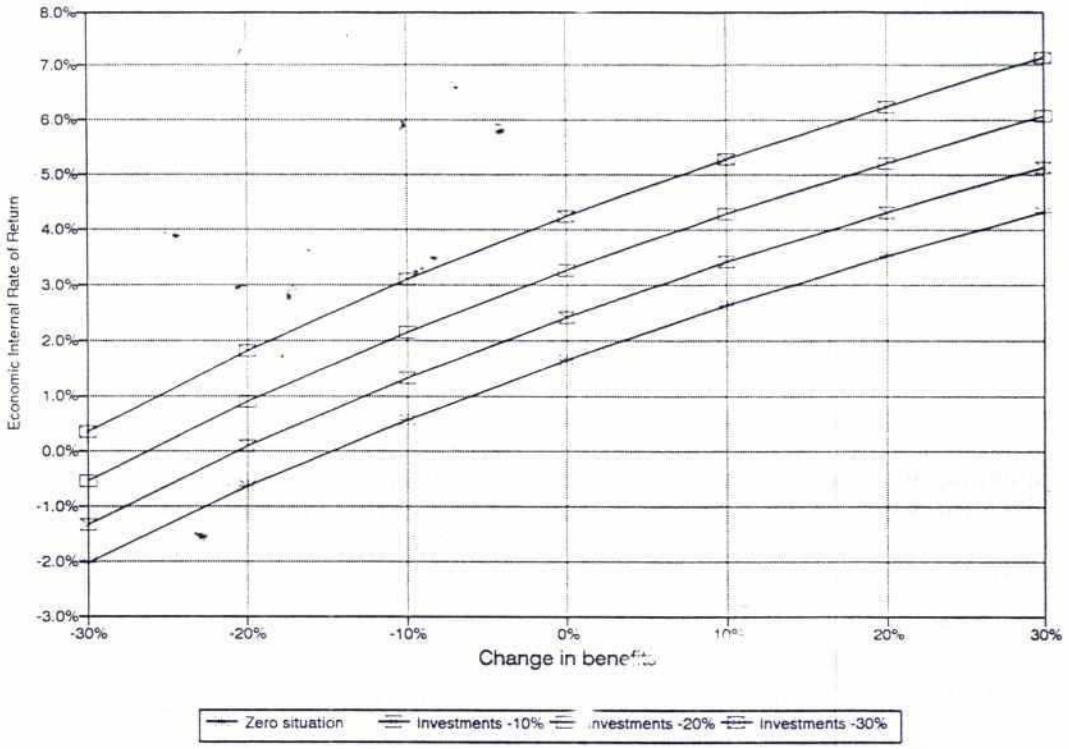
Change in	CHANGE IN BENEFITS:						
investm.	-30%	-20%	-10%	0%	10%	20%	30%
-30%	0.35%	1.81%	3.10%	4.24%	5.29%	6.25%	7.16%
-20%	-0.54%	0.90%	2.15%	3.27%	4.28%	5.22%	6.08%
-10%	-1.32%	0.09%	1.32%	2.41%	3.40%	4.31%	5.16%
0%	-2.03%	-0.63%	0.58%	1.65%	2.63%	3.52%	4.34%
10%	-2.67%	-1.29%	-0.09%	0.97%	1.93%	2.80%	3.61%
20%	-3.26%	-1.89%	-0.70%	0.35%	1.29%	2.15%	2.95%
30%	-3.80%	-2.44%	-1.26%	-0.22%	0.71%	1.56%	2.34%

Change in	CHANGE IN BENEFITS:						
Mon&Mai	-30%	-20%	-10%	0%	10%	20%	30%
-30%	-0.91%	0.38%	1.51%	2.53%	3.46%	4.31%	5.11%
-20%	-1.28%	0.04%	1.20%	2.24%	3.18%	4.05%	4.85%
-10%	-1.65%	-0.29%	0.89%	1.95%	2.90%	3.78%	4.60%
0%	-2.03%	-0.63%	0.58%	1.65%	2.63%	3.52%	4.34%
10%	-2.41%	-0.98%	0.26%	1.36%	2.35%	3.25%	4.08%
20%	-2.80%	-1.33%	-0.06%	1.06%	2.07%	2.98%	3.83%
30%	-3.20%	-1.68%	-0.38%	0.76%	1.78%	2.71%	3.57%

F.7.7.2 **Delays in construction**

When assuming that construction costs will not increase if the implementation of the works is postponed, it can be concluded from the cashflow that deferring the construction until 1998 is beneficial, since hardly any benefits are generated till this year. The EIRR will increase to about 3%.

FIGURES F.7.1 AND F.7.2 RESULTS OF SENSITIVITY ANALYSIS FOR GUIDE PROTECTION SCENARIO 3



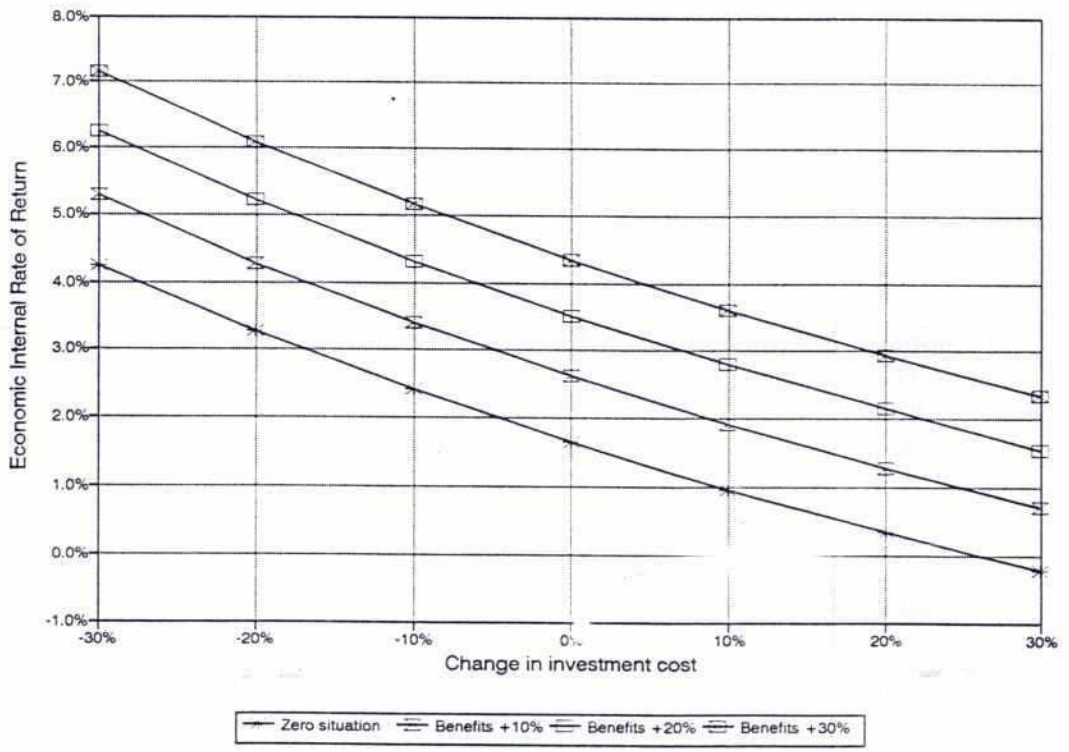
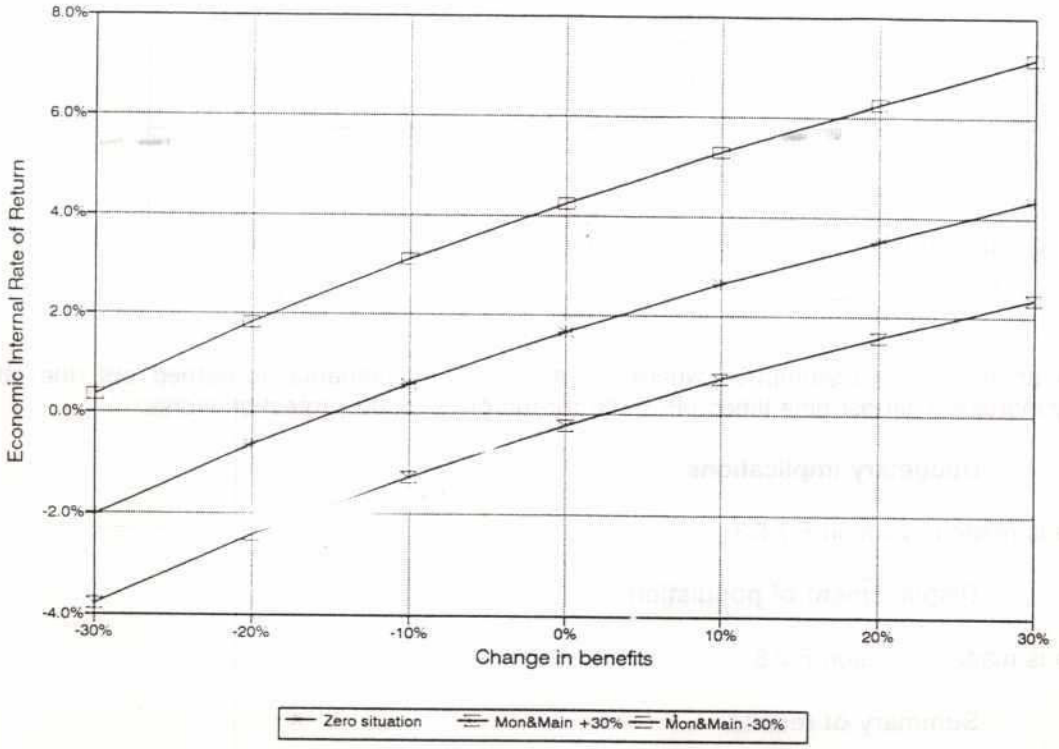


FIGURE F.7.3 SENSITIVITY ANALYSIS FOR GUIDE PROTECTION SCENARIO 3



F.7.8 **Displacement of population**

For the rural areas along the Lower Meghna no surveys were executed. Hence, there are no data for the number of persons displaced as a result of likely bank migration. Moreover, the 1991 Statistical Yearbook for Bangladesh is inconclusive with respect to population densities in the aforementioned rural areas. The overall population density for the country was 750 persons per km^2 in 1991 (Statistical Yearbook 1991). Present day rural population counts for about 70% and is expected to reduce to about 50% over the project period ('Developing the Infrastructure, Volume Three of the Report of the Task Forces on Bangladesh Development Strategies for the 1990's' 1991). The averaged rural population density is therefore estimated at 400 people per square kilometer.
The total rural area likely to be washed away by erosion during the 30-year project evaluation period is estimated at 315 ha. Hence an estimated 1,260 persons would be affected during the same period.

F.7.9 **Multi-criteria analysis**

F.7.9.1 **Economic criteria**

The economic criteria have already been discussed in detail in the previous chapters. Table F.7.11 just summarizes the results.

F.7.9.2 **Probability of failure**

For design purposes the accepted failure probability of the bank protection works has been evaluated. Under the assumption that maintenance works are realized for 80%, the accepted failure probability for the guide bund protection designed becomes five times in one thousand years (5.0 E-03).

TABLE F.7.11 SUMMARY OF RESULTS OF THE FEASIBILITY ANALYSIS

Type	EIRR	NPV(12%)	NPVR
Guide bunds: - scenario 1	1.82%	MTk. -417	-0.62
Guide bunds: - scenario 2	1.35%	MTk. -315	-0.57
Guide bunds: - scenario 3	1.65%	MTk. -216	-0.50

Based on an alternative assumption whereby virtually no maintenance is carried out, the failure probability increases almost nine times (45 E-03) for the guide bund protection works.

F.7.9.3 **Budgetary implications**

Reference is made to section F.7.5.3.

F.7.9.4 **Displacement of population**

Reference is made to section F.7.8.

F.7.9.5 **Summary of results**

Table F.7.12 summarizes the results of the multi-criteria analysis for river training and protection works at Haimchar.

TABLE F.7.12 MULTI-CRITERIA ANALYSIS, SUMMARY OF RESULTS

Data type	Guide bunds SC1	Guide bunds SC2	bunds SC3
1. Economic profitability	1.85% MTk. -417 -0.62 MTk.137	1.35% MTk. -314 -0.57 MTk.137	1.65% MTk. -216 -0.50 MTk.137
2. Probability of failure	5.0 E-03 45 E-03	5.0 E-03 45 E-03	5.0 E-03 45 E-03
3. Budgetary implications	Current prices: MTk. 11.2 MTk. 18.1 MTk. 47	Current prices: MTk. 9.0 MTk. 14.5 MTk. 57	Current prices: MTk. 6.1 MTk. 16.9 MTk. 63
4. Displacement of population	1,260	1,260	1,260

ANNEX F

Economics of protection works

F-8 Meghna R&H Bridge

F.8 MEGHNA R&H BRIDGE

F.8.1 Present situation and previous studies

Crossing the Meghna by bridge has only been possible by rail for a long time. The railway bridge in Bhairab Bazar exists already 50 years, but all other traffic used to cross the river by ferry. In 1990 the Meghna R&H Bridge was opened and it forms the first chain of bridges in the road network linking Dhaka and Chittagong.

Construction of the bridge was financed by the Government of Japan and executed by a contractor of the same country. The construction period lasted two years, which is extremely quick for such a large structure. Bank protection to safeguard the engulfment of abutments and the approach roads was included in construction works. However, at this date large parts of the protection are damaged.

F.8.2 Specific aspects related to the Meghna R&H Bridge

Protection works considered by the Meghna River bank Protection Short Term Study concentrate on training the river at a point some 2 kilometres upstream of the bridge and on protection of the old ferry ghat and the vortex area. Five alternatives have been studied for the protection of the bridge, of which four include protection of the ferry ghat and vortex area.

In the economic feasibility analysis of the Meghna R&H Bridge a comparison is made between a situation with river bank protection works (with-scenario) and one without protection works (without-scenario). As a result of the bank protection works executed in the with-scenario one may expect that bank erosion is completely stopped and that the risk of damage to the bridge's piles, abutments and approach road (i.e becoming outflanked) is reduced considerably.

The without-scenario is characterized by a continuation of the present situation. One may expect that without bank protection works the risk of failure of the bridge is very high. This would cause a disruption of road transport and incurr high costs to the economy. Hence, the loss to the economy and expenses needed to repair the bridge can be avoided.

F.8.3 Alternatives for river bank protection

Protection of the R&H Bridge can be undertaken in different ways. Based on the results of the geo-morphological study (Annex B) five scenarios have been developed for protection works. These scenarios can be grouped in three types of protection works: notably (a) repair of the existing bank protection together with protection of the ferry ghat and the vortex area, (b) a combination of the works undertaken under (a) and a groyne of 200 m upstream of the bridge and (c) construction of a groyne on the left bank near the ferry ghat.

F.8.4 Benefits of protection works

F.8.4.1 Disruption of road transport

(i) Methodology and result

Based on the results of the site investigation and the geo-morphological study of the upper Meghna, it is expected that the R&H Bridge, in the coming 30 years, may be damaged to such an extent that traffic is disrupted over a considerable period of time required for repairs. Consequently, a detailed study is needed to evaluate the impact of such a disruption to the national economy. In view of the data available only a limited analysis at pre-feasibility level has been carried out.

Damage to the bridge will cause a disruption of road traffic from and to Dhaka; passengers and cargo will either divert to other routes and modes or will have to cross the river by ferry to proceed to their destination. This involves the following:

- loss in time;
- extra cargo handling cost;
- extra transport cost for passengers and cargo.

For an economic evaluation of road traffic disruption the following cost components must be evaluated:

(a) Economic value of lost time
Depending on the length of the disruption, the total number of lost man-days can be calculated and appreciated in economic terms.

(b) Increased handling and transport cost
Increased transport and handling cost are evaluated over the length of the disruption period. One may expect that cargo transport will in general use the ferries although it is also foreseen that a small portion of cargo will divert to the rail transport mode.

(c) Repair cost
The cost for repair of damage to the bridge is evaluated and comprises a benefit to the project.

(d) Other cost
This refers in particular to the expenses needed for upgrading the ferry ghat and assuring that enough ferries are available.

In this study the analysis is based on a review of traffic flows over the bridge during a 12 months period. The incremental failure probability of various degrees of damage to the bridge has been assessed, together with the costs and time required for repairs. The total additional transport costs and the costs for repairs can then be evaluated as a (Gumbel extreme value) function of the failure probability. On the basis of this damage probability function the expected annual costs have been evaluated at Tk 207 million in economic mid-1991 terms.

(ii) Flows over bridge

From statistics provided by the R&H department the total flow over the bridge could be estimated. However, no long time series could be provided as the bridge only was only opened in 1990. Hence, only 1990/91 records are available. Per 12 months 11 million persons cross the bridge and 3 million ton of cargo passes. Table F.8.1 provides details.

(iii) Passenger's crossing

Failure of the bridge will result in a disruption of passenger traffic over the bridge. The most likely alternative for crossing by bus or car would be to cross the river by ferry or boat. This increases the trip by 4 to 5 hours. Hence, the total hours lost as result of bridge failure are estimated at 44.9 million hours per year.

Half of this time is considered an economic loss to the country, which is evaluated at Tk. 7.5 per hour (market prices), in agreement with the wage for unskilled labour. The SWR conversion factor is 0.71. Hence, this represents an economic loss to the country of Tk. 119.5 million on an annual basis (mid-1991 economic prices).

Ferry crossing has been evaluated from estimations made for the Jamuna Bridge study. Based on this study the estimated additional ferry cost are considered to be Tk. 2 per person (financial prices) or Tk. 1.6 per person (economic prices). Hence, the additional economic ferry cost per year are Tk. 18.4 million. Table F.8.2 gives details.

TABLE F.8.1 STATISTICS ON TRAFFIC CROSSING THE R&H BRIDGE

Period: 1990/91
Unit: passengers x 1,000, ton x 1,000

Item	Units	Average per unit	Total pers.	Total cargo
Bus	178,622	55	9,824	
Truck	474,054	6		2,844
Minibus	25,912	30	777	
Microbus	36,517	10	365	
Car/jeep	81,494	3	244	
Babi taxi	3,062	2	6	
M. cycle	5,548	1	6	
Other cargo				284
Total	805,209		11,223	3,129

Adapted from information R&H Department

TABLE F.8.2 ADDITIONAL ANNUAL COST PASSENGER TRANSPORT

Prices: mid-1991 economic prices
Unit: Tk.

Item	Unit	Unit value	Total (x 1000)
Additional time ferry crossing	hrs	4.0	44,892
Economic losses in time	hrs	50%	22,446
Economic cost of time losses	Tk.	5.3	119,524
Ferry crossing cost	Tk.	1.6	18,406
Total economic cost	Tk.x 1000		137,929

(iv) Cargo transport

Alternatives for cargo transport in case of bridge failure are difficult to predict because no detailed information could be provided on destinations and flows. Hence, likely cargo flows are estimated on the basis of prevailing flow patterns:

- Originating from Chittagong with destination Dhaka: 65% of volume;
- Originating from Dhaka with destination Chittagong: 25% of volume;
- Short distance transport over the bridge: 10% of volume.

Alternatives for transport between Chittagong and Dhaka vice versa are ferry crossing, railway and river transport. Few details are known on the likely reaction of transporters as to the choice of alternative transport modes. It is, however, very unlikely that any cargo will be diverted to Bangladesh Rail services. Water transport is more likely as an alternative, but this mode of transport can be neglected as it is more suitable for bulk products and special items, rather than for general cargo. Hence, it is assumed that all (long haul) cargo will use ferry services when the bridge will fail.
Short distance transport will also cross the river by ferry. Any possible additional cargo handling charges have been excluded, because additional cargo handling is not necessary and variations of cargo handling costs for different modes of transport are marginal.
Ferry costs are based on prevailing ferry costs in Bhairab Bazar and Daudkandi. Based on the assumption that all cargo is transported by five tons carriers and that crossing the river by ferry will take an additional four hours, the additional cost for ferry crossing has been estimated at Tk. 45 per ton in financial and Tk. 34 per tonne in economic prices.

Conclusively, it follows that the total additional transport cost in case of failure of the bridge amounts to Tk. 105 million per annum. Details are given in Table F.8.3

TABLE F.8.3 ADDITIONAL ANNUAL COST CARGO TRANSPORT

Prices: mid-1991 economic prices
Unit: Tk.

Item	unit	value	total (x1000)
Fractions:			
Chittagong-Dhaka	ton	65%	2 034
Dhaka-Chittagong	ton	25%	782
Short distance transport	ton	10%	313
Total	ton		3 129
Additional annual transport costs:			
Ferry crossings	Tk.	33.6	105 134

(v) Other cost

Since over a year the operation of ferries has ceased at the location of the bridge. During that period the ferry ghat have been damaged by the river and to start operation again would involve additional cost. Reparation of the existing ferry ghats is expected to cost Tk. 20 million (Tk. 200 lakh).

F.8.4.2 **Avoidable repair costs**

Three situations with a different degree of damage to the bridge have been investigated. For these situations the incremental failure probability has been assessed, the repair costs have been estimated and the period of disruption of transport indicated.
Since no detailed cost information was obtained related to the construction of the bridge, the preliminary cost estimates have been based on adjusted figures from the Jamuna Bridge. The situations considered are characterized by:

(a) Failure of abutment
- Incremental probability estimated at 4.0 E-01
- Repair costs estimated at Tk. 8.9 million
- Disruption of traffic for a period of one year

(b) Failure of abutment and two spans
- Incremental probability estimated at 1.0 E-01
- Repair costs estimated at Tk. 177.1 million
- Disruption of traffic for a period of one and a half year

(c) Failure of embankment approach road
- Incremental probability estimated at 5.0 E-02
- Repair costs estimated at Tk. 295.2 million
- Disruption of traffic for a period of two years

F.8.4.3 **Total avoidable transport and repair costs**

Total costs for each of the failure scenarios have been summarized in Table F.8.4.

