

THE PEOPLE'S REPUBLIC OF CHINA
MINISTRY OF EDUCATION

PRELIMINARY STUDY
ON
MIDDLE GRADE PROTECTION FROM
CLODY AND YAKA METEOROLOGICAL
OR
ANALYSIS OF THE ACTION PLAN

MAP 8A

REVISION

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**THE PEOPLE'S REPUBLIC OF BANGLADESH
FLOOD PLAN COORDINATION ORGANIZATION**

**FEASIBILITY STUDY
ON
GREATER DHAKA PROTECTION PROJECT
(STUDY IN DHAKA METROPOLITAN AREA)
OF
BANGLADESH FLOOD ACTION PLAN NO. 8A**

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SUMMARY

JUNE 1992

JAPAN INTERNATIONAL COOPERATION AGENCY

国際協力事業団

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PREFACE

In response to a request from the Government of the People's Republic of Bangladesh, the Government of Japan decided to conduct a study on Greater Dhaka Protection Project (Study in Dhaka Metropolitan Area) of Bangladesh Flood Action Plan No. 8A and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Bangladesh a study team headed by Mr. Hajime Tanaka of Pacific Consultants International 4 times between October 1990 and June 1992.

The team held discussions with officials concerned of the Government of Bangladesh and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the People's Republic of Bangladesh for their close cooperation extended to the team.

June 1992



Kensuke Yanagiya

President

Japan International Cooperation Agency

FEASIBILITY STUDY
ON
GREATER DHAKA PROTECTION PROJECT
(STUDY IN DHAKA METROPOLITAN AREA)
OF
BANGLADESH FLOOD ACTION PLAN NO.8A

June, 1992

Mr. Kensuke YANAGIYA
President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

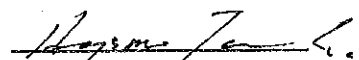
Dear Sir,

We are pleased to submit the final report entitled the "Feasibility Study on Greater Dhaka Protection Project (Study in Dhaka Metropolitan Area) of Bangladesh Flood Action Plan No.8A". This report has been prepared by the Study Team in accordance with the contract signed on September 1991 and May 1992 between the Japan International Cooperation Agency and Pacific Consultants International.

In the study, the Study Team has carried out a Feasibility Study on the priority areas identified by the Master Plan which was conducted from October 1990 to August 1991.

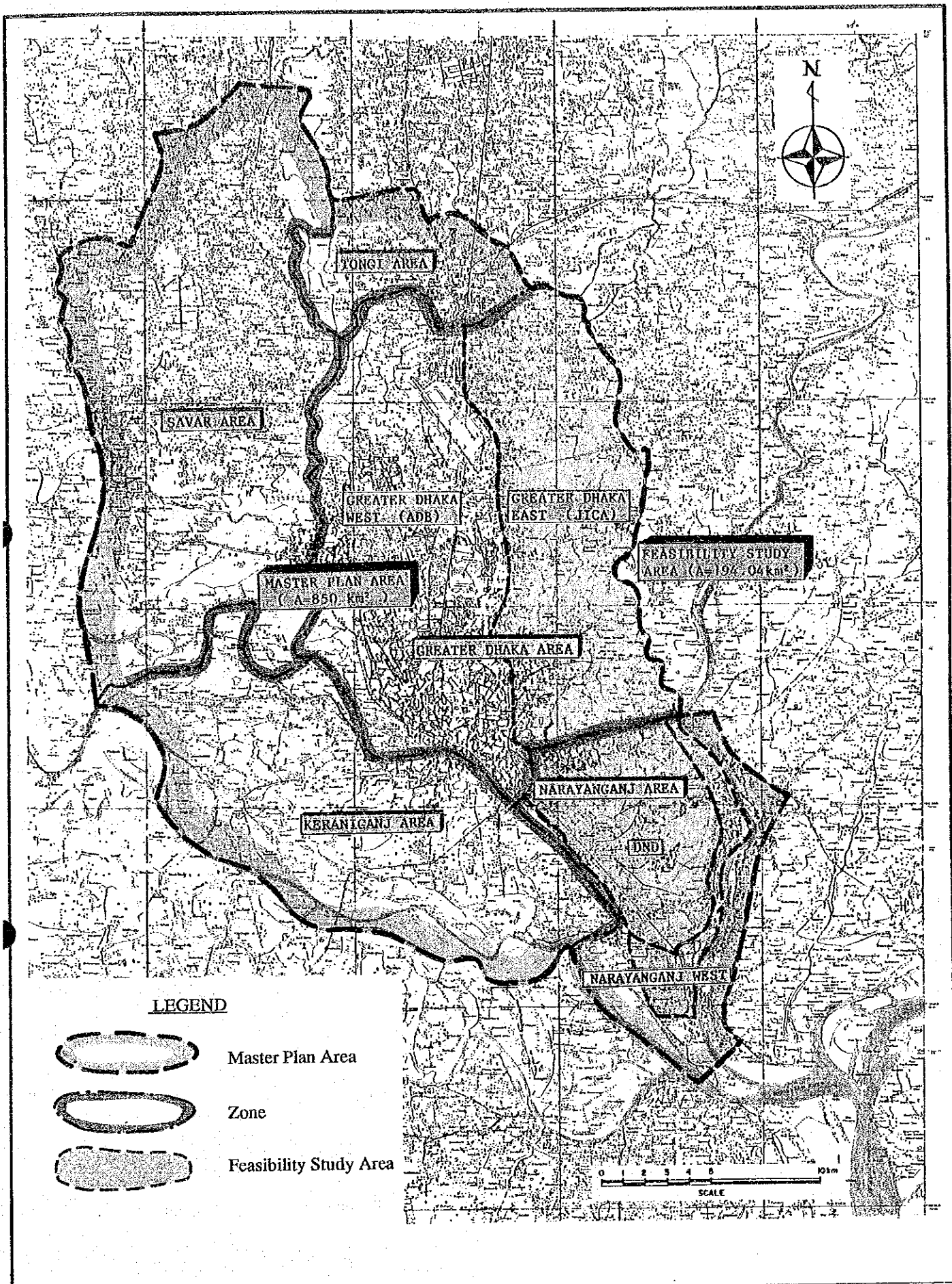
All members of the Study Team wish to express appreciation to the personnel of your Agency, Advisory Committee, Ministry of Foreign Affairs, Ministry of Construction, and Embassy of Japan in Bangladesh for their assistance. The team also like to thank officials and individuals of the Government of the People's Republic of Bangladesh.

