No. 02

PEOPLE'S REPUBLIC OF BANGLADESH
BANGLADESH WATER DEVELOPMENT BOARD

FEASIBILITY STUDY ON THE KURIGRAM IRRIGATION AND FLOOD CONTROL PROJECT - SOUTH UNIT

VOLUME I

MAIN REPORT

MARCH, 1993

Japan International Cooperation Agency
Tokyo, Japan

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PREFACE

In response to a request of the Government of the People's Republic of Bangladesh, the Government of Japan decided to conduct a feasibility study on the Kurigram Irrigation and Flood Control Project - South Unit and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to the People's Republic of Bangladesh a study team headed by Mr. Hiroshi Yamamoto, Nippon Koei Co., LTD., three (3) times between December, 1991 and January, 1993.

The team held discussions with the officials concerned of the Government of the People's Republic of Bangladesh, and conducted a field survey 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.

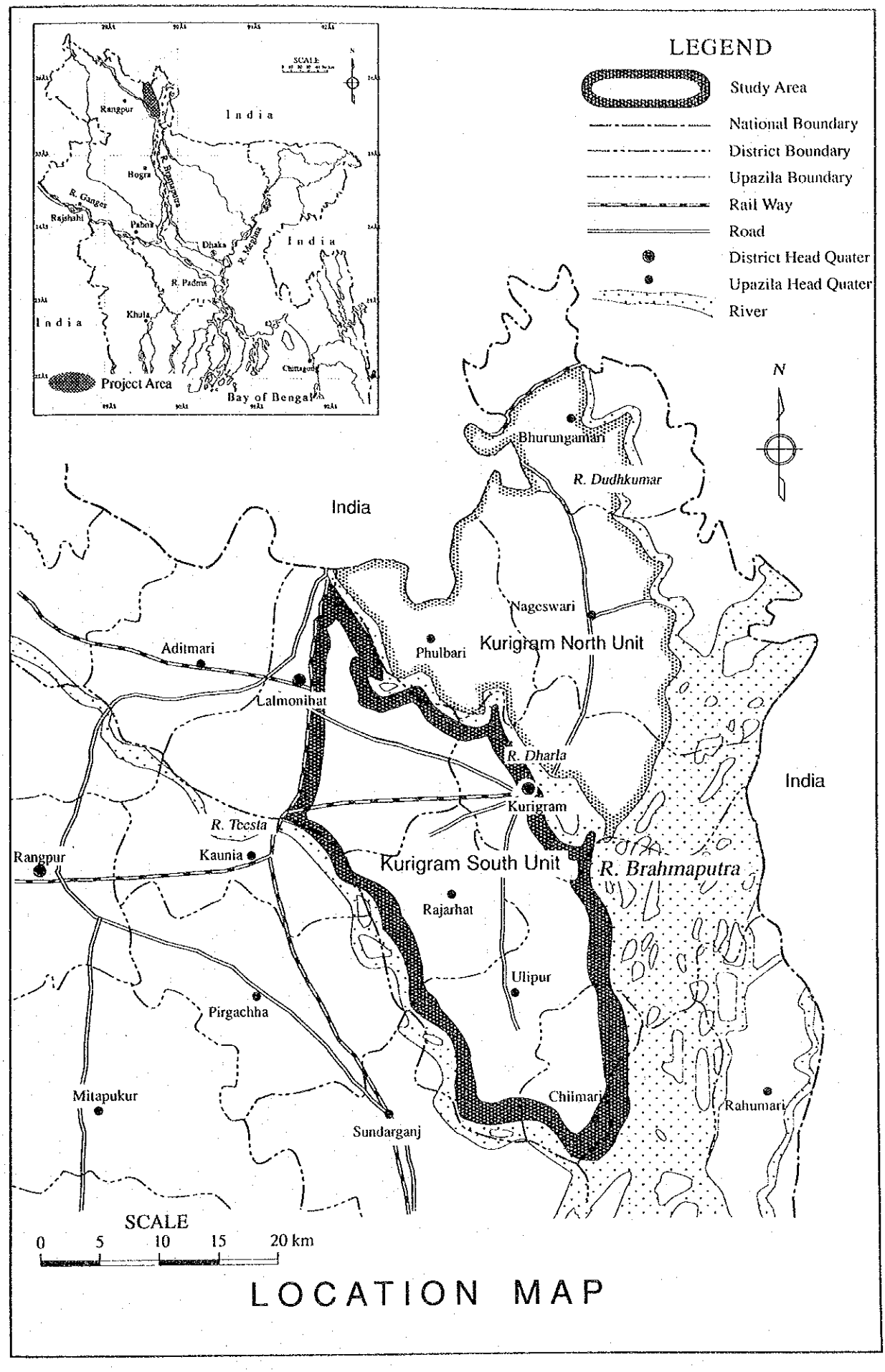
March, 1993

Kensuke Yanagiya

KENSUKE YANAGIYA

President

Japan International Cooperation Agency



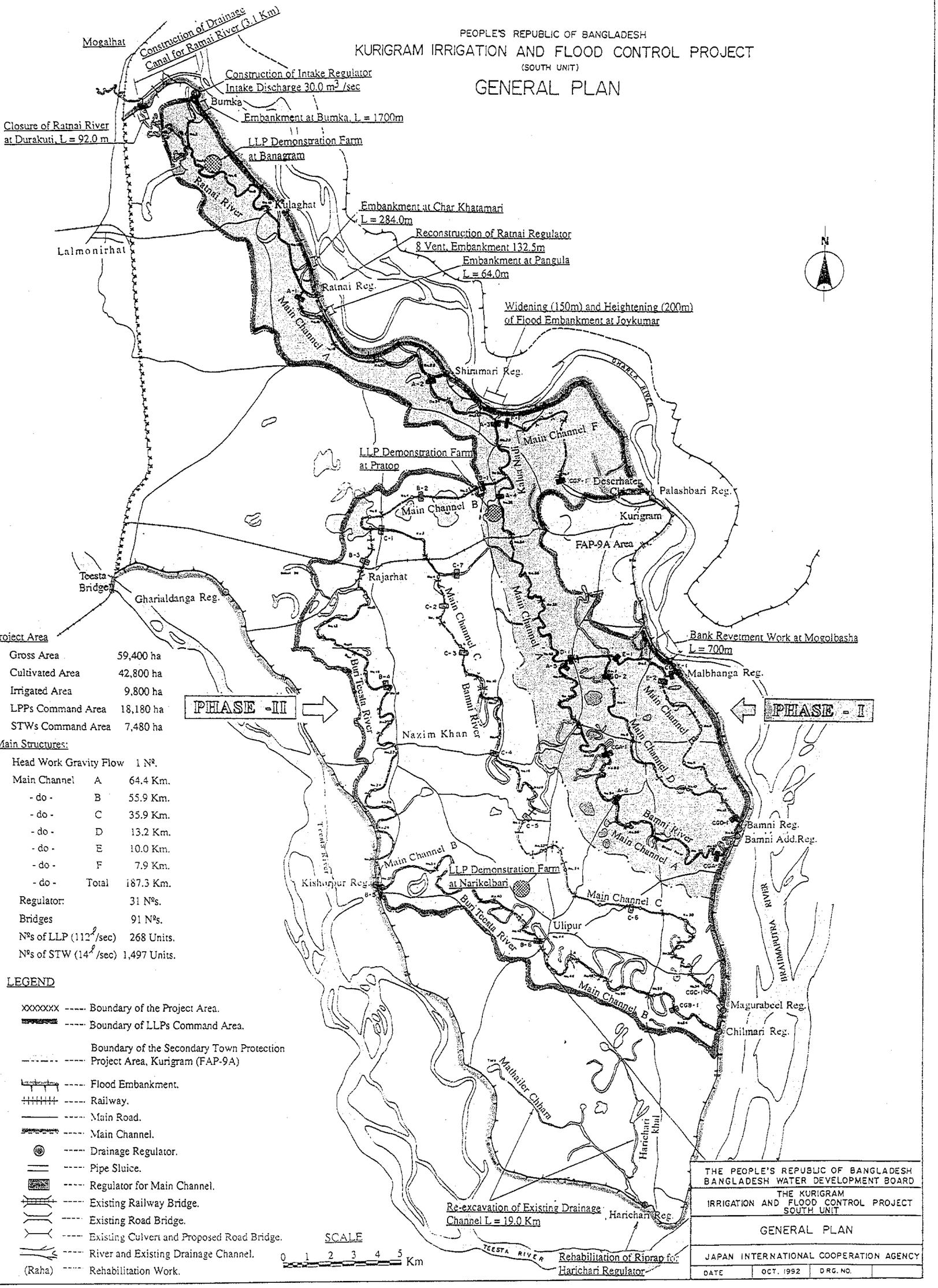
LOCATION MAP

PEOPLE'S REPUBLIC OF BANGLADESH

KURIGRAM IRRIGATION AND FLOOD CONTROL PROJECT

(SOUTH UNIT)

GENERAL PLAN



Project Area

Gross Area	59,400 ha
Cultivated Area	42,800 ha
Irrigated Area	9,800 ha
LPPs Command Area	18,180 ha
STWs Command Area	7,480 ha

Main Structures:

Head Work Gravity Flow		1 Nº.
Main Channel	A	64.4 Km.
- do -	B	55.9 Km.
- do -	C	35.9 Km.
- do -	D	13.2 Km.
- do -	E	10.0 Km.
- do -	F	7.9 Km.
- do -	Total	187.3 Km.
Regulator:		31 Nºs.
Bridges		91 Nºs.
Nºs of LLP (112 l/sec)		268 Units.
Nºs of STW (14 l/sec)		1,497 Units.

LEGEND

- xxxxxxx ----- Boundary of the Project Area.
- ----- Boundary of LLPs Command Area.
- ----- Boundary of the Secondary Town Protection Project Area, Kurigram (FAP-9A)
- ----- Flood Embankment.
- ----- Railway.
- ----- Main Road.
- ----- Main Channel.
- ----- Drainage Regulator.
- ----- Pipe Sluice.
- ----- Regulator for Main Channel.
- ----- Existing Railway Bridge.
- ----- Existing Road Bridge.
- ----- Existing Culvert and Proposed Road Bridge.
- ----- River and Existing Drainage Channel.
- (Raha) ----- Rehabilitation Work.

THE PEOPLE'S REPUBLIC OF BANGLADESH BANGLADESH WATER DEVELOPMENT BOARD			
THE KURIGRAM IRRIGATION AND FLOOD CONTROL PROJECT SOUTH UNIT			
GENERAL PLAN			
JAPAN INTERNATIONAL COOPERATION AGENCY			
DATE	OCT. 1992	DRG. NO.	

BASIC DATA OF BANGLADESH

Land and People (1991)

Land Area	147,960 km^2
Population	107,992,940
Population density	730 persons/km^2
Nos. of household	20,174,490
Average household size	5.31
Literacy rate	24.82%
Annual population growth (1981 - 1991)	2.17%

Macro-Economic Indicators

	1986	1987	1988	1989	1990
GDP at current price (Tk.billion)	466.2	539.2	597.1	659.6	747.7
Real GDP growth (%)	4.3	4.2	2.9	2.5	5.8
Consumer price inflation (%)	11.0	9.5	9.4	10.0	8.1
Population (million)	101.7	102.6	104.5	106.5	108.0
Rice production (million tons)	15.04	15.41	15.41	15.54	18.50
Jute production (million tons)	1.6	1.2	0.9	0.8	0.8
Export fob (US$ million)	908	1,000	1,317	1,280	1,482
Import cif (US$ million)	2,703	2,707	2,931	3,374	3,376
Current account (US$ million)	-627	-238	-273	-1,100	-429
External debt (US$ million)	7,202	8,977	9,499	9,926	—
Exchange rate (Tk per US$)	30.41	30.95	31.73	32.27	34.57

(as of Jan.15, 1992 Tk.38.80 per US$)

Origin of GDP for 1989

Agriculture	37.2%
Manufacturing	8.4%
Construction	6.0%
Trade	8.3%
Transport & Communication	10.9%
Public Administration	4.4%
Banking and Insurance	2.0%
Other services	22.8%
GDP at market price	**100.0%**

Components of GDP for 1989

Private consumption	88.5%
Public consumption	9.5
Gross capital formation	12.2%
Stock building	1.0%
Export	8.1%
Import	-19.3%
GDP at market price	**100.0%**

Principal Export for 1989 (US$ million)

Jute goods	288.3
Leather	140.2
Clothing	444.0
Fisheries products	163.0
Raw jute	87.5
Total including others	**1,280.0**

Principal Import for 1989 (US$ million)

Machinery & equipment	569.3
Fuels	358.3
Foodstuffs	705.7
Chemicals	115.7
Wool, cotton & fabric	359.0
Total including others	**3,374.0**

Source: (1) 1991 Statistical Yearbook of Bangladesh, November 1991
(2) Bangladesh, Country Report (No.4, 1991), EIU, October 1991
(3) Preliminary Report Population Census 1991, July 1991

SUMMARY

OUTLINE OF THE STUDY

01 The Study was carried out in the following two (2) phases :

Phase-I	:	Establishment of Basic Development Concept	
		Field Work	(Dec. 1991 - Mar. 1992)
		Home Office Work	(June 1992 - -July 1992)
Phase-II	:	Formulation of Development Plan	
		Field Work	(July 1992 - Oct. 1992)
		Home Office Work	(Oct. 1992 - Mar. 1993)

02 The following reports were submitted to BWDB during the course of the Study :

(1)	Inception Report	submitted in December, 1991
(2)	Progress Report No.1	submitted in March, 1992
(3)	Interim Report	submitted in July, 1992
(4)	Progress Report No.2	submitted in October, 1992
(5)	Draft Final Report	submitted in January, 1993
(6)	Final Report	submitted in March, 1993

03 The "Final Report " describing the results of the Study, contains the following three (3) volumes :

Volume I	:	Main Report
Volume II	:	Appendixes
Volume III	:	Drawings

BACKGROUND

04 Location

The Study area is located in the Northwest Region of Bangladesh adjacent to the northern international boundary. The area is bounded by the international border with India in the north, the railway line leading to Lalmonirhat in the west, the Teesta river in the south west and rivers Dharla and Brahmaputra in the north and east. The total area covers 59,400 ha.

05 Purpose of Project

The purpose of the Project is to bring about an increase in the agricultural production in the area by provision of water for irrigation, improvement of drainage system and prevention of annual flooding.

06 Project History

(1) The feasibility study (F/S) was carried out by WAPDA in 1969/71. Based on the F/S, FCD components were constructed during 1973 - 1984. Irrigation development plan was revised and updated in 1975 and again in 1982, but Irrigation component has been left undeveloped so far.

(2) The F/S for the North Unit was undertaken by JICA in 1989/90. The GOB requested to the Government of Japan the financial assistance for detailed design and implementation of the North Unit; however, the detailed design has not been started yet as of mid 1992.

(3) The GOB started the Flood Action Plan (FAP) from early 1991. The FAP-2 includes the Kurigram south unit, and concluded that FCD components of the South Unit has no economic viability due to present low agricultural production in the area. The FAP-12/13 studies carried out sample surveys in the South Unit in mid 1991. The FAP-12/13 studies suggested that tubewell irrigation should be promoted instead of large scale irrigation development, because such large investments are not likely to be justifiable.