TABLE F.8.4 ADDITIONAL COSTS DUE TO DISRUPTION TRANSPORT OVER R&H BRIDGE

Prices: mid-1991 economic prices
Unit: Tk. x 1M

Item	Freq. (failure)	Dur.fail. (yrs)	Repair cost	Repair ferry gh.	Ec.cost pers.	Ec.cost cargo	Total cost
No failure	1.0E+00	0	0.0	0.0	0.0	0.0	0.0
Abutment failure	4.0E-01	1	8.9	20.0	137.9	105.1	271.9
Failure 2 spans	[illegible]	1.5	177.1	20.0	206.9	157.7	561.7
Failure approach embankment	5.0E-02	2	295.2	20.0	275.9	210.3	801.3

Notes:
1) Tk. 36 is conversion rate for 1 US$

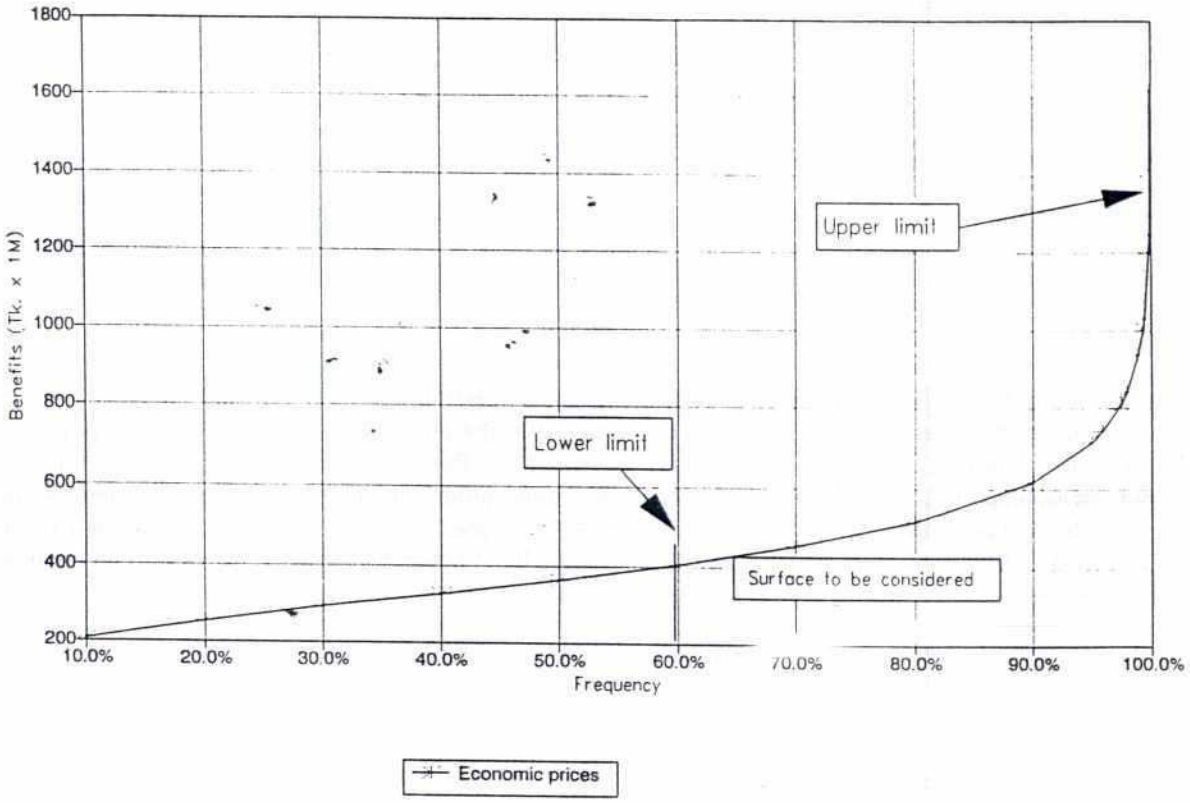
For each of the three situations the total costs of repair and additional transport and cargo handling have been estimated and these values have been correlated with the incremental failure probability of the bridge by fitting the Gumbel extreme value probability function. Based on this function and following the procedures outlined in the FPCO-guidelines for project assessment, the expected annual financial costs due to disruption of road traffic over the bridge has been evaluated at Tk. 223 million. Table F.8.5 gives the mathematical expectation of annual avoided cost. Figure F.8.1 presents the frequency-damage relationship for the R&H Bridge.

TABLE F.8.5 MATHEMATICAL EXPECTATION ANNUAL DAMAGE

PRICES: mid-1991 economic prices
UNIT: Tk. x 1 million

Freq. (non-exc)	Return period (yrs)	SAVINGS R_PAIR/ADD.COST: Total cost	C&F differ.	Cum C&F diff.
0.00%		0.0		0.0
10.00%		203.8	10.2	10.2
20.00%		252.0	22.8	33.0
30.00%		291.1	27.2	60.1
40.00%		327.8	30.9	91.1
50.00%	2	365.4	34.7	125.7
60.00%		406.4	38.6	164.3
70.00%		454.7	43.1	207.4
80.00%	5	517.8	48.6	256.0
90.00%	10	618.8	56.8	312.9
95.00%	20	715.6	33.4	346.2
95.90%	24	743.0	6.6	352.8
97.50%	40	810.6	12.4	365.2
98.00%	50	841.0	4.1	369.3
99.00%	100	934.9	8.9	378.2
99.40%	167	1,003.9	3.9	382.1
99.50%	200	1,028.5	1.0	383.1
99.86%	709	1,199.1	4.0	387.1
99.90%	1000	1,245.3	0.5	387.6
99.97%	3546	1,415.7	1.0	388.6
99.99%	16129	1,619.5	0.3	388.9

FIG. F.8.1 DAMAGE FREQUENCY CURVE MEGHNA R&H BRIDGE



F.8.5 **Costs of the river bank protection**

F.8.5.1 **Investment cost**

Five alternatives for protection have been considered.
Four scenarios for protecting the bridge include repairing the existing bank protection and protection of the ferry ghat and vortex area. In two scenarios protection works are combined with a groyne of 200 metre, which is constructed in the river some 2 kilometres upstream.
A fifth scenario comprises a groyne stretching out from the ferry ghat downstream.
Table F.8.6 gives a summary of investment cost.

F.8.5.2 **Monitoring and maintenance cost**

Monitoring and maintenance of protection structures is an important component, which affects directly the long term effectiveness of protection works. Monitoring and maintenance are an integral part of river bank protection, the probability of failure of the structures may very well increase rapidly in the future if they are poor.

Monitoring activities comprise sounding of bed and bank level. They are estimated at Tk 2.0 million per annum in economic terms. After critical judgement of protection work items it is assumed that annual maintenance is 4.0% of the investment costs of all revetment components. Table F.8.7 provides details on annual monitoring and maintenance.

TABLE F.8.6 SUMMARY OF INVESTMENT COST

Type	Investment cost and year	Local/foreign currency
Repair existing protection, ferry ghat and vortex	1993: MTk. 184.0	Local: 55% Foreign: 45%
Repair existing protection, ferry ghat and vortex plus groyne of 200m	1993: MTk. 184.0 2003: MTk. 312.2	Local: 43% Foreign: 57%
Repair existing protection, ferry ghat and vortex plus groyne of 200m	1993: MTk. 237.9	Local: 43% Foreign: 57%
Repair existing protection, ferry ghat and vortex	1993: MTk. 151.8	Local: 51% Foreign: 49%
Groyne	1993: MTk. 126.8	Local: 66% Foreign: 34%

TABLE F.8.7 SUMMARY OF MONITORING AND MAINTENANCE COST

Type	Maintenance expenditure	Monitoring cost
Repair existing protection, ferry ghat and vortex	1993: MTk. 2.1	MTk. 2.0
Repair existing protection, ferry ghat and vortex plus groyne of 200m	1993: MTk. 2.1 2003: MTk. 3.6	MTk. 2.0
Repair existing protection, ferry ghat and vortex plus groyne of 200m	1993: MTk. 2.8	MTk. 2.0
Repair existing protection, ferry ghat and vortex	1993: MTk. 1.8	MTk. 2.0
Groyne	1993: MTk. 0.3	MTk. 2.0

F.8.5.3 **Budgetary Implications**

Budgetary implications of the bank protection works relate in general to recurrent cost, which must be met by the national budget. The following cost are considered to be covered by this budget:

(i) Monitoring and maintenance expenses

In Table F.8.8 an overview of current expenditure for monitoring and maintenance operations at the start of the project, after five years and in the year 2008.

TABLE F.8.8 SUMMARY OF EXPENDITURES FOR MONITORING AND MAINTENANCE IN CURRENT PRICES

Type	Expenditure in 1993	Expenditure in 1998	Expenditure in 2008
Repair existing protection, ferry ghat and vortex	MTk. 5.0	MTk. 8.1	MTk. 21
Repair existing protection, ferry ghat and vortex plus groyne of 200m	MTk. 5.0	MTk. 8.1	MTk. 29
Repair existing protection, ferry ghat and vortex plus groyne of 200m	MTk. 5.9	MTk. 9.4	MTk. 24
Repair existing protection, ferry ghat and vortex	MTk. 4.6	MTk. 7.5	MTk. 19
Groyne	MTk. 2.8	MTk. 4.5	MTk. 12

(ii) Environmental monitoring

Costs of the required environmental monitoring are considered to be small and covered by the amount reserved for other cost in the cash flow analysis.

F.8.6 Economic feasibility analysis

F.8.6.1 Cash flow

The cash flow computation for river bank protection at the Mawa R&H Bridge makes a comparison of benefits and cost over the 30-year evaluation period. The investment costs have been discussed in the previous section. Project benefits were discussed in Section F.8.4.
In computing the benefits for the cash flow calculation, it has been assumed that the additional transport costs due to the failure of the bridge will increase annually by 3% reflecting the expected growth of population and economic activities.
In Table F.8.9 the economic cash flow is given for the groyne protection. The cash flow table requires no further discussion.

F.8.6.2 Economic Internal Rate of Return

The economic feasibility of the river bank protection works is first evaluated by comparing the discounted values of benefits against cost. The economic internal rate of return (EIRR) is the rate at which the present value of benefits and cost balance each other over the 30-year evaluation period.
The rate achieved for all of the protection scenarios is very high above one hundred percent. Investment cost are fully repaid within the period of one year after completion. Hence, all protection scenarios are fully justified in economic terms.

F.8.6.3 Net Present Value

The economic net present value for the five protection scenarios has been calculated for a discounting rate of 12% and amounts to over Tk 2000 million for the groyne alternative solution. The NPVR ratio as required by the FPCO-guidelines reaches 12.8.

TABLE F.8.9 ECONOMIC CASH FLOW FOR PROTECTION OF THE MEGHNA R&H BRIDGE BY A GROYNE

PRICES: mid-1991 economic prices
UNIT: Tk. x 1 million
START: 1993
CONSTR: 1 years

EIRR: 189.88% NPV: 2074.1 NPVR1: 12.78

	WITH-PROJECT SITUATION COST:				BENEFITS:	CASH	Cash F.
Year	Inv.	m&M	Other	Total	Bridge	FLOW	(US$x1M)
1993	126.8	2.3	0.1	129.3	0.0	-129.3	-3.59
1994	0.0	2.3	0.1	2.5	244.0	241.5	6.71
1995	0.0	2.3	0.1	2.5	251.3	248.8	6.91
1996		2.3	0.1	2.5	258.8	256.4	7.12
1997		2.3	0.1	2.5	266.6	264.1	7.34
1998	0.0	2.3	0.1	2.5	274.6	272.1	7.56
1999		2.3	0.1	2.5	282.8	280.4	7.79
2000		2.3	0.1	2.5	291.3	288.9	8.02
2001		2.3	0.1	2.5	300.1	297.6	8.27
2002		2.3	0.1	2.5	309.1	306.6	8.52
2003		2.3	0.1	2.5	318.3	315.9	8.77
2004		2.3	0.1	2.5	327.9	325.4	9.04
2005	0.0	2.3	0.1	2.5	337.7	335.3	9.31
2006		2.3	0.1	2.5	347.9	345.4	9.59
2007		2.3	0.1	2.5	358.3	355.8	9.88
2008		2.3	0.1	2.5	369.0	366.6	10.18
2009		2.3	0.1	2.5	380.1	377.6	10.49
2010		2.3	0.1	2.5	391.5	389.0	10.81
2011		2.3	0.1	2.5	403.3	400.8	11.13
2012		2.3	0.1	2.5	415.4	412.9	11.47
2013		2.3	0.1	2.5	427.8	425.4	11.82
2014		2.3	0.1	2.5	440.7	438.2	12.17
2015		2.3	0.1	2.5	453.9	451.4	12.54
2016		2.3	0.	2.5	467.5	465.0	12.92
2017		2.3	0.1	2.5	481.5	479.0	13.31
2018		[illegible]	0.1	2.5	496.0	493.5	13.71
2019		2.3	0.1	2.5	510.8	508.4	14.12
2020		2.3	0.1	2.5	526.2	523.7	14.55
2021		2.3	0.1	2.5	541.9	539.5	14.99
2022		2.3	0.1	2.5	558.2	555.7	15.44
SUM	126.8	70.3	3.8	200.9	11032.5	10831.6	300.88

Notes:
1) INVESTMENT COST (Tk. x 1M):
Year 1993 126.8
1998 0.0
2005 0.0
2) O&M COST (Tk. x 1M):
Maintenance: 1993 0.3
1998 0.0
2005 0.0
Monitoring 2.0
3) OTHER COST:
Tk. x 1M 0.1
4) BENEFITS (Tk. x 1M):
Savings repair cost 223.3
Annual increase 3%
5) Conversion US$ 1 = Tk. 36

F.8.6.4 Conclusion

The conclusion drawn from this preliminary analysis is obviously that the additional bank protection works to guarantee the stability of the bridge show a very high EIRR and are fully justified in economic terms. A sensitivity or multicriteria analysis is, at this preliminary stage, therefore not considered required.

ANNEX F

Economics of protection works

F-9 Maniknagar

F.9. MANIKNAGAR

F.9.1 Present situation and previous studies

Maniknagar is situated on the left bank of the Meghna, south of Bhairab Bazar. Erosion has attacked the river bank for more than a decade and is the result of both current and wave action. Agriculture is the main economic activity in the area. The area is the location for the future Gumti phase II project and erosion could very well threaten this irrigation project in the future.

The feasibility of the Gumti II project was studied in 1990 by a consortium of Bureau of Consulting Engineering Ltd. of Bangladesh and Sir William Halcrow and Partners Ltd. of the United Kingdom. The aim of the project is to increase agricultural production. For protection against floods a new embankment at some distance of the river was planned. However, the scope was not on river training works to avert erosion of the proposed embankment.

At this moment the area is part of the zone covered by FAP 5. However, the scope of this project is neither on river training or bank protection works. Hence, protection of river banks at Maniknagar was included in the terms of references of the Meghna River bank Short Term Study.

Without adequate protection the outer bend of the Meghna could migrate some 700 m inland in the coming 30 years and destroy the bazar. A substantial area of agricultural land would be engulfed as well. Hence, benefits of river training and bank protection works relate to a reduction of agriculture and urban losses.

F.9.2 Specific aspects related to Maniknagar

To protect the river bank at Maniknagar, design of river training and bank protection works have been undertaken by the Meghna River Bank Short Term Study at a pre-feasibility level. Along the shore of the Meghna there are a number of habitations and small commercial enterprises, which would be protected. The area of influence of the proposed river training and protection works reaches from the point where the Meghna splits in two arms just south of Bhairab Bazar to where both arms confluence again. The area protected covers lands bordering the river which will be parts of the future Gumti phase II irrigation project.

The economic pre-feasibility analysis covers four alternatives, notably (a) protection through groynes, (b) overall bank protection works over a length of 5,000 m, (c) a series of sand-sausages and (d) closure of the river arm at the bifurcation upstream of Maniknagar. A comparison is made between a future scenario with river training or protection works (with-scenario) and without any works being implemented (without-scenario).
The without-scenario is not equal to the present situation, but represents an extension of the present situation in the future. It is more than likely, that the river bank will recede considerably in the coming 30 years. On the base of the result of the geo-morphological study (Annex B), we expect that the existing process of bank migration continues at an annual rate of about 25 m. Subsequently the bazar and large stretches of agricultural land will be engulfed.
The analysis of the with-project scenario concentrate on benefits and cost that can be related to river training and bank protection. As a result of the work executed one can expect that less agricultural land will disappear and fewer structures will be damaged. Hence, expected investments give benefits which relate to less embankment construction, loss of agricultural land and destruction of structures.

F.9.3 Alternatives for protection

Four types of river bank protection have been investigated, notably (a) one large groyne or a series of groynes, (b) revetment of the existing bank, (c) sand-sausages in the river to train the flow and (d) closure of the river arm.

The first option, one large groyne, is attractive, because it is less expensive than any of the other options. High investment cost vis-a-vis benefits are affecting the rate of return for a series of groynes whose cost is much higher.
The second option, a continuous revetment, is more expensive than a series of groynes.
The third option, sand-sausages to train the river, is a new feature in Bangladesh. Although this type a river training works has been successfully applied in the Netherlands, it remains to be seen if it is as successful in Bangladesh.
Closure of the river branch at the left bank, the last option considered, is less attractive because of the likely opposition from fishermen and ship operators. Then, a shipping lock has to be included, but this will increase the cost considerably.

F.9.4 Benefits of Maniknagar of protection works

Benefits related to river training or protection works are considered the same. Hence, no distinction in benefits is made between the alternatives. Moreover, it is assumed that land will only be lost in the without scenario situation; losses are negligible when there is protection or river training.

F.9.4.1 Reduction in repair and maintenance expenses

Maintenance and repair expenses for damage caused by the Meghna have been negligible in the past. There is every reason to believe that this will remain so in the future without-scenario situation. Hence, there are no savings in maintenance and repair expenses which can be attributed to protection works.

F.9.4.2 Destruction of buildings and urban infra-structure

River bank erosion will cause loss of buildings and damage to existing structures. Some inhabitants move their homes every now and then more inland to protect them from the water of the Meghna during the flood season. However, other houses and commercial buildings in the area are still prone to erosion.
Many houses are simple one-storey kutcha structures which have a marginal value and can be moved at low cost, mainly labour. However, also structures of a more permanent nature and a market area exist. It is assumed, like in the case of Haimchar and Eklashpur, that about 10% of the area in Maniknagar is used for non-agricultural purposes, being either commercial enterprises or homes. This percentage also includes public infra-structure. See Chapters 6 and 7 of this Annex.

From the results of the geo-morphological study (see Annex B) it could be estimated how far the bank line will recede and how much land is likely to disappear. To estimate an average value of public and private property per square meter for Maniknagar, the same assumptions have been made as for Eklashpur and Haimchar, yielding an value of Tk 799. See Chapters 6 and 7 of this Annex. In Table F.9.1 the estimated economic value of destruction of buildings and urban infra-structure are presented.
As explained for Eklashpur and Haimchar, no account was taken of losses in revenues of commercial enterprises.

Apart from the infra-structural losses as a result of bank erosion, there is also loss of land to be considered. The fact that it washes away and is lost means that it must be considered in the economic evaluation. However, all land was accounted for in the analysis of agricultural production, assuming that agriculture is the nearest-best economic activity. Moreover, double-counting has been avoided.

F.9.4.3 Agriculture

Agricultural benefits are associated with protection of arable land which would otherwise be lost as a result of bank migration. In agreement with the FPCO-guidelines the agricultural benefits of river training and bank protection works result from reduction of net agricultural revenues lost due to erosion of arable land. Based on the results of the geo-morphological survey for the area, the change of the river bank position could be forecast. Hence, a prediction could be made of reduction in the area lost as a result of river training works, covering the evaluation period.

TABLE F.9.1 VALUE OF DESTRUCTION OF BUILDINGS AND URBAN INFRA-STRUCTURE

PRICES: constant mid-1991 economic prices
UNIT: Tk x 1000

Year	SITUATION [WO]: Area lost (ha)	Urban assets
1993	16.3	13 058.4
1994	11.4	9 127.7
1995	11.4	9 127.7
1996	11.4	9 127.7
1997	11.4	9 127.7
1998	11.4	9 127.7
1999	13.6	10 868.8
2000	13.6	10 868.8
2001	13.6	10 868.8
2002	13.6	10 868.8
2003	13.6	10 868.8
2004	14.1	11 238.1
2005		11 238.1
2006	14.1	11 238.1
2007	14.1	11 238.1
2008	14.1	11 238.1
2009	15.5	12 416.5
2010	15.5	12 416.5
2011	15.5	12 416.5
2012	15.5	12 416.5
2013	15.5	12 416.5
2014	16.6	13 278.3
2015	16.6	13 278.3
2016	16.6	13 278.3
2017	16.6	13 278.3
2018	16.6	13 278.3
2019	18.2	14 579.7
2020	18.2	14 579.7
2021	18.2	14 579.7
2022	18.2	14 579.7
SUM	445.4	356 024.2

Notes:
1) Tk. 0.799 x 1000 per sq.m is the estimated average value of ur... ...ra-structure and buildings
2) At 10% is estimated the urbanised area

The actual cropping pattern in the area was derived from the feasibility study of the Gumti phase II project. Net economic return of irrigated agriculture were adapted from Thompson (1990) and from results of work done by FAP 5. The annual net economic revenues of agricultural area lost due to erosion are taken into account as benefit of works undertaken at Maniknagar.

Apart from the annual net revenue of the area inside the embankment otherwise lost, a value of Tk. 1,677 per hectare associated with the irrigation infra-structure can also be considered as avoidable costs and, hence, as benefit of protection works in Maniknagar. This figure was derived from data supplied by FAP 5. The net annual economic revenues of actual cropping in the Gumti irrigation project have been evaluated at Tk. 10.593 per ha. Details are reported in Table F.9.2.