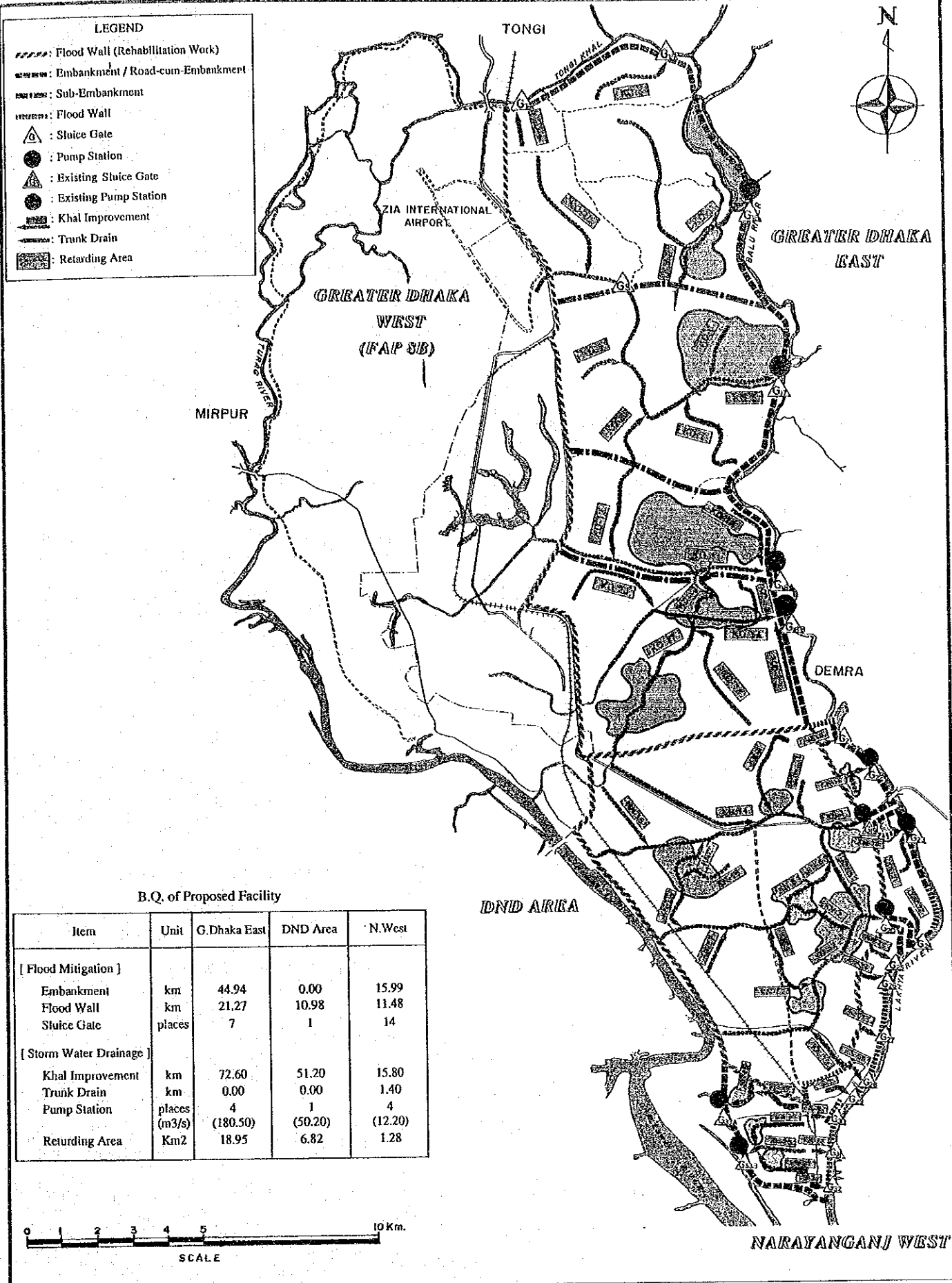
Yours Faithfully,



Hajime TANAKA

Team Leader





B.Q. of Proposed Facility

Item	Unit	G.Dhaka East	DND Area	N.West
[Flood Mitigation]				
Embankment	km	44.94	0.00	15.99
Flood Wall	km	21.27	10.98	11.48
Sluice Gate	places	7	1	14
[Storm Water Drainage]				
Khal Improvement	km	72.60	51.20	15.80
Trunk Drain	km	0.00	0.00	1.40
Pump Station	places	4	1	4
	(m ³ /s)	(180.50)	(50.20)	(12.20)
Retarding Area	Km ²	18.95	6.82	1.28

PROPOSED FLOOD MITIGATION AND DRAINAGE IMPROVEMENT PLAN

GREATER DHAKE PROTECTION PROJECT (STUDY IN DHAKE METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH



SUMMARY

1. Introduction

This is a summary of the findings of the Feasibility Study on flood control and storm water drainage improvement measures, for the identified priority areas by the previous Master Plan Study of Bangladesh Flood Action Plan No. 8A (FAP 8A), in Dhaka Metropolitan Area, dated November 1991.

- 1.2 In 1987 and 1988, Bangladesh experienced two of the most severe floods on record. Soon after the floods, various studies were conducted by different agencies, countries and the Government of Bangladesh. The World Bank coordinated the studies and framed a Flood Action Plan (FAP) with 26 components as the initial stage in the development of a long term for flood control, drainage and river management in Bangladesh, the activities are divided between 11 main compartments and 15 supporting studies or pilot projects. This study belongs to main component No. 8A along with ADB sponsored component No. 8B of Dhaka flood protection.

The Japan International Cooperation Agency (JICA), the official agency responsible for the implementation of technical cooperation programs, was assigned to undertake this feasibility study as the follow-up of the previous master plan study, in close cooperation with the Flood Plan Coordination Organization (FPCO) and other concerned authorities of GOB.

- 1.3 The entire master plan and feasibility study was composed of three (3) phases, and the respective period and objectives of each phases were as follows :

Phase I : From October 1990 to December 1990

- to prepare a general study program based on the Scope of Work,
- to review the existing conditions and to prepare a detailed study plan.

Phase II : From January 1991 to August 1991

- to carry out a master plan study on comprehensive flood control and storm water drainage for Dhaka Metropolitan area.
- to identify priority projects for a feasibility study.

Phases III : From September 1991 to April 1992

- to conduct a feasibility study on flood control and storm water drainage improvement measures for the priority area identified during the Phase II.

During the phase II, the priority areas were identified for a feasibility study. They are :

- Greater Dhaka West (FAP 8B, ADB)
- Greater Dhaka East
- DND
- Narayanganj West

The priority area of Greater Dhaka West was taken as a part of the immediate investment program by ADB financed consultants, FAP 8B. A feasibility study of FAP 8A has been decided to be carried out on the other priority areas.

- 1.4 The feasibility study areas, constitute a continuous zone along the eastern side of the town area. Due to the population and land use forecast for 1990 and 2010 done in the Master Plan Study, the population for 1990 and 2010 is estimated at 1.6 million and 4.4 million respectively. Accordingly the built-up area would be expanded from 58 km² (20% of the area) in 1990 to 145 km² (75% of the area) by 2010.

The existing built up areas are located mostly at the higher land above 5.0 m above mean sea level, however the forecast urban development areas, under current conditions, are still mostly flood prone and low-lying. The flood and storm water drainage problems would become sever constraints on future urban development.

- 1.5 The climate is classified as a tropical monsoon type, characterized by the three seasons i.e. monsoon (rainy season), post-monsoon (dry season) and pre-monsoon (transitional season). Average annual rainfall at Dhaka is about 2000 mm, 90% of which occurs during the monsoon from May to October.
- 1.6 The master plan study area is strongly affected by the three international rivers of the Ganges, the Brahmaputra - Jamuna River and the Meghna River, and surrounded by tributaries and distributaries of the Ganges and the Brahmaputra-Jamuna River. The river system is composed of the Tongi Khal in the north, the Balu River and the Lakhya River in the east, the Dhaleswari River in the south and the Buriganga River in the West. The floods are caused by these rivers, which are affected by the big flood

discharge through the Ganges and the Brahmaputra-Jamuna River on the high backwater stage of the Meghna River.

- 1.7 There are two types of floods, external and internal floods in the study area. External floods are caused by overflow of surrounding rivers, while internal floods are caused by storm water flooding in the built up area due to insufficient drainage facilities and poor O&M activities.

2. Flood

Major floods in the study area were recorded in 1954, 1958, 1970, 1980, 1984, 1987 and 1988. The study area experienced severe floods consecutively in 1987 and 1988. The 1987 floods were assessed as the medium size floods of a 10-year return period, while the 1988 floods were the largest floods recorded and estimated as the floods of a 70-year return period.