(4) Following the F/S on the North Unit, the F/S on the South Unit was commenced by JICA in December, 1991. Consistency with the on-going FAP studies was emphasized during the course of the F/S.

PRESENT CONDITION OF STUDY AREA

07 Agriculture is predominant, accounting for 82% of the total gross regional income. Population density is high (1,245/km^2), and no possibility remains for expansion of farmland, therefore the average farm size is very small (0.42 ha), and farm income is very low (US$370/household) compared to the national average.

08 In order to improve the rural income in the area, the agricultural production should be increased through improvement of land productivity which could be realized through implementation of the FCD/I project (in particular, irrigation component).

09 The existing farmland is 42,800 ha. Rechargeable groundwater potential is not enough to irrigate a whole area, and furthermore the surface water in the Dharla river can not allow to irrigate the whole area. Therefore, only conjunctive use of both water resources can give the way to irrigate the whole area.

10 The existing flood embankment is functioning, though some rehabilitation works are required and proper O&M is needed. Drainage congestion in the low-lying areas is serious and should be improved as much as possible.

11 Minor irrigation has been rapidly expanded, however, the whole area will not be irrigated by such minor tubewell systems due to limited groundwater potential. It should be noted that the minor irrigation has given heavy financial burden to the rural poor and is likely to widen the income gap among the local farmers. Supplemental surface irrigation is therefore required as early as possible.

12 Present condition of the Study area is summarized as follows:

PRESENT CONDITION OF STUDY AREA

(1) Study Area

Total gross area	:	70,000 ha	
Area inside existing embankment	:	59,400 ha	
existing cultivated land	:	42,800 ha	(72% of area inside embankment)
existing irrigated land	:	9,800 ha	(23% of cultivated land)

(2) Socio-economic Indicators

Population	:	739,300	(as of 1992)
No. of total households	:	130,500	(as of 1992)
No. of farm household	:	101,800	(78% of total household)
Average farm size	:	0.42 ha	
Gross regional domestic products	:	Tk 1,850 million	(US$48 million)
Share of agriculture in GRDP	:	82 %	

(3) Characteristics of the Dharla River

Catchment area	:	5,100 km^2	
Maximum probable discharge	:	4,200 m^3/sec	(1/50 years)
Minimum probable discharge	:	53 m^3/sec	(1/10 years)
Available discharge for irrigation	:	30 m^3/sec	

(4) Groundwater Resources

Lowest groundwater table	:	3.6 m - 5.6 m
Fluctuation of groundwater table	:	3.1 m - 5.1 m
Groundwater rechargeable volume	:	303 - 407 mm
Available recharge for irrigation	:	357 mm

(5) Innundation Condition of Cultivated Land

Seasonal flooding < 30 cm	:	16,600 ha	(39%)
Seasonal flooding 30 - 90 cm	:	22,000 ha	(51%)
Seasonal flooding > 90 cm	:	4,200 ha	(10%)
Perennial flooding > 180 cm	:	0 ha	(0%)
Total	:	42,800 ha	(100%)

(6) Present Agriculture

Annual cultivated area of paddy	:	67,400 ha	(157% of cultivated area)
Annual paddy production (grains)	:	175,000 ton	(240 kg/year/person)
Paddy yield (grains)	:	1.3 - 3.7 ton/ha	(average 2.5 ton/ha)
Cropping intensity	:	126% - 234%	(average 190%)
Unit net income per ha per crop	:	Tk. 4,900-Tk. 38,800	(average Tk19,000/ha)

(7) Inland Fishery

Area of fishery pond	:	180 ha in total (1,670 ponds)	
Unit net income per ha	:	Tk6,200-Tk18,300	(average Tk16,000/ha)

BASIC DEVELOPMENT CONCEPT

13 Basic Development Strategies

The following basic strategies for FCD/I development in the Kurigram South Unit were proposed in keeping consistency with the government policies on water resources development and on-going FAP studies, and were mutually agreed between the Study Team and BWDB :

Irrigation development will aim to expand the rabi cropping and also to stabilize the monsoon cropping by supplemental water supplies. Irrigation development will be made through conjunctive use of both groundwater and surface water resources.

Drainage improvement will be made by gravity in principle. Drainage network will be improved through desilting works of the existing drainage channels and beels.

Flood control component will be concentrated on the rehabilitation works of the existing flood embankment.

14 Public Consultation

Public consultation survey was carried out to reflect local needs and suggestions, and the above concept was discussed among the prospective beneficiaries. As a result, the concept was generally supported by the respondents. Especially, the surface irrigation with LLPs was mostly appreciated, and desilting works of the drainage channels as well as the improvement of the existing regulators were welcomed.

(% to respective respondent)

Item (Total nos. of respondents)	Landless (115)	Small (103)	Medium (101)	Large (95)	Very Large (63)	Others (288)	Total (765)
1. Surface irrigation with LLPs	61	93	84	79	81	64	68
2. Drainage Improvement	46	61	75	84	65	49	59
3. Rehabilitation of Embankment	8	61	81	43	33	45	45

PROPOSED DEVELOPMENT PLAN

15 Irrigation Development

(1) Cropping intensity : without roject : 190%, with project : 224%
(2) Farm water requirement : 8.83 mm/day
(3) Irrigation efficiency : 62% for application, 64% for conveyance
(4) Irrigation water requirement : 14.3 mm (1.65 l/sec/ha)
(5) Irrigation water sources : Surface water : 60% of drought discharge in the Dharla (30 m^3/sec)
Groundwater : available recharge (357 mm)
(6) Irrigation area :

Surface water :	18,200 ha
Groundwater :	7,500 ha
Total	25,700 ha

Items	Classification of Project Area			Total Area
	Northwest	Central	South	
(1) Total Farm Land	10,300	26,300	6,200	42,800
(2) Existing Irrigated Area	2,100	6,300	1,400	9,800
(3) FAP-9A Area	0	1,200	0	1,300
(4) Existing Rainfed Area (1) - (2) - (3)	8,200	18,800	4,800	31,800
(5) Irrigable Area	5,100	18,800	1,800	25,700
(a) Groundwater (STW)	5,100	600	1,800	7,500
(b) Surface water	0	18,200	0	18,200
(6) Irrigation Area with Project (2) + (5)	7,200	25,100	3,200	35,500
(7) Rainfed Area with Project (1) - (6)	3,100	1,200	3,000	7,300

16 Drainage Improvement

(1) Drainage basin : 8 drainage blocks
(2) Drainage system : Independent gravity drainage by block with mini-compartmentalization
(3) Drainage plan :

a) Diversion of the Ratnai river
b) Rehabilitation of Ratnai and Harichari regulators,
c) Construction of additional regulators to increase the drainage capacity, (Palashubari, Harichari, Kishorpur and Gharialdanga)
d) Desilting of existing drainage channels, creeks and beels.

17 Flood Protection Works

(1) Flood protection : Rehabilitation of existing embankment only
(2) Erosion protection : not included in the proposed Project

18 Rural Infrastructure Improvement

(1) Re-construction of the existing bridges accompanied with re-excavation of the existing drainage channels and creeks,

(2) Construction of new bridges and culverts accompanied with construction of new irrigation canals connecting the existing drainage channels.

PROPOSED PROJECT WORKS

19 The following project facilities are envisaged under the proposed project:

PRINCIPAL FEATURES OF PROPOSED PROJECT WORKS

IRRIGATION DEVELOPMENT

(1) Intake Regulator	Diversion Requirement	30 m^3/sec
	Intake water level	EL. 27.17 m
	Flood water level	EL. 32.51 m
	Elevation of Gate sill	EL. 25.45 m
	Top of embankment	EL. 33.41 m
	Size of vent	1.52 m (W) x 1.83 m (H)
	Nos. of vents	12 nos.
	Headrace canal	265 m
(2) Irrigation Canal	Water level at beginning	EL. 27.00 m
	Main canals	6 main canals with total length of 187.3 km
	Canal regulators	24 nos.
	Check gates	7 nos.
(3) Command Area Development (CAD) with LLPs	Total net irrigable area	18,200 ha
	Average size of CAD	70 ha per site
	Nos. of terminal CAD sites	268 sites
	Required capacity of LLP per site	2.0 cusec (56 l/sec) x 2 units
	Pump type	Centrifugal pump
	Pump bore size	150 mm
	Total head	7 m
	Prime mover	Diesel engine, 12.5 HP x 2 units
(4) Groundwater Development	Total net irrigable area	7,500 ha
	Development Mode	STW
	Pump capacity	3/4 cusec (21 l/sec)
	Pump type	Centrifugal pump
	Total head	7 m
	Prime mover	Diesel engine, 6 HP
(5) Demonstration Farms	Nos. of demonstration farms	3 locations, 260 ha in total

DRAINAGE IMPROVEMENT

(1) Diversion of Ratnai river	Length / Design discharge	3.3 km / 88.6 m^3/sec
(2) Drainage Regulators	- Rehabilitation of regulators	2 nos. (Ratnai and Harichari)
	- Additional regulators	4 nos. (Palashubari, Harichari, Kishorpur and Gharialdanga)
(3) Desilting Works	Length of drainage channels	19.0 km

FLOOD PROTECTION

(1) Flood Embankment	- Closing of public cuts/breaches	1.09 km in total
	- Rehabilitation of embankment	21.6 km in total

RURAL INFRASTRUCTURE

(1) Bridges / Culverts	Re-construction	52 nos.
	New construction	Bridges:30 nos./culverts: 9 nos.

CONSTRUCTION SCHEDULE AND COST ESTIMATES

20 Construction Schedule

The proposed project facilities will be constructed by local contractors. Most of the construction works will be executed by manual labour. The project will be completed within 10 year period, including 2 year period of detailed design and tendering procedures. Construction works will be executed in two (2) phase; each having 4 year period. Construction works under the first phase will commence with the diversion works of the Ratnai river, closing of the embankment at crossing site with the Ratnai river, construction of irrigation intake and irrigation main canals -A, -D, -E and -F from north to south. Construction works under the second phase will include rehabilitation of the embankment and Horichari regulator, and construction of additional regulators and main canals- B and -C. Command area development (CAD) with LLPs will be executed immediately after the completion of the canal construction, and the farmers will start irrigation practices simultaneously.

21 Total Project Costs

The total project cost is estimated to be Tk. 2,280 million in total as of mid 1992 consisting 1,658 million (73%) of local currency portion and Tk.622 million (27%) of foreign currency portion :

(Unit: Tk million)

Items	LC	FC	Total
1. Construction Costs	728.7	339.3	1,068.0
1) Irrigation Development	581.9	247.6	829.5
a) Irrigation Intake	59.2	61.6	120.8
b) Irrigation Canals	273.6	51.9	325.5
c) LLP development	217.3	65.1	282.4
d) STW development	27.8	65.5	93.3
e) Demonstration farm	4.0	3.5	7.5
2) Drainage Improvement	38.2	24.0	62.2
3) Flood Control Works	8.6	3.9	12.5
4) Rural Infrastructure	100.0	63.8	163.8
2. Associated Costs	173.4	69.4	242.8
1) Land Acquisition	62.4	0	62.4
2) Administration	26.1	21.6	47.7
3) Consulting Services	60.9	47.8	108.7
4) O&M costs during construction period	24.0	0	24.0
3. Physical Contingency	109.3	50.9	160.2
4. Price Contingency	646.5	162.2	808.7
Total	1,657.9	621.8	2,279.7

It is recommended that in due consideration of recent privatisation policy, CAD with LLP/STW will be made by farmers groups at their cost. In this sense, the estimated cost for LLP/STW development may be excluded from the above construction cost and be treated as a credit fund for LLP/STW development. Such re-adjustment of the cost structure can be made by BWDB without affecting the economic viability of the project.

ORGANIZATION AND MANAGEMENT

22 Project Implementation Arrangement

The Bangladesh Water Development Board (BWDB) will be the lead executing agency for the proposed project, and will be responsible for the implementation of major civil works, including:

(1) Rehabilitation of flood embankment and regulators,
(2) Re-excavation of the existing drains for drainage improvement as well as surface irrigation water supply,
(3) Construction of irrigation intake structure and irrigation canal systems, and
(4) Establishment of Demonstration Farms

23 The Bangladesh Rural Development Board (BRDB) and the Local Government Engineering Department (LGED) will also be the executing agencies, being responsible for the following components under overall coordination of BWDB :

(4) Command Area Development with LLPs (BRDB/LGED),
(5) Groundwater irrigation development (BRDB/LGED), and
(6) Rural infrastructure improvement (LGED)

The BWDB should establish a Project Implementation Office (PIO) at Kurigram and a Project Beneficiary Committee (PBC) in each of five (5) Thanas in the Project area. The PBCs will consist of representatives from the government offices, Thana Nirbahi Officer (TNO) and members of the Union Parishad and others directly representing farmers, fisherman and the landless, and will also include the representatives from NGOs.

24 O&M Arrangement

After completion of the project, the O&M responsibility should be given to a circle and a division with name and style as Kurigram O&M Circle and Kurigram O&M Division stationed at Kurigram under Project IV Zone, Rangpur. O&M responsibilities of the related agencies and local bodies needs to be elaborated with clear demarcation. These should be examined at central level during the implementation stage.

25 Irrigation Water Management

The main irrigation system will be operated by BWDB, while O&M of the terminal blocks irrigated by LLPs will be made by farmer groups. Coordination between BWDB and each farmer group will be indispensable for effective use of irrigation water for cultivation. In the Study area, Thana office has "Irrigation Management Committee (IMC)" to coordinate among the related agencies in development and O&M of irrigation schemes. Various agencies (DAE, LGED, BRDB, BADC) are involved in the IMC. It is expected that the BWDB and representatives of the PBC will participate in the IMC to discuss O&M issues and water management practices.

PROJECT JUSTIFICATION

26 Economic Evaluation

The proposed project was evaluated according to the "Guideline for Project Assessment" prepared by FPCO. The proposed project was justified with an economic internal rate of return (EIRR) of 28.5 % :

Item		Surface Irrigation	Groundwater	Proposed Project
1. Net Present Value (NPV) at 12%				
- Economic Benefits	(Tk million)	1,521	651	2,172
- Economic Costs	(Tk million)	602	67	669
- NPV (B-C)	(Tk million)	919	584	1,503
2. EIRR	(%)	24.0	63.9	28.5
3. Benefit-cost ratio (B/C)		2.5	9.7	3.2

27 Project Impact Analysis on Income Distribution

Net farm reserve was calculated under "with and without " project conditions to make the project impact analysis on income distribution. The proposed project will benefit all categories of farmers. The expected net farm reserve was compared between LLP and STW; LLP will give larger net farm reserve than STW.