TABLE F.9.2 ANNUAL NET REVENUES PER HECTARE GUMTI PHASE II

PRICES: constant mid-1991 economic prices
UNIT: Tk.

Item	Unit	Unit return	Fraction in area	Annual return
Culivation:				
Rabi crops 1)	ha	6,755	37.8%	
HYV Boro	ha	9 522	17.3%	1 647
B Aus	ha	316	15.1	48
TL Aman	ha	6 594	74.8%	4 932
Sub-total	ha		82.1%	9 180
Fish-ponds 2)	yr.	20 736	6.8%	1 410
Orchards 2)	yr	218	1.1%	2
Other areas			10.0%	
TOTAL				10 593
Rental value				51 681

Notes:
1) Rabi crop considered is wheat
2) Returns are adapted from Thompson (1990)
3) Rental value is adapted from crop budgets

Apart from the loss of agricultural production as a result of bank erosion, there is also the reduction in loss of land as a productive asset to be considered. The fact that land washes away and is directly lost for cropping means that it must be considered in the economic evaluation. Hence, the value of this asset must be estimated, while the reduction of lost agricultural land is considered as a benefit of river training works or bank protection.
As explained in F.2.5.4 the capitalized economic rental value of land has been considered in the economic evaluation. This value has been estimated at Tk. 51.681 per ha (see also Table F.9.2).

Table F.9.3 provides details of total agricultural benefits over the 30-year period of the feasibility study. In the table with and without-project scenarios are compared. Benefits of river training works are given by the balance, which represents the reduction in losses to cropping.

F.9.5 Cost of alternative protection options

F.9.5.1 Investment cost

Estimated cost for river training works are based on the preliminary design. The cost of individual items of work has been calculated by multiplying used quantities by unit rates. Economic investment cost for a large groyne at Maniknagar is estimated at US$ 7.38 million, which equals to Tk. 265.6 million. An estimated 43% of investment cost are local currency expenditure and the foreign component amounts to 57%. Also evaluated is the construction of a series of groynes, costing US$ 9.55 million or Tk. 343.7 million. No details are provided on construction of a closure dam because this solution may face strong resistance from river transporters and fisherman.
An second design for protection has been made, notably a continuous revetment of the existing bank. This type of protection is costing US$ 12.97 million or Tk 466.7 million. Local currency expenditure is 50% and foreign component totals 50%.
The third option comprises of sand-sausages to train the [illegible] of this type of investment economic investment cost are estimated at US$ 15.4 million or Tk. 554.9 million. An estimated 40% of investment cost are local currency expenditure and the foreign component is 60%. Table F.9.4 provides a summary of investment cost for all three options.

TABLE F.9.3 AGRICULTURAL BENEFITS

PRICES: constant mid-1991 economic prices
UNIT: Tk x 1000

Year	SITUATION [WO]: Area lost(ha)	Product. loss(CUM)	Land+Infr value	Total
1993	16.3	166.8	871.6	1 038.4
1994	11.4	283.3	609.2	892.6
1995	11.4	399.9	609.2	1 009.1
1996	11.4	516.4	609.2	1 125.7
1997	11.4	633.0	609.2	1 242.2
1998	11.4	749.6	609.2	1 358.8
1999	13.6	888.3	725.5	1 613.8
2000	13.6	1 027.1	725.5	1 752.6
2001	13.6	1 165.9	725.5	1 891.4
2002	13.6	304.7	725.5	2 030.2
2003	13.6	1 443.5	725.5	2 169.0
2004	14.1	1 587.0	750.1	2 337.1
2005	14.1	1 730.5	750.1	2 480.7
2006	14.1	1 874.1	750.1	2 624.2
2007	14.1	2 017.6	750.1	2 767.7
2008	14.1	2 161.1	750.1	2 911.2
2009	15.5	2 319.6	828.8	3 148.4
2010	15.5	2 478.2	828.8	3 307.0
2011	15.5	2 636.7	828.8	3 465.5
2012	15.5	2 795.3	828.8	3 624.1
2013	15.5	2 953.9	828.8	3 782.6
2014	16.6	3 123.4	886.3	4 009.7
2015	16.6	3 293.0	886.3	4 179.3
2016	16.6	3 462.6	886.3	4 348.8
2017	16.6	3 632.1	886.3	4 518.4
2018	16.6	3 801.7	886.3	4 688.0
2019	18.2	3 987.9	973.1	4 961.0
2020	18.2	4 174.0	973.1	5 147.2
2021	18.2	4 360.2	973.1	5 333.4
2022	18.2	4 546.4	973.1	5 519.6
SUM	445.4	65 513.9	23 763.5	89 277.4

Notes:
1) Tk. 1 677 per ha is the value of irrigation infra-structure based on an analysis of data from SERWRDP (FAP5)
2) At 50% is estimated the level of irrigation in the Maniknagar region
3) Tk. 10 593 is the economic unit value of land in the Maniknagar region
Tk. 9 824 is the economic value of non-irrigated land

F.9.5.2 **Monitoring and maintenance**

Monitoring and maintenance of river training works is an important component, which affects directly the long term effectiveness of protection against bank erosion. They form an integral part of protection works and the rate of failure of structures may increase rapidly in the future if maintenance works are carried out poorly.

TABLE F.9.4 SUMMARY OF ECONOMIC INVESTMENT COST FOR WORKS AT MANIKNAGAR

Type	Investment cost and year	Local/foreign currency
Large groyne	1993: MTk. 265.6	Local: 43% Foreign: 57%
Series of groynes	1993: MTk. 343.7	Local: 45% Foreign: 55%
Overall bank protection (5,000 m),	1993: MTk. 466.7	Local: 50% Foreign: 50%
Sand-sausages	1993: MTk. 554.9	Local: 40% Foreign: 60%

Monitoring comprises regular inspection of structures as well as topographic and bathymetrical measurements. The annual cost of monitoring is estimated at Tk. 2.0 million per year (mid-1991 economic prices). Annual maintenance is estimated at 4% of surface components, e.g. open stone asphalt, fascine mattress, boulders in falling apron and grouting of boulders.

Sand-sausages requires very few maintenance, although they have to be monitored more frequently to deter any damage. In the analysis no maintenance cost are considered, while monitoring expenses are considered to amount to Tk. 4.0 million. Details of monitoring and maintenance expenditure are provided in Table F.9.5.

TABLE F.9.5 ANNUAL MONITORING AND MAINTENANCE FOR WORKS AT MANIKNAGAR

Type	Maintenance expenditure	Monitoring cost
Large groyne	MTk. 3.0	MTk. 2.0
Series of groynes	MTk. 6.2	MTk. 2.0
Overall bank protection (5,000 m)	MTk. 10.7	MTk. 2.0
Sand-sausages	MTk. 0	MTk. 4.0

F.9.5.3 Budgetary implications

Monitoring and maintenance expenditure for river training works must normally be met by the national budget. Assuming a general level of price increase of 10% per annum, means that the cost met by the budget increase substantially over the years. Moreover, expenses for environmental monitoring and, if such is necessary, mitigative measure must equally be met by the national budget.

(i) Monitoring and maintenance expenses

In Table F.9.6 a summary is presented of current expenditure for monitoring and maintenance operations at the start of the project, after five years and in the year 2008.

TABLE F.9.6 MONITORING AND MAINTENANCE COSTS IN CURRENT PRICES

Type	Expenditure in 1993	Expenditure in 1998	Expenditure in 2008
Large groyne	MTk. 6.1	MTk. 9.8	MTk. 25
Series of groynes	MTk. 10.0	MTk. 16.1	MTk. 42
Overall bank protection (5,000 m)	MTK. 15.5	MTk. 24.9	MTk. 65
Sand-sausages	MTk. 4.9	MTk. 7.9	MTk. 20

(ii) Environmental monitoring

Cost of required environmental monitoring are negligible and could be easily covered by the reservations made for other cost. Details on the monitoring programme are presented in Annex I.

F.9.6 Economic feasibility study

F.9.6.1 Cash flow

The cash flow computation for river training works at Maniknagar makes a comparison of benefits and cost over the 30-year evaluation period. The investment costs have been discussed in the previous section. Project benefits were discussed in Section F.9.4.
The computation of the cash flow has been limited to the most profitable alternative. Table F.9.7 provides the cash flow for river training by a large groyne. The requires no further discussion.

F.9.6.2 Economic Internal Rate of Return

The economic feasibility of the river bank protection works is first evaluated by comparing the discounted values of benefits against cost. The economic internal rate of return (EIRR) is the discounting percentage at which the benefits balance cost over the 30-year evaluation period.
The construction of a groyne just gives a positive EIRR. This means that the economic value of the interests to be protected are just offset by the costs of the protective measures. All other protection options show a negative EIRR. Hence, none is acceptable on economic grounds.

F.9.6.3 Net Present Value

The economic NPV has been calculated for a discount rate of 12% and found to be negative for all options considered. The NPVR ration as required by the FPCO-guidelines has been evaluated at -0.53.

F.9.6.4 Conclusions

The conclusions drawn from this preliminary assessment are summarized below:

(i) Bank protection works to protect the present-day infrastructural and economic interests along the river bank are only marginally cover the associated costs. They are therefore not attractive from the economic point of view.

(ii) Within the framework of the Gumti II Project the benefits of bank protection works have to be compared with the option to withdraw the originally planned embankment alignment over about 700 m.

A sensitivity analysis, nor a multicriteria analysis, will give any added value to the conclusions drawn from this preliminary analysis and have not been presented in this report.

TABLE F.9.7 ECONOMIC CASH FLOW MANIKNAGAR RIVER TRAINING WORKS (LARGE GROYNE)

PRICES: mid-1991 economic prices
UNIT: Tk. x 1 million
START: 1993
CONSTR: 1 years

EIRR: 0.17% NPV: -190.6 NPVR1: -0.56

	WITH-PROJECT SITUATION COST:				BENEFITS:				CASH	Cash F.
Year	Invest.	M&M	Other	Total	Repair c.	Urban pr.	Agric.	Total	FLOW	(US$x1M)
1993	265.6	5.0	0.3	270.9	0.0	0.0	0.0	0.0	-270.9	-7.5
1994	0.0	5.0	0.3	5.2	0.0	9.1	0.9	10.0	4.8	0.1
1995	0.0	5.0	0.3	5.2	0.0	[illegible]	[illegible]	10.1	4.9	0.1
1996		5.0	0.3	5.2	0.0	9.1	1.1	10.3	5.0	0.1
1997		5.0	0.3	5.2	0.0	9.1	1.2	10.4	5.1	0.1
1998		5.0	0.3	5.2	0.0	9.1	1.4	10.5	5.2	0.1
1999		5.0	0.3	5.2	0.0	10.9	1.6	12.5	7.2	0.2
2000		5.0	0.3	5.2	0.0	10.9	1.8	12.6	7.4	0.2
2001		5.0	0.3	5.2	0.0	10.9	1.9	12.8	7.5	0.2
2002		5.0	0.3	5.2	0.0	10.9	2.0	12.9	7.7	0.2
2003		5.0	0.3	5.2	0.0	10.9	2.2	13.0	7.8	0.2
2004		5.0	0.3	5.2	0.0	11.2	2.3	13.6	8.3	0.2
2005		5.0	0.3	5.2	0.0	11.2	2.5	13.7	8.5	0.2
2006		5.0	0.3	5.2	0.0	11.2	2.6	13.9	8.6	0.2
2007		5.0	0.3	5.2	0.0	11.2	2.8	14.0	8.8	0.2
2008		5.0	0.3	5.2	0.0	11.2	2.9	14.1	8.9	0.2
2009		5.0	0.3	5.2	0.0	12.4	3.1	15.6	10.3	0.3
2010		5.0	0.3	5.2	0.0	12.4	3.3	15.7	10.5	0.3
2011		5.0	0.3	5.2	0.0	12.4	3.5	15.9	10.6	0.3
2012		5.0	0.3	5.2	0.0	12.4	3.6	16.0	10.8	0.3
2013		5.0	0.3	5.2	0.0	12.4	3.8	16.2	11.0	0.3
2014		5.0	0.3	5.2	0.0	13.3	4.0	17.3	12.0	0.3
2015		5.0	0.3	5.2	0.0	13.3	4.2	17.5	12.2	0.3
2016		5.0	0.3	5.2	0.0	13.3	4.3	17.6	12.4	0.3
2017		5.0	0.3	5.2	0.0	13.3	4.5	17.8	12.6	0.3
2018		5.0	0.3	5.2	0.0	13.3	4.7	18.0	12.7	0.4
2019		5.0	0.3	5.2	0.0	14.6	5.0	19.5	14.3	0.4
2020		5.0	0.3	5.2	0.0	14.6	5.1	19.7	14.5	0.4
2021		5.0	0.3	5.2	0.0	14.6	5.3	19.9	14.7	0.4
2022		5.0	0.3	5.2	0.0	14.6	5.5	20.1	14.9	0.4
SUM	265.6	149.3	8.0	422.9	0.0	[illegible]	88.2	431.2	8.3	0.2

Notes:

1) INVESTMENT COST:
   Tk. x 1M: 265.6
2) M&M COST (Tk. x 1M):
   Maintenance: 3.0
   Survey cost: 2.0
3) OTHER COST:
   Tk. x 1M: 0.3
4) BENEFITS (Tk. x 1M):
   Savings repair: 0.0
   Annual mainten.: 0.0
   Annual increase: 10%
5) Conversion US$ 1 = Tk. 36

	Large groyne	Serie of groynes
	265.6	343.7
	3.0	6.2
	2.0	2.0
EIRR:	0.17%	0.00%
NPV:	-190.6	-287.2
NPVR:	-0.56	-0.63

PV(12%) benefits:	
Tk. x 1M	88.8
US$ x 1M	2.5

ANNEX F

Economic assessment of long term protection

F-10 Lower Meghna

F.10 LOWER MEGHNA

F.10.1 Introduction

F.10.1.1 Scope of feasibility assessment

The Lower Meghna is the largest river of the region, discharging the flows from the Ganges, Jamuna and Meghna into the Bengal Gulf. Year after year the course of the Lower Meghna has shifted towards the east despite all efforts made by the authorities. Although, much attention has been paid in the past to protect the town of Chandpur and irrigation projects upstream and downstream of the town, no comprehensive concept has been proposed yet for long term protection.

Within the terms of reference of the Meghna River Bank Protection Short Term Study an assessment of an overall protection of the Lower Meghna was not included, although the short term measures to be proposed must be sustainable by themselves and must also allow being included in a long term strategic development plan of the Lower Meghna. Therefore, a preliminary assessment has been made of a possible river training scheme aiming at a complete regulation of the Lower Meghna incorporating the short term measures designed for Eklashpur, Chandpur and Haimchar.

In addition to the short term bank protection works elaborated for Eklashpur, Chandpur and Haimchar, preliminary designs have been prepared for structures in the intermediate zone, covering the area between Eklashpur and Chandpur and the area from Chandpur to Haimchar, aiming at fixing the left bank of the Lower Meghna in its present position.

At this stage of the study, only a preliminary economic assessment of of the long term protection scheme for the left bank of the Lower Meghna could be prepared. The basis of the assessment is provided by the sustained protection works for Chandpur town in combination with the short term protection works at Eklashpur and Haimchar and completed by protection works in the intermediate zone.

The methodology followed for the economic assessment of the long term bank protection scheme is largely based on data used for the calculation of economics of protecting Chandpur, Eklashpur and Haimchar. Hence, reference is made to chapters F.2, F.5, F.6 and F.7 of this Annex.

F.10.1.2 Area covered

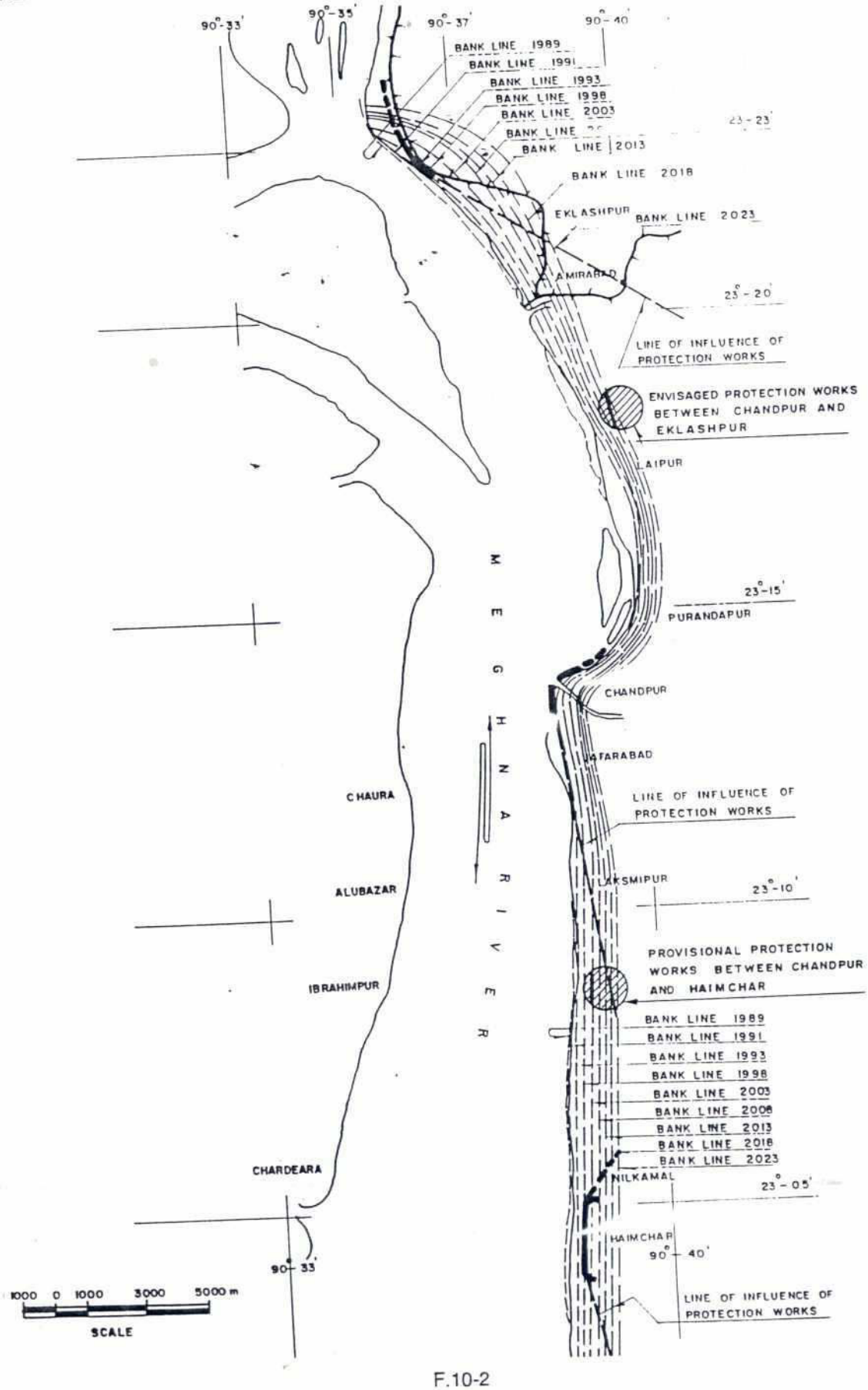
The feasibility assessment covers the left bank of the Lower Meghna where river bank protection and river training works are envisaged which are aimed at keeping the river within it present bed. The area covered ranges from the confluence of the Meghna and Padma just north of Eklashpur to Haimchar some 10 km south of Chandpur. Figure F.10.1 provides an overview of the area involved.

F.10.2 Alternatives for protection

The construction of long term protection works for the left bank of the Lower Meghna comprise a series of bank protection and river training structures. As a result of the preliminary nature of the analysis only one alternative was investigated which consists of the following works:

(a) Protection of the existing bank at Eklashpur to be executed in 1993, 1998 and 2005.
(b) Protection works between Eklashpur and Chandpur, envisaged for the year 2002.
(c) Sustainable town protection at Chandpur, first phase in 1993 and additional works to be executed in and 2003 and 2018.
(d) Protection between Chandpur and Haimchar, planned for the year 2002.
(e) Guide bund protection works at Haimchar to be executed in 1993, 1998 and 2008.

FIGURE F.10.1 AREA COVERED BY THE LOWER MEGHNA ECONOMIC ASSESSMENT



F.10.3 **Benefits of protection**

F.10.3.1 **Protection of Chandpur**

Reference is made to section F.5.4 of this annex. The following paragraph summarizes the results of the calculation of benefits for protection of Chandpur town.

(i) Savings on repair and maintenance, damage and loss

Based on total economic repair and maintenance expenses and cost of erosion damage for the recent past expected savings as a result of protection works are calculated. It is assumed that the annually recorded and estimated economic repair and maintenance expenses and cost of erosion damage have an extreme value distribution. The annual figures are ranked in size and a frequency is assigned in agreement with their ranking. The expenses are then correlated with their respective frequency by fitting the Gumbel extreme value probability functio.. In agreement with the FPCO-guidelines the mathematical expectation of avoidable cost can be calculated.
The mathematical expectation ...nual avoidable costs due to repair, maintenance, loss, damage and lost profits, is evaluated at Tk. 86 million economically. Of this Tk. 15 million refer to repair and maintenance expenses, while Tk. 71 million are the result of avoidable losses and damage to structures and economic activities. Details are presented in section F.5.4.4.
As a result of ongoing erosion over the years the expected value of the annual avoidable costs identified above are assumed to increase. Savings in repair and maintenance expenses are likely to increase by a 10% per annum, while avoidable losses and damage to structures and net economic returns increase by 3% per annum. This increase is not related to changes in the prices of commodities, but reflects merely aspects related to ever increasing cost to protect Chandpur, as well as population growth and increase of economic activity.