3. Development Trend

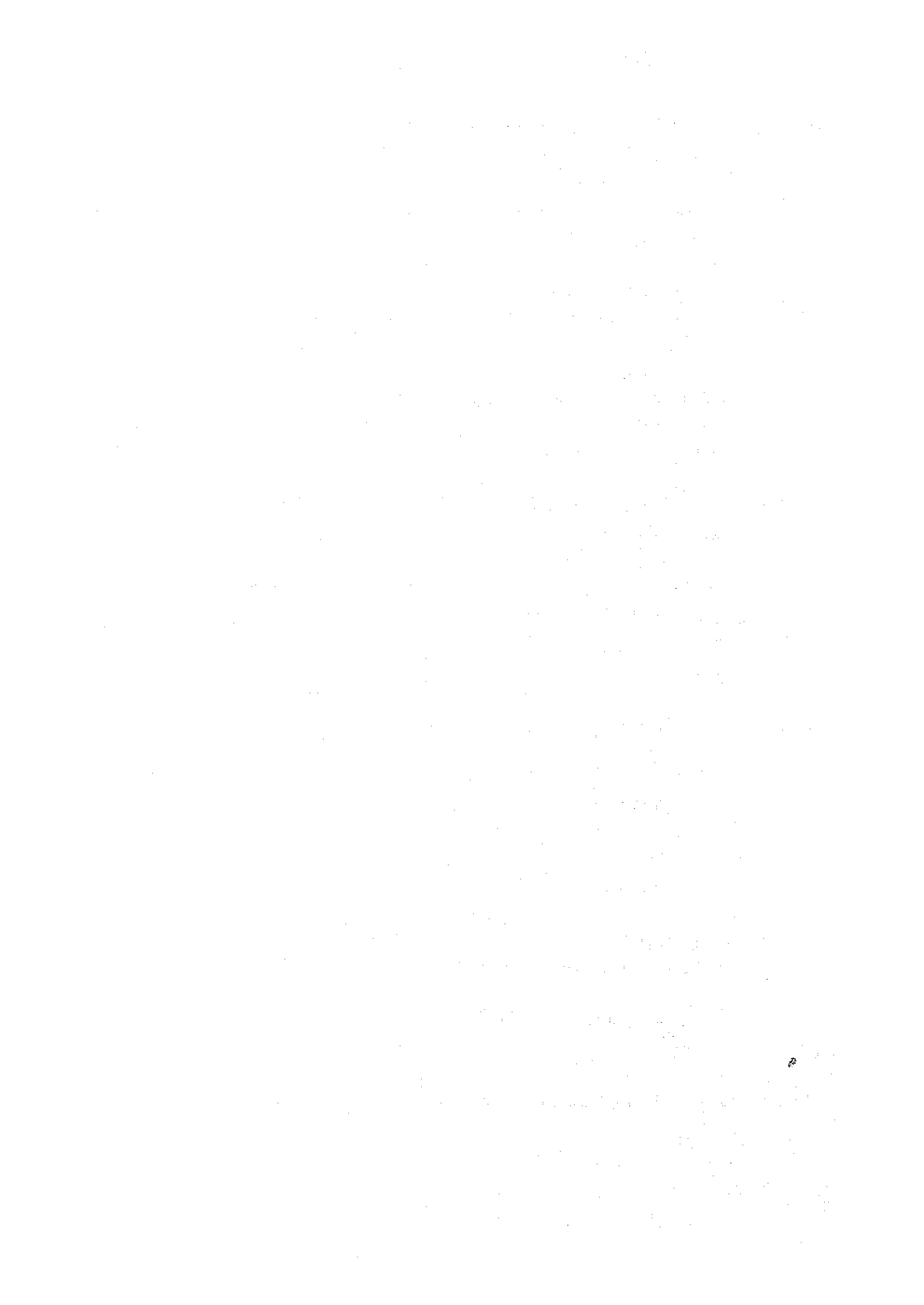
- 3.1 The Greater Dhaka East is the least developed among the feasibility study areas. This is mostly because, under current conditions, large parts of the central and the southern areas are flooded for most of the year. Considerable peripheral developments have taken place during the last decade by landfill especially in the southern portion close to the city center.

The construction of the Rampura-Biswa road has also provide a platform for further peripheral developments to the east. Further north, in Uttara, RAJUK has initiated sizable developments.

Further planned and unplanned peripheral developments may be anticipated during the next decade. Among the proposed four compartments, the southern compartment-2 (DC-4) will experience a high pressure of urban development and greater areas will be developed in the coming decade.

There are numerous canals which serve both as drainage channels and as navigation routes. Both passengers and freight services by boats take place throughout the year, due to unavailability of all weather road links between the Balu River and the Rampura-Biswa road area. When the various impacts the waterway transport system has, are considered, the existing water ways may be kept for the time being, until the provision of some road networks to replace the water ways.

- 3.2 The DND was developed for irrigation, but has been rapidly developed as urban area during the last decade, particularly in the north west corner, because of its proximity to the city and being relatively flood free. Currently RAJUK is preparing a housing development plan and together with RHD has started Dhaka-Narayanganj road. Further substantial development are anticipated over the next decade.
- 3.3 The Narayanganj West is much smaller but much more intensively developed. The town area is on relatively high land and developed independent from Dhaka. The major settlement areas are in the south-east and the linear northern area. Density decreases from east to west in the wider part of Narayanganj West. This leaves a small south-western part undeveloped. However the up-coming Dhaka - Narayanganj link road, coupled with RAJUK housing development scheme of Panchabati, will exert a development pressure to the north-western part at the wide segment.
- 3.4 Management and control of land use is needed if urban development is to proceed in accordance with a preferred strategy. The flood mitigation and drainage improvement strategy will be a major determinant of the city form. Since this will constitute the major expenditure, to ensure the availability of land where required, it will have to be delineated, and safeguarded. Management and acquisition power should be sufficient to:
- Maintain certain areas for agricultural and recreational uses ;
 - Acquire land for flood protection measures;
 - Control land filling in areas to be acquired;
 - Prevent encroachment into land earmarked for flood mitigation and drainage improvement facilities;
 - Set and maintain landfill and road crest heights;
 - Control / modify particular development proposals that would affect the flood mitigation and drainage improvement plans,
- 3.5 There are some specific issues with regard to the flood mitigation project, especially land use control of huge areas required for retarding basins. They are;
- Control of land use by speedy zoning by which the existing land use may be frozen.
 - Multiple beneficial uses of the retarding areas.



- Provision for enforcing retarding areas by developers, approximately 12% of their land to be developed in each of their housing projects.
- Preparation of a zoning master plan by RAJUK, for the feasibility area, especially newly developing areas, incorporating flood protection needs.

3.6 A number of studies are underway to bring about more efficient land management and cost recovery.

These studies will examine and make subsequent recommendations with regard to the present inadequacies of current mechanisms in a comprehensive manner. Until comprehensive measures are enacted, existing methods must be used more efficiently.

3.7 Development control is required during execution and subsequent management of the flood protection project. Development control is categorized into the followings;

- On and around flood mitigation and drainage improvement structures; embankment, retarding area and drainage channel
- Regulation for site development
- Minimum height for landfill and development,
- Required on-site retarding area,
- Multiple use of retarding areas
 - Recreation,
 - Agriculture,
 - Fish pond.

4. Environmental Aspects

4.1 The environmental study in the feasibility study (FS) stage is principally targeted at the anticipated major environmental consequences, both of direct and indirect nature, by the implementation of the proposed flood control and drainage works. Though urbanization itself would lead to much direct environmental impacts, living environmental issue with specific concern to sanitation and its socioeconomic aspect is only analyzed as the priority element in this flood control and drainage project.

4.2 A comprehensive ecological survey, principally based on available secondary data, was carried out for establishing the base line conditions of existing ecological resources in the priority areas and hence to identify the impacts on such resources by the project implementation. The ecological resources targeted by the survey are fauna and flora,

termed as general ecological resources, and aquaculture and agriculture, termed as productive ecological resources in consideration to their direct economic value.