(Unit : Tk/year)

Item	Landless (<0.2ha)	Small (0.20-0.5ha)	Medium (0.6-1.9ha)	Large (2.0-3.9ha)	Very Large (4.0ha<)	Whole (average)
Increment of Net Farm Reserve						
(1) Without Project	250	3,770	13,890	35,540	73,610	4,910
(2) With Project	1,340	8,970	26,210	63,960	122,040	10,790
(3) Incremental Reserve	1,090	5,200	12,320	28,420	48,430	5,880
Comparison between LLP and STW in incremental net reserve						
- LLP	1,150	5,690	13,680	31,500	54,060	6,480
- STW	940	4,010	9,020	20,930	34,770	4,420
- Ratio (LLP / STW)	1.2	1.4	1.5	1.5	1.6	1.5

28 Socio-economic Impacts

The proposed project would bring about the following socio-economic impacts :

(1) Increase in employment opportunity,
1.8 million man-days in total for construction period and 0.12 million man-days for O&M works per annum after completion of the construction works.
(2) Increase in land value, and
(3) Improvement of local transportation.

29 Environmental Impacts

The proposed project has no negative impact with high magnitude. However, the following items have some negative impacts with moderate magnitude. These should be monitored and evaluated during and after the construction of the project.

(1) sedimentation of canals,
(2) changes in natural vegetation cover,
(3) loss of wildlife habitat,
(4) adverse effect on fish habitat,
(5) deterioration of water quality, and
(6) potential of structural failure.

CONCLUSIONS AND RECOMMENDATIONS

30 The proposed project is verified to be technically sound and economically feasible with overall EIRR of 28.5% and considered eligible for early implementation. However, since there are many other FCD/I projects throughout the country including those newly identified by the FAP studies, the implementation priority of the project should be examined in a long-term FCD/I development programme of BWDB.

31 Currently available topographic maps are out of date and are not suitable for detailed design of the project. Photo-mapping with a proper scale would be needed as early as possible. Additional survey and investigation would also be needed for detailed design, including geological investigation with test boring at major structures sites and soil testing for embankment materials.

32 Serious river bank erosion is observed at Moglbasha, Chilmari and Kishorpur. However, these erosion protection works are not included in the proposed project, mainly because such works are rather urgently required and should not be delayed until the proposed project be implemented. The Study Team examined the required protection works at these sites. It is hoped that our suggestion would be useful for BWDB to undertake the protection works.

33 Installation of tubewells and LLPs will be made by farmer groups at their cost. For successful implementation of CAD, the government supports should be extended to the farmers in particular for organizing farmers groups, arrangement of credits and technical guidance in construction and O&M. These supports should be made by BRDB and LGED under close coordination with BWDB.

34 In order to support such private initiatives for CAD with tubewells/LLPs, it is strongly recommended that demonstration farms be established in the project area and operated jointly by BWDB / DAE / BRDB. The "demonstration farms" should have the following objectives :

(1) institutional build-up and arrangement for CAD,
(2) physical planning and design of CAD, and
(3) irrigation water management for crop cultivation.

35 It is recommended that in order to ensure close coordination among the agencies, an inter-ministerial coordination committee comprising MIWDFC, MOLGRDC, MOA, MOFL, Planning Commission and MOF should be established, and the "Government Order" demarcating responsibilities of each agency in project implementation be set out before the commencement of the construction works.

FEASIBILITY STUDY ON
KURIGRAM IRRIGATION AND FLOOD CONTROL PROJECT (SOUTH UNIT)

FINAL REPORT
VOLUME I (MAIN REPORT)

Table of Contents

Page

List of Tables

List of Figures

Attachments

Volume II (Appendixes)

Volume III (Drawings)

Abbrebiation

AED	Agro-Ecological Division
BADC	Bangladesh Agricultural Development Corporation
BBS	Bangladesh Bureau of Statistics
BKB	Bangladesh Krishi (agricultural) Bank
BRDB	Bangladesh Rural Development Board
BWDB	Bangladesh Water Development Board
CAD	Command Area Development
CIDA	Canadian International Development Agency
DAE	Department of Agricultural Extension
DOF	Department of Fisheries
DOL	Department of Livestock
DTW	Deep Tubewell (with positive displacement pump)
EE	Executive Engineer
EIRR	Economic Internal Rate of Return
GDP	Gross Domestic Product
GOB	Government of Bangladesh
FAP	Flood Action Plan
FAO	Food and Agriculture Organization
FFW	Food-For-Works
FPCO	Flood Plan Coordination Organization
FCD	Flood Control and Drainage
FCD/I	Flood control, Drainage and Irrigation
IBRD	International Bank for Reconstruction and Development (world Bank)
IDA	International Development Association (World Bank)
IFAD	International Fund For Agricultural Development
HYV	High Yielding Variety
JICA	Japan International Cooperation Agency
LCS	Landless Contracting Society
LGED	Local Government Engineering Department (former LGEB)
LLP	Low Lift Pump
MPO	Master Plan Organization
NGO	Non-governmental Organization
NPV	Net Present Value
NPVR	Net Present Value Ratio
NWP	National Water Plan
O&M	Operation and Maintenance
PBC	Project Beneficiary Committee
PCC	Project Coordination Committee
PIE	Project Impact Evaluation
PIO	Project Implementation Office
STW	Shallow Tubewell (with suction pump)
S/W	Scope of Work
SCF	Standard Conversion Factor
SE	Superintending Engineer
UCCA	Upazila Central Cooperative Association
UNDP	United Nations Development Programme
UNO	Upazila Nirbahi Officer (principal staff officer of Upazila Parishad)
WARPO	Water Resources Planning Organization (formerly MPO)
WFP	World Food Programme
WHO	World Health Organization

Glossary

Aman	Main monsoon season paddy crop (Aug./Sept. - Nov/Dec.)
Aus	Late dry season/early monsoon paddy crop (Mar./Apr. - July/Aug.)
Beel, Bil	Small lake, swamp or body of year-round standing water
Boro	Winter (dry) season paddy crop (Dec./Jan. - Apr.)
Bundh	Earthen embankment
Chhatak	290 - 350 grammes
Chain	100 feet
Cropping intensity	Ratio of acreage of crops cultivated in a year to the total acreage under cultivation
Crore	Ten million (10,000,000)
Ghog	Animal burrow in embankment
Ghee	Edible oild made from milk
Khal	Natural channel/minor river/tidal creek
Khalashis	"Cleaner" (actually guard) of regulator/sluice
Khas	Government owned
Kharif	Summer (wet) season
Kutcha	Locally made, not manufactured; earthen (of roads, structures)
Lakh	Hundred thousand (100,000)
Maund	37.3 kg
Mauza	Revenue village (comprise several physical settlements)
Nala	Excavated canals
Parishad	Elected council of Upazila or Union
Rabi	Winter (dry) season
Thana	New Administrative unit between Union and Zila
Union	Administrative level below Upazila, typically 10 per Upazila
Upazila	Former Administrative unit between Union and Zila
Zila	District, main sub-regional administrative unit

Abbreviation of Measurements

Length

mm	= millimeter		
cm	= centimeter	=	0.39 in.
m	= meter	=	1.09 yd.
km	= kilometer	=	0.62 ml.
in.	= inch	=	2.54 cm
ft.	= foot	=	30.48 cm
yd.	= yard	=	91.44 cm
ml.	= mile	=	1.61 km

Volume

lit.	= liter		
m3	= cubic meter	=	1,000 lit.
MCM	= million m3		
ft3	= cubic feet	=	0.028 m3
ac-in	= acre-inch	=	102.80 m3
ac-ft	= acre-feet	=	1,234 m3

Area

m2	= square meter	=	10.76 ft2
km2	= square kilometer	=	100 ha
ha	= hectare	=	2.47 ac
ac	= acre	=	0.405 ha
ft2	= square feet	=	0.09 m2
mile2	= square mile	=	2.59 km2

Weight

kg	= kilogram	=	2.20 lb
ton	= ton	=	1,000 kg
lb	= pound	=	0.454 kg
md	= maund	=	37.32 kg
Ck.	= Chhatak	=	0.30 kg

Time

sec.	= second
min.	= minute
hr.	= hour
day	= 84,600 sec.
yr.	= year

Electric Measures

kW	= kilowatt	=	1,000 watt
MW	= Megawatt	=	1,000 kW
GW	= Gigawatt	=	1,000 MW
kV	= Kilovolt	=	1,000 volt

Other Measures

%	= percent	
lakh	= ten thousand	
crore	= 10 million	
HP	= horse power	= 0.746 kW
TPH	= ton per hour	

Derived Measures

m3/sec	= 35.31 ft3/sec		
ft3/sec	= 0.028 m3/sec		
md/ac	= 92.23 kg/ha	=	0.092 ton/ha
ton/ha	= 2.47 tons/acre	=	10.84 md/ac
ton/acre	= 0.405 ton/ha	=	4.39 md/ac

Currency

Tk	= Taka	(US$1.0 = Tk38.8 = ¥125, as of February, 1992)
US$	= US dollar	
¥	= Japanese Yen	

CHAPTER I INTRODUCTION

1.1 Authority

This report is prepared in accordance with the "Scope of Work (S/W) for Feasibility Study on the Kurigram Irrigation and Flood Control Project - South Unit (the Study)", agreed upon between the Government of Bangladesh through the Bangladesh Water Development Board (BWDB) and the Japan International Cooperation Agency (JICA) on August 20, 1991. The S/W is incorporated in this Report as Attachment - 3.

The Study was carried out in two (2) phases, from December 1991 to March 1993 with a total period of 16 months. The Phase-I aims to establish the basic development concept, and the Phase-II to formulate the definitive development plan.

(1) Phase-I : Establishment of Basic Development Concept (Dec.1991 - July.1992)

Preparatory Work in Japan (December 1991)
(1) Preparation of work programme, and
(2) Preparation of Inception Report.

Field Work in Bangladesh (December 1991 - March 1992)
(1) Explanation and discussion on Inception Report,
(2) Field reconnaissance and data collection,
(3) Field survey and investigation in the dry season, and
(4) Preparation of Progress Report No.1 and discussion with BWDB.

Home Office Work in Japan (May 1992 - July 1992)
(1) Establishment of basic development concept,
(2) Preparation of work programme for Phase-II studies, and
(3) Preparation of Interim Report.

(2) Phase-II : Formulation of Development Plan (July 1992 - March.1993)

Field Work in Bangladesh (July 1992 - October 1992)
(1) Explanation and discussion on Interim Report,
(2) Field survey and investigation in the wet season, and
(3) Preparation of Progress Report No.2 and discussion with BWDB.

Home Office Work in Japan (October 1992 - March 1993)
(1) Formulation of development plans,
(2) Preparation of Draft Final Report,
(3) Explanation and discussion on Draft Final Report (in Bangladesh)
(4) Finalization of Draft Final Report, incorporating comments from GOB.

This Report deals with all the findings and results under Phase-I and Phase-II from December 1991 to March 1993.

1.2 Objectives and Scope of the Study

(1) Objectives of the Study

The objective of the Study is to formulate the irrigation and drainage development and flood control plan in the Kurigram South Unit for the increase and improvement of agricultural production. The Study also aims to undertake transfer of technology to the Bangladesh governmental personnel concerned in the course of the Study.

(2) The Study Area

The Study area covers about 70,000 ha and is located inside the embankment already constructed in the Kurigram South Unit by BWDB and the adjoining areas relevant to the Project (see Location Map).

(3) Schedule of the Study

The Study was commenced in December 1991 and was completed in March 1993 with a total period of 16 months. The general work schedule of the Study is given in Fig.1.2.1. The Study was executed jointly by the JICA Study Team comprising 12 experts, and the counterpart personnel despatched from BWDB. The personnel participated in the Study is listed in Table 1.2.1. The assignment schedule of the JICA Study Team for the Study is shown on Fig.1.3.2.

(4) Preparation of Reports

The following reports are to be prepared and discussed during the course of the Study:

(1)	Inception Report	submitted on December 18, 1991
(2)	Progress Report No.1	submitted on March 3, 1992
(3)	Interim Report	submitted on July 19, 1992
(4)	Progress Report No.2	submitted on October 3, 1992
(5)	Draft Final Report	submitted on January 12, 1993
(6)	Final Report	submitted in March, 1993

1.3 Activities during Phase-I

The Phase-I study started on December 16, 1991 and was completed on July 16, 1992. During the Phase-I period, the Team made the following activities :

(1) Field reconnaissance along the existing embankment,

(2) Collection of data and reports relevant to the Study,

(3) Field surveys and investigation including:

1) Topographic survey along the Dharla river (sublet to local consultants),
2) Geo-technical investigation at major structural sites (sublet to local consultants),
3) Soil and land use survey,
4) Water quality analysis (sublet to local consultants),
5) Socio-economic baseline survey (on a preliminary basis),
6) investigation on the existing minor irrigation systems,
7) Inland fishery survey, and
8) Environmental survey.

(4) Assessment of the existing FCD (flood control and drainage) facilities,

(5) Review of the previous F/S reports and on-going FAP studies,

(7) Preparation of the Progress Report No.1 and discussion with GOB,

(8) Comparative studies on possible alternatives for irrigation development ,

(9) Establishment of basic development plan, and

(10) Preparation of Interim report.

1.4 Activities during Phase-II

The Phase-II study was commenced on July 17, 1992. The Team made the following activities during the Phase-II period :

(1) Discussion with GOB on the "Interim Report",

(2) Field Reconnaissance and supplemental data collection,

(3) Field surveys and investigation including:

1) Plane table survey at major structure sites and canal route survey along the proposed irrigation and drainage canals (sublet to local consultant),
2) Groundwater potential survey,

3) River engineering survey,
4) Supplemental soil and land use survey,
5) Socio-economic baseline survey (sublet to local consultant),
6) Public consultation survey (sublet to local consultant),
7) Inventory survey on the existing STWs/DTWs,
8) Supplemental inland fishery survey,
9) Environmental impact survey (including interviews with local public), and
10) Preparation of "Progress Report No.2"

(4) Preparation of "Progress Report No.2" and discussion with GOB,

(5) Formulation of FCD/I development plan, consisting of:

1) Future land use and cropping pattern with the project,
2) Proposed farming practices,
3) Inland fishery development plan,
4) Irrigation and drainage development plan,
5) Agricultural support services,
6) Operation and maintenance plan
7) Facility plan and preliminary designs,
8) Construction plan and cost estimates,
9) Environmental impact assessment,
10) Project benefit estimates, and
11) Project evaluation.

(6) Preparation of the "Draft Final Report".

The Phase-II field survey was completed on October 14, 1992. The Team carried out further analysis and studies in Japan, and prepared the "Draft Final Report" in December 1992. The "Draft Final Report" was submitted to BWDB through JICA Bangladesh Office in mid January, 1993. The Study Team visited Bangladesh from January 15 to January 23, 1993 to discuss the "Draft Final Report" with the GOB. The "Final Report" was prepared and submitted in March , 1993, incorporating the comments and suggestions from the GOB and JICA.

CHAPTER II BACKGROUND OF THE PROJECT

2.1 Project History

The Kurigram Flood Control and Irrigation Project (both north and south units) was first studied by Pakistan Techno-Consult Consulting Engineers for the East Pakistan Water and Power Development Authority (WAPDA, present BWDB), with the prime objectives of facilitating an increase in agricultural production by means of flood protection, improved drainage and irrigation. The surveys and investigations were carried out during the period between May 1967 and December 1969. The draft feasibility study report was submitted to WAPDA in December 1969, and the final report in October 1971. The planned pumping plant at Bumka and the Dharla barrage for the South Unit were proposed by this original feasibility study as the most promising plan among various alternatives.