(ii) Railway complex and IWTA terminal

Protection of the town of Chandpur would avoid the engulfment of the railway complex and the IWTA terminal. Details of the cost avoided are presented in chapter F.5, section F.5.4.5. Benefits range between Tk. 1.4 million per year and Tk. 4.7 million per year depending on the stage of erosion.

(iii) Agricultural benefits

The agricultural benefits as a result of protection works at Chandpur are associated with the protection of arable land of the Meghna-Dhonagoda ar ! Chandpur Irrigation projects upstream and downstream of Chandpur due to the permanent bank protection works proposed in the project. In agreement with the FPCO-guidelines the benefits ...t from a reduction of net agricultural revenues lost and loss of irrigation infra-structure or land due to erosion. Details are presented in section F.5.4.5 of this annex and are summarized in Tables F.5.9 and F.5.10.

F.10.3.2 **Protection Eklashpur**

A detailed discussion of benefits related to protection works in Eklashpur is provided in section F.6.4. This section summarizes the results.

(i) Savings on repair and maintenance

Without any protection works a retirement of the embankment is foreseen every five years from 1998 onwards. Because only small sections of the embankment are renewed, emergency protection cannot be neglected altogether. Based on the considerable amount spent by the BWDB in 1990/91, we expect that annual amounts for repair and maintenance will rapidly increase. For the 1991 situation an anual repair and maintenance budget of Tk. 2.6 million has been estimated. This value is expected to increase annually by about 10%.

(ii) Relocation of pump station

One pump station of the Meghna-Dhonagoda irrigation project is located at a spot which could be eroded by the river in the year 1998, according to the results of the geo-morphological study. A relocation of this pump station to a site more inland is needed. The estimated economic cost for relocation of the pump station are Tk. 32.4 million.

(iii) Retirement of embankments

As the river bank shifts towards the east, it will destroy the existing embankment. From the results of the geo-morphological study (see Annex B) it could be estimated how far the bank line will recede. The without-project scenario foresees that every five years a new stretch of embankment must be constructed in order to protect the Meghna-Dhonagoda irrigation project. Because, no new retired embankment construction is required if the proposed protection works are implemented, the cost figures from the table are savings. Hence, they represent expected benefits. A summary is given in Table F.6.2.

(iv) Damage and loss to public and private property

River bank erosion will cause loss of buildings and damage to existing structures. Already inhabitants have moved their homes more inland to protect them from the water of the Meghna. However, there remain a considerable number of houses and commercial buildings in the area prone to erosion. for details on the avoidable damage and destruction to urban structure reference is made to section F.6.4.4. In Table F.6.3 the balance of damage to and destruction of urban assets ara presented for the with- and without scenarios.

(v) Agricultural benefits

Agricultural benefits are associated with protection of arable land which would otherwise be lost as a result of bank migration. Behind the embankment one finds mainly irrigated lands, while outside the embankment non-irrigated cropping takes place. Hence, for economic feasibility analysis it has been assumed that irrigated agriculture takes place inside the embankment and non-irrigated agriculture outside it. Details on the agricultural benefits are presented in section F.6.4.5 and reference is made to Table F.6.5.

F.10.3.3 **Protection of Haimchar**

A detailed discussion of benefits related to protection works in Eklashpur is provided in section F.7.4. This section summarizes the outcome.

(i) Savings on repair and maintenance

Maintenance and repair of the embankments of the Chandpur irrigation project is carried out each year by the BWDB. In the past the allocated amount has been very small. However, a retirement of the embankment is foreseen every five years from 1993 onwards. Because only small sections of the embankment are renewed, emergency protection and repair cannot be neglected altogether. Similar estimates as made for Eklashpur were made for the annual amount to be spend on repair and maintenance of the non-sustainable bank protection works on Haimchar in the without-scenario. An annual expenditure of Tk. 2.4 million has been estimated. This amount is expected to increase by an annual 10%.

(ii) Retirement of embankments

As the river bank shifts towards the east, it will destroy the existing embankment. From the geo-morphological survey results it could be estimated how far the bank line will progress. The without-project scenario foresees that every five years a new stretch of embankment must be constructed in order to protect the Chandpur irrigation project. Reference is made to Table F.7.2 for details on the cost

of the retired embankments envisaged. Because no new retired embankment construction is required if the proposed river training or protection works are implemented, the cost figures from the table are savings. Details are presented in section F.7.4.2 of this annex.

(iii) Damage to and loss of public and private infrastructure

River bank erosion has caused loss of buildings and damage to existing structures in the recent past. Already inhabitants have moved their homes more inland to protect them from the water of the Meghna. However, a considerable number of houses and commercial buildings in the area is still prone to erosion. In section F.7.4.3 and Table F.7.3 the balance of damage to and destruction of houses and commercial buildings has been presented for the with- and without-scenarios.

(iv) Agricultural benefits

Agricultural benefits are associated with protection of arable land which would otherwise be lost as a result of bank migration. In agreement with the FPCO-guidelines the agricultural benefits of river training and bank protection works result from reduction of net agricultural revenues lost due to erosion of arable land. Based on the results of the geo-morphological survey for the area, the change of the river bank position could be forecast for scenarios with and without investments.

Table F.7.5 provides details of total agricultural benefits on lands prone to erosion covering the 30-year period of the feasibility study. In the table with and without-project scenarios are compared. Benefits of river training works are given by the balance, which represents the reduction in losses to cropping. More details can be found in section F.7.4.4 of this annex.

F.10.3.4 **Protection of the intermediate zone**

The calculation of benefits in the intermediate zone comprises reduced losses to urban infra-structure and agriculture. Based on the results of the geo-morphological study it has been estimated that without protection 1,200 ha would be lost from the year 2002 until 2022. The annual losses are estimated as the average yearly erosion between 2002 and 2022, which is 57 ha per year. It is assumed that there is no need for retirement of the embankments of the Meghna-Dhonagoda and Chandpur Irrigation Projects.

(i) Damage to and loss of urban infra-structure

As everywhere in Bangladesh the population lives along the river banks, where at regular intervals one finds clusters of houses. Often such clusters form a village with a small market. Although many houses will be moved when the waters of the Meghna rise, damage to and loss of structures are still to be expected every year. Protection against bank erosion will prevent the loss of houses and market infra-structure. The benefits as a result of avoidable losses in urban infra-structure are calculated in the same manner as for Eklashpur or Haimchar. Table F.10.1 provides a summary of these losses for the whole of the Lower Meghna.

(ii) Agricultural benefits

Agricultural benefits are associated with protection of arable land which would otherwise be lost as a result of bank migration. In agreement with the FPCO-guidelines the agricultural benefits of river training and bank protection works result from reduction of net agricultural revenues lost due to erosion of arable land. Most of the lands prone to erosion form part of the Meghna-Dhonagoda and Chandpur Irrigation projects.
The production value and rental value of land lost as a result of erosion is based on the assumption that the average of those values for Eklashpur and Haimchar give a good estimate of the values for the intermediate zone. Based on the annual loss of 57 ha per year between 2002 and 2022, the avoidable agricultural losses are calculated. Table F.10.2 summarizes the total losses to the agriculture for the Lower Meghna.

TABLE F.10.1 VALUE OF DESTRUCTED BUILDINGS AND URBAN INFRA-STRUCTURE FOR THE LOWER MEGHNA

PRICES: constant mid-1991 economic prices
UNIT: Tk x 1M

	EKLASH.	HAIM.	INTERMEDIATE ZON		TOTAL
Year	Total	Total	Area(ha)	U.assets	
1993	1.4	0.0	0.0	0.0	1.4
1994	2.1	0.0	0.0	0.0	2.1
1995	2.1	0.0	0.0	0.0	2.1
1996	2.1	0.0	0.0	0.0	2.1
1997	2.1	0.0	0.0	0.0	2.1
1998	2.1	0.0	0.0	0.0	2.1
1999	23.4	4.2	0.0	0.0	27.6
2000	23.4	4.2	0.0	0.0	27.6
2001	23.4	4.2	0.0	0.0	27.6
2002	23.4	4.2	57.1	4.6	89.3
2003	23.4	4.2	57.1	4.6	89.3
2004	35.9	16.7	57.1	4.6	114.4
2005	35.9	16.7	57.1	4.6	114.4
2006	35.9	16.7	57.1	4.6	114.4
2007	35.9	16.7	57.1	4.6	114.4
2008	35.9	16.7	57.1	4.6	114.4
2009	18.8	14.9	57.1	4.6	95.5
2010	18.8	14.9	57.1	4.6	95.5
2011	18.8	14.9	57.1	4.6	95.5
2012	18.8	14.9	57.1	4.6	95.5
2013	18.8	14.9	57.1	4.6	95.5
2014	30.1	24.7	57.1	4.6	116.5
2015	30.1	24.7	57.1	4.6	116.5
2016	30.1	24.7	57.1	4.6	116.5
2017	30.1	24.7	57.1	4.6	116.5
2018	30.1	24.7	57.1	4.6	116.5
2019	48.9	33.0	57.1	4.6	143.6
2020	48.9	33.0	57.1	4.6	143.6
2021	48.9	33.0	57.1	4.6	143.6
2022	48.9	33.0	57.1	4.6	143.6
SUM	748.8	434.6	1 200.0	95.9	2 479.3

Notes:
1) Table does not cover Chandpur town protection
2) Tk. 0.799 x 1000 per sq.m is the estimated average value of urban infra-structure and buildings
3) At 10% is estimated the urbanised area

F.10.4 Cost of protection works

F.10.4.1 Investment cost

Total investment cost for the Lower Meghna are high, although not all investments are made in the same year; implementation is staggered. The first part of protection works is constructed as short term protection in 1993. In later years more works are carried out in order to guarantee a long term sustainable bank protection of the Lower Meghnad. Table F.10.3 provides details on the investment cost and the year construction would take place. It is noted that an additional investment of Tk. 270 million might be required between Eklashpur and Chandpur in the year 2002. This will reduce the EIRR by about 1%.

TABLE F.10.2 AGRICULTURAL BENEFITS FOR THE LOWER MEGHNA

PRICES: constant mid-1991 economic prices
UNIT: Tk x 1M

Year	CHANDPUR:		EKLASH.	HAIM.	INTERMEDATE ZONE:			TOTAL
	Upstr.	Downstr.	Total	Total	Area(ha)	Prod(CUM	Infra/land	
1993	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1
1994	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.4
1995	0.0	0.3	0.2	0.0	0.0	0.0	0.0	0.5
1996	0.0	0.3	0.2	0.0	0.0	0.0	0.0	0.5
1997	0.0	0.4	0.2	0.0	0.0	0.0	0.0	0.6
1998	0.0	0.4	0.2	0.0	0.0	0.0	0.0	0.7
1999	0.0	0.8	2.0	0.3	0.0	0.0	0.0	3.1
2000	0.3	0.9	2.2	0.3	0.0	0.0	0.0	3.7
2001	0.3	1.0	2.5	0.4	0.0	0.0	0.0	4.2
2002	0.4	1.1	2.8	0.4	57.1	0.6	3.9	66.2
2003	0.4	1.1	3.1	0.4	57.1	1.2	3.9	67.3
2004	0.5	1.8	4.2	1.5	57.1	1.8	3.9	70.8
2005	0.7	2.0	4.6	1.7	57.1	2.4	3.9	72.4
2006	0.8	2.1	5.0	1.9	57.1	3.0	3.9	73.9
2007	0.9	2.3	5.5	2.1	57.1	3.6	3.9	75.3
2008	0.9	2.5	5.9	2.3	57.1	4.2	3.9	76.8
2009	1.1	3.1	5.0	2.3	57.1	4.8	3.9	77.4
2010	2.2		5.2	2.5	57.1	5.4	3.9	79.7
2011	2.4	3.6	5.5	2.6	57.1	6.1	3.9	81.1
2012	2.6	3.8	5.7	2.8	57.1	6.7	3.9	82.5
2013	2.8	4.0	5.9	3.0	57.1	7.3	3.9	83.9
2014	3.0	4.5	7.1	3.9	57.1	7.9	3.9	87.4
2015	3.5	4.8	7.4	4.1	57.1	8.5	3.9	89.4
2016	3.8	5.1	7.8	4.4	57.1	9.1	3.9	91.1
2017	4.0	5.3	8.2	4.7	57.1	9.7	3.9	92.9
2018	4.2	5.6	8.5	5.0	57.1	10.3	3.9	94.7
2019	4.6	6.3	10.2	5.8	57.1	10.9	3.9	98.8
2020	5.5	6.7	10.7	6.2	57.1	11.5	3.9	101.6
2021	5.8	7.0	11.3	6.6	57.1	12.1	3.9	103.8
2022	6.2	7.3	11.9	7.0	57.1	12.7	3.9	106.1
SUM	56.9	87.7	149.2	72.1	1 200.0	139.8	81.1	1 786.8

Notes:
1) Total 1 200 ha land is saved as result of river training between Eklashpur and Chandpur-upstream and between Chandpur-downstream and Haimchar (intermediate zone)
2) Tk. 6 031 per ha is the value of irrigation infra-structure based on an analysis of data from SERWRDP (FAP5)
3) Tk. 10 591 per ha is the economic production value of lands in the intermediate zone
4) Tk. 61 570 per ha is average rental value of lands in the in the intermediate zone

F.10.4.2 Monitoring and maintenance cost

Monitoring and maintenance of river training works is an important component, which affects directly the long term effectiveness of protection against bank erosion. They form an integral part of protection works and the rate of failure of structures may increase rapidly in the future if maintenance works are carried out poorly.

TABLE F.10.3 SUMMARY OF INVESTMENT COST FOR THE LOWER MEGHNA

PRICES: mid-1991 economic prices
UNIT: Tk. x 1M

Protection	Year investm.	Total cost	Annual maint.	Annual monitor.	Total
Chandpur town	1993	2 075.5	19.0	2.0	21.0
Haimchar (1st part)	1993	314.6	3.8	2.0	5.8
Eklashpur (1st part)	1993	290.3	3.5	2.0	5.5
Eklashpur (2nd part)	1998	236.5	2.8	2.0	4.8
Haimchar (2nd part)	1998	236.5	2.8	2.0	4.8
Chandpur (length 400m)	2003	216.0	2.6	2.0	4.6
Eklashpur (3rd part)	2005	236.5	2.8	2.0	4.8
Haimchar (3rd part)	2008	299.1	3.6	2.0	5.6
Total		3 904.9	40.9	16.0	56.9

Notes:
1) Maintenance % based on average of detailed designs:
   average for LME investmen 1.20%
2) Compounded conversion factor for changing financial prices into economic prices is 0.8

Monitoring comprises regular inspection of structures as well as topographic and bathymetrical measurements. The annual cost of monitoring is estimated at Tk. 2.0 million per year (mid-1991 economic prices) per site. With protection works for which a detailed design and costing was prepared, annual maintenance is estimated at 4% of surface components, e.g. open stone asphalt, fascine mattress, boulders in falling apron and grouting of boulders. Annual maintenance for all other protection works was estimated from total investments by using the fraction of respective maintenance in total cost of works with a detailed design and costing. Details of monitoring and maintenance expenditure are provided in Table F.10.3.

F.10.4.3 Budgetary implications

Monitoring and maintenance expenditure for river training works must normally be met by the national budget. Assuming a general level of price increase of 10% per annum, means that the cost met by the budget increase substantially over the years. As a result of staggered investments in protection works for the Lower Meghna, these cost increase dramatically. Annual monitoring and maintenance cost in current prices are calculated as follows:

- 1993: Tk. 39.3 million
- 1998: Tk. 82.3 million
- 2008: Tk. 289 million

F.10.5 Economic feasibility assessment

F.10.5.1 Cash flow

The cash flow computation makes a comparison between benefits and cost of river training works for the Lower Meghna, covering the 30-year evaluation period. The benefit and cost have been discussed in detail in the previous sections. For reasons already explained in e.g. Chapter F.2, it has been assumed that the avoidable maintenance and repair expenses increase annually by 10%. This increase is justified by the ever increasing cost of protecting land against the water of the Meghna in the present situation without sustainable river bank protection. Other benefits associated with population growth and increas-

ing economic activities have been assumed to increase by 3% per year. This reflects the economic growth of Bangladesh, which was between 3 and 4% over the last planning period.

Table F.10.4 provides the outcome of the cash flow calculation. The figures in rows for town protection benefits and avoidable repair and maintenance expenses are higher than the mid-1991 economic values; they have been increased with the annual growth percentage for the respective years of the cash flow. Moreover, the method of calculation and the table require no further explanation.

TABLE F.10.4 ECONOMIC CASH FLOW FOR LOWER MEGHNA RIVER BANK PROTECTION

PRICES: mid-1991 economic prices
UNIT: Tk. x 1 million
STARTING 1993
CONSTR: 1 years

EIRR: 6.69% NPV: -1313.5 NPVR1: -0.34

	WITH-PROJECT SITUATION COST:				PROJEC. BENEFITS:						CASH	Cash F.
Year	Invest.	S&M	Other	Total	T.prot.	BR/IWTA	Rep/maint.	Nw.emb.	Rural	Total	FLOW	(US$x1M)
1993	2680.3	32.3	2.7	[illegible]				9.4		9.4	-2705.8	-75.2
1994		32.3	[illegible]	34.9	77.8	3.8	26.5		2.5	110.6	75.7	2.1
1995		32.3	2.7	34.9	80.1	3.8	29.2		2.6	115.7	80.8	2.2
1996		32.3	2.7	34.9	82.5	3.8	32.1		2.6	121.1	86.2	2.4
1997		32.3	2.7	34.9	85.0	3.8	35.3		2.7	126.9	91.9	2.6
1998	473.0	41.9	3.2	518.1	87.6	4.7	38.9	66.1	2.8	200.0	-318.1	-8.8
1999		41.9	3.2	45.1	90.2	4.7	42.8		30.7	168.3	123.3	3.4
2000		41.9	3.2	45.1	92.9	4.7	47.0		31.3	176.0	130.9	3.6
2001		41.9	3.2	45.1	95.7	4.7	51.7		31.8	183.9	138.8	3.9
2002	0.0	41.9	3.2	45.1	98.6	4.7	56.9		155.5	315.7	270.6	7.5
2003	216.0	46.5	3.4	265.9	101.5	4.0	62.6	49.3	156.6	374.0	108.2	3.0
2004		46.5	3.4	49.9	104.6	4.0	68.9		185.1	362.6	312.7	8.7
2005	236.5	51.8	3.6	291.9	107.7	4.0	75.7		186.8	374.3	82.3	2.3
2006		51.8	3.6	55.4	110.9	4.0	83.3		188.3	386.5	331.1	9.2
2007		51.8	3.6	55.4	114.3	4.0	91.7		189.7	399.6	344.2	9.6
2008	299.1	58.0	3.9	360.9	117.7	1.5	100.8	59.5	191.2	470.7	109.7	3.0
2009		58.0	3.9	61.9	121.2	1.5	110.9		172.8	406.4	344.6	9.6
2010		58.0	3.9	61.9	124.8	1.5	122.0		175.1	423.5	361.6	10.0
2011		58.0	3.9	61.9	128.6	1.5	134.2		176.5	440.8	378.9	10.5
2012		58.0	3.9	61.9	132.4	1.5	147.6		178.0	459.5	397.6	11.0
2013		58.0	3.9	61.9	136.4	1.4	162.4	86.9	179.4	566.5	504.7	14.0
2014		58.0	3.9	61.9	140.5	1.4	178.6		203.9	524.4	462.5	12.8
2015		58.0	3.9	61.9	144.7	1.4	196.5		205.9	548.5	486.6	13.5
2016		58.0	3.9	61.9	149.1	1.4	216.1		207.6	574.3	512.4	14.2
2017		58.0	3.9	61.9	153.5	1.4	237.7		209.4	602.1	540.2	15.0
2018		58.0	3.9	61.9	158.1	2.1	261.5	117.5	211.1	750.3	688.5	19.1
2019		58.0	3.9	61.9	162.9	2.1	287.7		242.4	695.1	633.2	17.6
2020		58.0	3.9	61.9	167.8	2.1	316.4		245.3	731.6	669.7	18.6
2021		58.0	3.9	61.9	172.8	2.1	348.1		247.5	770.5	708.6	19.7
2022		58.0	3.9	61.9	178.0	2.1	382.9		249.7	812.7	750.8	20.9
SUM	3904.9	1488.9	[illegible]	5499.1	3518.0	84.0	3946.1	388.7	4264.7	12201.5	6702.4	186.2

Notes:

1) INVESTMENT COST:	1993	1998	2002	2003	2005	2008
Tk. x 1M	2 680.3	473.0	0.0	216.0	236.5	299.1
2) S&M COST (Tk. x 1M):	32.3	9.7	0.0	4.6	4.8	5.6

3) OTHER COST:
As % investments 0.1%

4) BENEFITS (Tk. x 1M):
Protection Chandpur town 71.2
Annual increase 3%
Savings repair/maintenance:
Chandpur 15.2
Eklashpur 2.6
Haimchar 2.1
Annual increase repair/maintenance: 10%

5) Conversion US$ 1 = Tk. 36

F.10.5.2 **Economic Internal Rate of Return**

The Economic Internal rate of Return (EIRR) is evaluated by comparing the discounted value of benefit and cost. The EIRR is the interest rate at which the discounted values of benefits and costs over the 30-year evaluation period are in balance.
The bank protection scheme for the whole Lower Meghna give an EIRR of about 7%%. This means that the benefits are sufficient to offset the cost. As has already been mentioned in section F.10.4.1 the EIRR will reduce to about 6% when an additional investment of Tk. 270 million will be required in the year 2002 to provide an additional hard point between Eklashpur and Haimchar.