The impacts by the project on ecology, both due to the direct dry up effect of embankment and the subsequent change in land use due to urbanization, was evaluated to be insignificant when assessed from a broad perspective on a national basis.

- 4.3 Environmental effects by the project will be predominantly beneficial though adverse to some extent. Specifically adverse effects would be social in nature that is felt by the immediate concerns in the vicinity of project implementation, such as those population displaced in making way for the project facilities and others.

However, it is emphasized that the benefits expected by the project implementation is overwhelming, for both the existing and future urban area the anticipated adverse effects in no way could justify the vice-versa.

- 4.4 Major beneficial effects of short and long term realized by the project are summarized below.

- Employment opportunity increment
- Flood damage mitigation
- Land use potential enhancement
- Public health improvement
- Generation of employment

- 4.5 Significant adverse effects of short and long term are given below.

(Short term)

- Severance in general implies inconvenience or difficulties such as accessibility.

(Long Term)

- Resettlement of population displaced by land acquisition for the project,
- Living environment due to subsequent urbanization and the resultant potable water, pollution load and solid waste generation by the increased population.
- Decrease in agricultural and both the open water and potential culture fishery lands.

5. Proposed Flood Mitigation and Storm water Damage Improvement Facilities

(Greater Dhaka East)

5.1 Flood mitigation facility plan is based on the followings:

- (1) To protect the forecast urban area until the target year of 2010, from a 100-year frequency floods, a flood embankment is planned along the Tongi Khal and the Balu river.
- (2) The alignment of embankment along the Tongi Khal and the Balu River is to follow the proposed one by GOB in the Phase II program of the Greater Dhaka Flood Control Committee.
- (3) The area is proposed to be divided into four compartments in order to increase safety and to facilitate a phased development.
- (4) The alignment of sub-embankment for compartmentalization is basically designed along the existing road.
- (5) The embankment material is proposed to be obtained from the riverside flat lowland nearby the alignment.

According to the results of laboratory tests on soil samples from borrow pits along the river, the soil material is suitable in general for construction of a homogeneous type embankment. Required workability, shear strength and low permeability will likely be attained by proper quality control during construction stage.

- (6) However along the proposed alignment, a soft layer of N-values less than 4 is developed close to the ground surface. According to the relationship between the ground's bearing strength and the embankment stability, the ground's bearing strength is partly not sufficient for the design height of embankment of which the maximum height is 8.50 m and the average height is 5.5 m.

In order to mitigate large settlement and the sliding failure which are observed at the existing embankment of Dhaka West, the embankment stability requires foundation treatment by vertical sand drain or geotextile drain and dual or triple staged construction method.

- (7) Revetment is designed in order to protect the embankment's toe and the slope from scouring by wave action. The flood water flow velocity is not so fast, about 1.0 ~ 1.5m/s, so tractive force is not so strong. Scour is caused mainly by waves due to wind and navigation.
- (8) A sluice gate of box culvert type is planned from economical and technical aspects of its lower cost for construction and easy O & M.

5.2 Stormwater drainage improvement facility plan is based on the followings :

- (1) The area is divided into four drainage zones of DC-1 to DC-4 and nine (9) sub-zones according to the existing topographic conditions, khal systems, road networks and the proposed four compartments,
- (2) The design flood water levels are applied for demarcation of pump or gravity drainage system of each sub-zone along the Tongi khal and the Balu River, based on the probable flood water levels at Tongi and Demra gauging stations.
- (3) The pump facility is designed to discharge out the runoff amount of 2 days consecutive rainfall with a 5-year return period within 2 days and to cope with the flood of a 100-year flood frequency.
- (4) Retarding pond capacity is based on 2 days consecutive rainfall with a 5-year return period, and determined by mass curve analysis so as to pond the maximum difference between the accumulated amount of rainfall and that of pump discharge during 2 days.
- (5) For designing khal improvement, rainfall runoff calculation is conducted by the rational formal using a rainfall intensity curve of a 5-year return period and the values of run-off coefficient by land use projected for the target year of 2010.
- (6) The conveyance capacities of the existing khal channels are too small to meet the required capacities. Khal improvement by widening and dredging is required.

The proposed types for khal improvement are :

(i) Open Channel

- Type (1) : Trapezoidal shape with 1:2 slope lined by sodding
- Type (2) : Trapezoidal shape with 1:1 slope lined by brick

Type (1) is applied for the khal situated in agricultural area where land acquisition is expected comparatively easy. Type (2) is proposed for the khal located in built-up areas where land acquisition is likely to be difficult.

5.3 The proposed facilities are shown in the following tables :

Proposed Flood Mitigation Facility : Dhaka East

<u>Compartment</u>	<u>Facility</u>	<u>Main Features</u>
1. Northern compt. (DC-1)	1. Embankment 2. Sub-Embankment 3. Flood Wall 4. Sluice Gate	L= 14.00 km (E.33 + 200 ~ E.69) L= 6.40 km (SA.0 ~ SA.16) L = 5.00 km (R.16 + 150 ~ R.22) No = 4 Places
2. Central Compt. (DC-2)	1. Embankment 2. Sub-Embankment 3. Flood Wall 4. Sluice Gate	L= 6.00 km (E.18 + 200 ~ E.33+200) L= L = 4.85 km (R.11 + 300 ~ R.16+150) No = 1 Place
3. Southern compt-1 (DC-3)	1. Embankment 2. Sub-Embankment 3. Flood Wall 4. Sluice Gate	L= 2.97 km (E.11 + 150 ~ E.18+200) L= 4.71 km (SB.0-SB.12) L = 2.50 km (R.8 + 300 ~ R.11+300) No = 1 Place
4. Southern Compt-2 (DC-4)	1. Embankment 2. Sub-Embankment 3. Flood Wall 4. Sluice Gate	L= 4.55 km (E.0 ~ E.11+150) L= 6.31 km (SC.0 ~ SC.13) L = 8.07 km (R.0 ~ R.8+800) No = 1 Place
Total (DC-1 to DC-4)	1. Embankment 2. Sub-Embankment 3. Flood Wall 4. Sluice Gate	L= 27.52 km (E.0 ~ E.69) L= 17.42 km (3 Sub-Embankments) L = 21.27 km (R.0 ~ R.22) No = 7 Places

5.4 Proposed drainage improvement facilities are shown in the following tables :

Pump station and Retarding Area

Zone	Area (km ²)	Required Pump Capacity (m ³ /s)		Required Storage Volume of Retarding Area (x 10 ⁶ m ³)	
		Specific	Total	Specific	Total
DC-1	22.11	1.14	25.6	0.12	2.65
DC-2	47.88	1.14	54.6	0.12	5.75
DC-3	46.58	1.14	53.1	0.12	5.59
DC-4	41.34	1.14	47.2	0.12	4.96
Total :	157.91	-	180.5	-	18.95

Khal Improvement

Drainage Zone	Khal Improvement Length (km)		Number of Bridge Construction (Nos.)	
	Type (1)	Type (2)	Road Bridge	Railway Bridge
DC-1	12.70	---	---	---
DC-2	24.30	---	8	1
DC-3	12.10	---	---	---
DC-4	21.90	2.20	4	---
Total :	71.00	2.20	12	1

(DND)

5.5 Flood mitigation facility plan is based on the followings :

- (1) To protect the forecast urban area of the target year of 2010, from a 100-year frequency flood, flood mitigation measures are planned to rehabilitate and reinforce the existing flood wall and embankment.

The design top level of the existing flood wall was designed at the level of 1988 flood water level plus 2 feet. However some portions require to be raised or improved.