Based on the original feasibility study, assistance of the World Bank was sought for financing the project in 1969/71. An IDA mission upon reviewing the report recommended certain additional investigations and studies, which included the possibility of utilization of groundwater wholly or partly and utilization of drainage channels as irrigation supply canals.

The original feasibility study report (1969/71) was subsequently revised and updated by Techno Consult Eastern Limited for the Bangladesh Water Development Board (BWDB) through substantial surveys and investigations together with additional studies on ground water, agronomic, agricultural extension and economic analysis. The revised and updated feasibility report was submitted to BWDB in January 1975. The study proposed, through comparative studies on possible alternatives, new development concept for irrigation that the northern part (upper) of the South Unit would be irrigated by exploitation of groundwater through tubewell development and the southern part (lower) by the Dharla barrage as the original plan indicated. The other major differences between 1969/71 and 1975 reports are the introduction of drainage pumps (1975) instead of gravity drainage (1969/71).

Meanwhile, construction of the flood control and drainage aspects in the South Unit started from July 1973, based on the original plan (1969/71). The flood embankment of about 108 km long was completed in 1983/84, and a total of 11 as against 5 drainage sluices originally planned in 1969/71 were also constructed. These embankment and drainage sluices were constructed mainly by utilizing the local resources with assistances under World Food Programme and aid from CIDA.

However, the irrigation component was never implemented by BWDB, while there has been a considerable expansion of tubewell development in the Project area since the original plan was proposed in 1969/71, reducing the area which would benefit from surface irrigation.

The Project (South Unit) was again revised and updated by the Task Force Team of BWDB in 1982 for asking the financial assistance to the Saudi Fund for Development (SFD). The revised and updated study endorsed the feasibility of the irrigation plan proposed in 1975 with minor modifications of tubewell development, and recommended gravity drainage sluices instead of drainage pumps. The revised study was compiled within very short period of 4 weeks, and therefore lacked in most of the technical, economic and financial, social and environmental details of the proposed plan.

During the period of July 1989 - October 1990, the North Unit was studied at the feasibility level by the Japan International Cooperation Agency (JICA). The Government officially requested to the Government of Japan the financial assistance for detailed design and implementation of the North Unit, based on the feasibility study by JICA; however, the detailed design has not started yet, as of December, 1992.

Following the feasibility study on the North Unit, BWDB requested again JICA to undertake another feasibility study on the South Unit. In August 1991, JICA despatched a preliminary survey mission to Bangladesh and concluded the Scope of Work (S/W) for the Study with BWDB. Consistency with on-going FAP studies and previous F/S on the North Unit was emphasized during the discussion with the BWDB. The feasibility study on the South Unit was commenced in December 1991 and completed in December, 1992.

2.2 General Economic Situations of Bangladesh

Bangladesh has a land area of 147,960 km^2 and, with a population officially estimated at 108 million as of July 1991, it is among the world's most populated countries with a density of 730 persons per km^2. The population grew at 2.17% per annum during the last decade. Bangladesh is bordered by India on the west, north and east and by Burma on the south-east. Its southern coastal line faces the Bay of Bengal. The land is mostly flat, although there are hills in the northeast and southeast. Much of the land is intersected by numerous rivers and streams of the massive Ganges-Brahmaputra delta, where annual flooding gives serious damages to agricultural produce and social infrastructures. The

climate is of monsoon type with average rainfall exceeding 2,500 mm and mainly falling between July and October.

Bangladesh is one of the world's poorest countries. Its GDP was Tk747.7 billion in total or Tk6,900 (US$192) per capita in 1989/90. Agriculture is most important sector in the economy, accounting for 37% of the GDP and 44% of the total export earnings and employing 57% of the total labour force. There has been progress in increasing rice production and diversifying the crop base where wheat and winter vegetables have realized a considerable success.

However, the country is likely to suffer from adverse weather, usually in the form of flooding, which constantly threatens to disrupt various development plans and make targets unattainable. Loss of food and cash crops is a common occurrence, seriously disrupting the entire economy by unanticipated food imports. In addition, with a poor resource base, most of non-agricultural raw materials are imported. The constraints to economic growth are severe. Opportunity for diversifying the economic base is limited and, faced with a continuous trade deficit, the country relies heavily on foreign aid assistance.

2.3 Fourth Five Year Plan 1990 - 1995 (FFYP)

The Fourth Five Year Plan (FFYP) covering the period of 1990/91 - 1994/95, began on July 1, 1990 with the following major objectives:

(1) Accelerating economic growth (annual growth rate of 5.0%);

(2) Poverty alleviation and employment generation; and

(3) increased self-reliance.

The total outlay for the FFYP is estimated at TK689.3 billion (US$17.95 billion) to be divided between the public and the private sectors in the ratio of 60:40 (Tk419.3 billion : Tk 270.0 billion). Domestic resources are expected to provide 48% of the total outlay with the remainder coming from external resources (52%). The development and diversification of agriculture are an important part of the plan strategy, as is the maximum utilization of the endowed domestic resources to meet a higher proportion of domestic demand and to contribute more to export earnings. The FFYP give the following major strategies to realize the plan's objectives:

(1) Integration of sector-based planning with socio-economic group based planning;

(2) Achieving inter-sectoral balance in sector planning;

(3) Creation of an efficiency culture in the economy;

(4) Integration of structural adjustment with rural sector growth (involvement of the rural poor and the disadvantages in the center of development process);

(5) Bringing women in the mainstream of development planning;

(6) Reduction in the rate of population growth;

(7) Re-structuring of fiscal, monetary and commercial policies (mainly tax policy); and

(8) Re-structuring the administrative system.

2.4 Agricultural Development Policy

The FFYP has accorded the top priority to agricultural, rural and water resources development, with the largest sectoral allocation of TK18.23 billion (US$473.5 million) for the plan period. In the agricultural sector, the following strategies are given by the FFYP:

(1) Attain self-sufficiency in food, especially rice along with increased production of other nutritional crops;

(2) Ensure sustained agricultural growth through more efficient and balanced utilization of domestic resources;

(3) Promote rapid and appropriate technological transformation and diversify agricultural production especially nutritional line;

(4) Contribute to increased foreign exchange earnings through agricultural exports;

(5) Reduce rural poverty and promote income equality over socio-economic groups/regions; and

(6) Promote economic and employment opportunities and access to resources such as credit for landless and small farmers and other disadvantaged groups especially backward regions.

2.5 Water Development Policy and National Water Plan

In the water resources sector, the following objectives are given by the FFYP.

(1) Rapid Increase of irrigated area to sustain technological transformation;

(2) Provision of supplementary irrigation facilities along with complementary FCD facilities in consonance with other resources to bring improvements in crop yields and production during the Kharif season;

(3) Provision of timely and dependable supply of irrigation water in order to achieve crop production targets;

(4) Regulation and control of floods and drainage, salinity, tidal water inundation, river erosion and other physical damages and human sufferings;

(5) Promotion of efficient use of water resources in respect of time and spatial location through emphasis on interbasin water balance and optimal cropping patterns and without causing harmful environmental effects; and

(6) Generation of productive employment opportunities for rural people in order to ensure equitable distribution of benefits of development.

The development area targets during the plan period is given as follows:

(Unit: 1.000 ha)

Programme	1990	1995	Increment (%)
Surface Water Irrigation			
Gravity Flow	212	500	135.8
LLP	783	1,088	39.0
Traditional Methods	300	200	-66.7
Ground Water Irrigation			
STW	1,251	2,200	75.9
DTW	500	700	40.0
HTW	54	54	0.0
Flood Control and Drainage	3,239	3,644	12.5

Source: The Fourth Five Year Plan, Planning Commission, October 1990

Major strategies in the fields of the flood control and water resources development are given by the FFYP as follows:

Short Term Strategies

(1) Maximum utilization of the existing facilities and improvement of productivity in the areas already covered by irrigation facilities;

(2) Speedy completion of incomplete projects;

(3) Implementation of small/medium scaled FCD/I projects (gravity irrigation and minor tubewell irrigation projects will get priority for implementation);

(4) Participation of beneficiaries in all stages of project implementation;

(5) Privatization of activities in minor irrigation sector;

(6) Demonstration of high input/continuous cropping with irrigation to the farmers; and

(7) Encouragement of government efforts in backward and difficult regions where opportunities for expansion of STWs/DTWs are limited.

Long-term Strategies

(1) Use of main rivers; augmentation of small river flows from big rivers such as Baral, Bangali, Dhaleshwari, Old Brahmuputra and various other rivers from the rivers, the Ganges, the Brahmuputra, and the Meghna through use of large capacity floating/berge-mounted pumps;

(2) Basin-wise development of surface and underground water in an integrated framework for water balance with season and area variants; and

(3) Continuation of long-term projects like Teesta Barrage.

The National Water Plan Project (NWPP) initiated by the Government of Bangladesh, the World Bank and UNDP in 1983, produced in May 1991, a comprehensive master plan for development of water resources in Bangladesh up to the year of 2018, through enormous efforts including the establishment of a permanent Master Plan Organization (MPO), together with nationwide data collection in the concerned technical and engineering fields, hydraulic modelling and analysis, and evaluation of on-going development plans and preparation of a long-tern water development programme with certain policy issues. The MPO now holds most of essential data and information needed for formulation of FCD/I projects, and provides technical assistance to other agencies. The above policy issues of the FFYP, largely depend on the outcomes of the NWPP.

2.6 Flood Action Plan (FAP)

After the disastrous floods of 1987 and 1988, the Government of Bangladesh undertook a comprehensive review of its flood policy, and proposed an integrated programme known as Flood Action Plan (FAP) in June 1989. The proposed FAP programme was discussed and endorsed at G-7 Summit held in Paris in July, 1989 and presently implemented by the Ministry of Irrigation, Water Development and Flood Control. The Flood Plan Coordination Organization (FPCO), being the arm of the Ministry, coordinates all activities of various FAP components with the BWDB as the executing agency. The FAP comprises 11 main components and 15 supporting activities, as shown below (for details, see Attachment-1):

Main Components			Donors
FAP-1	:	Brahmaputra Right Bank Strengthening	IDA
FAP-2	:	North West Regional Study	UK/Japan
FAP-3	:	North Central Regional Study	EEC/France
FAP-4	:	South West Water Management Study	ADB/UNDP
FAP-5	:	South East Regional Study	IDA/UNDP
FAP-6	:	North East Regional Study	Canada
FAP-7	:	Cyclone Protection Project	EEC
FAP-8A	:	Greater Dhaka Protection Project	Japan
FAP-8B	:	Dhaka Integrated Town Protection Project	ADB/Finland
FAP-9A	:	Secondary Town Protection Project	ADB
FAP-9B	:	Meghna Left Bank Protection Project	IDA
FAP-10	:	Flood Forecasting and Early Warning Project	UNDP/Japan
FAP-11	:	Disaster Preparedness Program	UNDP
Supporting Studies			
FAP-12	:	FCD/I Agricultural Review	UK/Japan
FAP-13	:	O&M Study	UK/Japan
FAP-14	:	Flood Response Study	USA
FAP-15	:	Land Acquisition and Resettlement Project	Sweden
FAP-16	:	Environmental Study	USA
FAP-17	:	Fisheries Study and Pilot Project	UK
FAP-18	:	Topographic Mapping	Swiss/France/Finland
FAP-19	:	Geographical Information System (GIS)	USA
FAP-20	:	Compartmentalization Pilot Projects	Netherlands/Germany
FAP-21/22	:	Bank Protection and AFPM Pilot Project	Germany/France
FAP-23	:	Flood Proofing Pilot Project	USA
FAP-24	:	River Survey Program	EEC
FAP-25	:	Flood Modelling and Management Project	Denmark/France/UK/NL
FAP-26	:	Institutional Development Programme	UNDP/France
Special Economic Study			World Bank

For details, see Attachment-1, Outline of Flood Action Plan (FAP)

The following FAP studies are directly related to the Study. The Study Team has been requested by the BWDB to review these FAP studies, paying special attention to the consistency with the study results as well as the guidelines given by these FAP studies during the course of the Study.

(1) FAP- 2: North West Regional Study, covering 34,600 km^2 inclusive of the Kurigram South area, to prepare a regional flood control and drainage plan.

(2) FAP-9A: Secondary Town Protection Project which includes Kurigram town protection as one of the priority sites that are prone to erosion and inundation.

(3) FAP-12: Agricultural Review of the existing FCD/I projects which includes the Kurigram South as one of the study areas for project impact assessment.

(4) FAP-13: O&M Study which will identify constraints for O&M of the existing FCD/I projects including the Kurigram South area, and recommend O&M procedures for future FAP projects.

(5) FAP-15: Land Acquisition and Resettlement Project for assessment of social impact of land acquisition process to suggest prospective improved procedures and guidelines for FAP studies (the Kurigram South area was surveyed as one of the sample area).

(6) FAP-16: Environmental Study for asessment of environmental impact (EIA) of FAP projects, development of criteria and EIA techniques for use in regional studies and project preparation and establishment of an EIA's unit for necessary arrangement.

2.7 Institutional Framework for FCD/I Projects

The Bangladesh Water Development Board (BWDB) under the Ministry of Irrigation, Water Development and Flood Control, is the main authority for FCD/I projects in the country, with the following primary role:

(1) Developing country's water resources in all respects,

(2) Planning, designing and construction of major, medium and small scale irrigation, drainage and flood control projects of the country; and

(3) Ensuring efficiency and proper performance of water resources projects in the country through monitoring and evaluation.

The FCD/I projects aim to increase agricultural production by means of flood protection, improvement of drainage condition and irrigation development, and thereby to improve the rural income and welfare. Such objectives of FCD/I projects could only be achieved with full supports from the related sectors, and such cooperation with the related sectors should be maintained for sustainability of the completed projects. There are a number of organizations related to the FCD/I development; at least, the following government agencies seem to be either directly or indirectly related to the FCD/I projects:

Ministry of Irrigation, Water Development and Flood Control

(1) Master Plan Organization (MPO)
   (a) Updating technical data for planning of water resources development
   (b) Providing the technical assistance to other concerned agencies

(2) Flood Control Coordination Organization (FCPO)
   (a) Coordination of all FAP components
   (b) Functioning as initial executing agency for new FAP components

Ministry of Local Government, Rural Development and Cooperatives

(3) Local Government Engineering Department (LGED)
- (a) Implementing irrigation schemes at Thana level
- (b) Implementing feeder roads, zila parishad roads, upazila connecting roads, including bridges and culverts
- (c) Undertaking O&M of the above irrigation and road schemes
- (d) Acting as a support arm of the Government to Upazila Parishads

(4) Bangladesh Rural Development Board (BRDB)
- (a) Providing credit support for irrigation equipment
- (b) Forming irrigation groups for improvement of irrigated agriculture

Ministry of Agriculture

(5) Bangladesh Agricultural Development Corporation (BADC)
- (a) Promotion of the tubewell irrigation system supports
- (b) Providing O&M support at the field level

(6) Department of Agricultural Extension (DAE)
- (a) Providing all kinds of agricultural extension services
- (b) Organizing and training of field extension workers

Ministry of Communications

(7) Road and Highway Department (RHD)
- (a) Planning, designing and construction of regional roads and highways
- (b) Improvement, rehabilitation and maintenance of roads, bridges and culverts

Ministry of Fisheries and Livestock

(8) Department of Fisheries (DOF)
- (a) Development of fishery resources of the country
- (b) Working as a participating agency in FCD/I projects for fishery development

(9) Department of Livestock Services (DLS)
- (a) Providing technical services through network at different levels
- (b) Organizing training for livestock resources development

Activities of NGOs

Apart from the governmental activities, there are more than 1,100 NGOs working in Bangladesh. The NGO Affairs Bureau (NAB) was established in 1990, for providing various supports to NGOs, as an institute under the President Secretariat. In the fields of irrigation, agricultural and rural development in Bangladesh, the NGO's activities are highly appreciated in the sense of guiding the rural people to self-reliant status through manifold approaches.

CHAPTER III THE STUDY AREA

3.1 Location

The Study Area is located in the north west region of Bangladesh adjacent to the northern boundary with India between latitudes 25°30'N - 26°10'N and longitudes 89°27'E - 89°47'E. The area is bounded by the international border with India in the north, the railway line leading to Lalmonirhat in the west, the Teesta river in the south-west and, rivers Dharla and Brahmaputra in the north and east. The gross area surrounded by these boundaries covers approximately 70,000 ha, comprising the five (5) Thanas of Kurigram, Rajarhat, Ulipur, Chilmari and Lalmonirhat. The total area protected by the existing embankment is 59,400 ha. The area is located at a distance of approximately 250 km from Dhaka, the Capital of Bangladesh. The main urban centre is Kurigram town which is centrally located in the Study area.

3.2 Socio-economic Situations

The total population of the Study area (inside of the embankment) is estimated at approximately 739,300 (as of 1992), with a population density of 1,245 persons per km^2 which is 27% higher than the national average. The total number of household is also estimated at 130,500 with an average family member of 5.7 persons per household, which is slightly larger than the national average of 5.3 persons per household.

The Study area is predominantly agricultural, with 101,800 farm households or 78% of the total households relying on agriculture. The average farm size is 0.42 ha per farm household, which is almost half of the national average of 0.81 ha. The Study area is characterized by large proportion of landless (including very small farmers cultivating less than 0.2 ha which accounts for 59% of the households. Small and medium farmers cultivating 0.2 to 1.9 ha, represent 37% of households. Land ownership is unequally distributed, with 77% of the total cultivated land being owned by 21% of the households who are categorized as the medium to very large farmers cultivating more than 1.9 ha.

The labour force is mostly agricultural and generally suffers from a high level of underemployment. The average working days vary within the range of 200 - 250 days per annum. Agricultural labour is primarily drawn from the landless and small farmers, and wage rates vary depending on the localities within the range of Tk15 - Tk30 per day. Major income source is crop production accounting for 79% of total income. Other sources include

business/service (18%), livestock (2%) and fisheries (1%). The Study area is very poor, with an average per capita and per household income of Tk2,500 (US$64) and Tk14,400 (US$371) respectively per annum, which is considerably lower than the national average.

3.3 River Systems

The Study area is surrounded by the three large rivers, namely the Brahmaputra, Dharla and Teesta rivers. The Brahmaputra river originates the eastern Himalayan piedmont far beyond the Indian border with Bangladesh, and is confluent with the Dharla and Teesta rivers at the eastern and southeastern corners of the Study area respectively.

The Dharla river originates near the southwestern region of Bhutan and India and flows down southeastward to traverse the Indian border with Bangladesh at Lalmonirhat. The physical feature in the Bangladesh territory can be summed up as follows:

Catchment area (whole)	:	about 5,100 km^2
River reach	:	55 km
Average riverbed slope	:	about 1/4,500 to 1/6,500
Average width of dry season channel	:	300 m to 500 m
Channel depth up to river bank ground level	:	about 5 m
Average height of existing embankment	:	2 to 3 m
Conveyance capacity	:	2,000 to 6,000 m^3/sec

The Teesta river, originating near the Himalayan piedmont in Darjeeling region, flows down and enters the Bangladesh territory in Nilphamari district. The physical feature in the Bangladesh territory can be summed up as follows:

Catchment area (whole)	:	12,500 km^2
River reach	:	125 km
Average riverbed slope	:	1/1000 to 1/5,300
Average width between both river bank	:	500 m (Kaunia bridge)
Channel depth (riverbed to river bank)	:	about 5 m (at outfall)
Average height of embankment	:	2 to 4 m.
Conveyance capacity	:	3,000 to 10,000 m^3/sec

3.4 Meteorology and Hydrology

The existing meteorological station, rainfall stations and water gauging stations is shown in Fig. 3.4.1. Most of the data are available for 30 years from 1960 to 1990. According to the meteorological data at Rangpur Station, maximum temperature varies from about 24 to 34°C, minimum is 10 to 26°C and mean temperatures range between about 17 to 29°C. The humidity is high through the year with average humidity varying from 71 to

87%. The sunshine hours of average monthly range between from 4.1 to 5.5 hours/day during the monsoon season and from 6.5 to 8.5 hours/day during the dry season. Wind speeds are relatively low except during the pre-monsoon season and monsoon periods when the average wind speed of monthly are from 1.2 to 1.8 m/sec. Maximum evaporation of average monthly range between from 2.3 to 6.0 mm/day and annual mean is 4.1 mm/day.

Five (5) stations out of 8 rainfall stations in and around the Study area were selected for data analysis. Annual rainfall frequency for 5 stations is as follows:

(unit:mm/year)

Rainfall Station	Frequency (year)						
	2	5	10	20	25	50	100
Chilmari	2,200	2,756	3,123	3,476	3,587	3,932	4,275
Kaunia	2,363	3,000	3,421	3,827	3,954	4,350	4,743
Kurigram	2,284	2,706	2,986	3,254	3,389	3,601	3,862
Lalmonirhat	2,476	3,046	3,423	3,786	3,900	4,254	4,605
Ulipur	2,226	2,619	2,879	3,129	3,208	3,452	3,694

Discharge data at Kurigram station for the Dharla river are available for about 18 years from 1973 to 1990. Frequency analysis for Kurigram in the Dharla river was made for estimating the maximum, minimum and 355-day discharge.

(unit:m^3/sec)

Item	Frequency (year)								
	2	3	5	10	20	25	50	100	200
maximum	2,050	-	2,890	3,440	3,970	4,130	4,630	5,160	5,780
minimum	60	54	49	44	40	-	36	34	-
355 day	67	64	55	50	45	-	41	38	-

3.5 Water Resources

3.5.1 Surface water resources

Although beels and khals are the important surface water sources available for irrigation development in the Study area at present, their quantity is too small to apply for irrigation plan during the dry-winter season. For the large scale irrigation development, exploitation of new perennial surface flow would be essential. The Brahmaputra river is endowed with tremendous water resources, however, the exploitation of its water resources will be much costly due to geographical and topographical conditions. Its abundant water resources are worthless for the irrigation development in the Study area.

The Teesta river is also blessed with abundant water resources. In addition to the irrigation water exploitation in the Indian territory, the large-scale Teesta Project with an irrigation area of 315,000 ha has been recently launched in the Bangladesh territory. Moreover, vast land resources extending along the right bank of the Teesta river are expected to be irrigated in the near future depending on the Teesta river. Considering the long-term water resources development in North West region, the water resources in the Teesta river should be reserved for future irrigation development in such areas.

Based on the 10-day mean discharge of the Dharla river at the Kurigram gauging station, during 1973 to 1990 (see Table 3.5.1) a frequency analysis is made by various methods. The flow of 49 m^3/sec estimated with 10-year return period would be assessed to be dependable for irrigation development in the Study area.

In the meantime, the National Water Plan stipulates that less than about 60 % of the dependable draught flow should be diverted for irrigation use in due consideration of navigation, industrial use, inland fishery development, environmental aspects, etc. in the downstream in the future. Following this concept, the dependable surface water resources in the Dharla river would be assessed at 30 m^3/sec with a proper frequency.

3.5.2 Groundwater resources

Aquifer formation in the Study area is divided into 3 units of top aquitard layer, composite aquifer and main aquifer. The top aquitard layer consists of clayey and silty materials with thickness of 0 to 6 m from the surface. The composite aquifer consists of very fine to fine sand, sometimes medium sand with occasional silty layer with thickness of 9 to 15 m. Development potential of the composite aquifer is poor because its grain size is too fine. The main aquifer is one of a series of medium to coarse sands containing gravel layer, situated below the composite aquifer at about 12 to 18 m deep from the ground surface and its thickness is more than from 40 m. This aquifer is suitable for groundwater development by using high discharge screened wells in view of the materials characteristics.

According to the weekly measurement by BWDB, the lowest groundwater level ranges from 2.7 to 6.5 m from the ground surface in April. The groundwater level rises from May, and reaches its highest level in late July, keeping the highest level upto September. The groundwater level gradually draws down to its lowest level from October. Seasonal fluctuation of the groundwater level ranges from 2.1 to 5.7 m.

The comprehensive assessment of groundwater resources in Bangladesh has been made in the National Water Plan at Thana level. The optimum groundwater development has been derived through simulating the recharge, available storage in the aquifer system, well technology and hydraulic constrains. According to the assessment, the total available groundwater recharge in the Study area amounts to 210 MCM (353 mm in depth). Thana level development potential has assessed by pumping technology, in which pumping limits are 7 m in STW and 20 m in DTW from the surface as considering the safe-yield basis. The development potential can be summarized as follows:

Thana	Area (km^2)	Usable Recharge (MCM)	Unconstrained Development Potential			
			STW (0.5 cusec)		DTW (2 cusec)	
			Volume (MCM)	Depth (mm)	Volume (MCM)	Depth (mm)
Lalmonirhat	120.7	49.85	47.44	393	49.85	413
Rajarhat	147.5	66.38	49.86	338	66.38	450
Kurigram	71.1	24.03	13.69	191	24.03	338
Ulipur	217.3	81.49	79.75	367	81.49	375
Chilmari	37.4	14.03	9.39	251	14.03	375
Total (mean)	594.0	235.78	200.13	(337)	235.78	(397)

The total groundwater development potential in the Study area of 594 km^2 is estimate at 200 MCM or 337 mm for STW and 236 MCM or 397 mm for DTW.

3.6 Geology and Soil Mechanics

The Study area physiographically extends on the lower Teesta floodplain, and is geologically underlain by alluvium which have formed by the interstream and meander deposits of the Teesta, Brahmaputra and Dharla rivers. The alluvium consists of the silty materials in the upper most portion, the fine sand, the fine to medium sand and the medium to coarse sand in the deeper portion.

According to the seismicity analysis of the past earthquake data from 1833 to 1971, earthquakes likely affecting to the Study area were 92 events. From this analysis, the horizontal seismic coefficient of 0.08 on the basis of 50 years return period, the same value as the Bangladesh standard, is recommended for the design criteria of the structures.

Based on the SPT and general design criteria, allowable bearing capacities of the foundation ground were estimated at 52.8 ton/m^2 at the pumping station, 12.9 ton/m^2 at the barrage and 9.6 ton/m^2 at the regulator. According to the results of the test boring, sheet

piling is recommended in the rehabilitation work of the regulators as countermeasures against scoring and piping. Both the sandy and silty soil strata in the shallow portion shall be used as the embankment materials. For the stability analysis of the embankments made by both silty and sandy soil materials, the embankments are assumed to have a slope of 1:3 and a 4.2 m wide crest width. The safety factors is required at not less than 1.5 against the normal condition and not less than 1.2 against the seismic condition. The linear sliding method is employed for the sandy soil embankments and the Janbu's slope stability chart for the silty soil embankment. Based on the stability analysis, the embankment height with slope of 1:3 must be must less than 8 m with safety factor more than 1.5.

The embankment materials of the surface layers consist of the silty layer and the poorly-graded fine sand, and have an extremely small erosion resistance with uniformity coefficients of 7.9 for the silty layer and 3.4 for the sand. The slope protection works should be furnished even in stable condition against the sliding failure on the basis of observation of existing condition. The sand layer foundation in the Study area has no high risk of liquefaction during earthquake based on the average grain size of sand layer, uniformity coefficient, distribution of N-values and affection of earthquakes.

3.7 Soil and Land Resources

Land type is commonly used to express inundation depth or flood level for agricultural land. For the studies conducted under the BWDB, MPO set 5 land types such as F0: 0 - 30 cm of inundation depth, F1: 30 - 90 cm, F2: 90 - 180 cm, F3: 180 - 360 cm and F4: more than 360 cm. Area by land type in the Study area are as follows:

	F0 0 - 30 cm	F1 30 - 90 cm	F2 & F3 > 90 cm	Water body	Study area total
Area	23,600 ha (40%)	28,600 ha (48%)	5,700 ha (10%)	1,500 ha (2%)	59,400 ha (100%)

The soils in the Study area are classified into 12 soil series; Pirgacha series are extending over F0 land with about 4,000 ha (6.7% of the Study area), and have moderately well drainage condition and medium texture such Silt loam to Sandy loam. Bonarpara, Chilmari, Gangachara, and Palasbari series are situated on F0 and F1 land with about 24,200 ha (40.7%). The soils have medium to medium fine texture such Silt loam to Silty clay loam. Amgaon, Farabari, Kaunia, Laskara, Uttargaon, and Ulipur series occupies about 28,200 ha (47.4%) on F1 and F2 land, and have medium to fine texture such Silt loam to clay. Sand and Silty alluvium complex is found on the very gently undulating old

charland of F1 and F2 land with 1,500 ha (2.5%) with courser texture like Sand to Silty clay loam, and poor drainage condition.

The factors governing land suitability for irrigation cultivation are slope, land type, drainage condition, permeability, soil texture, effective soil depth, top soil consistency and soil reaction of the land. The requirements of those factors are different by crops. The requirements of crops are applied to the land units, which are combination of soil series and land types, and then land suitability classes for crops are rated. The main factors to limit suitability in the Study area are inundation condition and soil texture. Most of the land in the study area is suitable for HYV rice and other upland crops.

3.8 Present Condition of Agriculture

The Study area is classified into 3 categories namely cultivated area, settlements (including roads, houses, buildings, structures, etc.) and water bodies in terms of land use. The cultivated land is further divided into gross area and net area, as shown below:

Cultivated		Settlement	Water Surface	Total
Gross	Net			
50,500	42,800	7,400	1,500	59,400
85%	72%	12%	3%	100%

The condition of cultivated land is estimated on the basis of land use survey. The results show that the net cultivated area of 42,800 ha , as follows:

	F0	F1	F2 & F3	Total
Rainfed land	13,100 (31%)	17,200 (40%)	2,700 (6%)	33,000 (77%)
Irrigated land	3,500 (8%)	4,800 (11%)	1,500 (4%)	9,800 (23%)
Total area	16,600 (39%)	22,000 (51%)	4,200 (10%)	42,800 (100%)

Generally, the crop seasons comprise the "kharif" which corresponds to summer and monsoon season (March - September) and "rabi" which means winter and dry season (October - February). Kharif can further be sub-divided into the early kharif (March - May) and the kharif proper (June - September). Introduction of irrigation practices in recent years, also made a sub-division in the "rabi"; the rabi proper (October - December) and the late rabi (January - February). The climatic data by 10 days at Rangpur meteorological station are shown on Fig. 3.8.1.

The cropping patterns can be generalized according to the land types as well as the availability of irrigation water. The generalized cropping pattern under the present condition is illustrated on Fig.3.8.2, and summarised as follows:

Land Type (Flooding Depth)	Cropping Sequences	Cropping intensity	Area
Seasonal Flooding F0: 0 - 30 cm	Irrigated HYV Boro - HYV Aman - Rabi crops /Fallow	234%	3,500
	Rainfed HYV.Aus/ Jute - HYV Aman - Fallow /Rabi crops	202%	13,100
	Average/Sub-total	208%	16,2600
Seasonal Flooding F1: 30 - 90 cm	Irrigated HYV Boro - HYV Aman - Fallow /Rabi crops	213%	4,800
	Rainfed HYV Aus /Jute - L.T.Aman - Fallow /Rabi crops	182%	17,200
	Average/Sub-total	189%	22,000
Seasonal Flooding F2 & F3: > 90 cm	Irrigated HYV Boro - L.T.Aman /Jute - Fallow H.T. Boro - Fallow - Fallow	133%	1,500
	Rainfed Jute /L.B.Aus - L.T Aman /Fallow - Fallow /Rabi crops L T. Boro - Fallow - Fallow	126%	2,700
	Average/Sub-total	129%	4,200
Total		190%	42,800

sources: mainly based on land use survey, 1992

Most of farming practices are carried out by labours and draft animals. Farmers use their own seeds multiplied by themselves, particularly rice and jute seeds. Rice seedlings are kept in nursery bed for 40 to 50 days. Land is ploughed in the depth of about 15 cm through two to three times using a pair of bullocks or oxen. For HYV Aman followed by jute or Aus rice crops, land preparation and transplanting are made immediately after harvesting the previous crops. Manure is applied before land preparation and mixed with soils by first ploughing. After transplanting or sowing, fertilizers are applied for HYV varieties in several times, but rarely applied for local varieties. Sometimes spraying is carried out for crop protection. Weeding is generally carried out by hands in two to three times. Thining is important operation for jute. All crops are manually harvested. Jute is dried by hanging bamboo bar, through rotting after two to three weeks of submersion under water.

The cultivated areas, crop yields and production of major crops in the Study area is estimated as follows:

Crops	Cultivated area (ha)	Unit yield (ton/ha)	Production (tons)	Crops	Cultivated area (ha)	Unit yield (ton/ha)	Production (tons)
HYV Boro	10,200	3.68	37,500	Jute	4,400	1.48	6,500
L.T.Boro	1,000	1.84	1,,800	Sugarcane	1,900	27.00	51,300
HYV Aus	19,500	2.40	46,800	Wheat	3,600	2.03	7,300
B.Aus/L.T.Aus	4,300	1.25	5,400	Oil seeds	1,200	0.60	700
HYV Aman	26,300	2.77	72,900	Pulses	1,000	0.74	700
L.T.Aman	6,100	1.75	10,700	Potatoes	1,000	9.05	9,100
				Spices	500	4.84	2,400
Rice Total	67,400	2.54	175,100	Vegetables	500	6.18	3,100

Cattle provide almost all the draught power for cultivation, while their wastes are principal means of replenishing soil nutrients and major source of fuel. Livestock products provide a useful source of protein and cash income. Moreover, livestock is an asset easily converted into cash, and often represent a significant proportion of total farm capital. There are at least 100,000 heads of cattle and nearly 300,000 of sheep and goats in the Study area. Livestock is feeding on crop residues and wasteland natural vegetation. There is a limited potential for increasing animal numbers in the area; a constraint to increasing cattle numbers is the very limited availability of fodder.

The District Office at Kurigram of the Department of Agricultural Extension (DAE) has an agricultural extension network which reaches down to the union level. In the Study area, the DAE executes the "marginal and small farm systems crop intensification project" from 1987 to 1993, and is very actively working with the Rangpur-Dinajpur Rural Service, NGO. This project comprises manifold work items such as construction of growth centres and feeder roads, crop development and researches, household credit supports, strengthening of agricultural extension, and enhancement of non-crop activities. The target beneficiaries are defined as all of the "marginal" and "small" farmers in Kurigram District

Large scale surface water irrigation is the responsibility of the BWDB; however, such irrigation development has not been realized in the Study area, on the contrary, small scale irrigation using mainly groundwater resources has been enhanced by various agencies. The lead agency for such minor irrigation development is BADC, with credit supply from BKB. The private sector is also much involved in the minor tubewell development for irrigation.

Six (6) commercial banks operate in the Study area (Sanali, Janata, Agrani, Pubali, Krishi and Grameen banks). The Grameen bank, established to provide credit to the landless, individually or in group, is expanding its operation to all upazilas. Other important source of credit is the BRDB cooperative funds which are channelled to the cooperatives mainly for crop loans and purchasing irrigation equipment.

BARI (Bangladesh Agricultural Research Institute) has a regional station at Rangpur, executing the wide field of farming system research. The farm input supplies (seeds, fertilizers and agro-chemicals) are largely privatized in the area. There is a district livestock officer at Kurigram, but the development of livestock services is still at an early stage.

3.9 Inland Fisheries

Annual fishery production is estimated at about 560 ton, accounting for per capita availability of 1.4 kg per annum which is much lower than the national average of per capita fish consumption (2.2 kg) for the lowest income groups.

There are about 2,600 fish ponds or tanks covering 260 ha, however, 36% of the ponds are lying derelict. The ponds under operation are medium sized (0.1 ha) and carp polyculture is practiced in 70% of the ponds. Culture fishery supplies 167 ton or about 30% of the total production at the unit production of 900 kg/ha, which is quite low as compared to a potential of 3,300 kg/ha for well-fertilized ponds stocked with carp. The net production value of pond culture is estimated at Tk.16,000/ha, balancing between gross production value of Tk.27,800/ha and total cost of Tk.11,800/ha. Main reasons for low productivity are (1) unsuitable design of ponds, (2) extensive low inputs/yield techniques, (3) minimal preparation or supervision of ponds, (4) no availability of quality fish seed/fingerings, (5) multiple ownership and use of ponds, (6) financial constraints, (7) limited technical knowledge, (8) risk of floods, drought, diseases and (9) short of marketing facilities.

Annual fish catch is estimated at about 400 ton from 2,000 ha of water surface, which consists of 1,740 ha of the major three rivers and 260 ha of canals, beels and flood plains. The average unit catch is 216 kg/ha from the major rivers and 84 kg/ha from other water surface, in total 194 kg/ha. Fish species of captured fishery can be classified into two groups of river fish and beel fish.

Impact on fisheries can be measured for the existing FCD structures since irrigation components has not been implemented yet . According to the inventory survey of fishermen

community, catches of capture fishery in FCD area is lower than in non-FCD area. Then, income from capture fishery in FCD area are about 4 to 10% lower than in non-FCD area.

Positive impact of FCD/I may be expected on culture fishery through encouraging regular stocking and improved culture methods, however, there is little evidence that the potential of positive impact has been realized in the past. The past experience indicates that the positive impact is expected only in the case supplemental stocking programme ensures increase of fish seed supply from fish hatcheries. In addition to this, adverse impact is expected that expansion of groundwater irrigation accelerates seepage from fish ponds and causes decreasing water level below the minimum water depth required for culture fishery.

3.10 Rural Infrastructures

The current status of rural infrastructures are investigated by the Rural Employment Sector Programme of LGED in each upazila. The currently available information at Thana level on this aspect is shown in Table 3.10.1.

Road network for transportation by vehicle have been extended in passable accomplishment, as shown on Fig 3.10.1. Only one route of regional highway from Teesta bridge to Kurigram which is further going to Chilmari is paved by bituminous concrete. However, the greater part of feeder road have left unpaved. Consequently, it is difficult to pass through those routes by vehicle during the wet season. There are a number of bridges and culverts along such feeder roads, some of them are eroded or washed away and have remained in a state of disrepair; therefore, passing by vehicles is hardly possible along such routes even during the dry season.

Urban water supply systems by pipe network have been developed in the district towns only, Kurigram and Lalmonirhat. Other towns and villages entirely depend the domestic water on their own pumping systems such as hand pump, threadle pumps and other pumping means. Water is not treated at all in such areas. Electric transmission lines have been extended to all the upazilas in the Study area; they are mostly installed along major road network.

3.11 Current Status and Achievement of FCD/I Development

3.11.1 Flood embankment and river protection works

Flood embankment of 108 km long has been constructed; it was designed based on the maximum design flood level with 50 years return period; however, the free board of the embankment is not enough for design flood level in most of the sections, according to the survey conducted in 1989 by Division-I of the BWDB's Kurigram district office.

Bank protection works, inclusive of groyne, cross bar and bank revetment, have been constructed at four locations along the embankment. These bank protection works include the Kurigram Town Protection Scheme, the Joykumar Protective work, Mogolbasha Protection work and Biddananda Protection work. The existing flood control and river protection works are shown on Fig. 3.11.1

3.11.2 Drainage system and flooded condition

There are some drainage rivers and channels in the Project area and these drains are connected with the existing 11 Regulators for draining out the internal excess water. The existing drainage facilities together with the drainage system are shown on Fig. 3.11.1. The Project area is divided into eight (8) drainage blocks based on the existing rivers and channels. The existing drainage regulator and pipe sluice are listed in Table 3.11.1.

3.11.3 Minor irrigation development by STW/DTW

Present condition of minor irrigation development is summarized as follows :

Thana	STW Installed (nos.)	STW Irri.Area (ha/well)	DTW Installed (nos.)	DTW Operated (1992) (nos.)	DTW Irri.Area (ha/well)
Lalmonirhat	523	3.6	45	25	18.9
Rajarhat	850	4.0	64	55	21.6
Kurigram	339	4.2	30	16	16.6
Ulipur	969	4.1	128	120	19.4
Chilmari	139	4.2	40	20	15.7
Total/(Weighted Average)	2,820	(4.0)	292	236	(19.4)

All of the tubewells are not in operation due to mechanical trouble, no commission or no consensus by farmers users group. Actual operation hours during 1992's irrigation

season, from January to May, are generally 8 to 10 hours/day. In the case of the DTWs, annual operation hours are 521 hours on an average and 18 hours/day in the maximum. The area irrigated by STWs ranges from 3.6 to 4.2 ha with an average of 4.0 ha. The irrigated area by DTWs varies from 10 to 38 ha with an average of 19.4 ha against the command area of 14 to 50 ha.

Among the existing irrigated area of 9,800 ha, about 4,600 ha (47 %) are covered by DTWs in this season and the rest of 5,200 ha (53%) are irrigated by STWs. The number of operational STWs is estimated at about 1,300 which are about 46% of the existing installed number of STWs. The decrease in operational number of STWs is supposedly due to use for other purposes (cultivation, transportation, milling, etc.), depreciation over durable years, low capacity and less profitability, weak farmers' group, etc.

3.12 O&M Activities of Existing FCD/I Facilities

The O&M Division of BWDB has the Superintendent Engineer's (SE) office for the NW Region at Dinajpur, more than 100 km west of Kurigram. Under the SE's office, one Sub-Divisional Engineer's office is located at Saidpur and the other at Lalmonirhat. In Kurigram district, there is no O&M office. Therefore, the maintenance work of the existing FCD facilities is being carried out by the Kurigram Executive Engineer's office under the Implementation Division of BWDB. The existing FCD facilities have not been transferred to the O&M Division of BWDB yet .

The major O&M problems are summarized as (1) limited institutional support by BWDB, (2) shortage of fund for O&M activities, (3) general lack of public consultation, (4) constraints of canal water flow due to sliding or falling of the bridges or culverts, (5) shortage of manpower and vehicles for monitoring of the embankments during flood season and for its maintenance and services, and (6) shortage of training facilities to upgrade the capabilities of the officers and staff.

The existing embankments and regulators are more or less kept functional under very severe conditions with the limited available resources, although there are serious O&M problems as mentioned above.

CHAPTER IV REVIEW OF PREVIOUS AND ON-GOING STUDIES

4.1 Previous Studies related to the Study

There are three (3) previous studies related to the Kurigram FCD/I Project (Chapter II, to be referred):

(1) Feasibility Study on the Kurigram FCD/I Project in 1969/72,
(2) Revised and Updated F/S on the Kurigram FCD/I Projects in 1975, and
(3) Revised and Updated F/S on the Kurigram FCD/I Project (south unit) in 1982

The project components proposed by the previous studies are flood control, drainage improvement and irrigation development; however, salient features of the proposed facilities are different as summarized in Table 4.1.1.

In addition to the above studies, the feasibility study on the Kurigram Town Protection Project was made during 1970 - 1972, to draw up a development scheme for sustainable protection of Kurigram Town from floods, river bank erosions and drainage congestion.

4.1.1 Feasibility study in 1969/71

This original feasibility study envisaged full irrigation development depending upon surface water resources without any use of groundwater resources, and the following four (4) alternative plans for irrigation development were examined :

Alternative-1: (Development Area = 34, 400 ha)
Only northern area of 34,400 ha would be irrigated by one power pumping station at Bumka, and the remaining southern area of 16,800 ha would be left out under the Project.

Alternative-2: (Development Area = 51,200 ha)
Both northern and southern areas would be irrigated by two power pumping stations, respectively.

Alternative-3: (Development Area = 36,900 ha)
Only the southern area of 36,900 ha would be irrigated by gravity from the Dharla Barrage. The northern area of 14,300 ha would be left out under the Project.

Alternative-4: (Development Area = 51,200 ha)
The northern area of 16,400 ha would be irrigated by a power pumping station at Bumka, and the southern area of 34,900 ha would be irrigated by gravity from the Dhalra Barrage.

The original feasibility study concluded that the Alternative-4 (Bumka power pumping plant and Dhalra barrage) would be the most viable technically and economically. The estimated EIRR of the proposed plan was rather low with 11.7%, due to the high capital cost required for large structures in comparison with the anticipated project benefits.

4.1.2 Revised and updated feasibility study in 1975

The original feasibility study was subsequently revised and updated by Techno Consult Eastern Limited with substantial surveys and studies on groundwater, agricultural and economic analysis. The revised and updated feasibility report was submitted to BWDB in January 1975. Additional comparative studies were made in this report for the following three (3) alternative plans with the full development concept for the area of 49,800 ha :

Alternative-1: (Development Area = 49,800 ha)
The irrigation water would be supplied to 49,800 ha by shallow tubewells; however, irrigation intensity would become low due to limitation of groundwater resources.

Alternative-2: (Development Area = 49,800 ha)
Northern area of 20,500 ha would be irrigated with shallow tubewells, and the remaining southern area of 29,300 ha would be irrigated by gravity with a barrage and an irrigation canal network.

Alternative-3: (Development Area = 49,800 ha)
Northern area of 24,600 ha would be irrigated with a power pumping station, and the remaining southern area of 25,200 ha would be irrigated with shallow tubewells.

The study concluded that the Alternative-2 (the northern area by tubewell development and the southern area by the Dharla barrage) would be technically sound and economically viable. The other major differences between 1969/71 and 1975 reports are the introduction of drainage pumps (1975) instead of gravity drainage (1969/71). The possibility of utilization of drainage channels as irrigation canals was denied in this report. The estimated EIRR of the proposed project remarkably improved as 38.9% owing to the reduction in project costs and the increases in anticipated benefits.