F.10.5.3 **Net Present Value**

The economic net present value of the bank protection scheme for the Lower Meghna, evaluated at a discout rate of 12%, is negative (Tk. -658 million). The NPVR ratio as required by the FPCO-guidelines can be calculated at -0.17.

F.10.6 **Sensitivity analysis**

The preliminary assessment of the bank protection scheme is based on uncertain future events and imperfect data. Therefore, a sensitivity analysis is presented. This implies an analysis of the economic internal rate of return as function of changes in investment cost, monitoring and maintenance expenditure and estimated value of benefits. Details are provided in Table F.10.5 and Figures F.10.2 to F.10.4.

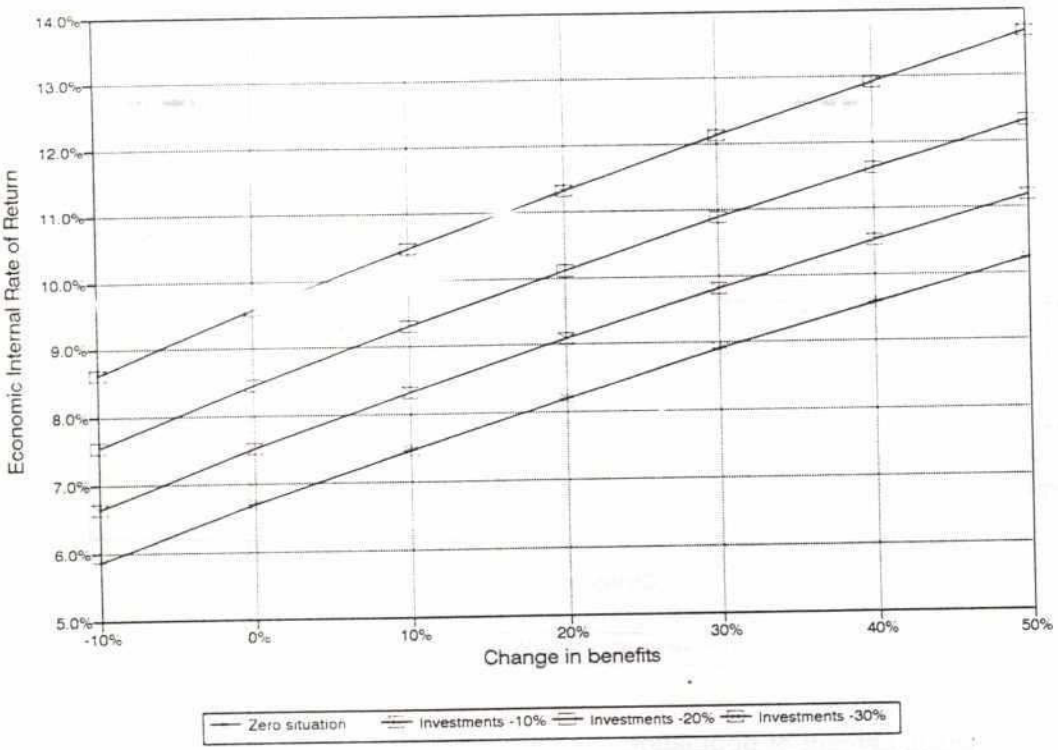
TABLE F.10.5 SENSITIVITY ANALYSIS LOWER MEGHNA

VALUES: Economic Internal Rate of Return (EIRR)
UNIT: percent

Change	CHANGE IN BENEFITS:						
investm.	-10%	0%	10%	20%	30%	40%	50%
-30%	8.62%	9.57%	10.47%	11.32%	12.13%	12.92%	13.67%
-20%	7.55%	8.46%	9.30%	10.11%	10.87%	11.61%	12.32%
-10%	6.65%	7.51%	8.32%	9.09%	9.82%	10.52%	11.19%
0%	5.86%	6.69%	7.47%	8.21%	8.91%	9.58%	10.22%
10%	5.17%	5.97%	6.73%	7.44%	8.12%	8.76%	9.38%
20%	4.55%	5.33%	6.07%	6.76%	7.42%	8.04%	8.64%
30%	3.99%	4.76%	5.48%	6.15%	6.79%	7.40%	7.98%

Change	CHANGE IN BENEFITS:						
M&M	-10%	0%	10%	20%	30%	40%	50%
-30%	6.16%	6.99%	7.76%	8.50%	9.19%	9.86%	10.50%
-20%	6.06%	6.89%	7.67%	8.40%	9.10%	9.76%	10.40%
-10%	5.96%	6.79%	7.57%	8.31%	9.00%	9.67%	10.31%
0%	5.86%	6.69%	7.47%	8.21%	8.91%	9.58%	10.22%
10%	5.76%	6.59%	7.38%	8.12%	8.82%	9.49%	10.13%
20%	5.66%	6.49%	7.28%	8.02%	8.72%	9.40%	10.04%
30%	5.55%	6.40%	7.18%	7.93%	8.63%	9.30%	9.95%

FIGURES F.10.2 AND F.10.3 RESULTS OF SENSITIVITY ANALYSIS FOR THE LOWER MEGHNA



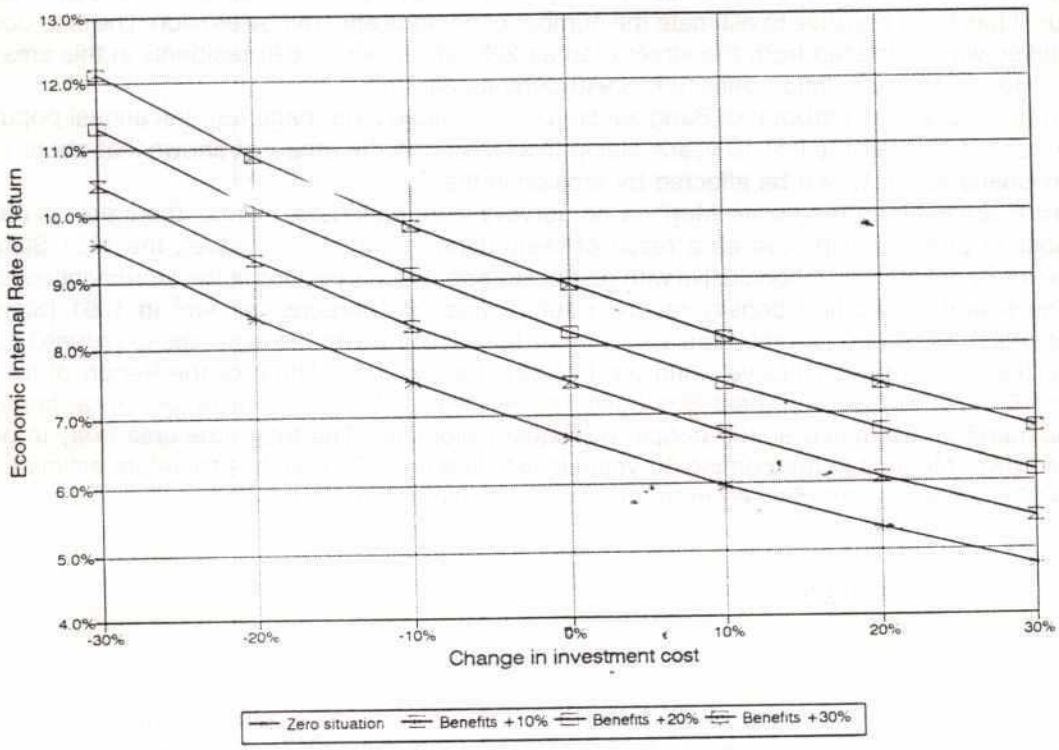
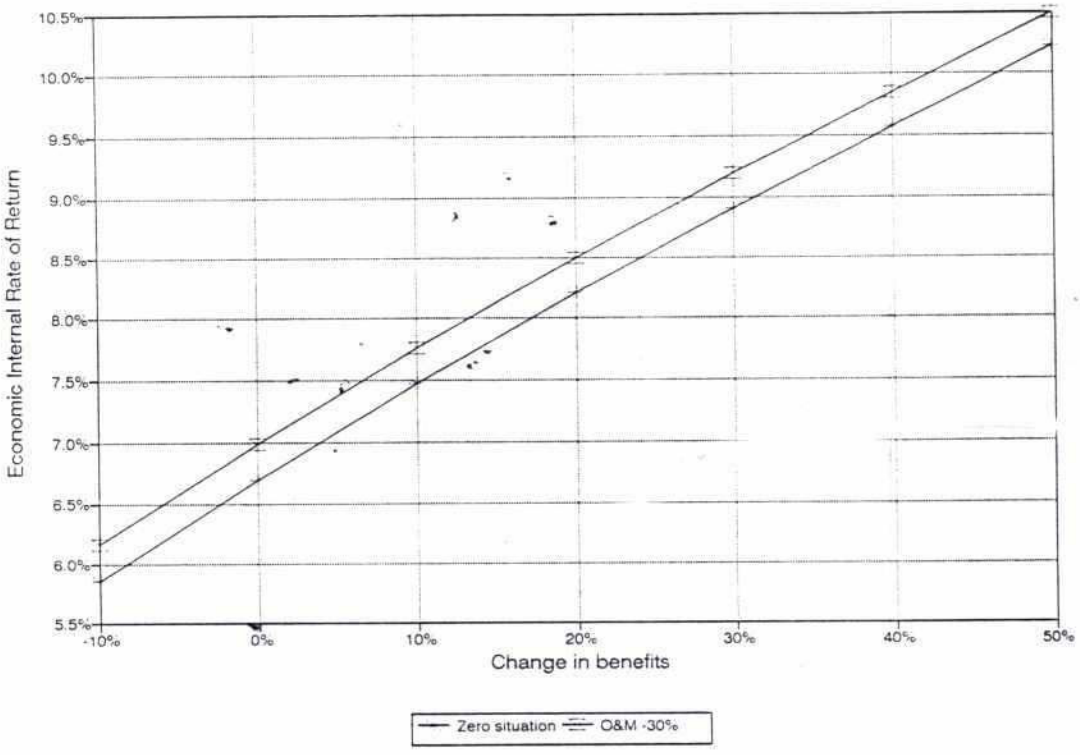


FIGURE F.10.4 RESULTS OF SENSITIVITY ANALYSIS FOR THE LOWER MEGHNA



F.10.7 Displacement of population

Based on the result of the socio-economic survey and the migration of the bankline in the town area of Chandpur, it has been possible to estimate the number of persons affected by erosion. The area covered by the survey was estimated from the street map as 293,000 m^2 and 2,620 residents in this area were identified. Hence, the population density is 8,940 persons per km^2.
Based on the Statistical Yearbook of Bangladesh for 1991 (table 2.08, page 45), the annual population increase was 2.17% over the last 10 years. Using this factor and the area lost shows that about 17,000 people in Chandpur Town will be affected by erosion in the coming 30 years.
For the rural areas along the Lower Meghna no surveys were executed. Hence, there are no data for the number of persons displaced as a result of likely bank migration. Moreover, the 1991 Statistical Yearbook for Bangladesh is inconclusive with respect to population densities in the aforementioned rural areas. The overall population density for the country was 750 persons per km^2 in 1991 (Statistical Yearbook 1991). Present day rural population counts for about 70% and is expected to reduce to about 50% over the project period ('Developing the Infrastructure, Volume Three of the Report of the Task Forces on Bangladesh Development Strategies for the 1990's' 1991). The averaged rural population density is therefore estimated at 400 people per square kilometer. The total rural area likely to be lost along the Lower Meghna in the coming 30 years is estimated at 3,570 ha. It is therefore estimated that about 14,000 people will be affected in the rural areas outside Chandpur Town.

F.10.8 Conclusions

The conclusions from this preliminary economic assessment read:

(i) Although protection of the whole Lower Meghna gives an EIRR below the opportunity cost of capital, the assessed rate might be considered as acceptable for this type of infrastructural works.

(ii) A more detailed study is justified and required to provide more substantiated conclusions.

ANNEX F

APPENDIX F/1

Basic Data

Appendix F/1 BASIC DATA

F/1.1 Introduction

The economic feasibility analysis of protection works in the project locations under review is based on surveys and field observations. Key indicators obtained from survey results and field observations were imputed in the economic evaluation. This appendix gives first results of the socio-economic surveys executed in the areas prone to erosion in Bhairab Bazar, Munshiganj and Chandpur. Subsequently, the appendix records information from other sources and gives insight into the calculation of used unit values.

For some of the project locations no specific economic information was available at the time of execution of the feasibility studies. Hence, the study team has made an effort to collect much of these information in the locations itself. Consequently, the team opted for an approach where the economic feasibility analysis is supported by a survey with coverage of key indicators, which is supplemented by information collected in a more informal way.

In the following paragraphs the results of the socio-economic surveys are presented, subsequently information collected from other sources is given, economic value of property, erosion damage to property. In the two final paragraphs repair cost to bridges and power supply is addressed.

F/1.2 Socio-economic surveys

F/1.2.1 General

For the feasibility study of the protection works in Bhairab Bazar, Munshiganj and Chandpur information is needed to evaluate the benefits and costs of the project. The cost estimates could be provided by the engineers designing the protection works. However, information on the benefit side must depend on data collected in the field.

The aim of data collection and surveys is to obtain up-to-date information on the damage to townships as result of erosion. This information forms the base for an assessment of benefits of bank protection works. It comprises:

(a) Collection of general information of erosion damage

The principal source of information for this part of the required information is the Upazila and the Municipality. Statistics of the Municipality may yield the information required. Otherwise the Upazila could provide information, but it covers the complete Upazila area, which is far larger than the Municipality. A correction would be needed then.

(b) Surveys of households and commercial enterprises in the zones prone to erosion by River Meghna

This activity is composed of the following distinct survey activities, notably:

(i) Count of the number of households and commercial/industrial enterprises in the areas prone to destruction.

(ii) Selection of a representative sample for further investigations;

(iii) Survey of the physical composition and economical value of constructions, economic indicators, demographic data and employment.

F/1.2.2 **Survey methodology**

For the design of a sample survey of households and commercial/industrial enterprises in the area prone to erosion by River Meghna no detailed base information is available. Only very old cadastral and town maps exist. They have, however, no virtual value to the study. Glob[illegible] plan maps of the areas bordering the river are available for Bhairab Bazar and Chandpur and, although they are not up-to-date, proved to be helpful for planning the surveys. For Munshigan[illegible] however, no maps at all were found.

In view of the unavailability of reliable maps and time constraints the approach for the survey was simplified. The first activity envisaged was a quick census of all households and commercial enterprises in the area under consideration. This provided a frame of the total number of households and commercial/industrial enterprises involved.

One can distinguish the following major types of trading activities, although there are variations for the three survey locations.

- dry chilly, onion and garlic;
- malease/sugar syrup;
- salt;
- retail shops (groceries, pharmacies);
- rice and grains;
- hardware;
- timber;
- betel leafs;
- many sorts of street vendors.

Then the information collected during the census was analyzed and regrouped in various homogenous strata. The individual commercial activities are an important charac[illegible] and have been chosen to form each a separate stratum. A representative sample of about 30 commercial enterprises and households hase been selected for further investigation.
Of each stratum a sample of up to three commercial/industrial activities or individual households was selected randomly for further analysis.

F/1.2.3 **Special survey feature Chandpur**

At the moment of the surveys it was not possible to evaluated the area likely to be eroded in the coming 30 years because the geo-morphological data were not yet available. Consequently, a much smaller area was surveyed, notably the area likely to disappear in the next 5 years. Survey details for this sub-sample were extrapolated for the total area likely to be affected if no protection is undertaken.

F/1.2.4 **Field work**

The survey required three questionnaires to be completed, comprising:

(i) Census questionnaire for the enumeration of all households and enterprises.

(ii) Form for assisting sample selection from the enumerated households and commercial enterprises.

(iii) Questionnaire for the survey of building materials, economic activities, population and employment.

Sample selection is the most critical phase in the survey process. It comprises the following steps:

(i) All the households and commercial enterprises from the census were grouped in strata. A stratum is defined as all those buildings with similar designation and/or economic activities. In practice this means that there will be different strata for:

- Habitations without commercial activities;
- Distinct commercial activities: e.g. retail shops, spice trade, timber trade, hardware shops, dried fish merchants, etc. (street vendors without fixed shops must not be include as their trade is so mobile that they can easily shift).

(ii) For each stratum the number of households or commercial/industrial enterprises to be visited during the sample survey was assessed by making use of the following table.

TABLE F/1.1 SAMPLE SIZE PER STRATUM

... per stratum	Sample size
< 10	1
10 - 30	2
> 30	3

In some instances it was not possible to complete the survey form because either the respondent did not want to cooperate, was absent or for any other reason failed to do so . The procedure followed was to take as replacement the next household or enterprise in the stratum column.

F/1.2.5 **Survey results Bhairab Bazar**

For the design of the survey in Bhairab Bazar, the extent of the erosion prone area of the town was determined on the available global street plan of the area bordering the river. Because this global street plan dated from a number of years ago, it had to be updated and redrawn. See Figure F/1.1.

The survey team comprising one economist and two survey assistants carried out the fieldwork from 21 April to 6 May, 1991. First they enumerated all the buildings within the area defined as prone to erosion, collecting name of the main occupant, address, use of the building, size of the land area and general nature of the construction; e.g. number of stories, type of materials used. Each building was given a number.

The census revealed that 85 buildings are used as habitation, 133 buildings are commercial enterprises and 16 buildings contain small industries. Within the survey area no large industrial estates are located. There were 4 hotels within the survey area. These have been treated as industrial enterprises in the calculation of results because investment in assets (furniture and equipment) is needed as is the case with industries. Moreover, there are only a limited number of combined buildings, which have a commercial or industrial enterprise on the ground floor and a home on the second floor.

After a critical analysis of the census results it was decided to define 14 strata for commercial enterprises and 4 strata for industrial enterprises. The number of buildings per stratum varied between 1 and 25 for commercial enterprises and between 1 and 7 for industrial enterprises. All habitations formed one stratum.
Sample selection was done randomly. The total size of the sample selected according to the criterium explained in the introduction to this chapter, was 30. This represents an overall sample fraction of 13%. For the individual large groups of buildings the sample fraction varied from 40% for small industries to 6% for habitations.

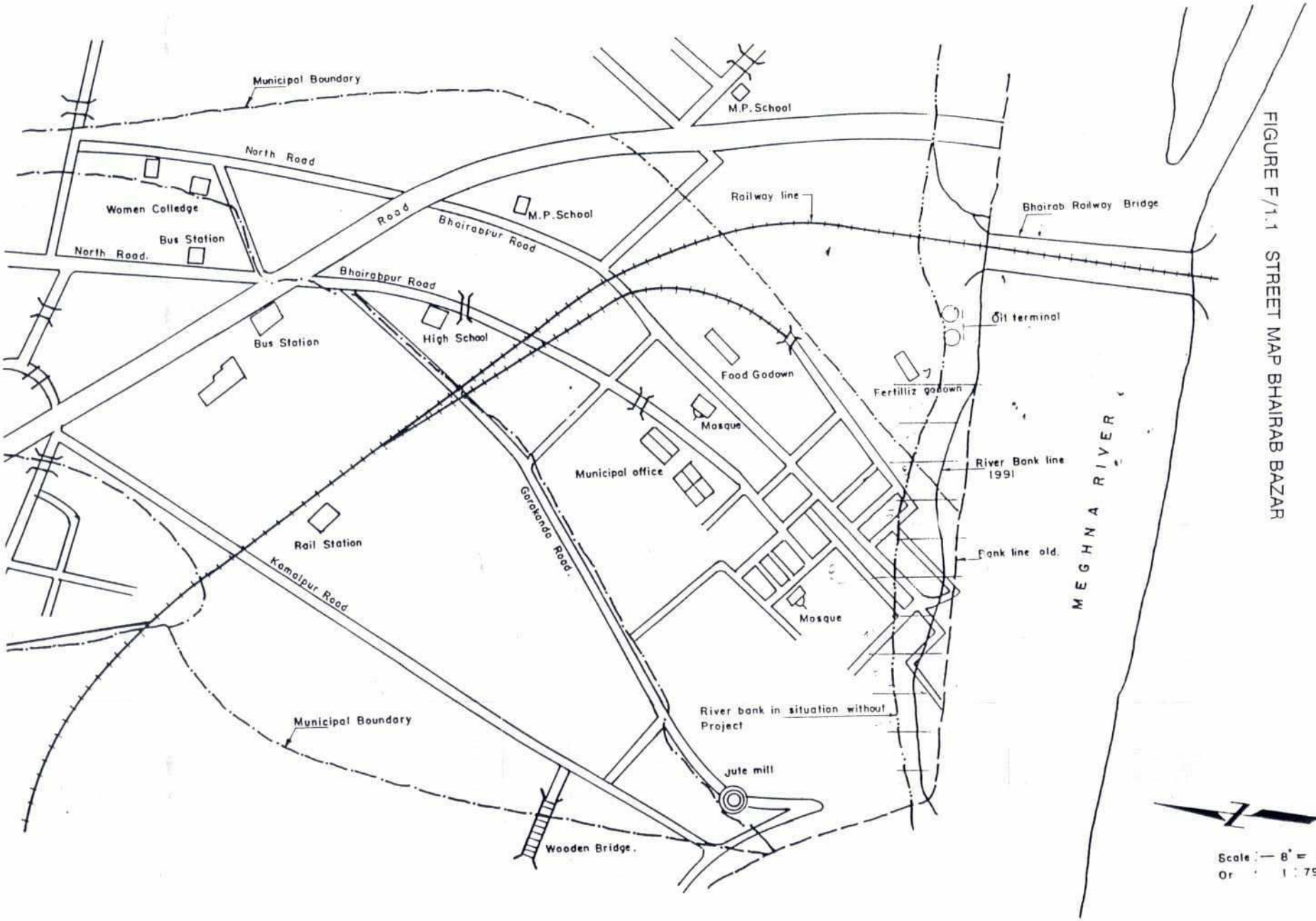


FIGURE F/1.1 STREET MAP BHAIRAB BAZAR

The number of habitants per buildings has been enumerated for the selected sample buildings. The total number of persons living in the area prone to erosion is calculated at 760 persons. The average number of persons per habitation is calculated at 8.