- (2) A culvert type sluice gate is proposed at the proposed pump station of Adamjee Nagar.
- (3) Stop log structures are proposed for closing the openings in the existing flood wall. However, for small openings less than 5.0m wide or 1.0m high, simple counter measures such as sand bags and timber stoppers are proposed.

5.6 Stormwater drainage improvement facility plan is based on the followings :

- (1) The DND area (56.79 km²) was developed as an agricultural development area. The storm water is collected and conveyed to Kharder Ghoshpara by the major khal and discharged into the Lakhya River through the Demra pumping station.

In order to cope with the future run-off increase due to the forecast urbanization by 2010, the area is proposed to be divided into two drainage zones i.e. northern zone (NA-1): 15.10 km²) and the southern zone (NA-2:31.69 km²).

- (2) The design flood water level is adopted for each drainage zone based on the probable water levels at Demra and Narayanganj gauging stations.

NA - 1 : 5.75 m PWD

NA - 2 : 5.65 m PWD

- (3) The criteria of design rainfall, run-off coefficient and run-off ratio are the same as those of Greater Dhaka East.
- (4) The existing Demra pump station is to be utilized, though the pump capacity of 14.50 m³/s is less than the required pump capacity of NA-1 (28.6 m³/s). The additional requirement of 14.1 m³/s is to be added to the proposed new pump station of NA-2 in order to meet the design capacity.
- (5) Retarding areas are proposed in low-lying areas with seemingly low potential for future urbanization and will likely remain as an agricultural area in 2010.

5.7 The proposed flood mitigation facilities are shown in the following tables :

Proposed Flood Mitigation Facilities : DND

<u>Route</u> (Total length)	<u>Facility</u>	<u>Main Features</u>
1. Chasara to Buriganga Bridge (DW) (L= 10.63 km)	1) Flood Wall Construction :	L= -
	2) Rehabilitation Work :	
	(1) Foot Protection :	L= 3.63 km
	(2) Flood Wall Raising:	L= -
	3) Stop Log Structure :	14 places
2. Buriganga Bridge to Demra (DN) (L= 8.58 km)	1) Flood Wall Construction :	L= 0.8 km
	2) Rehabilitation Work:	
	(1) Foot Protection :	L= 5.6 km
	(2) Flood Wall Raising:	L= 4.4 km
	3) Stop Log Structure :	17 places
3. Chasara to Hajiganj (DS) (L= 2.15 km)	1) Flood Wall Construction :	L= 1.75 km
4. Hajiganj to Demra (DE) (L= 10.16 km)	1) Flood Wall Construction :	L= 1.05 km
	2) Rehabilitation Work:	
	(1) Foot Protection :	L= 8.40 km
	(2) Flood Wall Raising:	L= 3.20 km
	3) Stop Log Structure :	27 places
	4) Sluice Gate :	1 place
Total	1) Flood Wall Construction :	3.38 km
	2) Rehabilitation Works :	
	(1) Foot Protection :	17.60 km
	(2) Flood Wall Raising :	7.60 km
	3) Stop Log Structure :	58 places
	4) Sluice Gate :	1 place

- 5.8 The proposed stormwater drainage improvement facilities are shown in the following tables :

Pump station and Retarding Area

Zone	Area (km ²)	Required Pump Capacity		Required Storage Volume of Retarding Area	
		Specific (m ³ /s/km ²)	Total (m ³ /s)	Specific (m ³ /km ²)	Total (m ³)
NA-1	25.10	1.14	28.6	0.12	3.01
NA-2	31.69	1.14	36.1	0.12	3.80
Total :	56.79	-	64.70	-	6.81

Khal Improvement

Zone	Open Channel (km)		Bridge (Place)		Railway Bridge	Aqueduct
	Type (1)	Type (2)	Reconst.	New Const.	Reconstruction	Reconstruction
NA - 1	15.80	8.10	9	3	--	1
NA - 2	17.90	9.40	19	3	4	1
Total :	33.70	17.50	28	6	4	2

Note : Types of bridge are the same as those of Greater Dhaka East

(Narayanganj West)

- 5.9 Flood mitigation facility plan is based on the followings :
- (1) In order to protect the forecast urban area until the target year of 2010, from a 100-year frequency flood, embankment, road-cum-embankment and flood wall are planned.
 - (2) The road-cum-embankment is planned from Panchabati to Narayanganj along Panchabati via Saiyedpur on the western part. This embankment is connected to the DND flood wall. The alignment is planned along the existing road as a trunk road in future.

The flood wall and embankment are planned from Narayanganj to Demra along the Lakhya river. This alignment is planned along the river bank in order to protect the existing built up area and industrial property as much as possible.

- (3) The standard cross-section of the road-cum-embankment is almost the same type as the embankment.

For the flood wall along the Lakhya river, two types i.e. sheet pile type and inverted T-shaped wall type are proposed. However, some variations will be required according to the site conditions.

The standard cross-section of the embankment along the Lakhya river is the same as that of Greater Dhaka East. At 0.8 km of this stretch foundation treatment is planned due to the poor subsoil conditions.

- (4) The culvert type sluice gate is proposed at crossing of the existing khal channels and at the proposed pump stations from technical and economical aspects, easy maintenance and low construction cost.
- (5) For the flood wall along the Lakhya river, many openings are required for loading and unloading at the godowns and the factories. Stop log structures are planned.

5.10 Stormwater drainage improvement facility plan is based on the followings :

- (1) The area covering 18.63 km² consists of a narrow strip between the Demra Narayanganj Road and the Lakhya River, and Narayanganj town area.

The area is divided into five small drainage zones, NB-1 to NB-5, based on the proposed alignment of the flood protection facilities, inner drainage systems and road networks.

- (2) The design flood water levels are adopted for each zone based on the probable water levels at Demra, Narayanganj, Hariharpara and Kalagachia gauging stations. They are as follows :

- NB-1 zone : 5.80 m PWD
- NB-2 zone : 5.70 m PWD
- NB-3 zone : 5.45 m PWD
- NB-4 zone : 5.50 m PWD
- NB-5 zone : 5.45 m PWD

- (3) Design rainfall, and the method of rainfall runoff calculation are the same as those of Greater Dhaka East.

- (4) 70% of the area is already built-up, the proposed measures are pumping facilities with retarding areas, and khal improvement works. However lateral drains and tertiary drainage pipes are not included in this project.
- (5) Four (4) drainage zones are proposed as pump drainage areas due to the existing ground levels and the design flood water level. One small pumping station by each zone is proposed.
- (6) The conveyance capacities of the existing khal and trunk drains located in the Narayanganj town do not meet to the design discharges. Improvement of khal channels by widening and dredging, or replacement of trunk drainage channels or pipes are required.

The proposed types for khal and drainage improvement are :

- (i) Open Channel

The types are the same as those of the Greater Dhaka East.

- (ii) Covered Channel or Pipe

- Type (1) : Brick pipe
- Type (2) : Concrete box culvert

The type (1) is basically applied for the trunk drains. However type (2) is proposed for the trunk drains sections with design discharge more than $10\text{m}^3/\text{s}$. The concrete slab or concrete girder bridge are proposed for the road crossing.