4.1.3 Updating works in 1982

BWDB undertook an updating of the revised and updated feasibility report in 1982 in order to request the financial assistance for implementation to the Saudi Fund for Development (SFD). No further alternative study was made in this task. Only minor modification was made depending on the ratio of commanding area between groundwater and surface water, resulting in changes in number of tubewells, total length of embankment,

and cropping intensity and yield. While, the project costs and benefits were significantly modified, and EIRR was further increased by 56.2%.

4.1.4 Kurigram Town Protection Project

The study presented the following two (2) proposals based on a magnitude of 7,100 m^3/sec, or 100-year probable flood in the Dharla river.

Proposal-1: Stabilization of Banks and Channel Improvement

The proposal envisaged stabilization of both the right and left banks of the Dharla river as well as regulation of the river channel through a concept of river training technology, and proposed provision of bank revetments with sinking apron at the places where erosion is severe, and flexible fencing and planted shrubs and trees at other places. The proposal was composed of the following protection works :

(1)	Right Bank Training Works	
	-continuous revetments in two different paces :	5,240 m in total
	-parallel fencing :	7,310 m in total
(2)	Left Bank Training Works	
	-continuous revetments :	3,720 m in total
	-parallel fencing :	8,840 m in total

Proposal-2: Right Bank Protection

The proposal envisaged protection of the town by making protective works only the right bank of the Dharla river through construction of groynes, bank revetments and embankments at the points where erosion are severe, and no protective measures on the left bank and as such the river would be free to migrate leftward by limiting rightward swing of the river channel. The proposal is composed of the following protection works :

(1)	Works for upstream	
	- Groyne No.1:	195 m with a T-shaped head
	- Groyne No.2:	275 m with a T-shaped head
	- Bank revetment at Palashbari	
(2)	Works for downstream	
	- Krishnapur Groyne :	305 m with a T-shaped head
	- Krishnapur bank revetment	

The total costs for the Proposal-1 were estimated within the range of Tk56.5 million to Tk95.6 million, while the Proposal-2 from Tk23.6 million to Tk28.4 million. The B/C ratios ranged from 4.10 to 6.94 for the Proposal-1 and from 2.40 to 2.89 for the Proposal-2. BWDB finally adopted the combined concepts of both proposals, and has been executing the works by own budgets. As of the end of 1991/92, the works have been expedited to the overall cumulative progress of 62 % with an expenditure of Tk166.5 million

4.2 On-going FAP Studies related to the Study

The following FAP studies are directly related to the Study. The Study Team reviewed these FAP studies under Phase-I, paying attention to the development policies and guidelines given by these FAP studies.

(1)	FAP- 2:	North West Regional Study
(3)	FAP-9A:	Secondary Town Protection Project
(2)	FAP-12:	Agricultural Review of the existing FCD/I projects
(4)	FAP-13:	O&M Study
(5)	FAP-15:	Land Acquisition and Resettlement Project
(6)	FAP-16:	Environmental Study

4.2.1 Northwest Regional Study (FAP-2)

(1) Objectives of the study

Main objectives of the FAP-2 study are summarized hereinafter:

1) to assess the possible flood control and drainage options in NW region (34,600 km^2) , and to establish preferable solutions,
2) to prepare a Regional Water Development Plan, and
3) to undertake feasibility studies of the first priority projects.

(2) Comments on the Kurigram south unit

The Kurigram South Unit area is included in the FAP-2 study area. The FAP-2 proposes the following full FCD works for the Kurigram South Unit:

1)	Heightening/strengthening of existing flood embankment:	108 km
2)	Provision of new spur dikes	8.05 km
3)	Rehabilitation of existing regulators	2 nos
4)	Improvement of existing drainage channel	45.5 km
5)	Provision of new drainage channel	3.5 km

Major economic factors for the proposed FDC works in the Kurigram South Unit are summarized as follows:

Net cultivable area:	65,430 ha
Total cost:	Tk1,878 million
Per hectare cost:	Tk28,702 (US$ 820)
O&M cost:	Tk110 million
Net present value ratio (NPVR):	-0.82 (1988), -0.68 (1989)

As given above, the proposed FCD works for the Kurigram South Unit were evaluated economically unfeasible with low social-biophysical-external impacts, and were finally ranked low for development in the NW regional plan.

4.2.2 Secondary Towns Protection Project (FAP-9A)

(1) Objectives of the study

FAP-9A is a study for the protection of district or medium sizes towns that are prone to erosion and inundation. The study includes the feasibility studies on the selected priority towns. Six towns namely Khulna, Kurigram, Panchagarh, MoulviBazar, Habiganj and Dinajpur were identified initially as the first priority candidates for the feasibility study.

(2) Proposed project works for Kurigram Town

The FAP-9A study proposes the following works:

Flood protection works			
1)	Rehabilitation of the existing embankment	:	2 km
2)	Construction of additional regulators	:	2 nos
Bank protection works			
3)	Rehabilitation of the existing groyne and spur	:	2 nos
4)	Construction of additional groyne and spur	:	2 nos
5)	Bank revetment (4 locations)	:	4 km
Drainage improvement works			
6)	Rehabilitation of existing drains	:	15.2 km
7)	New main drainage channel	:	21.3 km
8)	New tertiary drainage channel	:	10.0 km
9)	Crossing culverts	:	30 nos

(3) Project Costs and Justification

Direct cost of three (3) components for the Kurigram town protection is estimated respectively at January, 1992 price level, as listed below:

1)	Flood protection works	:	Tk.6.61 million
2)	Bank erosion protection works	:	Tk.114.29 million
3)	Drainage improvement works	:	Tk.43.07 million
	Total Direct Cost	:	Tk.163.97 million

The economic internal rate of return (EIRR) of the proposed project works is calculated to be 14%. The proposed project works for the Kurigram town are technically and economically justified.

4.2.3 FCD/I agricultural review (FAP-12)

(1) Objectives of the study

The FAP-12 Study has three principal objectives:

1) to assess agricultural, economic, social and environmental impact of the existing FCD/I projects, and
2) to develop guidelines and criteria for planning, design, implementation and O&M under the FAP projects.

(2) Comments on the Kurigram South Unit

The Kurigram FCD/I project is selected as one of the five (5) FCD/I projects for the PIE evaluation. The FAP-12 extends comments and recommendations from various aspects on the Kurigram South Unit FCD/I project. The following are the main comments extracted from the Final Report :

1) The flood embankment requires frequent rehabilitation for flooding and river erosion. Substantial retirement of the embankment is needed in the low-lying areas in the south. River protection works in the low-lying areas appears to be very costly and not cost-effective.

2) Two particular weak spots are currently threatened by catastrophic flooding; at Kashorpur regulator on the Teesta river bank and at the mouth of the Sanyashil khal on the Dharla river bank. Urgent protection works will be needed at these spots.

3) The proposal to develop a large scale surface irrigation system do not appear justifiable. Land acquisition seems to be a serious problem for large scale irrigation development. Need for environmental impact assessment will become more important if large-scale surface irrigation is implemented. Given the rapid expansion of minor irrigation, it should be re-appraised in comparison with the alternative costs of further promoting the groundwater irrigation development.

4) Cuts and breaches have been abandoned for a long period without any repair. About two-thirds of the embankment are occupied by illegal migrants, further weakening erosion prone reaches of the embankment. There are conflicts between BWDB and local people over breaches and cuts in the embankment as well as the O&M of the regulators. All the drainage channels have now silted up and require desilting works.

5) More concentrated efforts by DOF and NGOs would be justified to accelerate the process of fisheries expansion.

4.2.4 FCD/I operation and maintenance study (FAP-13)

(1) Objective of the study

The main objectives of FAP-13 are summarized as follows:

1) to identify the constraints on O&M practices of the existing FCD/I projects,
2) to draw up countermeasures for overcoming these constraints both for the existing projects and new FAP projects in the future, and
3) to recommend ways of ensuring the maximum participation of beneficiaries, and mobilization of local resources for O&M of the FCD/I project.

(2) Comments on the Kurigram south unit

The following are the comments and recommendations given by FAP-13 for the Kurigram South Unit :

1) The embankment has been eroded at a number of points, and public cuts and breaches remain open without repair works. There is a serious lack of

routine maintenance. Drainage congestion has been observed in the lower part of the area, resulting in frequent public cuts.

2) The embankment has left open at one point where the Ratnai river enters the area. This could be improved by creating a diversion channel and extending the embankment up to the railway line.

3) Maps available with BWDB are badly out of date and fail to indicate state of location of different water bodies.

4) The regulators seems to be relatively well operated. The problem is just in lack of capacity to drain out the excess water in the area. Khalashis (Guard of Regulator) appears to be operating regulators in spite of no instruction or practical training for operation needs. There is no committee for O&M of FCD facilities.

5) The drainage system should be re-assessed, and the drainage and flood problems over the area should be mapped and quantified so that the priorities for the drainage improvement can be set out.

6) As of 1991, there are 79 staff working for the Kurigram South project at an annual cost of Tk4.2 million (Tk66/ha). Out of 79 staff, engineers and technical staff are limited to only 15 which may be insufficient to carry out routine maintenance works.

7) Given extensive housing development on the embankment, maintenance teams might not be needed for these sections, if households can be persuaded to carry out routine maintenance for the embankment.

8) Public consultation will be needed to improve the project development plan. It is important to develop ways and means by which local institutions could be associated with managing the project. There is a need to involve NGOs and government agencies in exploiting potential of the area.

4.2.5 Land acquisition and settlement study (FAP-15)

(1) Objectives of the study

The main objectives of FAP-15 are summarized as follows:

1) to assess land acquisition procedures and methods of compensation, and
2) to develop guidelines and criteria for the FAP projects so as to minimize the land acquisition and to improve welfare of the displaced families.

(2) General Comments for Land Acquisition

A tentative conclusion on land acquisition is given by FAP-15 as follows:

1) Burdens of land losses are likely to be distributed over all land-holding categories. The burden is highest in the category of poor households.

2) The restricted definition of "target group" to land-poor households who have lost land, seems to kick out a very important category of losers; namely households who lose no land but whose living has been threatened by floods due to a consequence of becoming located outside of embankment. In this

connection, re-examination of the target-group should be needed for setting up a program of assistance for the affected communities.

3) Current methods for calculation of compensation levels represent a serious valuation problem. This includes immoral manipulations, procedural delays, and arbitration suits. A more rational calculation of compensation levels should be worked out as a key priority.

4) To the extent that resettlement programs pick out only land-poor households as their target group, substantial portion of affected households will be disregarded in compensation of land acquisition. Assistance to the affected communities should be better envisaged in terms of minimizing direct and indirect costs of land acquisition through more effective procedures along with the focus on resettlement assistance to worst-off households.

4.2.6 Environmental impact study (FAP-16)

(1) Objectives of the study

The following are the main objectives of the FAP-16 study:

1) to study environmental impacts of FCD/I projects, and prepare guidelines for use in FAP studies, and
2) to assess needs for training of GOB personnel in EIA methodology and propagate knowledge and experience on the subject.

(2) General Comments for Environmental Impact Assessment

The study commenced in May, 1991, and the guidelines for EIA was issued together with two volumes of EIA manual in May 1992. The guidelnes generally pointed out environmental impacts on FCD development as follows:

1) Major potential environmental impacts of structural flood control measures arise from the elimination of the natural patterns of flooding. Floodplains are generally productive environments because of flooding, which recharges soil moisture and replenishes soils with silt deposits. Elimination of flooding has the potential for impoverishing floodplain agriculture, wildlife and livestock population on the floodplain and revirine fisheries which are adapted to the natural flood cycles.

2) Embankment on one side of a channel may cause an increase in flooding on a non-embanked opposite side.

3) Dredging, smoothing the channel bed / walls, and straightening the channels by eliminating meanders, will increase the the volume of the channels and/or the velocity of flow, and help increase the rate at which water is passed through the system, thus preventing flooding.

4) Overflow basins may be artificially constructed in low-lying areas between river levees. On-site detention basins, or small impoundments used often near urban areas to intersect and collect runoff before it reaches the stream channel are effective in reducing peak flows.

5) Flood control structures may impart a false sense of security in that the risk of flooding is not eliminated but only diminished. This may encourage

development on the floodplain with disastrous results in the events of an unusual high floods or if control structures fail.

6) Flood protection measures potentially produce a large number of positive and negative impacts on social well-being, health and safety. A major concern is usually the unequal distribution of benefits and costs incurred for population affected by flood control measures. In cases where traditional uses of the floodplain for fisheries and/or agriculture dependent on the natural flooding cycles are disrupted by flood control measures designed to protect other communities, the rural dwellers frequently are not adequately compensated for the losses incurred.

CHAPTER V BASIC DEVELOPMENT CONCEPT

5.1 Current Situations and Constraints for Agricultural Development

The Kurigram South Unit is one of the poorest districts in Bangladesh, with an average per capita and per household income of Tk2,500 (US$64) and Tk14,400 (US$371) as of 1992, which is considerably lower than the national average. The total gross regional income is estimated at Tk1,850 million (US$48 million). Major source of income is crop production that accounts for 79% of the total. Other sources are business/services (18%), livestock (2%) and fisheries (1%). The economic performance of the Kurigram South Unit predominantly relies on agricultural production. Therefore, improvement of the agricultural production has been and will continuously be the key factor for the improvement of the rural economy and welfare of rural people in the Kurigram South Unit.

The Kurigram South Unit is densely populated. It has a gross area of 59,400 ha. The total population is estimated at 0.74 million as of 1992. The population density is 1,245 per km^2. Total number of households is about 130,000, of which the farm household relying agriculture accounts for 102,000 (78%). The total cultivated farmland is estimated at 42,800 ha (72%). The average farm size is 0.42 ha, which is very small compared to the national average of 0.81 ha. Other non-agricultural areas mainly comprise towns, villages, roads, settlements and water bodies. There is no large possibility to expand the farmland. Therefore, only the increase of cropping intensity and/or unit crop yields on the currently available farmland will lead to the increase of agricultural production as a whole, which will eventually accelerate the rural economy and improve the rural welfare.

The average cropping intensity is 190% at present with triple cropping area of 11%, double cropping of 69% and single cropping of 20%. The major constraints for increasing the cropping intensity are the risk of flooding during the monsoon season (including drainage congestion in low-lying areas) and lack of irrigation during the rabi season. The present cropping intensity varies place by place from 126% to 234%, depending upon the degree of flooding and availability of irrigation. Cropping intensity could therefore be much increased by improvement of drainage congestion and expansion of irrigation area.

There is also a high potential for increasing unit crop yield, because of the fertile alluvial soils, a climate that is suitable for year-round cropping, hardworking farmers, and unexploited water resources for irrigation. Unit yield of rice per ha varies from 1.25 tons/ha to 3.68 tons/ha at present, depending upon varieties used and availability of irrigation.

Local varieties are generally used either broadcasted or transplanted in the flood prone areas and/or poorly drained low-lying areas. More than 14,000 ha of paddy fields are still planted with local varieties, resulting in the low unit yield of rice. Drainage improvement will be the key factor to expand the areas to be planted with HYVs. Irrigation will also enhance the crop yields particularly in the rabi season.

The FCD/I development will be fundamental and essential requirement for improving the agricultural production in the Kurigram South Unit. Other development efforts such as agricultural research, extension, farm input supplies, rural credit, rural infrastructures will also be required for maximizing the benefits. These should also be executed in parallel with the FCD/I development.

5.2 Current Status and Achievement of FCD/I Development

The original feasibility study was carried out by WAPDA in 1969/71. Based on the original feasibility study, only flood control and drainage (FCD) components were constructed during 1973 - 1984, and most of the facilities were completed. Irrigation development plan was revised and updated in 1975 and again in 1982, but the irrigation component has not been implemented so far. The salient achievement of the Kurigram FCD project can be itemized as follows:

(1)	Construction of embankment	:	108 km
(2)	Regulators (Drainage Sluice)	:	11 nos.
(3)	Flushing sluices	:	5 nos.
(4)	Desilting works of drains	:	Very limited
(5)	Minor irrigation by STW & DTW	:	9,800 ha

The flood embankment of 108 km along river banks of three boundary rivers was already completed to protect the Kurigram South Unit of 59,400 ha. However, the entire length of the embankment was constructed with low quality and has been poorly maintained at present. There are a number of public cuts and breaches along the embankment, and left unrepair for long time, resulting the occasional flood inflow which induces serious damages to the crop production and other agricultural activities. The Study area has been threatened by flooding throughout the monsoon season every year. The rehabilitation and enforcement of the embankment are essential and urgent.

Desilting works of the existing drainage canals and construction of drainage sluices were also executed for ensuring the efficient drainage of the internal excess runoff caused

by rainfall. However, some of the sluices have been seriously damaged by recent flooding, and most of the drainage channels were heavily silted again due to habitual inundation in the embankment, resulting in lost of their function. Drainage congestion seems to be seriously caused in the lower part of the South Unit, resulting in frequent public cuts of the embankment thereabouts. Further improvement of the internal drainage networks would be essential as proposed in the previous feasibility studies.

The power pumping station and the Dharla barrage together with the main canal system were not constructed due to shortage of budget allocation and change of national water policies. However, minor irrigation schemes such as STWs, pipe sluices and LLPs have been rapidly expanded in the area, owing to the recent government policy on promotion of minor irrigation development. In spite of the rapid expansion of such minor irrigation schemes, the crop intensity during the rabi season still remains low. In parallel with the minor irrigation development by STWs and DTWs, a large scale but low cost irrigation systems which depend on the surface water resources, is definitely needed in view of the limited groundwater resources.

5.3 Basic Strategies and Possible Alternatives for FCD/I Development

5.3.1 Basic development strategies

The following basic strategies for FCD/I development in the Kurigram South Unit were proposed in keeping consistency with the government policies on water resources development and on-going FAP studies, and were mutually agreed between the Study Team and BWDB during the discussion held on March 10, 1992 (see Attachment-6):

Flood control component will be concentrated on the upgrading and rehabilitation works of the existing flood protection facilities, and will also include the bank protection works at the intake site. Drainage improvement will be made by gravity drainage system in principle. Drainage networks will be improved through desilting works of the existing channels and beels. With respect to drainage improvement in low-lying area, land use therein will be coped with fishery development program. Irrigation development will aim mainly to expand the rabi season cropping and also to stabilize the monsoon season cropping by supplemental irrigation water supplies. Irrigation development will be made through conjunctive use of both groundwater and surface water resources.

In formulating the FCD/I development plan, the following will be taken into account in view of the government policies and on-going FAp studies :

1) Man-power execution of most of civil works for creation of employment opportunities and ensuring the economic feasibility of the project,

2) More simple FCD/I system for future operation and maintenance by participation of local people,

3) Development oriented less negative impacts on environments and relevant sectors aspects,

4) Mitigation of social conflicts and tension for implementation,

5) Effort for reduction of land acquisition problems, and

6) Assurance of project benefits with full supports from the related agencies.

5.3.2 Selection of basic development plan

Based on the above basic strategies, the possible development alternatives for FCD/I components were identified and each of the alternatives was scrutinized during the Phase-I period. Details of the comparative studies on the possible alternatives were presented in the "Interim Report", and the study process and selected proposal were accepted by the BWDB through the discussion held on July 27, 1992 (see Attchment-7). The following is a conclusion of the comparative studies :

Flood control works:

No alternative study was made for flood control component. Only rehabilitation of the existing embankment of 108 km including repair works of public cuts and breaches, and bank protection works at the intake site were proposed.

Drainage improvement works:

Two alternatives, (i) drainage improvement by gravity for whole area and (ii) drainage improvement by gravity with mini-compartmentalization in low-lying area, were studied, and (ii) drainage improvement by gravity with mini-compartmentalization was recommended through comparative studies.

Irrigation development works:

There are nine (9) possible alternatives for irrigation development:

Alternatives	Northern Part	Southern Part
Alternative-1:	Pumping Plant	Barrage
Alternative-2:	Pumping Plant	Pumping Plant
Alternative-3:	Pumping Plant	Tubewell
Alternative-4:	Tubewell	Barrage
Alternative-5:	Tubewell	Tube well
Alternative-6:	Tubewell	Pumping Plant
Alternative-7:	Tubewell	Irrigation Sluice with LLP
Alternative-8:	Irrigation Sluice with LLP	Irrigation Sluice with LLP
Alternative-9:	Irrigation Sluice with LLP	Tube well

These alternative plans were preliminarily assessed on the basis of the previous studies and three (3) alternatives, Alternatives-4, -6, -9, were selected for comparative studies. The finally selected alternative was:

Alternative-9: Irrigation Sluice with LLPs and Tubewell
Large scale surface irrigation development with the Irrigation Sluice (free intake facilities with gates) with use of LLPs for pumping water from the improved drainage channels together with DTW development in the remaining part.

Comparative studies on irrigation development and drainage improvement are described in detail in Appendix-XI.

5.4 Public Consultation on the Proposed Development Concept

In order to reflect local needs and suggestions in the proposed development plans, public consultation survey was carried out, and the above development concept was discussed among the prospective beneficiaries.

As a result, the above concept agreed between BWDB and the JICA Study Team were likely to be supported by the respondents. Especially, the surface irrigation with use of LLPs was mostly appreciated by the respondents. Desilting works of the existing drainage channels as well as the improvement of the existing regulators were also basically welcomed. Rehabilitation of the existing embankment was also supported by the respondents as a whole, but it was denied by the landless groups because about 10% of them currently occupies the embankment as habitat.

(% to respective respondent)

Item (Total nos. of respondents)	Landless (115)	Small (103)	Medium (101)	Large (95)	Very Large (63)	Others (288)	Total (765)
1. Surface irrigation with LLPs	61	93	84	79	81	64	68
2. Drainage Improvement	46	61	75	84	65	49	59
3. Rehabilitation of Embankment	8	61	81	43	33	45	45

Note : Multiple answer

Detailed discussions on the basic development concept were taken place in the focus group discussions. The opinions and suggestions presented during the discussions at Thana level are given in Appendix-VII. The main suggestions are summarized as follows:

(1) Suggestions for Improvement of the Existing FCD Facilities

1) Desilting and re-excavation of the existing drainage channels and beels,
2) Construction of more drainage channels according to the requirement of the area,
3) Construction of linkage channels,
4) Use of pumps for draining out the stagnant water where necessary,
5) Increase of the number of regulators and number of vents in the existing regulators,
6) Proper and regular repair of the embankment and regulators,
7) Immediate and quick repair of the public cuts and breaches by BWDB,
8) Involvement of Union Parishad in maintenance of the embankment, and
9) Arrangement for organizing a committee consisting of BWDB and local authorities for proper maintenance of the facilities.

(2) Suggestions on the Proposed FCD/I Project

Flood Control :

1) Proper maintenance and immediate repairs of public cuts and breaches (rain cuts) are more essential than raising the height of the embankment;
2) Sandy soils should not be used for repairing the breaches;
3) River training work may be needed; and
4) Tree plantation on the embankment may hamper routine maintenance work.

Drainage Improvement :

1) The proposed desilting works of the existing drainage channels are appreciated very much. Local administration should be involved in these desilting works, because the channel beds are currently used for cropping and some social dispute is foreseeable;
2) Linkage channels will also be appreciated because water logging problem is serious in low-lying areas;
3) Rehabilitation of the existing regulators will be appreciated very much. The number of regulators and the number of vents should be increased, and
4) Chilmari and Ratnai regulators should be repaired with increased vents.

Irrigation Development

1) The surface water irrigation with use of LLPs is appreciated very much, because
   - the surface water is iron-free while the ground water is with high iron content;
   - surface irrigation water will be less costly than groundwater irrigation; and
   - groundwater level goes down during the dry season and water supply capacity of DTWs / STWs drastically becomes low;
2) Supply of spare parts for LLPs may be the problem. Credit facilities are also required for purchase of the spare parts;
3) The extraction of water from the Dhalra may cause the silting-up the river beds and dredging of the river may become essential;
4) Water reservoir should be considered within the whole command area for emergency supply of irrigation water;
5) Independent irrigation society may be formed with the water users. BWDB and DAE can take responsibility for forming such society with the help of Union Parishad;

6) Coordination between BWDB and other related agencies, i.e., DAE, DOF, BRDB and LGED, will be needed to support the farmers and the landless groups, but coordination at the national level is indispensable for the execution of proper coordination at the field level;
7) Coordination committee comprising BWDB / DAE / DOF / BRDB / LGED should be organized for proper implementation, operation and maintenance of the proposed FCD/I project. Beneficiary groups can be organized under the guidance of BRDB; and
8) Demonstration farm will be needed. Demonstration can be taken up to identify and define the pattern of the involvement and coordination among the concerned agencies.

(3) Mobilization of Local Resources for O&M of the Proposed Project

1) Most of the people lead their lives below poverty level. Therefore, voluntary labour does not work for implementation and maintenance; and
2) Beneficiaries can contribute some amount to build funds that can be used for operation and maintenance of the project components as an "Irrigation charges".

5.5 Proposed Components of the Project

Following the development concept and preliminary results of the public consultation survey mentioned above, the project components are proposed as follows:

(1) Flood control works:

1) Rehabilitation of the embankment of 108 km including repair works of public cuts and breaches.

(2) Drainage improvement works:

1) Consolidation of main drainage networks through desilting works of the existing drainage channels, beels and khals, coupled with new construction of linkage canals;

2) Channel diversion of the Ratnai river and re-construction of the Ratnai regulator;

3) Rehabilitation of Harichari regulator;

4) Improvement of the existing regulators with the increased number of vents as required; and

5) Desilting and development of beels and khals for both retention of excess water and pisciculture as required.

(3) Irrigation development works:

1) Construction of Irrigation Regulator at Bumka;

2) Construction of main irrigation canal system depending on surface water resources (use of the existing creeks as drainage as well as irrigation canal with modification will reduce land acquisition and provide a condition for irrigation development through farmer's initiative and participation in O&M);

3) Command area development with LLPs;

4) Groundwater development for irrigation by DTWs in the areas where surface irrigation can not benefit due to limited availability of surface water resources (with the provision of access to the credit); and

5) Establishment of demonstration farms.

(4) Rural Infrastructures Improvement:

1) Construction of bridges crossing the proposed irrigation / drainage canals.

(5) Non Structural Component:

1) Organization of O&M groups for the maintenance works of the project facilities such as embankment, regulators and drainage / irrigation canals;

2) Organization of farmer groups for operation and maintenance of LLPs; and

3) Promotion of agricultural support services particularly for Boro cultivation, fish culture and duck raising with full use of the increased availability of water.

CHAPTER VI FORMULATION OF DEVELOPMENT PLAN

6.1. Irrigation Development Plan

6.1.1 Proposed cropping pattern and rotation

The proposed cropping pattern is generally formulated to (1) increase the current cropping intensity, particularly in rabi season, (2) increase yield through introducing high yielding variety and (3) stable agricultural production through expansion of irrigated land utilizing both the surface water and groundwater resources. Crops are selected on the basis of the following considerations :

(1) Physical and climatic condition as well as present cropping pattern in the Study area,

(2) National Agricultural Development Policy given in the Fourth Five Year Plan : 1) attainment of self-sufficiency in food, particularly rice, 2) diversification of crops from rice cultivation in terms of improvement of people's nutritional level, and 3) limiting rice cultivation within the lands only available for rice and shifting lands to other crops depending on the suitability,

(3) Supply of materials for requirement of rural living life for local people,

(4) Contribution to the national economy and farm income,

(5) Full use of the effects of the agricultural supporting services projects now under implementation by the various organizations in the Study area.

Rice is selected as the main crop for all the land type and location, and HYV varieties is allocated as much as possible where the maximum potential yield can be attained. HYV Aman is the main crop in the rainy season in F0 land where no severe inundation affects the rice crop, and this crop saves irrigation water supply for rice cultivation by utilizing effective rainfall. Short term variety of HYV Aus is mainly placed before HYV Aman to increase rice cropping intensity. HYV Boro is cropped in F2 & F3 land in the dry rabi season, however, low temperature below 10°C in late December to early January permits transplanting seedlings from late January. Local variety of transplanted Aman (L. T. Aman) is limited to a part of F1 land where HYV Aman can not be planted.

Jute has important role to supply materials for housing and house keeping in rural living life inspite of low price in the market, and jute is planned to cultivate in the kharif season under rainfed condition through utilizing summer fallow land for irrigation crops. Dryland crops are concentrated in the rabi winter season with rotation of rice crops. The main rabi crops are wheat, oil seeds (mustard), pulses, potatoes, spices (onion) and vegetables. Those crops are cultivated after Aman rice and harvested before Boro or Aus

rice. Accordingly, average cropping intensity will be increased to 224% after implementation of the project. The proposed cropping pattern is illustrated in Fig. 6.1.1, and summarized below:

Land Type		Cropping Sequence
F0	Triple cropping	HYV Aus/Jute - HYV Aman - Rabi Crops
	Double cropping	HYV Boro - HYV Aman
		HYV Aus - Rabi Crops
F1	Double cropping	HYV Aus/Jute - Rabi Crops
	L. T. Aman - Rabi Crops	
F2 & F3	Double cropping	HYV Boro - Rabi Crops

6.1.2 Irrigation water requirement

(1) Reference crop evapotranspiration (ETo)

Reference Crop Evapotranspiration (ETo) is estimated according to "Modified Penman Method"which is recommended by FAO on the basis of the data at the Rangpur Climatological Station nearby the Study area. The following is a summary of estimated average monthly crop evapotranspiration in comparison with the recommended ETo in Rangpur by MPO in the National Water Plan. As given below, the difference between both estimates are negligible small, and the estimated Penman ETo therefore would be applied for calculation of irrigation water requirement hereinafter.

Month	ETo by Penman (mm)	ETo by MPO (mm)	Difference (mm)
January	2.53	2.32	0.21
February	3.48	3.32	0.16
March	5.08	4.36	0.72
April	5.71	5.65	0.06
May	5.18	5.43	-0.25
June	4.76	4.44	0.32
July	4.23	4.32	-0.09
August	4.53	4.16	0.37
September	3.98	4.10	-0.12
October	3.89	3.55	0.34
November	3.26	2.95	0.31
December	2.46	2.35	0.11
Annual ETo	1494	1428	66