For each of the selected buildings area occupied and construction materials have been enumerated. The Resident Commissioner of Lands in Bhairab Bazar provided unit values for land in the town were, local shops provided unit prices for construction materials. Only material cost were enumerated, later in the analysis labour and other cost were included.

Table F/1.2 provides the results of the field work. Based on the results of the survey it can be calculated that the weighted average value of construction materials per building is Tk. 308.7 thousand for commercial buildings. Tk. 278.3 thousand for small industrial buildings and Tk. 141.8 thousand for habitations. With respect to the average value of land the data are Tk. 352.7 thousand for commercial buildings, Tk. 345.9 thousand for small industries and Tk. 62 thousand for habitations.

The selected commercial and industrial enterprises were visited during the survey in order to collect information on economic parameters. Results are published in table F/1.3. It is noted that compensation for the owner was not collected during the survey. The figure of Tk. 72 thousand per year was provided by the Planning Commission. From the table it can be calculated that the weighted average net returns per enterprises is Tk. 50.4 thousand per year.

Data on salaries, wages and persons permanently employed were also collected with the commercial and industrial enterprises. A total number of 750 persons are permanently employed in the area prone to erosion. Table F/1.4 provides details. Based on the wages paid one can estimate the number of man-hours this represents. The minimum wage is Tk. 7.5 per hour in Bangladesh. Hence the number of man-hours is 905 thousand per annum.

F/1.2.6 Survey results Munshiganj

For the design of the survey in Munshiganj, the extent of the erosion prone area of the town was determined on a sketch only as no maps could be obtained with either BWDB, the Municipality or the Upazila. This sketch (see Figure F/1.2) was moreover not to scale. Satellite images covering the town were of no use as their scale is far too large for drawing a street-plan. Hence, no accurate measurement of the total area prone to erosion could be made. A stretch of 300 to 500 metre bordering the river was considered as the area likely to be eroded in the coming 30 years and was chosen as area to be surveyed. As the economic analysis makes use of average values, this practice is fully acceptable.

The survey team comprising one economist and two survey assistants carried out the fieldwork from 11 to 26 May, 1991. First they enumerated all the buildings within the area defined as prone to erosion, collecting name of the main occupant, address, use of the building, size of the land area and general nature of the construction; e.g. number of stories, type of materials used. Each building was given a number.

The census revealed that 444 buildings are used as habitation, 31 buildings are commercial enterprises and 85 buildings contain industries. There are no combined buildings, which have a commercial or industrial enterprise on the ground floor and a home on the second floor.

After a critical analysis of the census results it was decided to define 4 strata for commercial enterprises and 5 strata for industrial enterprises. The number of buildings per stratum varied between 3 and 10 for commercial enterprises and between 3 and 42 for industrial enterprises. All habitations formed one stratum.

Sample selection was done randomly. The total size of the sample selected according to the criterium explained in the introduction to this chapter, was 19. This represents an overall sample fraction of 3%. For the individual large groups of buildings the sample fraction varied from 19% with commercial enter-

FIGURE F/1.2 STREET MAP OF MUNSHIGANJ

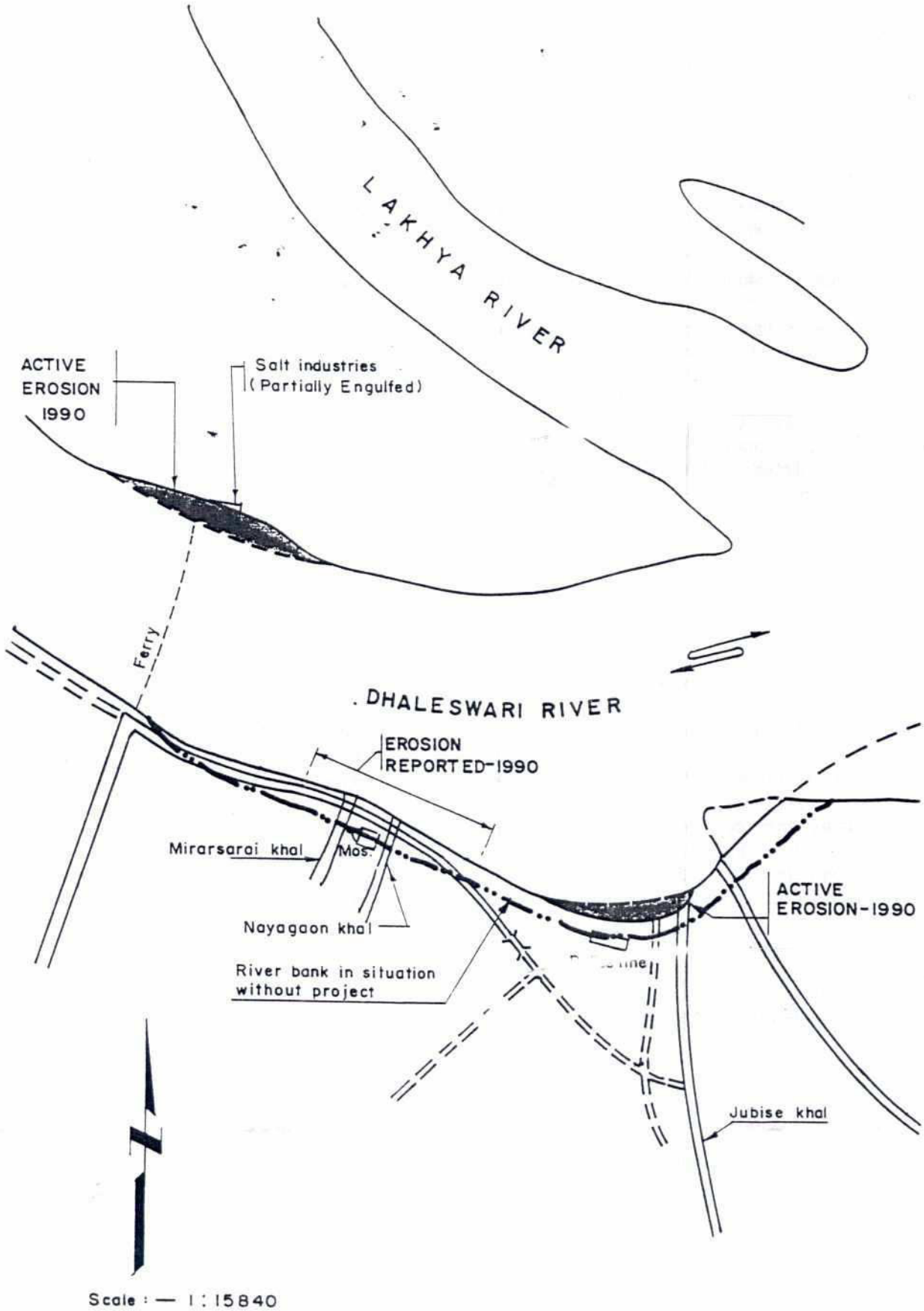


TABLE F/1.2 VALUE OF PROPERTY BHAIRAB BAZAR

PRICES: mid-1991 financial prices
UNIT: Tk. x 1,000

Stratum	Total number	Total sample	AVERAGE VALUE: Comm/ind	Habit.	Land	TOTAL	GRAND TOTAL: COMM/IN	HABIT.	LAND	TOTAL
Rice/paddy t.	5	1	823.6	536.4	647.9	2007.9	4 118	2 682	3 240	6 800
Kerosine/oil t.	6	1	161.8		182.0	343.8	971	0	1 092	971
Fertliser trade	2	1	158.2		65.0	223.2	316	0	130	316
Retail shops	10	2	522.7		692.4	1215.1	5 227	0	6 924	5 227
Onion/garlic/g.	14	2	196.4		217.5	413.9	2 749	0	3 045	2 749
Ground nut t.	1	1	149.1		325.0	774.1	449	0	325	449
Gossery shops	6	1	1 14.5		1665.0	2779.5	6 687	0	9 990	6 687
Salt trade	6	1	: 18.2		216.0	434.2	1 309	0	1 296	1 309
Tobacco trade	10	2	350.9		424.0	774.9	3 509	0	4 240	3 509
Molases trade	17	2	227.3		277.0	504.3	3 864	0	4 709	3 864
Dried chilly t.	10	2	493.6	243.6	468.0	1205.3	4 936	2 436	4 680	7 373
Rice/wh.bran t.	5	1	507.3		648.0	1155.3	2 536	0	3 240	2 536
Canned food t.	25	2	82.7		44.0	126.7	2 068	0	1 100	2 068
Timber trade	16	2	145.0		181.5	326.5	2 320	0	2 904	2 320
TOTAL COMM.ENTERP.	133	21	308.7	341.2	352.7	1002.7	41 061	5 118	46 915	46 179
Saw mill	7	1	138.2		451.0	589.2	967	0	3 157	967
Oil mill	1	1	554.5		625.0	1179.5	555	0	625	555
Drum factory	4	1	152.7		86.0	238.7	611	0	344	611
Hotel	4	1	580.0	414.5	352.0	1346.5	2 320	1 658	1 408	3 978
TOTAL INDUSTRIES	16	4	278.3	414.5	345.9	838.5	4 453	1 658	5 534	6 111
Habitations	85	5		141.8	62.0	203.8	0	12 055	5 270	12 055
GRAND TOTAL	234	30	194.5	181.1	246.7	868.8	45 514	18 831	57 719	64 345

Notes:
1) All figures for fin.year 1990/91
2) Construction materials represent 55% of construction cost

PRICES: mid-1991 financial prices
UNIT: Tk. x 1,000

Stratum	Total number	Total sample	AVERAGE ECONOMIC PERFORMENCE: Turn-over	Operat. expenses	Other expenses	Compens. owner	Net return	TOTAL ECONOMIC PERFORMENCE: TURN-OVER	OPERAT. EXPENS.	OTHER EXPENS.	COMP. OWNERS	NET RETURN
Rice/paddy t.	5	1	2697.0	2460.0	37.5	72.0	127.5	13 485	12 300	188	360	638
Kerosine/oil t.	6	1	1662.5	1411.0	40.5	72.0	139.0	9 975	8 466	243	432	834
Fertliser trade	2	1	751.0	655.0	21.0	72.0	3.0	1 502	1 310	42	144	6
Retail shops	10	2	470.7	307.4	44.3	72.0	47.0	4 707	3 074	443	720	470
Onion/garlic/g.	14	2	1065.0	956.0	24.0	72.0	13.0	14 910	13 384	336	1 008	182
Ground nut t.	1	1	968.0	834.0	37.0	72.0	25.0	968	834	37	72	25
Gossery shops	6	1	3128.0	2866.0	47.0	72.0	143.0	18 768	17 196	282	432	858
Salt trade	6	1	1206.0	1089.0	21.0	72.0	24.0	7 236	6 534	126	432	144
Tobacco trade	10	2	1304.5	1156.0	26.0	72.0	50.5	13 045	11 560	260	720	505
Molases trade	17	2	779.5	689.5	17.0	72.0	1.0	13 252	11 722	289	1 224	17
Dried chilly t.	10	2	848.5	723.5	34.0	72.0	19.0	8 485	7 235	340	720	190
Rice/wh.bran t.	5	1	1276.0	1078.0	39.0	72.0	87.0	6 380	5 390	195	360	435
Canned food t.	25	2	978.0	860.5	26.0	72.0	19.5	24 450	21 513	650	1 800	488
Timber trade	16	2	746.0	622.5	20.0	72.0	31.5	11 936	9 960	320	1 152	504
TOTAL COMM.ENTERP.	133	21	1121.0	981.0	28.2	72.0	52.1	149 [illegible]8	130 477	3 750	9 576	5 295
Saw mill	7	1	111.0	885.0	41.0	72.0	113.0	7 777	6 195	287	504	791
Oil mill	1	1	905.0	1616.0	54.0	72.0	63.0	1 805	1 616	54	72	63
Drum factory	4	1	24.0	432.0	19.0	72.0	1.0	2 096	1 728	76	288	4
Hotel	4	1	34.0	90.0	21.0	72.0	1.0	736	360	84	288	4
TOTAL INDUSTRIES	16	4	7 [illegible]5.9	618.7	31.3	72.0	44.5	12 414	9 899	501	1 152	862
GRAND TOTAL	149	25	1084.0	942.1	28.5	72.0	50.4	161 512	1[illegible]0 376	4 251	10 728	6 157

Notes:
1) All figures for fin.year 1990/91
2) Compensation for the owner is evaluated at Tk. 72,000 per annum

PRICES: mid-1991 financial prices
UNIT: Tk. x 1,000

Stratum	Total number	Total sample	AV. PER ENTERPR: Nbr. of workers	Paid salaries	Paid wages	ALL ENTERPRISES: NBR. OF WORKER	PAID SALARIES	PAID WAGES	TOTAL S & W
Rice/paddy t.	5	1	5	150.0	71.0	25	750	355	1 105
Kerosine/oil t.	6	1	4	108.0	67.0	24	540	402	942
Fertiliser trade	2	1	2	57.0	31.0	4	285	62	347
Retail shops	10	2	7	176.4		70	882	0	882
Onion/garlic/g.	14	2	6	105.0	68.0	77	525	952	1 477
Ground nut t.	1	1	7	107.0	68.0	7	535	68	603
Gossery shops	6	1	12	172.0	125.0	72	860	750	1 610
Salt trade	6	1	3	90.0	31.0	18	450	186	636
Tobacco trade	10	2	6	110.0	59.0	60	550	590	1 140
Molases trade	17	2	4	78.5	34.5	60	393	587	979
Dried chilly t.	10	2	6	109.5	66.0	55	548	660	1 208
Rice/wh.bran t.	5	1	6	112.0	72.0	30	560	360	920
Canned food t.	25	2	3	60.0	30.5	63	300	763	1 063
Timber trade	16	2	6	120.0	20.0	88	600	320	920
TOTAL COMM.ENTERP	133	21	5	111.1	57.2	652	7 777	6 054	13 831
Saw mill	7	1	6	120.0	85.0	42	600	595	1 195
Oil mill	1	1	8	240.0	75.0	8	1 200	75	1 275
Drum factory	4	1	2	36.0	16.0	8	180	64	244
Hotel	4	1	10	72.0		40	360	0	360
TOTAL INDUSTRIES	16	4	7	58.7		98	2 340	734	3 074
GRAND TOTAL	149	25	12	117.6	115.8	750	10 117	6 788	16 905

Notes:
1) All figures for fin.year 1990/91

prises to less than 1% with habitations. Although the sample size for habitations is somewhat on the low side, the information collected shows little variation.

The number of habitants per buildings has been enumerated for [illegible] sample buildings. The total number of persons living in the area prone to erosion is calculated at 4,260 persons. The average number of persons per habitation is calculated at 9.6.

For each of the selected buildings area occupied and construction materials have been enumerated. The Resident Commissioner of Lands in Munshiganj provided unit values for land in the town area. local shops provided unit prices for construction materials. Only material cost were enumerated, later in the analysis labour and other cost were included.

Table F/1.5 provides the results of the field work. Based on the results of the survey it can be calculated that the weighted average value of construction materials per building is Tk. 215.8 thousand for commercial buildings, Tk. 4.5 million for industrial buildings and Tk. 42.2 thousand for habitations. With respect to the average value of land the data are Tk. 316.3 thousand for commercial buildings, Tk. 700 thousand for industries and Tk. 33.3 thousand for habitations.

The selected commercial and industrial enterprises were visited during the survey in order to collect information on economic parameters. However, it is noted that a number of industries and commercial enterprises did not want or could not provide this type of information. Results are published in table F/1.6. It is noted that compensation for the owner was not collected during the survey. The figure of Tk. 72 thousand per year for small commercial enterprises was provided by the Planning Commission. For industries a higher compensation for the owner is used, notably Tk. 144 thousand per year, because of their better profitability. However, it is noted that saw mills are not even able to give this compensation to owners otherwise they would make a loss. From the table it can be calculated that the weighted average net returns per enterprises is Tk. 2.3 million per year for industries and Tk. 17.5 thousand for commercial enterprises.

Data on salaries, wages and persons permanently employed were also collected with the commercial and industrial enterprises. A total number of 1,679 persons are permanently employed in the area prone to erosion. Table F/1.7 provides details. Based on the wages paid one can estimated the number of man-hours this represents. The minimum wage is Tk. 7.5 per hour in Bangladesh. Hence the number of man-hours is 3.08 million per year.

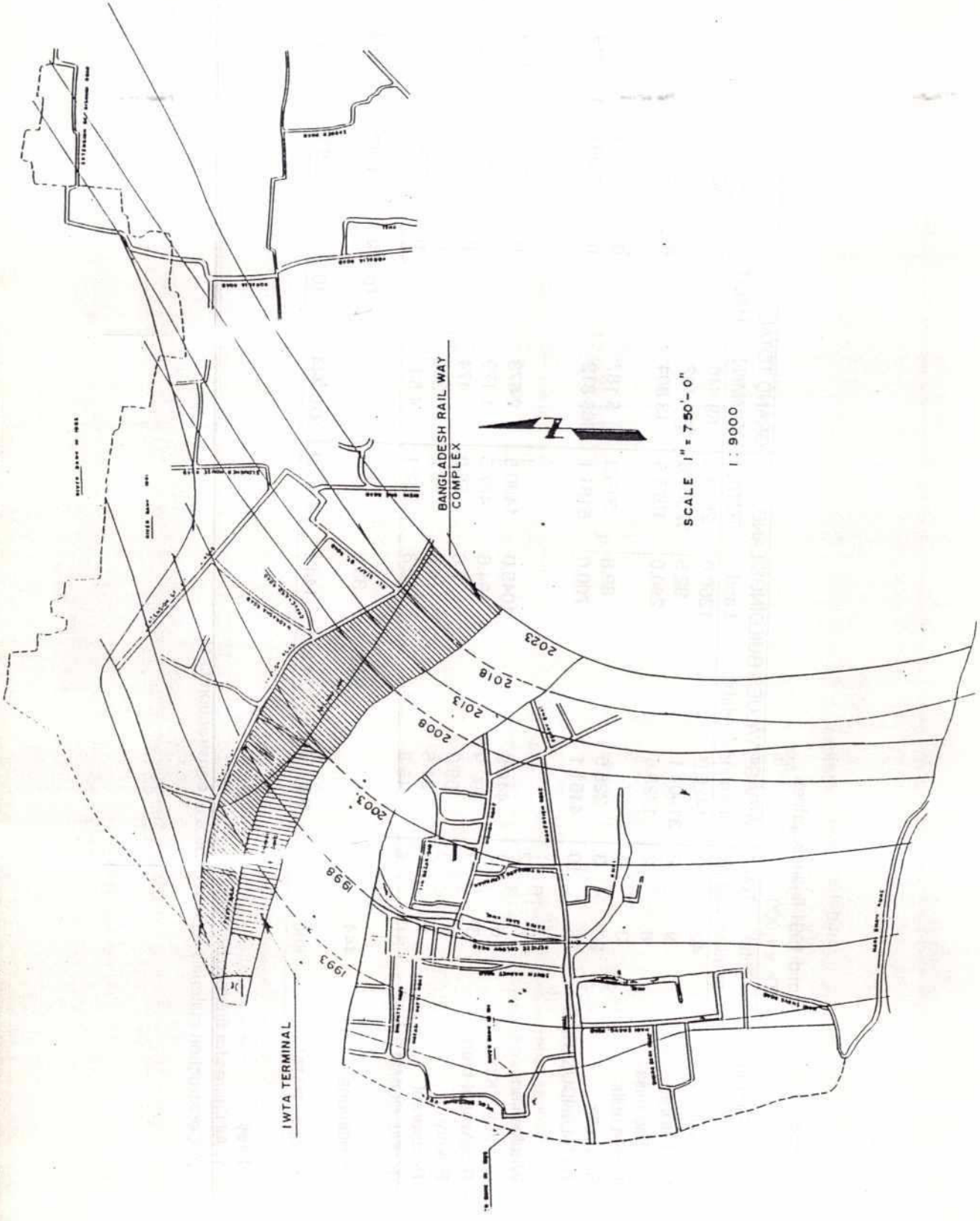
F/1.2.7 Survey results Chandpur

In Chandpur it was not possible to identify the area prone to erosion at the start of the survey. Hence, a smaller area was considered. However, attention was paid to the fact that this area represented well the urban features of the likely area to be affected by erosion. The survey results discussed in this chapter refer to this sub-area. The values per square meter have been used for extrapolation to the whole area prone to erosion. See Figure F/1.3.

For the design of the survey in Chandpur, the extent of the erosion prone area of the town was determined on the available global street plan of the area bordering the river. Because this global street plan dated from a number of years ago, it had to be updated and redrawn. See Figure F/1.2.

The survey team comprising one economist and two survey assistants carried out the fieldwork from 31 March to 12 April, 1991. First they enumerated all the buildings within the area defined as prone to erosion, collecting name of the main occupant, address, use of the building, size of the land area and general nature of the construction; e.g. number of stories, type of materials used. Each building was given a number.

FIGURE F/1.3 STREET MAP OF CHANDPUR



PRICES: mid-1991 financial prices
UNIT: Tk. x 1,000

Stratum	Total number	Total sample	AVERAGE VALUES BUILDINGS/LAND: Comm/ind	Habit.	Land	TOTAL	GRAND TOTAL: COMM/IN	HABIT.	LAND	TOTAL
Rice mills	42	2	1420.0		1250.0	2670.0	59 640	0	52 500	112 140
Cold stores	9	2	31909.1		92.5	32001.6	287 182	0	833	288 014
Twisling mills	8	2	1725.5		250.0	1975.5	13 804	0	2 000	15 804
Textile mills	3	1								0
Saw mills	23	3	225.5		89.8	315.3	5 187	0	2 064	7 251
TOTAL INDUSTRIES	85	10	4461.1		700.0	5161.1	365 812	0	57 397	423 209
Wholesalers	10	2								
Grocery shops	6	1	445.5		1045.0	1490.5	2 673	0	6 270	8 943
Rice/wheat bran	3	1	392.9		94.6	487.5	1 179	0	284	1 463
Bakery	8	1	59.3		7.6	66.9	474	0	61	535
Restaurant	4	1	51.5		6.8	58.2	206	0	27	233
TOTAL COMM.ENTE	31	6	215.8		316.3	532.1	4 531	0	6 642	11 173
Habitations	444	3		24.2	33.3	57.6	0	10 764	14 800	25 564
GRAND TOTAL	560	19	359 .6	24.2	144.1	3763.9	370 344	10 76	78 839	459 946

Notes:
1) All figures for fin.year 1990/91
2) Construction materials represent 55% of construction cost

TABLE F/1.6 ECONOMIC INDICATORS MUNSHIGANJ

PRICES: mid-1991 financial prices
UNIT: Tk. x 1,000

Stratum	Total number	Total sample	AVERAGE ECONOMIC PERFORMENCE: Turn-over	Operat. expenses	Other expenses	Compens. owner	Net return	TOTAL ECONOMIC PERFORMENCE: TURN-OVER	OPERAT. EXPENS.	OTHER EXPENS.	COMP. OWNERS	NET RETURN
Rice mil	42	2	23 914	23 629	77	144	64	1 004 367	992 418	3 234	3 048	2 667
Cold sto s	9	2	25 271	24 645	188	144	295	227 439	221 805	1 688	296	2 651
Twisling ills	8	2	36 060	35 723	129	144	65	288 480	285 784	1 028	152	516
Textile m s	3	1	(no response from owners or mana ier)									
Saw mills	23	3	950	875	14	60	(0)	21 842	20 133	330	1 380	(0)
TOTAL IN USTRIES	85	10	18 806	18 538	77	120	71	1 542 128	1 520 140	6 279	9 76	5 833
Wholesalers	10	2	(no response from owners or manager)									
Grocery shops	6	1	1535.0	1362.0	35.0	72.0	66.0	9 210	8 172	210	432	396
Rice/wheat bran	3	1	960.0	854.8	31.0	72.0	2.2	2 880	2 564	93	216	7
Bakery	8	1	492.0	433.0	5.0	54.0	0.0	3 936	3 464	40	432	0
Restaurant	4	1	102.0	81.0	1.5	19.5	0.0	408	324	6	78	0
TOTAL COMM.ENTER	31	6	714.5	631.5	15.2	50.3	17.5	16 434	14 524	349	1 158	403
GRAND TOTAL	116	16	18 336	18 055	78	130	73	1 558 562	1 534 664	6 628	11 034	6 236

Notes:
1) All figures for fin.year 1990/91
2) Compensation for the owner is evaluated at Tk. 72,000 per annum for commercial enterprises and small industries, while for larger industrial operations the compensation is T. 144,000 per annum. However, in one case the gross margin was not high enough to provide for full compensation.

TABLE F/1.7 EMPLOYMENT MUNSHIGANJ

PRICES: mid-1991 financial prices
UNIT: Tk. x 1,000

Stratum	Total number	Total sample	AV. PER ENTERPR: Nbr. of workers	Paid salaries	Paid wages	ALL ENTERPRISES: NBR. OF WORKER	PAID SALARIES	PAID WAGES.	TOTAL S & W
Rice mills	42	2	25	450.0	225.0	1 050	18 900	9 450	29 400
Cold stores	9	2	25	1050.0	1270.0	225	9 450	11 430	21 105
Twisling mills	8	2	25	750.0	130.0	200	6 000	1 040	7 240
Textile mills	3	1				0	0	0	0
Saw mills	23	3	5	111.0	27.0	107	2 553	621	3 281
TOTAL INDUSTRIES	85	10	19	450.0	274.9	1 582	36 903	22 541	61 026
Wholesalers	10	2	6	108.0	69.0	36	648	414	1 098
Grocery shops	6	1	7	168.0	65.0	21	504	195	720
Rice/wheat bran	3	1	3	43.0		24	344	0	368
Bakery	8	1	4	25.0		16	100	0	116
Restauran'	4	1	5	76.0	67.7	97	1 596	609	2 302
TOTAL CC 'MM.ENTE	31	6							
GRAND TC 'AL	116	16	24	526.0	342.6	1 679	38 499	23 150	63 328

Notes:
1) All figure for fin.year 1990/91

The census revealed that 55 buildings are used as habitation, 319 buildings are commercial enterprises and 18 buildings contain small factories. Within the survey area no large industrial estates are located. Moreover, 63 combined buildings, which have a commercial enterprise on the ground floor and a home on the second floor were found.

After a critical analysis of the census results it was decided to define 15 strata for commercial enterprises and 1 stratum for small factories. The number of buildings per stratum varied between 5 and 66 for commercial enterprises. All habitations as well as combined buildings formed one stratum.

Sample selection was done randomly. The total size of the sample selected according to the criterium explained in the introduction to this chapter, was 36. This represents an overall sample fraction of 8%. For the individual large groups of buildings the sample fraction varied from 11% with small factories to 5% with combined buildings.

The number of habitants per building has been enumerated for the selected sample buildings. The total number of persons living in the survey area is calculated at 2,620 persons. The average number of persons per habitation is calculated at 20. This indicates clearly how densely populated the old town of Chandpur is.

For each of the selected buildings area occupied and construction materials have been enumerated. The Resident Commissioner of Lands in Chandpur provided unit values for land in the town area, local shops provided unit prices for construction materials. Only material cost were enumerated, later in the analysis labour and other cost were included.

Table F/1.8 provides the results of the field work. Based on the results of the survey it can be calculated that the weighted average value of construction materials per building is Tk. 238.8 thousand for commercial buildings, Tk. 282.1 thousand for small industrial buildings and Tk. 213.2 thousand for habitations. With respect to the average value of land the data are Tk. 137.9 thousand for commercial buildings, Tk. 215.1 thousand for small industries and Tk. 140 thousand for habitations.

The selected commercial and industrial enterprises were visited during the survey in order to collect information on economic parameters. Results are published in table F/1.9. It is noted that compensation for the owner was not collected during the survey. The figure of Tk. 72 thousand per year was provided by the Planning Commission. From the table it can be calculated that the weighted average net returns per enterprises is Tk. 207.6 thousand per year.

Data on salaries, wages and persons permanently employed were also collected with the commercial and industrial enterprises. A total number of 2,966 persons are permanently employed in the area prone to erosion. Table F/1.10 provides details. Based on the wages paid one can estimated the number of the number of man-hours this represents. The minimum wage is Tk. 7.5 per hour in Bangladesh. Hence the number of man-hours is 2.0 million per annum.

F/1.3 Social and urban infra-structure

F/1.3.1 Analysis Bhairab Bazar

During the census of buildings in Bhairab Bazar the enumerators recorded the plot size of each building. The built-on area thus enumerated does not included the surface occupied by social and urban infra-structure such as mosques, schools, clinics or streets. The total area used for building as well as social and urban infra-structure can be measured on the base survey map (Figure F/1.1).
Based on the plots occupied by buildings it could be calculated how much the built-on surface is for the area prone to erosion. The total area prone to erosion has been measured on the street plan. The built-on area is calculated as 45,056 m^2, while the total gross area prone to erosion covers 56,500 m^2. The balance between both figures is 25% and represents the social and urban infra-structure, e.g mosque, school, streets with electricity and standpipes.

PRICES: mid-1991 financial prices
UNIT: Tk. x 1,000

Stratum	Total number	Total sample	AVERAGE VALUE: Comm/ind.	Habit.	Land	TOTAL	GRAND TOTAL: COMM/IND	HABIT.	LAND	TOTAL
Whole salers	66	3	351.8		207.6	559.4	23 220	0	13 702	36 922
Grocery shops	25	2	159.5	46.2	112.0	317.6	3 986	1 155	2 800	7 941
Small groceries	66	3	211.8		102.0	313.8	13 980	0	6 732	20 712
Pulses trade	16	2	199.1		131.3	330.3	3 185	0	2 100	5 285
Onion/garlic/ginger	9	1	220.9	257.3	166.0	644.2	1 988	2 315	1 494	5 798
Cloth and materials	29	2	145.1		47.0	192.1	4 208	0	1 363	5 571
Dried chilly trade	7	1	160.0		115.0	275.0	1 120	0	805	1 925
Rice/wheat bran	13	2	181.1		134.0	315.1	2 354	0	1 742	4 096
Gunny bags trade	21	2	208.2		173.0	381.2	4 372	0	3 633	8 005
Salt trade	5	1	234.2		140.0	374.2	1 171	0	700	1 871
Kerosine trade	16	2	215.0		75.8	290.8	3 440	0	1 212	4 652
Paddy trade	9	1	259.5		164.0	423.5	2 335	0	1 476	3 811
Rice trade	17	2	276.5		242.5	519.0	4 700	0	4 123	8 822
Flour trade	10	2	173.6		69.0	242.6	1 736	0	690	2 426
Edible oil trade	10	2	437.3		142.3	579.5	4 373	0	1 423	5 795
TOTAL COMM.ENTER	319	28	238.8	102.1	137.9	478.7	76 168	3 470	43 994	123 632
										0
Small factories	18	2	335.9		215.1	551.0	6 046	0	3 872	9 918
Habitat. cum comm.	63	3	282.1	258.4	135.0	675.5	17 774	16 777	8 505	42 556
Habitations	55	3		230.3	143.3	373.6	0	12 467	7 883	20 550
GRAND TOTAL	455	36	250.0	213.2	141.2	604.4	99 988	32 414	64 254	196 656

Notes:
1) All figures for fin.year 1990/91
2) Construction materials represent 55% of construction cost

PRICES: mid-1991 financial prices
UNIT: Tk. x 1,000

Stratum	Total number	Total sample	AVERAGE ECONOMIC PERFORMENCE: Turn-over	Operat. expenses	Other expenses	Compens. owner	Net return	TOTAL ECONOMIC PERFORMENCE: TURN-OVER	OPERAT. EXPENS.	OTHER EXPENS.	COMP. OWNERS	NET RETURN
Whole salers	66	3	1179.3	367.3	31.0	2.0	709.0	77 836	24 244	2 046	4 752	46 794
Grocery shops	25	2	3178.5	2892.5	42.5	2.0	171.5	79 463	72 313	1 063	1 800	4 288
Small groceries	66	3	2523.7	2256.7	38.7	72.0	156.3	166 562	148 940	2 552	4 752	0 318
Pulses trade	16	2	2739.5	2433.0	34.0	72.0	200.5	43 832	38 928	544	1 152	3 208
Onion/garlic/ginge	9	1	1642.0	1357.0	35.0	72.0	178.0	14 778	12 213	315	648	602
Cloth and materials	29	2	2474.5	2195.0	24.0	72.0	183.5	71 761	63 655	696	2 088	5 322
Dried chilly trade	7	1	3708.0	3371.0	12.0	72.0	253.0	25 956	23 597	84	504	1 771
Rice/wheat bran	13	2	1703.0	1432.0	28.5	72.0	170.5	22 139	18 616	371	936	2 217
Gunny bags trade	21	2	1083.0	899.0	21.5	72.0	90.5	22 743	18 879	452	1 512	1 901
Salt trade	5	1	1874.0	1602.0	37.0	72.0	163.0	9 370	8 010	185	360	815
Kerosine trade	16	2	3464.0	3085.5	33.5	72.0	273.0	55 424	49 368	536	1 152	4 368
Paddy trade	9	1	4794.0	4532.0	37.0	72.0	153.0	43 146	40 788	333	648	1 377
Rice trade	17	2	5267.5	4909.0	54.0	72.0	232.5	89 548	83 453	918	1 224	3 953
Flour trade	10	2	3650.0	3295.5	29.5	72.0	253.0	36 500	32 955	295	720	2 530
Edible oil trade	10	2	2217.0	1937.5	34.0	72.0	173.5	22 170	19 375	340	720	1 735
TOTAL COMM.ENTER	319	28	2449.0	2054.3	33.6	72.0	289.0	781 227	655 334	10 729	22 968	92 197
Small factories	18	2	1928.5	1780.3	13.5	72.0	62.7	34 713	32 045	243	1 296	1 129
Habitat. cum comm.	63	3	1624.0	1431.3	14.7	72.0	106.0	102 312	90 174	924	4 536	6 678
GRAND TOTAL	400	33	2295.6	1943.9	29.7	72.0	207.6	918 252	777 553	11 896	28 800	100 003

Notes:
1) All figures for fin.year 1990/91
2) Compensation for the owner is evaluated at Tk. 72,000 per annum

PRICES: mid-1991 financial prices
UNIT: Tk. x 1,000

Stratum	Total number	Total sample	AV. PER ENTERPR: Nbr. of workers	Paid salaries	Paid wages	ALL ENTERPRISES: NBR. OF WORKER	PAID SALARIES	PAID WAGES	TOTAL S & W
Whole salers	66	3	12	251.0	42.3	792	16 566	2 794	19 360
Grocery shops	25	2	6	128.5	30.3	150	3 213	756	3 969
Small groceries	66	3	9	168.3	44.7	572	11 110	2 948	14 058
Pulses trade	16	2	7	102.5	64.5	104	1 640	1 032	2 672
Onion/garlic/ginger	9	1	3	72.0	68.0	27	648	612	1 260
Cloth and materials	29	2	7	135.0	3.5	189	3 915	103	4 018
Dried chilly trade	7	1	4	90.0	68.0	28	630	476	1 106
Rice/wheat bran	13	2	3	83.5	51.0	39	1 086	663	1 749
Gunny bags trade	21	2	3	59.0	24.0	63	1 239	504	1 743
Salt trade	5	1	3	75.0	27.0	15	375	135	510
Kerosine trade	16	2	6	117.5	63.0	96	1 880	1 008	2 888
Paddy trade	9	1	8	121.0	75.0	72	1 089	675	1 764
Rice trade	17	2	7	141.5	76.5	111	2 406	1 301	3 706
Flour trade	10	2	7	123.0	50	65	1 230	371	7 995
Edible o trade	10	2	7	117.5	48 5	65	1 175	315	7 638
TOTAL COMM.ENTE	319	28	6	151.1	42 9	2 387	48 201	13 692	74 434
Small factories	18	2	7	120.0	39.	117	240	254	14 040
Habitat. cum comm.	63	3	7	101.7	34.0	462	305	249	46 970
GRAND TOTAL	400	33	6	121.9	35.5	2 966	48 746	14 195	135 444

Notes:
1) All figures for fin.year 1990/91

Because the construction cost of social and urban infra-structure are not much different from the construction cost of buildings, it is correct to use the area fraction. Moreover, the price of land will be equal to the land-price for buildings. Hence, values for the gross area, including social and urban infra-structure are calculated by multiplying the total value for habitations, commercial and industrial enterprises by a factor 1.25.

F/1.3.2 Analysis Munshiganj

An analysis of the area occupied by social and urban infra-structure done for Bhairab Bazar, could not be made for Munshiganj because a reliable base map was not available. Hence, the factors calculated for Bhairab Bazar and Chandpur were used for Munshiganj.

Based on the plots occupied by buildings it could be calculated how much the built-on surface is for the area prone to erosion. The built on area is calculated as 2,648,764 m^2, while the total gross area could not be calculated because of the lack of a reliable map. The balance between both figures represents the social and urban infra-structure, e.g mosque, streets with electricity and standpipes, school. Based on the survey results in Bhairab Bazar and Chandpur the area for social and urban infra-structure is 25% of the built-on area.

Because the construction cost of social and urban infra-structure are not much different from the construction cost of buildings, it is correct to use the area fraction. Moreover, the price of land will be equal to the land-price for buildings. Hence, values for the gross area, including social and urban infra-structure are calculated by multiplying the total value for habitations, commercial and industrial enterprises by a factor 1.25.

F/1.3.3 Analysis Chandpur

During the census of buildings in Chandpur the enumerators recorded the plot size of each building. The built-on area thus enumerated does not included the surface occupied by social and urban infra-structure such as mosques, schools, clinics or streets. The total area used for building as well as social and urban infra-structure can be measured on the base survey map. However, it is noted that in Chandpur a large area of Nutan Bazar is used for the railway complex and the terminal of IWTA. This area has been excluded form the analysis. This type of infra-structure is treated separately in the economic analysis.

Based on the plots occupied by buildings it could be calculated how much the built-on surface is for the surveyed area. The gross surveyed area has been calculated from the street plan. The built on area is calculated as 238,170 m^2, while the total gross area covers 293,200 m^2. The balance between both figures is 23% and represents the social and urban infra-structure, e.g mosque, streets with electricity and standpipes, school. The fraction that relates to the built-on area prone to erosion is taken as 25%.

Because the construction cost of social and urban infra-structure are not much different from the construction cost of buildings, it is correct to use the area fraction. Moreover, the price of land will be equal to the land-price for buildings. Hence, values for the gross area, including social and urban infra-structure are calculated by multiplying the total value for habitations, commercial and industrial enterprises by a factor 1.25.

F/1.3.4 Analysis rural area Lower Meghna and Maniknagar

During field visits to Eklashpur, Haimchar and Maniknagar it has been estimated that the area occupied by mosques, houses, shops, schools or any other type of building covered around 10% of the land threatened by erosion. As no reliable maps or areal photographs were available, this figure is used to evaluate the erosion damage to the non-agricultural fraction of land at these sites.

F/1.4 Displacement of population

F/1.4.1 Bhairab Bazar

The survey in Bhairab Bazar revealed that the number of habitants in the area prone to erosion is 760 persons. Without any adequate protection this area will disappear in the coming 30 years. As no detailed geo-morphological information is available on bank-migration per five-year period, we assume that the per period migration will be the same for each five-year period. Based on the Statistical Yearbook of Bangladesh for 1991 (table 2.08, page 45), the annual population increase was 2.17% over the last 10 years. Using this factor for the coming 30 years would give total numbers for each five-year period, see table F/1.11.

TABLE F/1.11 DISPLACEMENT OF POPULATION IN BHAIRAB BAZAR

Period	Number of persons displaced
1993-1998	140
1998-2003	155
2003-2008	175
2008-2013	195
2013-2018	215
2018-2013	240
Total	1,120

Source: Socio-economic survey 1991

F/1.4.2 Munshiganj

From the socio-economic survey of Munshiganj follows that in the area prone to erosion live 4,260 persons. These persons would be displaced in the coming 30 years if no protection works are built. As no detailed geo-morphological information is available on bank-migration per five-year period, we assume that the per period migration will be the same for each five-year period. Based on the Statistical Yearbook of Bangladesh for 1991 (table 2.08, page 45), the annual population increase was 2.17% over the last 10 years. Using this factor for the coming 30 years would give total numbers for each five-year period, see table F/1.12.

F/1.4.3 Chandpur

For Chandpur a somewhat different analysis has been used to estimated the displacement of persons, because the survey only covered part of the area prone to erosion. Hence, it is possible to calculate the population density in the surveyed area. Moreover, migration of the bankline in Nutan Bazar and Puran Bazar, north of Station Road (this means that the complex of Bangladesh Rail, the market along the shores of Dakatia River and the terminal of IWTA are not considered) is known per period of five years. The population density of the surveyed area has been applied to calculate the number of persons to be displaced if no protection works are executed.

TABLE F/1.12 DISPLACEMENT OF POPULATION IN MUNSHIGANJ

Period	Number of persons displace
1993-1998	700
1998-2003	880
2003-2008	980
2008-2013	1,090
2013-2018	1,210
2018-2013	1,350
Total	6,300

Source: Socio-economic survey 1991

TABLE F/1.13 DISPLACEMENT OF POPULATION IN CHANDPUR

Period	Area lost in Puran B. and Nutan B. (North Station Rd	Number of persons displaced
1993-1998	180,250 + 42,040 m^2	2,230
1998-2003	198,450 + 33,130 m^2	2,560
2003-2008	207,520 + 63,340 m^2	3,340
2008-2013	75,650 + 52,890 m^2	1,760
2013-2018	66,260 + 133,730 m^2	3,060
2018-2013	81,000 + 143,050 m^2	3,810
Total	1,279,310 m^2	16,760

Source: Annex B and socio-economic survey 1991

The gross area covered by the survey was measured on the street map and covered 293,200 m^2. The number of persons living in this area has been surveyed, there were 2,620 residents. Hence, the population density is 8,940 persons per km^2. The same population density applies for the area prone to erosion. Based on the Statistical Yearbook of Bangladesh for 1991 (table 2.08, page 45), the annual population increase was 2.17% over the last 10 years. Using this factor and the area lost for the coming 30 years would give total numbers for each five-year period, see table F/1.13.

F/1.4.4 **Rural areas Lower Meghna and Manikn**

For the rural areas along the Lower Meghna and in M niknagar no surveys were executed. Hence, there are no data for the number of persons displaced as result of likely bank migration. Moreover, the 1991 Statistical Yearbook for Bangladesh is inconclusive with respect to population densities in the aforementioned rural areas. The overall population density for the country was 750 persons per km^2 in 1991 (Statistical Yearbook 1991).
Present day rural population counts for about 70% and is expected to reduce to about 50% over the project evaluation period ('Developing the Infrastructure. Volume Three of the Report of the Task Forces on Bangladesh Development Strategies for the 1990's' 1991). The averaged rural population density is therefore estimated at 400 people per square kilometer. This figure is used to estimate the number of people affected by ongoing erosion during the project evaluation period.

F/1.5 **Structures**

F/1.5.1 **Destruction of houses**

When property has been washed away persons cannot return to their homes and consequently economic resettlement cost must be used. This leaves two options for costing resettlement, notably at (i) replacement cost of habitations or (ii) at the value of compensation. In practice, authorities do not compensate in cash; piecemeal compensation is paid in the form of building materials (quite insufficient) and test relief/food for works etc. As a result replacement cost of houses are born by the affected inhabitants in their own way.

It must be clear, that compensation does not reflect the shadow price of buildings in a proper manner. However, it is unlikely that the inhabitants move to houses of the same quality and standing as the ones they have vacated, because the old traditional houses do not exist any more. Today buildings would be different and less expensive as result of different design and modern construction materials. Hence, it would be incorrect to use the replacement value of the existing houses in the economic calculations. However, there is no statistical evidence that allows for defining the value of newly constructed homes; such statistics are simply not kept.

Moreover, people have to meet the cost of constructing a new home by their own means. This means that many times the alternative is a less expensive house or no house at all. Statistical evidence shows that more than 25% of the urban population is homeless (according to TOR of FAP-8A and UNICEF). Hence, it seems logic that part of those losing a house as result of erosion remain homeless, simply because they do not possess the money for another house. This would mean that only part of the total value of homes eroded in a year would be replaced. Using a percentage of 25%, means that in economic terms only 75% of the homes will be re-constructed.

Hence, it seems appropriate to impute for the total economic cost of destroyed habitations less than one hundred percent of total construction cost after correction for the foreign exchange premium. For Bangladesh the standard conversion factor is 0.82. Because there is no statistical evidence that would allow for calculating the lesser value of the new homes occupied by displaced persons we have used two-third of the total value of actual construction as the replacement value or 65%. This takes into account lower construction values for new homes and takes note of the fact that part of those loosing their home would remain homeless.

F/1.5.2 **Destruction of commercial and industrial buildings**

When commercial and industrial enterprises are destroyed by floods it is very likely that traders and industrialist will engage again in their traditional occupation in one way or another. They may possess enough savings to start trading again. Or else they could obtain a loan from a supplier, which enables them to start again.

With respect to the destruction of commercial and industrial enterprises the items of concern in deriving opportunity cost are:

- value of net returns foregone as result of destruction;
- replacement cost of stocks lost: and
- replacement/repair cost of premises and equipment destroyed.

The value of net return foregone is expressed as the loss of trading and industrial production profits. This need no further explanation.

The economic cost of stocks and equipment lost are likely to be negligible. One may expect that well before erosion happens persons are informed and have removed stock and equipment. Hence, no account is taken of any loss or damage to stocks and equipment.

The economic valuation of commercial or industrial buildings is more a problem. As result of riverbank protection the loss or damage of these is deterred. The benefits of protection work must thus evaluate the prevented loss of these fixed assets at their economic price.

One may expect that in Bangladesh considerations of investment security and prestige may have pushed land and building prices well above their economic value. Hence, their market prices is not a realistic economic estimator eith... these instances, we will not want to accept the market purchase price as a good estimate of the economic opportunity cost and must search for an alternative. Many times that alternative will be to take the rental value of the land', according to Price Gittinger (World Bank, 1982), when discussing the economic value of agricultural land.

This applies also to the value of commercial or industrial buildings; a renter is not likely to pay a premium for prestige or investment security and thus will not pay a rent higher than the contribution the land or building can make to the economic activity he proposes to undertake. Hence, the rental value is more appropriate than the market price or replacement value.

Squire and Van der Tak (World Bank, 1975) give some additional refinement to this. 'Factors in fixed supply, such as land, mineral resources, or sites, may earn rents reflecting their scarcity value. To shadow-price factors in fixed supply, an estimate must be made of the opportunity cost to the economy of using these factors to satisfy project demand. The rent earned by these factors may not be an adequate measure of the shadow price; distortions in the product and capital markets may have to be taken into account to derive the shadow rental from the market rental.' The standard conversion factor of the Planning Commission is the most adequate means to take account of these possible distortion.

The economic rental value is a good indicator for the annual costing purposes. During the socio-economic surveys in Bhairab Bazar and Chandpur a number of respondents to the questionnaire on economic parameters gave information on he rent paid and the ground surface of the building they rented. It is noted that commercial enterprises in Bhairab Bazar have a larger floor space, but pay a rent very much in line with those in C...pur, which have a smaller floor space. In Bhairab Bazar Tk. 56,240 was paid per year for 2,000 square feet, while in Chandpur slightly more (Tk. 57,600) was paid for only 800 square feet.

From the survey it appears that 2,000 square feet is the usual ground surface in Bhairab Bazar used by enterprises, while 800 square feet is a normal surface for Chandpur. Hence, a value of Tk. 57,000 was considered the rental value for a commercial or small industrial building. The economic rental value becomes after correction for foreign exchange premium (using 0.82 as the correction factor) Tk. 46,740 per year. As information on the rental value of buildings has not been given by any of the respondents in Munshiganj, the same rent also applies. The rent is not only used for a single year, but applies for the full period of the study. Hence, this rental value should be discounted over a range of 30 years at an interest rate which reflects the opportunity cost of capital. For doing so an interest rate of 12% has been applied as recommended by the Planning Commission. The net present value thus derived has been imputed in the economic appraisal of investments.

F/1.5.3 **Erosion damage to houses**

Houses near the river bank could be damaged by the erosion force of the river. This does not mean directly that these houses are destroyed, but merely that part of the walls are damaged or that some of the foundation works are washed away. In almost all cases it means that the owner will vacate the house and tear it down, thus saving building materials. With this materials a new home will be built elsewhere or the owner may sell materials and find other means of accommodation.

Although many persons will be in the position to tear down their home and rebuild it somewhere else, there will also be persons who remain in their damaged home for the reason that they do not possess the means to tear it down and rebuild it. Very much in line with the reasoning given for the destruction of homes, this group is estimated at 25% of the owners (buildings).

For those buildings which are torn down and rebuilt this means in economic terms that the following cost are involved:

- labour for tearing down the old building;
- transport cost for bringing materials to a new building site;
- labour cost for rebuilding the home; and
- additional material cost to replace what was lost.

With respect to land the situation is less unambiguous: the land vacated may or may not be used again, say for the construction of a temporary store or shop, like those on poles which can be observed in Bhairab Bazar or Munshiganj or the land could be left as it is. There are no statistics to support any assumption for the use of land, although it is accepted that only a small part of the land is washed away, most of it remains in place. Hence, it seems logic not to account for any loss of land or change in its economic value.

Based on a handbook for the design of structures from Prokaushali Sangad Ltd (Dhaka), a break-down of construction cost for homes is given in table F/1.14.

TABLE F/1.14 BREAK-DOWN OF CONSTRUCTION COST BUILDINGS

Element	as % constr. cost
Labour - skilled	20%
Labour - unskilled	10%
Building materials	55%
Plumbing, etc.	15%

Source: Prokaushali Sangsad Ltd

From the above cost break-down for constructions, the factors for tearing down and rebuilding houses have been estimated in consultation with building engineers. The results for the total of all houses damaged is presented in table F/1.15. The percentage used in the table refer to the construction cost of the building damaged. This is logic as these cost are resulting from the socio-economic surveys.

Hence, the damage to houses is estimated as 50% of total construction cost of these buildings. The economic value of damaged houses is found after correction for the foreign exchange premium. For Bangladesh the standard conversion factor is 0.82.

TABLE F/1.15 COST OF REBUILDING

Element	as % initial constr. cost
Labour for tearing down building	10%
Labour for re-building	30%
Additional materials and transport	25%
Total (if all houses would be rebuilt)	65%
Total, after correction for those not re-building	50%

Source: Consultants' estimates

F/1.5.4 **Erosion damage to commercial and industrial enterprises**

Commercial and industrial enterprises damaged by erosion are likely to be left and the owners will start operation elsewhere. In this respect damage cost are the same as cost of destruction, although with this difference that hardly any land is lost. Hence, the economic cost of damage to structures is similar to these cost when buildings are destructed; this means that the rental value is used as an indicator for the economic cost. For details reference is made to section F/1.5.2.

F/1.6 **Agriculture**

F/1.6.1 **Crop budgets**

The major crops considered for the economic analysis are paddy and wheat. Crop budgets for these crops are calculated from data supplied by the South-East Region Water Resources Development Program (FAP-5). It is noted that the commodities are prices in mid-1991 prices for the year 2005, which is near the middle of the 30 year evaluation period. Prices are based on the World Bank commodity price forecast. The tables F/1.16 to F/1.20 provide the crop budgets, which need no further explanation.

F/1.6.2 **Value agricultural land**

One may expect that in Bangladesh considerations of investment security and prestige may have pushed land prices well above their economic value. Hence, the market price is not a realistic economic estimator. 'In these instances, we will not want to accept the market purchase price as a good estimate of the economic opportunity cost and must search for an alternative. Many times that alternative will be to take the rental value of the land', according to Price Gittinger (World Bank, 1982), when discussing the economic value of agricultural land.

The economic rental value is a good indicator for shadow pricing purposes. The economic rental value of cropped land is based on share cropping arrangement in the area. For each individual crop the rent has been calculated as the money value of production quota provided by the share cropper to the landowner. The share cropping arrangement are presented in the crop budgets.

TABLE F/1.16 CROP BUDGET FOR HYV BORO

TABLE Crop budget for 1 ha

CROP: HYV BORO (winter paddy)
TYPE OF CULTURE: Irrigated
SOWING PERIOD: December/January
TRANSPLANTING: January/February
AREA: 1 ha
PRICES: mid-1991 constant economic prices
VALUES: Tk.

Item	Unit	Unit price	Quantity	Value yr.2005
Family labour	m-days	28.40	[illegible]	5 822
Draft animals	pair-days	65.30	51	3 346
Seeds	kg	9.94	30	298
Fertiliser:				
Urea	kg	5.90	228	1 345
TPS	kg	10.76	105	1 130
MP	kg	8.27	18	149
Dung/manure	kg	0.28	0	0
Pesticides	kg	455.00	0.5	228
Irrigation (LLP)	u	2733	1	2 733
Total fixed cost				9 228
Production:				
Main crop	tonne	6.02	3.74	22 515
By-product	tonne	0.55	3.74	2 057
Total				24 572
Gros margin				15 344
Gros margin per m-day				75
Profit				9 522
Share cropping arr.	P	33%	22 515	7 430

Source: South East Region Water Resources Development Program
Notes:
1) Share cropping arrangement; landowner receives 33% of production value

TABLE F/1.17 CROP BUDGET FOR L BORO

TABLE Crop budget for 1 ha

CROP: L BORO (winter paddy)
TYPE OF CULTURE: Non-irrigated
SOWING PERIOD: December/January
TRANSPLANTING: no
AREA: 1 ha
PRICES: mid-1991 constant economic prices
VALUES: Tk.

Item	Unit	Unit price	Quantity	Value yr.2005
Family labour	m-days	28.40	135	3 834
Draft animals	pair-days	65.60	30	1 968
Seeds	kg	9.94	40	398
Fertiliser:				
Urea	kg	5.90	7	41
TPS	kg	10.76	3	32
MP	kg	8.27	1	8
Dung/manure	kg	0.28	0	0
Pesticides	kg	455.00	0.12	55
Irrigation (LLP)	u	2733	0	0
Total fixed cost				2 502
Production:				
Main crop	tonne	5.75	2.38	13 685
By-product	tonne	0.52	4.76	2 475
Total				16 160
Gros margin				13 658
Gros margin per m-day				101
Profit				9 824
Share cropping arr.	P-Fc	50%	11 183	5 591

Source: South East Region Water Resources Development Program
Notes:
1) Share cropping arrangement; landowner receives 50% of production value after deduction of inputs

TABLE F/1.18 CROP BUDGET FOR B AUS

TABLE Crop budget for 1 ha

CROP: B AUS (quick maturing paddy)
TYPE OF CULTURE: non-irrigated
SOWING PERIOD: March/April
TRANSPLANTING: no
AREA: 1 ha
PRICES: mid-1991 constant economic prices
VALUES: Tk.

Item	Unit	Unit price	Quantity	Value yr.2005
Family labour	m-days	28.40	140	3 976
Draft animals	pair-days	65.60	44	2 886
Seeds	kg	9.94	85	845
Fertiliser:				
Urea	kg	5.90	42	248
TPS	kg	10.76	20	215
MP	kg	8.27	3	25
Dung/manure	kg	0.28	2000	560
Pesticides	kg	455.00	0	0
Irrigation (LLP)	u	2733	0	0
Total fixed cost				4 779
Production:				
Main crop	tonne	5.63	1.36	7 657
By-product	tonne	0.52	2.72	1 414
Total				9 071
Gros margin				4 292
Gros margin per m-day				31
Profit				316
Share cropping arr.	P-Fc	50%	2 877	1 439

Source: South East Region Water Resources Development Program
Notes:
1) Share cropping arrangement; landowner receives 50% of production value after deduction of inputs

TABLE F/1.19 CROP BUDGET FOR LT AMAN

TABLE Crop budget for 1 ha

CROP: LT AMAN (late monsoon paddy)
TYPE OF CULTURE: non-irrigated
SOWING PERIOD: June/July
TRANSPLANTING: July/August
AREA: 1 ha
PRICES: mid-1991 constant economic prices
VALUES: Tk.

Item	Unit	Unit price	Quantity	Value
Family labour	m-days	28.40	130	3 692
Draft animals	pair-days	65.60	42	2 755
Seeds	kg	9.94	35	348
Fertiliser:				
Urea	kg	5.90	114	673
TPS	kg	10.76	53	570
MP	kg	8.27	9	74
Dung/manure	kg	0.28	0	0
Pesticides	kg	455.00	0.25	114
Irrigation (LLP)	u	2733	0	0
Total fixed cost				4 534
Production:				
Main crop	tonne	6.44	1.95	12 558
By-product	tonne	0.58	3.90	2 262
Total				14 820
Gros margin				10 286
Gros margin per m-day				79
Profit				6 594
Share cropping arr.	P-Fc	50%	8 024	4 012

Source: South East Region Water Resources Development Program
Notes:
1) Share cropping arrangement; landowner receives 50% of production value after deduction of inputs

TABLE F/1.20 CROP BUDGET FOR WHEAT

TABLE	Crop budget for 1 ha
CROP:	WHEAT (rabi crop)
TYPE OF CULTURE:	non-irrigated
SOWING PERIOD:	December/January
TRANSPLANTING:	no
AREA:	1 ha
PRICES:	mid-1991 constant economic prices
VALUES:	Tk.

Item	Unit	Unit price	Quantity	Value
Family labour	m-days	28.40	130	3 692
Draft animals	pair-days	65.60	40	2 624
Seeds	kg	12.01	110	1 321
Fertiliser:				
Urea	kg	5.90	150	885
TPS	kg	10.76	69	742
MP	kg	8.27	12	99
Dung/manure	kg	0.28	0	0
Pesticides	kg	455.00	0.25	114
Irrigation (LLP)	u	2733	0	0
Total fixed cost				5 786
Production:				
Main crop	tonne	9.74	1.62	15 779
By-product	tonne	0.28	1.62	454
Total				16 232
Gros margin				10 447
Gros margin per m-day				80
Profit				6 755
Share cropping arr.	P-Fc	50%	9 993	4 997

Source: South East Region Water Resources Development Program
Notes:
1) Share cropping arrangement; landowner receives 50% of production value after deduction of inputs

F/1.6.3 Irrigation infra-structure

Irrigation infra-structure values are based on information collected with the South-East Region Water Resources Development Program (SWRP-5). All irrigation has been considered to be done with low lift pumps (LLP). It is noted that with erosion not all elements of irrigation infra-structure are lost; the pump and other equipment can be removed, but canals and fixed structures are lost. Table F/1.21 provides details.

TABLE F/1.21 COSTING IRRIGATION INFRA-STRUCTURE

COMMAND AREA (ha): 16
UNIT: Tk.

Item	Value	Remarks
Pump, trolly, coupling	5 440	1988-economic prices
Engine	45 277	1988-economic prices
Acessoires, pipes etc	6 400	1988-economic prices
Canal system	6 482	1988-economic prices
Structures	6 031	1988-economic prices
TOTAL	69 630	
Replacement cost of	12 512	1988-economic prices
irrigation infra-	17 486	mid-1991 economic prices
structure	26 835	for 2005 (mid-1991 prices)
Average per ha	677	

Source: South East Region Water Resources Development Program

F/1.7 Failure electricity supply

F/1.7.1 Consumer prices electricity

The financial price paid for electricity by commercial users is Tk. 3.7 per kWh, while the domestic price is only Tk. 1.65 per kWh. The price they pay is not subsidized and in many respects it represents the commercial market price, because if the PDB would overcharge it is likely that industries would generate their own power. Moreover, power production in Bangladesh does not rely heavily on imported fuel as most stations use natural gas. Consequently, it is appropriate to use for shadow-pricing purposes the overall conversion factor of the Planning Commission (0.82).

There is ample reason to assume that the economic electricity price is equal to its production price. The PDB is a government institution, which is likely to produce against cost price, thus not making much profit. Hence, one may assume that the economic price of power generation and distribution equals the economic price of electricity charged to users.

F/1.7.2 Power consumption

Statistics provided by the Planning Commission's Energy Wing provide details on consumption by user group in 1989/90. Table F/1.22 gives details. The average tariff calculated by the Planning Commission is Tk. 2.32 per kWh. This value has been used in the computations. The same distribution over users applies to the power line crossing the Meghna at Bhairab Bazar as no detailed statistics are known on the users of that line.

TABLE F/1.22 POWER CONSUMPTION PATTERN BANGLADESH 1989/90

User group	Consumption (GWh)	%
Industrial	2,503	53.2%
Commercial	380	8.1%
Domestic	1,167	24.3%
Agriculture	75	1.6%
Others	580	12.3%
TOTAL	7,733	100%

Source: Planning Commission

F/1.8 Railway complex and IWTA terminal at Chandpur

F/1.8.1 Railway complex Chandpur

The railway complex in Chandpur is a very large compound and harbours schools, a hospital and mosque as well as accommodation for railway personnel. The total surface of the complex is 72 ha, according to information collected in Chandpur with BR and the Municipality. No one can give an exact value for the whole complex; the station building is very old while some of the other buildings are of later date. Hence, some other type of estimation had to be made for calculation of the value.

The most logic method to calculate the value of the railway complex is by making use of the average value per unit area as found through the socio-economic survey (see section F/1.3.3). This is an acceptable approach because the complex covers houses, social and other types of urban infra-structure. The total value of land and buildings found from the survey is Tk. 196.7 million, covering a built-on area of 238 thousand m^2. This means an average value of just under Tk. 700 per m^2.

Based on this average value per square meter it becomes possible to estimate the value of the railway complex. The total value is thus estimated at Tk. 500 million. This amount is in financial prices, which must be converted to economic prices with the help of the overall conversion factor of 0.82. Hence, the economic value of the complex is Tk. 410 million.

F/1.8.2 IWTA terminal

Information of the IWTA terminal has been collected with the association in Dhaka and in Chandpur. It has been possible to evaluate the value of the terminal in economic prices. The terminal and its buildings cover and area of 36 thousand m^2. Details on the value are provided in table F/1.23.

F/1.8.3 Forecast of erosion damage

The railway complex lays between Station Road and Dakatia River in Launch Ghat Bazar. Within this stretch of land the terminal of IWTA is also located. Without any protection works year after year part of the complex and the terminal would be eroded. However, within 30 years not the whole complex will vanish. Over the 30 year evaluation period a total of 120 thousand m^2 will be eroded according to the geo-morphologic investigations.

For an estimation of the avoidable losses to railway complex and IWTA terminal we have made use of a deterministic approach. Based on the map of bank migration of Chandpur waterfront, see figure F/1.1,

the areas of the railway complex and the IWTA terminal that will erode in the coming 30 years are measured. By multiplying these areas with the average value per area unit, it becomes possible to calculate the avoidable losses. These losses are imputed in the cash flow for their respective year. Table F/1.24 summarizes the results.

TABLE F/1.23 DETAILS IWTA TERMINAL AT CHANDPUR

BUILT-ON SURFACE: 36 414 M2
PRICES: mid-1991 financial and economic prices
UNIT: Tk. x 1,000

Item	Financial price	Convers. factor	Economic price
Land value	4 500	1.00	4 500
Terminal building	25 000	0.82	20 500
Gangway with 2 pontoons	13 000	0.61	7 930
Housing facilities	20 000	0.82	16 400
Pilot house etc.	2 000	0.82	1 640
Jetty (wood)	500	0.82	410
TOTAL	65 000		51 380
Re-location cost	52 000		43 450

Sources: IWTA Planning and Energy Wing and FCPO-guidelines
Notes:
1) Re-location implies that the land has been eroded, so that a new area must be purchased

TABLE F/1.24 EROSION OF RAILWAY COMPLEX AND IWTA TERMINAL

PRICES: mid-1991 economic prices
UNIT: Tk. x 1,000

Period	BR COMPLEX: Area eroded (m2)	Unit value (Tk/m2)	Economic loss	IWTRA TERMINAL: Area eroded (m2)	Unit value (Tk/m2)	Economic loss	TOTAL ECONOMI LOSS
1993-1998	11 260	574	6 463	10 530	1 193	12 565	19 028
1998-2003	15 310	574	8 788	12 390	1 193	14 784	23 572
2003-2008	34 990	574	20 084	0	1 193	0	20 084
2008-2013	12 960	574	7 439	0	1 193	0	7 439
2013-2018	12 560	574	7 209	0	1 193	0	7 209
2018-2023	18 310	574	10 510	0	1 193	0	10 510
TOTAL	105 390		60 494	22 920		27 349	87 843

Source: Annex B and socio-economic survey 1991
Note:
1) Before 1993 it is expecred that part of the railway complex and the IWTA terminal will already have been eroded