5.11 The proposed flood mitigation facilities are shown in the following tables :

Proposed Flood Mitigation Facility : Narayanganj West

<u>Route</u> <u>Total length)</u>	<u>Facility</u>	<u>Main Features</u>
1. Narayanganj to Panchabati (NW) (L = 5.64 km)	1) Road-Cum-Embankment	: 4.10 km (NW.8+100~ NW.29)
	2) Embankment	: 1.54 km (NW.0~NW.8 +100)
	3) Sluice Gate	: 2 places
2. Narayanganj to Demra (NE) (L = 21.83 km)	1) Flood Wall	: 11.48 km (NE.0~NE.48, NE.55~NE.62, NE.87~NE.88)
	2) Embankment	: 10.35 km (NE.48~NE.55, NE.62~NE.87)
	3) Sluice Gate	: 12 places
	4) Stop Log Structure	: 17 places
Total	1) Road-Cum-Embankment	: 4.10 km
	2) Embankment	: 11.89 km
	3) Flood Wall	: 11.48 km
	4) Sluice Gate	: 14 places
	5) Stop Log Structure	: 17 places

5.12 The proposed stormwater drainage improvement facilities are shown in the following tables :

Pump Station and Retarding Area

Zone	Area (km ²)	Required Pump Capacity		Required Storage Volume of Retarding Area	
		Specific (m ³ /s/km ²)	Total (m ³ /s)	Specific (x 10 ⁶ m ³ /km ²)	Total (x 10 ⁶ m ³)
NB-1	1.73	1.14	2.0	0.12	0.21
NB-2	1.92	1.14	2.2	0.12	0.23
NB-4	2.36	1.14	2.7	0.12	0.28
NB-5	4.65	1.14	5.3	0.12	0.56
Total :	10.66	---	12.2	---	1.28

Khal and Drainage Improvement

Zone	Khal Improvement (km)		Trunk Drain		Bridge	
	Type (1)	Type (2)	Type (1)	Type (2)	Road	Railway
NB-1	1.20	0.40	---	---	1	---
NB-2	0.90	2.20	---	---	---	1
NB-3	---	2.60	0.90	0.50	2	2
NB-4	1.40	1.40	---	---	2	---
NB-5	0.80	4.90	---	---	6	---
Total :	4.30	11.50	0.90	0.50	11	3

Note : Type of bridge are the same as those of Greater Dhaka East and DND.

- 5.13 The operation and maintenance (O & M) measures of the project are the routine activities to ensure the due benefits of the project.

The flood mitigation and drainage improvement facilities, once completed, will encourage people to settle in areas where formerly they would not have settled because of a high risk of flooding. Accordingly inadequate O & M could lead to even greater damage to life and property than without the project. For realization of the expected benefits, proper O & M activities will be indispensable.

The O & M demands for the flood mitigation and drainage improvement facilities are summarized as follows :

- Routine O & M activities for major facilities i.e. embankment, flood wall, regulator, drainage channel/pipe, pump station and retarding area.
- Routine O & M equipment,
- Required organization,
- Regular training for technical staff and field staff,
- Collaboration and coordination between the operating and implementing agencies and other government agencies, in order to minimize adverse impacts and avoid operational conflicts,
- Preparation of guidelines for planning, designing, construction supervising and proper O & M,
- Participation of local residents in field level activities, actual operating / maintenance or supervising / reporting tasks,

6. Summary of Project Cost

The project costs are summarized as follows :

1) Greater Dhaka East

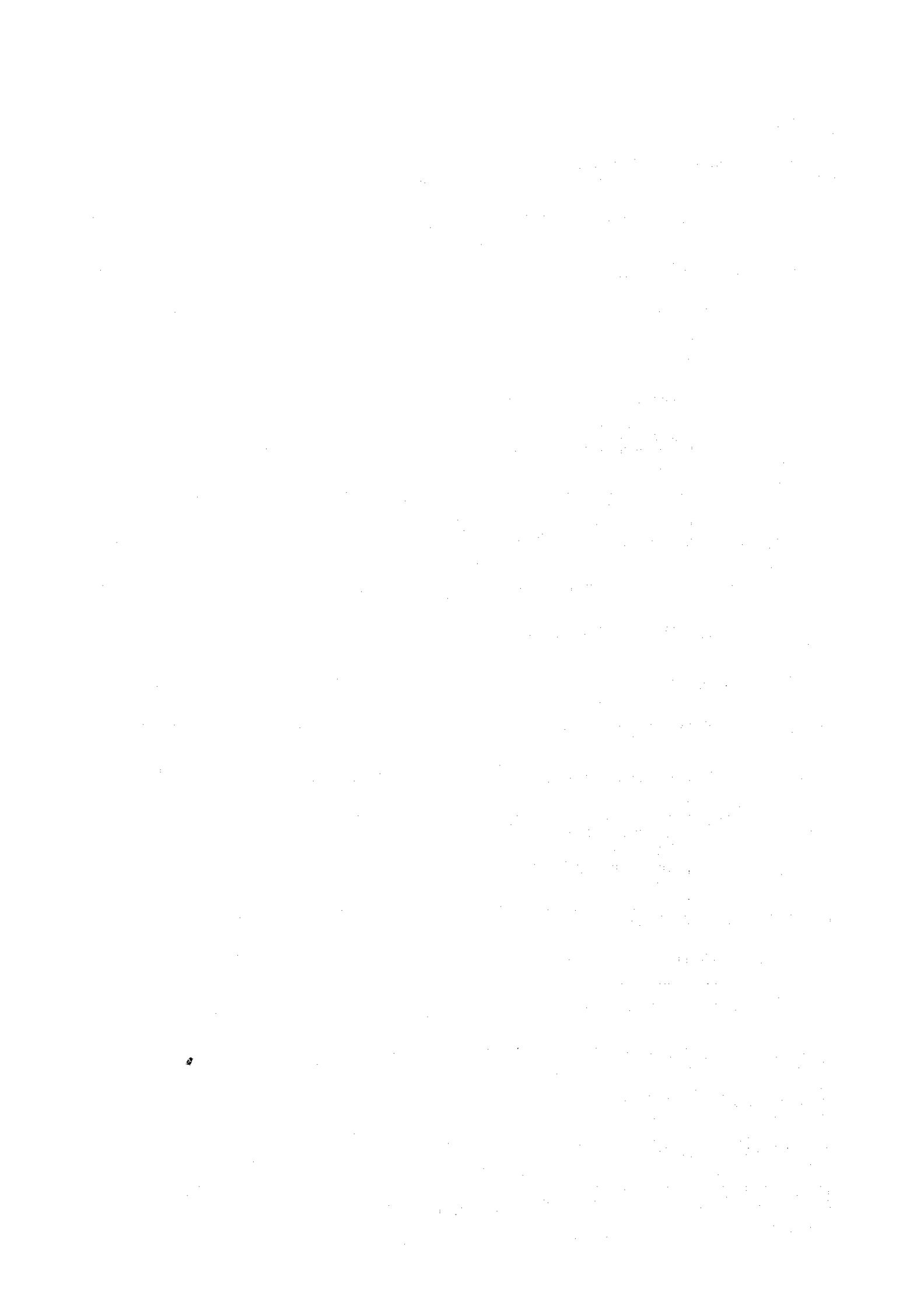
(Whole Area) (Unit : Tk. Million)

Item	F/C	L/C	Total
1. Construction Cost	7,558	3,358	10,916
2. Indirect Cost			
Land Acquisition/compensation	0	1,487	1,487
Administration	0	328	328
Engineering Service	869	387	1,256
3. Physical Contingency	1,134	501	1,635
4. CDST & Tax	0	2,674	2,674
Total	9,561	8,735	18,296

Note : Tk. 36 = US\$ 1.0 = ¥ 137

(DC-1) (Unit : Tk. Million)

Item	F/C	L/C	Total
1. Construction Cost	2,332	1,127	3,459
2. Indirect Cost			
Land Acquisition/compensation	0	565	565
Administration	0	104	104
Engineering Service	268	130	398
3. Physical Contingency	349	169	518
4. CDST & Tax	0	565	565
Total	2,949	2,667	5,616



(DC-2)

(Unit : Tk. Million)

Item	F/C	L/C	Total
1. Construction Cost	1,705	686	2,319
2. Indirect Cost			
Land Acquisition/compensation	0	272	272
Administration	0	72	72
Engineering Service	196	79	275
3. Physical Contingency	256	102	358
4. CDST &Tax	0	706	706
Total	2,157	1,917	4,074

(DC-3)

(Unit : Tk. Million)

Item	F/C	L/C	Total
1. Construction Cost	1,667	661	2,328
2. Indirect Cost			
Land Acquisition/compensation	0	238	238
Administration	0	70	70
Engineering Service	192	76	268
3. Physical Contingency	250	98	348
4. CDST &Tax	0	709	709
Total	2,109	1,852	3,961

(DC-4)

(Unit : Tk. Million)

Item	F/C	L/C	Total
1. Construction Cost	1,854	884	2,738
2. Indirect Cost			
Land Acquisition/compensation	0	412	412
Administration	0	82	82
Engineering Service	213	102	315
3. Physical Contingency	279	132	411
4. CDST &Tax	0	687	687
Total	2,347	2,298	4,645

2) DND

(Unit : Tk. Million)

Item	F/C	L/C	Total
1. Construction Cost	1,742	914	2,656
2. Indirect Cost			
Land Acquisition/compensation	0	400	400
Administration	0	80	80
Engineering Service	200	105	305
3. Physical Contingency	261	137	398
4. CDST & Tax	0	755	755
Total	2,203	2,391	4,594

3) Narayanganj West

(Unit : Tk. Million)

Item	F/C	L/C	Total
1. Construction Cost	1,421	633	2,054
2. Indirect Cost			
Land Acquisition/compensation	0	1,082	1,082
Administration	0	62	62
Engineering Service	163	73	236
3. Physical Contingency	213	94	307
4. CDST & Tax	0	356	356
Total	1,797	2,300	4,097

7. Project Assessment

7.1 Project assessment was done by comparing the flood damages in the with and "without project" situation, based on the FAP's Guidelines for Project Assessment.

To make an overall assessment of the project, not only the economic efficiencies, but also the socio-economic and environmental effects are taken into account. The socio-economic and environmental effects are assessed in quantitative terms to the extent possible.

7.2 The flood damages which were surveyed and assessed, are classified into the following five categories :

- direct damages to properties,
- direct damages to infrastructures,
- income / profit losses for economic units,
- profit losses for the public enterprises,
- traffic damages.

7.3 According to the economic evaluation, all the three projects will be feasible from flood mitigation and drainage related benefits. Their EIRR values of the Greater Dhaka East, the DND and the Narayanganj West are 15.8%, 14.5% and 14.3% respectively. The EIRR values of the compartments are varied i.e. DC-1: 14.8%, DC-2: 8.0%, DC-3: 13.9% and DC-4: 18.4%, and show a priority order of each compartment from economic aspects.

7.4 The Socio-Economic positive impacts by the project implementation is overwhelming for both the short and long terms.

As negative social impacts of the project, one can cite people to be displaced from the locations they are inhabited by the construction of flood protection facilities, people earning a livelihood by agriculture, inland water fisheries and transportation to be affected by the depletion of flood water.

According to the assessment on the survey data by the study team, the socio-economic impacts of the construction of the embankment along the Balu River on the boating trade seem not much in comparative terms, because the people and their earning likely affected by the construction of the embankment account for 0.3 to 1.4% of the total labour force and 0.4 to 1.2% of the total earnings in the Greater Dhaka East.

In fishing activities in the area, over 756 households are involved with different intensity. More than 90% of them are occasional fishermen. Full-time fishermen have proved to be few.

As an overall assessment it can be said that of the people concerned, those with positive mental attitudes toward resettlement and their economic activities are rather low. Hence, adequate compensation is a crucial issue, and a proper job training/reorientation is a "must".

On the other hand, as positive social impacts, one can quote the mitigation of flood damages, the generation of employment opportunity, the reduction of water-borne diseases which are apt to break out, especially, as the consequence of a big and protracted flood, the removal of psychological burden people are habitually forced to bear and its beneficial effects on their attitude to life, and enhancement of land use potential of flood protected land, thus accelerating its urbanization.

7.5 Environmental factors considered for possible positive and negative impacts on them by the project implementation also included

general ecological elements of flora and fauna, productive ecological elements of agriculture and aquaculture/fishery, public health, surface water quality, and others in addition to the social impact elements.

7.6 The results of project assessment and environmental impact evaluation are summarized respectively in Table S.1 and Table S.2.

The environmental impacts were assessed qualitatively by assigning integer values for each considered elements within a range of ± 3 . The project in itself is highly beneficial, directly. However, conditional future urban environment improvement measures of living environment and water pollution control will be necessary for realizing long term benefit. Still, flood control and drainage forms the basis of such urban environmental enhancement measures.

7.7 Institution of stream water quality monitoring station in the retarding areas would become necessary with the implementation of this project. This will assist in formulating and implementing the necessary pollution control measures abreast the change in land use.

8. Implementation Methods

8.1 Executing Agency

The overall coordination for the project will be provided by the Ministry of Irrigation, Water Development and Flood Control (MIWDFC), and the execution of the project will be the responsibility of the BWDB, which will be the lead project executing agency. The other implementing agencies will be DWASA and Narayanganj Municipality, while RAJUK and DOE will be involved in supporting roles such as overall land use management and environmental monitoring.

8.2 The implementation program for the project is based on :

- (1) The whole proposed flood mitigation and storm water drainage improvement measures will be complete by the target year of 2010.
- (2) The phased implementation programs proposed in the Master Plan Study, was reviewed from economical efficiency, social and environmental aspects and modified.
- (3) The other on-going project or committed projects are considered to ensure consistency with the proposed phased implementation programs.
- (4) Though three project components of the Greater Dhaka East, the DND and Narayanganj West, were identified in the Master Plan Study for F/S areas, the Greater Dhaka East is divided into four compartments considering safety against floods, easiness for O & M, economic efficiency and social effects of development.

8.3 Phased Programs are made based on the followings :

- (1) The proposed phased program is composed of preparation stage, initial construction stage, monitoring / reviewing stage and completion stage.
- (2) The proposed construction schedule is so as to minimize to the extent possible the likely adverse effects as caused by implementation of the proposed works.
- (3) The proposed construction schedule is prepared based on the order of priority. The area with a high development pressure and high economic efficiency, will be given a high priority sequence for early implementation.

The southern compartment -2 and the DND have very high priority due to their intense development pressure and high economic efficiency.

- (4) The existing water transport system which connects the Rampura area with the Balu River, shall be kept for the time being.

Accordingly the development of the southern compartments-1 and the central compartment, which are located in the middle of Greater Dhaka East could be phased later, to facilitate completion of some road networks to replace the existing water ways.

The proposed implementation schedule of the projects are shown in Fig. S.1.

9. Conclusion and Recommendation

Recommendations from the study are summarized below :

- 9.1 It is concluded that the proposed flood mitigation and storm water drainage improvement plans for the feasibility study areas, i.e. Greater Dhaka East, DND and Narayanganj West, will be feasible in technical, economical, social and environmental terms.

The feasibility study areas constitute a continuous zone along the eastern side of the Dhaka Metropolitan area and anticipated to encounter a high population pressure. The areas will most likely be developed as urban areas, however the areas are extremely vulnerable to floods due to low and flat topography. The flood and storm water drainage problems would be severe constraints to future urban development

The whole study area needs immediate action for implementation of the proposed measures. However, in order to attain the expected project benefit, prompt actions will be required for improving land use management and O&M activities.

- 9.2 Also early execution of a comprehensive urban development study and supporting development studies including multiple uses of retarding areas are needed.

The Metropolitan Development Plan commenced by RAJUK in March, 1992 will make an in-depth study in these areas. Then the supporting development studies should be done based on their recommendations.

The objectives of the supporting development studies should be :

- Strategic development zones,
- Transportation network system,
- Housing / industrial / commercial development
- Recreation facilities development
- Major public facilities development,
- Urban utilities and sanitation / solid waste management system development,
- Multiple uses of flood mitigation facilities.

- 9.3 Early establishment of proper management and control of land use are needed based on the urban development plan mentioned above.

The flood mitigation and drainage improvement strategy will be a major determinant of the urban development. If urban development is to proceed in accordance with a preferred strategy, land use management and control will be very decisive.

RAJUK is the planning and land development authority for the Dhaka Metropolitan area. It should have the necessary authority to control development.

The existing legislation for land use control, and land acquisition may require revision in order to facilitate the implementation of the project.

- 9.4 Improvement of O&M activities for flood mitigation facilities are essential. After implementation of the project, proper O&M activities will be decisive measures for security of the schemes.

Although poor O&M activities are widely pronounced, the GOB is fully responsible for proper O&M activities.

Also budget constraints are frequently cited constraint on O&M reported by the GOB. If so, it should be solved without fail.

Everyone in Dhaka would get benefits from flood protection measures. Everyone should in principle contribute towards the cost. A tax based on the increase in land values (as suggested in the ADB Aide memories) would be an equitable measure.

Also the GOB should prepare routine O&M manuals and training programs for its staff and local participants.

- 9.5 Establishment of an environmental monitoring system for surface water is needed.

Surface water quality is the prime indicator of pollution, however available data and information are still quite limited. Without proper monitoring systems the environmental laws and regulation standards are useless.

- 9.6 Improvement of major access roads in the flood prone areas is needed for evacuation purposes.

A number of rural settlements at low-lying areas are isolated during floods. By improvement of the major access roads, the situation could be greatly improved.

- 9.7 The projects are proposed to be implemented with progressing urbanization, monitored and reviewed periodically.

After implementation of the proposed facilities of the initial stage, the major facilities such as pumps, trunk channels and retarding areas shall be monitored and reviewed before undertaking the scheme in full scale.

- 9.8 Conservation and development studies of ecological resources in the proposed flood plain management and other rural areas of the master plan in Keraniganj and Savar are recommended.

TABLE S.1 PROJECT EVALUATION

Item	Greater Dhaka East					Narayanganj		Remarks
	DC-1	DC-2	DC-3	DC-4	Combined	DND	West	
1. Economic Evaluation								
1) EIRR (%)	14.8	8.0	13.9	18.9	15.8	14.5	14.3	
2) NPV (Tk. million)	274	-98	263	1,032	1,501	371	152	
3) B/C	1.22	0.74	1.19	1.55	1.31	1.21	1.18	
4) NPVR (2)	0.162	-0.155	0.147	0.416	0.228	0.151	0.110	
2. Socio - Economic Impacts								
1) Population to be Saved from Inundation by 1988 - Scale Flood in 2010	655,996	261,856	847,139	1,218,397	2,993,388	1,685,439	981,873	
2) Area to be Saved from Inundation by 1988-Scale Flood in 2010 (ha)	3,036	1,146	2,977	2,635	9,794	4,270	1,720	
3) Labour Force to be Employed during Construction (man-years)	10,693	8,616	5,968	13,637	38,914	19,974	7,625	
4) Resettlement								
(1) No. of People to be Displaced	1,337	734	433	1,127	3,631	1,783	1,639	
(2) Compensation (Tk. million)	34.4	21.7	13.6	31.2	100.9	61.7	165.5	
5) Boating Trade to be Affected								
(1) No. of Boatmen to be Affected	853 118	415 -	1,207 305	150 150	2,625 573	- -	- -Seriously
(2) Annual Sales to be Affected (Tk.)	30,675,750 3,701,250	4,727,800 -	12,513,100 9,061,150	5,355,000 5,355,000	53,268,650 18,117,400	- -	- -Seriously

Source : JICA

TABLE S.2 QUALITATIVE EVALUATION OF ENVIRONMENTAL IMPACT

a) Direct Effect by Flood Control and Drainage

Item	Degree of Environmental Impact				Remarks
	Beneficial (+)		Adverse (-)		
	Short term	Long term	Short term	Long term	
1. Flood damage	-	+3	-	-	Major reason for project formulation
2. Landuse potential	-	+3	-	-	The principal benefit in future urban area
3. Employment	+3	+1	-	-	Construction employment benefit is short term while O/M is long term
4. Navigation	-	-	-1	-	Phased development of Greater Dhaka East will moderate the impact
5. Resettlement	-	-	-2	-1	Resettlement compensation is incorporated as a negative project benefit
6. Construction activity	-	-	-1	-	Better construction management will reduce even the short term impact
7. Aquatic wild flora and fauna	-	-	-	-1	Aquatic wildlife sanctuary/conservation is recommended
8. Terrestrial wild flora and fauna *	+2	-	-	-	Change in landuse to urban will exert long term effect
9. Agriculture *	+2	-	-	-	Change in landuse to urban will exert long term effect
10. Aquaculture/fishery *	-	-	-	-2	Effect due to dry up of flood plains of open water capture fishery
11. Public health *	+2	+1	-	-	Future urbanization and population increase will exert additional living environmental improvement demand.

b) Indirect Long Term Effect by Change in Landuse

Item	Degree of Environmental Impact (Long term)		Remarks
	Beneficial (+)	Adverse (-)	
8. Terrestrial wild flora and fauna *	-	-1	Terrestrial wildlife sanctuary/conservation is recommended
9. Agriculture *	-	-2	Effect due to change in agricultural landuse to urban and others
10. Aquaculture/fishery *	-	-1	Potential effect on culture fishery (aquaculture) due to change in landuse
11. Public health**	(+2)	(-2)	Effect due to increased living environmental demand
12. Surface water quality*	(+3)	(-3)	Effect due to increased pollution load generation
13. Domestic flora of fauna	+2	-	Effect due to increased homestead plants and domestic animals with progressing residential development

Note : Evaluation point of impact is assigned qualitatively as an integer within the range of ±3

* An item encountered twice under both direct and indirect effects is treated as a single element

* The public health and surface water quality items are interrelated, and could be dealt with integrally as future living environmental and water quality improvement projects of water supply, sewerage and sanitation and solid waste management. Such measures are conditional in order to realize a long term urban environmental benefit.

Phase	'92	'93	'94	'95	'96	'97	'98	'99	2000	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	Remarks	
Preparation Stage by GOB																					
G.Dhaka East																					
1. NORTHERN COMPT. (DC-1)																					
A. Project Preparation																					
B. Flood Mitigation																					Including Sub-Emb. SA
C. Storm Water Drainage																					
2. CENTRAL COMPT. (DC-2)																					
A. Project Preparation																					
B. Flood Mitigation																					
C. Storm Water Drainage																					
3. SOUTHERN COMPT. -1 (DC-3)																					
A. Project Preparation																					
B. Flood Mitigation																					Including Sub-Emb. SB
C. Storm Water Drainage																					
4. SOUTHERN COMPT. -2 (DC-4)																					
A. Project Preparation																					
B. Flood Mitigation																					Including Sub-Emb. SC
C. Storm Water Drainage																					
Narayanganj																					
1. DND																					
A. Project Preparation																					
B. Flood Mitigation																					
C. Storm Water Drainage																					
2. Narayanganj West																					
A. Project Preparation																					
B. Flood Mitigation																					
C. Storm Water Drainage																					

Note:

- 1). Preparation stage by GOB :Including development study, etc.
- 2). Sub-Emb:Sub-Embankment.

FIG. S.1

PROPOSED IMPLEMENTATION SCHEDULE

GREATTER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH



