THE PEOPLE'S REPUBLIC OF BANGLADESH

THE MASTER PLAN STUDY ON THE MODEL RURAL DEVELOPMENT PROJECT PHASE II FOR KACHUA, NABINAGAR, BANCHARAMPUR AND DEBIDWAR UPAZILAS

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DECEMBER 1991

JAPAN INTERNATIONAL COOPERATION AGENCY

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ABBREVIATIONS (1/2)

AUDP	Annual Upazila Development Programme
BADC	Bangladesh Agricultural Development Corporation
BARC	Bangladesh Agricultural Research Council
BARD	Bangladesh Academy for Rural Development
BARI	The Bangladesh Agricultural Research Institute
BAU	Bangladesh Agricultural University
BB	Bangladesh Bank
BBS	Bangladesh Bureau of Statistics
BKB	Bangladesh Krishi Bank
BPDB	Bangladesh Power Development Board
BRAC	Bangladesh Rural Advancement Committee
BRDB	Bangladesh Rural Development Board
BRRI	Bangladesh Rice Research Institute
BS	Block Supervisor
BSBL	Bangladesh Samabaya (Cooperative) Bank Ltd.
BSCIC	Bangladesh Small and Cottage Industries Corporation
BSS	Bhumiheen-Bityaheen Samabaya Samity
BWDB	Bangladesh Water Development Board
CERDI	Central Extension Resources Development Institute
DAE	Department of Agriculture Extension
DOC	Department of Cooperatives
DOF	Department of Fisheries
DPHE	Department of Public Health Engineering
DTW	Deep Tube-Well
FAO	Food and agricultural Organiation of the United Nations
FFW	Food-for-Work
FFYP	Fourth Five Year Plan
GDP	Gross Domestic Product
GNP	Gross National Product
GOB	Government of Bangladesh
HTW	Hand Tube-Well
HYV	High Yielding Varieties
IDP	Infrastructure Development Programme
IMP	Irrigation Management Programme
JICA	Japan International Cooperation Agency
JSARD	Joint Study on Agricultural and Rural Development
KSS	Krishak Samabaya Samity
LGEB	Local Government Engineering Bureau
LLP	Low-Lift Pump
MBSS	Mahila Bhumiheen-Bityaheen Samabaya Samity
MFL	Ministry of Fisheries and Livestock
MJSS	Fishermen Cooperative Society

ABBREVIATIONS (2/2)

MOA	Ministry of Agriculture
MRDPP	Model Rural Development Project Programme
MSS	Mahila Samabaya Samity
NCB	Nationalized Commercial Bank
NGO	Non-Governmental Organization
PBS	Pali Bidui Samittes
PLMCS	Primary Land Mortgage Cooperative Society
PSGCS	Primary Sugarcane Growers Society
RAKUB	Rajshahi Krishi Unnayan Bank
RDA	Rural Development Academy
RDTI	Rural Development Training Institute
REB	Rural Electrification Board
RHD	Roads and Highways Department
RMP	Road Maintenance Programme
RWSP	Rural Water Supply Programme
S/W	Scope of Work
SEBS	Socio-Economic Baseline Survey
SFFW	Special Food-for-Works
STW	Shallow Tube-Well
T & V	Training and Visit
TSS	Wavers Cooperative Society
UCCA	Upazila Central Cooperative Association
UCMDS	Union Cooperative Multipurpose Society
UEO	Upazila Extension Officer
UIC	Upazila Irrigation Committee
UIT	Upazila Irrigation Team
UNDP	The United Nations Development Programme
UNICEF	United Nations Children's Fund
UPU	Universal Postal Union
UTDC	Upazila Training and Development Center
VGF	Vulnerable Group Feeding Programme
WFP	World Food Program
WHO	World Health Organization

ABBREVIATIONS OF MEASUREMENTS

Length

mm	=	millimeter		
cm	=	centimeter		
	=	0.39 in.		
m	=	meter	=	1.09 yd
	=	3.28 ft.		
km	=	kilometre	=	0.62 ml
in.	=	inch	=	2.54 cm
ft.	=	foot	=	30.48 cm
yd.	=	yard	=	91.44 cm
ml.	=	mile	=	1.61 km

Area

cm^2	=	square centimeter		
m^2	=	square meter		
km^2	=	square kilometer		
	=	100 ha		
ha	=	hectare	=	0.01 km^2
	=	2.5 ac		
ac	=	acre	=	0.41 ha
	=	4,047 m^2		
ft^2	=	square feet		
	=	0.09 m^2		
$mile^2$	=	square mile	=	2.59 km^2

Electrical Measures

kW	=	kilowatt	=	1,000 watt
MW	=	megawatt	=	1,000 KW
GW	=	gigawatt	=	1,000 MW
kV	=	kilovolt	=	1,000 volt

Other Measures

%	=	percent
°	=	degree
'	=	minute
"	=	second
°C	=	degree in Celsius
lakh	=	10^5
crore	=	10^7
Hp, PS	=	horse power
TPH	=	ton per hour

Volume

lit.	=	litter		
cm^3	=	cubic centimeter		
m^3	=	cubic meter		
	=	1,000 lit.		
MCM	=	million m^3		
	=	$1x10^3$ m^3		
ft^3	=	cubic feet	=	0.028 m^3
	=	28.32 lit.		
ac-in.	=	acre inch	=	102.79m^3
ac-ft.	=	acre feet	=	1,234 m^3

Weight

g	=	gram			
kg	=	kilogram			
t	=	metric ton	=	1,000	kg
lb	=	pound	=	454	g
cavan	=	sack (bag)			
		paddy	=	50	kg/sack
		paddy seed	=	45	kg/sack
		corn seed	=	50	kg/sack
		pod peanut seed	=	25	kg/sack

Time

sec	=	second		
min	=	minute	=	60 seconds
hr	=	hour	=	60 minutes
	=	3,600 seconds		
day	=	24 hrs	=	1,440 minutes
	=	86,400 seconds		
yr	=	year		

Derived Measures

m^3/sec	=	cubic meter per second (Cumec)
ft^3/sec	=	cubic foot per second (Cusec)

Monetary

US$	=	US dollar
¥	=	Japanese yen
TK	=	Bangradesh Taka

ANNEX F
IRRIGATION, DRAINAGE AND MINOR FLOOD CONTROL

ANNEX F IRRIGATION, DRAINAGE AND MINOR FLOOD CONTROL

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1. NATURAL CONDITION

1.1 Study Area and Topography

The study area consisting of four (4) Upazilas of Old Comilla District is situated on the left bank of Gumti river, i.e. branch of Meghna river. The total extent of the study area is 1.017 km^2 comprising Bancharampur (207 km^2), Nabinagar (335 km^2), Katchua 236 km^2) and Debidwar (239 km^2). According to the recently reorganized administrative structure of local governments, Kachua Upazila falls in Chandpur District, Nabinagar and Bancharampur in Brahmanbaria, and Debidwar in Comilla.

Nabinagar and Bancharampur is located on the right bank of Meghna river between Latitude 23°50' N and 23°45' N Longitude 19°00' E and 90°40' E, Debidwar and Katchua lies between Latitude 23°45' N and 23°20' N Longitude 91°00' E and 90°40'E.

The Old Comilla District including the study area is in the shape of slope down gradually from the foot to Tripura Hills (India) toward the west. The slope is so gradual that it does not create any radial change on the continues flat surface of the land. The study area is prone to shallow to deep flooding during the monsoon season by the Meghna, Titas, Gumti, Dhanagoda and Dakatia rivers.

Relationship between acreage and ground elevation in the study area is shown in the following table.

Bancharampur			Nabinagar			Kachua			Debidwar		
Ground (m in PWD)	Area	Accumu-lation	Ground (m in PWD)	Area	Accumu-lation	Ground (m in PWD)	Area	Accumu-lation	Ground (m in PWD)	Area	Accumu-lation
m	ha	ha	m	ha	ha	m	ha	ha	m	ha	ha
0 ~ 1.5	1,200 (6)	1,200 (6)	0 ~ 1.5	2,200 (7)	2,2000.5 (7)	~ 2.4	400 (2)	400 (2)	1.0 ~ 3.2	200 (1)	200 (1)
1.5 ~ 2.1	800 (4)	2,0001.5 (10)	~ 2.1	3,400 (10)	5,6002.4 (17)	~ 3.0	3,600 (15)	4,0003.2 (17)	~ 3.7	1,200 (5)	1,400 (6)
21. ~ 3.0	6,300 (30)	8,3002.1 (40)	~ 3.0	7,600 (22)	13,200 (39)	3.0 ~ 3.7	9,200 (39)	13,200 (56)	3.7 ~ 4.6	8,900 (37)	10,300 (43)
3.0 ~ 4.0	6,800 (33)	15,100 (73)	3.0 ~ 4.0	8,800 (27)	22,000 (66)	3.7 ~ 4.6	5,800 (25)	19,000 (81)	4.6 ~ 6.1	13,600 (57)	23,900 (100)
4.0 ~ 4.6	3,600 (17)	18,700 (90)	4.0 ~ 4.6	5,400 (16)	27,400 (82)	.6 ~ 5.5	4,600 (19)	23,600 (100)			
4.6 ~ 5.5	2,000 (10)	20,700 (100)	4.6 ~ 6.5	6,100 (18)	33,500 (100)						

Note: Perenthesized figures indicate the percentage.
Source : Computed from the counter Map (S = 1/15,840)

1.2 Meteorology

1.2.1 General

Bangladesh has a typically tropical climate with cleared seasonal pattern. The seasonal pattern are classified with three main seasons, as (1) a hot summer season with high humidity from March to June, (2) a hot and humid monsoon season with heavy rainfall from June to October, and (3) a relatively cooler and drier winter season from November to March. Maximum temperatures range between 20~40°C with the highest temperatures experienced during the pre-monsoon period March to May and minimum temperature just above 0°C. Rainfall in Bangladesh varies widely, not only from season to season, but also from one region to another and the average rainfall ranges from 1,500 mm to 3,500 mm.

1.2.2 Meteorological Features

The climate in the project area are :

(1) Temperature

Maximum temperatures vary from about 23°C to 33°C with highest temperatures experienced during March to May and minimum temperatures range between about 10~15°C during the dry season in winter period December to January.

(2) Humidity

The humidity is high through the year with average humidity varying from 70 percent to 88 percent. The humidity is highest during the monsoon period June to September.

(3) Evaporation and Evaportranspiration

Maximum evaporation of average monthly ranges between 3.6~3.9 mm with the pre-monsoon period and minimum evaporation 1.7~2.4 mm with the dry season period.

Potential evaportranspiration rates reflect the seasonal pattern with the highest rates of up to 6.1 mm/day during the pre-monsoon months April to May. The lowest rates estimated as 3.3 mm/day occur during the winter months December and January.

(4) Wind Speed

Wind speeds are relatively low except during the pre-monsoon and monsoon periods when the average speed of monthly are 2~4 m/sec.

(5) Sunshine

The Sunshine of average monthly ranges between 4.3~7.6 hr/day during the monsoon period and 7.8~9.2 hr/day during the other months.

The summary data of above mentioned is shown in the following table and the detail data of Table. F.1.3 ~ 1.6.

(Station : Comilla)

Items \ Month		Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Remarks
Temperature (oC)	Max	25.7	28.0	31.4	32.0	32.4	31.4	30.7	31.1	31.6	31.3	29.7	26.6	Mean 30.1
	Min	12.5	15.1	19.9	23.1	24.4	25.5	25.6	25.5	25.4	23.6	19.2	13.8	Mean 21.1
Humidity (%)		73	70	73	79	81	85	87	86	85	82	78	74	Mean 79
Evaporation (mm)	Monthly	53	67	117	116	109	82	77	85	84	75	65	51	
	Daily	1.7	2.4	3.8	3.9	3.6	2.8	2.5	2.8	2.8	2.4	2.2	1.7	
Wind Sped (Knots)		4	4	5	7	6	6	6	6	5	4	4	4	Mean 5 knots (2.6 m/sec)
Sunshine (hr/day)		9.2	8.6	8.6	7.6	8.4	6.2	4.3	6.7	5.8	7.6	7.8	8.2	
Potential Evapotranspiration (mm/day)		3.4	4.3	5.5	5.9	6.1	5.1	4.5	5.0	4.4	4.5	3.7	3.3	

1.2.3 Rainfall

Annual rainfall is fairly uniform over the project area ranging from about 2.100 mm to 3,200 mm. The rainfall occurs a typical seasonal pattern with up to two-thirds of the annual total experienced during the monsoon period June to September. The period from December to March is significantly dry with less than 5 percent of the annual total. The seasonal rainfall distribution is clearly illustrated in the following table.

Rainfall Seasons

Season	Period	% of Annual Rainfall	Rainfall (mm)
Pre-monsoon	April ~ May	22	460~700
Monsoon	June~September	66	1,390~2,110
Post-monsoon	October~November	9	190~290
Dry	December~March	3	60~100

The maximum ten days rainfall of recurrence frequency during the pre-monsoon and post-monsoon seasons are shown in the following tables.

Ten Days Rainfall

(1) Pre-Monsoon Period

Unit : mm

Station Name	Probable	Jan			Feb			Mar			Apr			May		
		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Comilla (356) Date:1961-86	1/2	3	1	2	8	4	5	7	11	20	39	78	58	97	107	108
	1/5	9	2	7	19	9	18	17	24	40	81	166	97	161	206	176
Nabinagar (367) Date:1961-85	1/2	6	0	2	5	3	5	9	15	18	36	77	52	110	97	99
	1/5	21	1	5	13	7	17	20	32	41	84	144	89	178	159	170

(2) Post -Monsoon Period

Unit : mm

Station Name	Probable	Oct			Nov			Dec		
		1	2	3	1	2	3	1	2	3
Comilla (356)	1/2	85	39	42	19	14	6	6	5	1
Date : 1961-86	1/5	140	80	97	48	39	16	24	20	4
Nabinagar (367)	1/2	72	40	28	10	5	7	7	2	1
Date : 1961-85	1/5	123	92	63	26	16	36	28	9	3

The annual rainfall, the maximum two-days and ten-days rainfall are shown in the Table. F 1.5 ~ 1.6.

1.3 Hydrology

1.3.1 River System in the Study Area

Bangladesh lies across the delta of four major rivers, Ganges-Padma, the Brahmaputra-Jamuna, the Meghna and Teesta. These rivers and their distributaries discharge about 140,000 m^3/sec into the Bay of Bengal at peak periods. Total inflow to Bangladesh from India is approximately 90 percent of total available streamflow in the country. The Meghna river lies on the western border of the Study Area and is formed by the confluence of Surma and Kushiyara river, both of which have similar orgins. The annual average discharge is about 3,500 m^3/sec, about the same as that of the Nile.

The other river in the Study Area is Gumti and Titas rivers which raise in India. The characteristics of the river flows and water levels closely reflect the rainfall pattern, and are tidal, although the tidal range is not significant during the period. The Meghna and Titas river water levels rise steadily during the monsoon period to peak about the beginning of August with a post monsoon recession from October. The Gumti River peaks earlier, during mid to late July.

1.3.2 Water Level and Discharge

The water level and discharge measuring stations on the Meghna, Titas, Gumti and Dakatia rivers are particularly important in connection with the irrigation and drainage studies. The available station in order from the most upstream station in each river are given in below Table and their relative locations is shown in Figure. F.1.1.

Stations on Meghna, Titas, Gumti and Dakatia Rivers

River	Station No.	Name	Data
Meghna	273	Bhairab Bazar	Q, H
	274	Narsingdi	H
	275	Badyer Bazar	"
	115	Daudkandi	"
	277	Chandpur	"
Titas	298	Nabinagar	H
Gumti	110	Comilla	Q, H
	113	Kongsanagar	H
	114	Jibanpur	Q, H
Dhanagoda	79	Matlab Bazar	H
Dakatia	58	Haziganj	H

Q : Discharge (m^3/sec)

H : Water Level (m in PWD)

The arrangement and analysis of the hydrological data base are carried out due to the irrigation and drainage plan.

These analysis results are the following Table

(1) Flood Peak Freak Frequency

Station Name	River	Drainage Area	Flood Peak (m^3/sec) 5 Year	20 Year	Highest Peak
273. Bhairab Bazar	Meghna	80.200 Km2	14,500	18,000	19,800 (11.7.1988)
110 Comilla	Gumti	2,210	570	690	1,160 (6.8.1983)

(2) Maximum One-Day Average Flood level of Selected Recurrence Intervals.

Station		River	Flood Level (m in PWD) 5 Year	10 Year	20 Year	50 Year	Highest Level
298	Nabinagar	Titas	6.63	6.87	7.09	7.36	7.34 (10.9.1988)
275	Baidyer Bazar	Meghna	5.65	5.82	5.98	6.16	6.98 (4.9.1988)
115	Daudkandi	Gumti	5.61	5.79	5.94	6.14	6.27 (3.9 1988)
79	Matlab Bazar	Dhana-goda	5.33	5.47	5.60	5.76	-
277	Chandpur	Meghna	4.96	5.08	5.18	5.31	5.16 (29.8.1988)
58	Hajiganj	Dakatia	4.85	5.03	5.21	5.44	5.22 (9.9.1988)

(3) Minimum Discharge Frequency (Ten Daily Average)

Unit : m^3/sec

Station Name		Discharge Frequency	Feb (1~10)	Feb (11~20)	Feb (21~28)	Mar (1~10)	Mar (11~20)	Mar (21~31)	Remarks
273	Bhairab Bazar (Meghna)	Max.	474	478	523	576	501	816	Period of Record Use: 1970~1989 NA=1977~1984
		Mean	260	230	253	287	307	394	
		Min	64	47	42	63	207	211	
		5 Year	125	98	102	147	228	255	
110	Comilla (Gumti)	Max	36	35	36	32	34	97	Period of Record Use: 1970~1990
		Mean	21	20	19	19	18	23	
		Min	7	6	6	6	5	5	
		5 Year	15	12	12	12	10	10	
114	Jibanpur (Gumti Bridge Point)	Max	31	28	28	33	49	79	Period of Record Use: 1970~1990
		Mean	18	16	16	17	17	19	
		Min	5	4	4	4	4	3	
		5 Year	10	10	9	9	7	7	

(4) Minimum Water Level (Dry Season)

Unit: m in PWD

Station No.	Station Name	W.L.	Jan. H.W.L	Jan. L.W.L	Feb. H.W.L.	Feb. L.W.L	Mar. H.W.L.	Mar. L.W.L	Remarks
298	Nabinagar (Titas)	Max	1.94	1.18	1.93	1.10	2.50	1.60	Period of Record Use: 1977~1990
		Min	1.70	0.96	1.60	0.70	2.12	1.08	
79	Matlab Bazar (Dhanagada)	Max	2.56	1.05	2.33	1.00	2.54	0.97	1978~1990
		Min	2.00	0.73	1.95	0.38	2.23	0.58	NA=1979~1982
58	Hajiganj (Dakatia)	Max	2.07	1.16	1.92	0.87	2.37	0.98	1970~1990
		Min	1.58	0.66	1.52	0.61	1.65	0.43	NA=1981~1983

No.	Station Name		Jan	Feb	Mar	Apr	Remarks
114	Jibanpur (Gumti Bridge)	Max	5.21	5.15	6.77	6.99	1978~1990
		Min	3.64	3.55	3.51	3.41	NA=1980, 1981

(5) Tidal Influence in the Meghna and Titas (Approximately)

Station Name	Dry Season (Feb ~ Mar)	m	Monsoon Season (Aug ~ Sep)	m
Nabinagar (298)	H.W.L. =	1.3 ~ 1.5	H.W.L.=	6.0 ~ 6.5
	L.W.L. =	1.1 ~ 1.3	L.W.L.=	5.99 ~ 6.47
	Range =	0.2 ~ 0.3	Range =	0.01 ~ 0.03
Matlab Bazar (78)	H.W.L. =	1.0 ~ 2.5	H.W.L.=	4.5 ~ 5.4
	L.W.L. =	0.6 ~ 1.5	L.W.L.=	4.4 ~ 5.0
	Range =	0.4 ~ 1.0	Range =	0.1 ~ 0.4
Hajiganj (58)	H.W.L. =	1.3 ~ 1.5	H.W.L.=	4.6 ~ 5.3
	L.W.L. =	1.1 ~ 1.3	L.W.L.=	4.6 ~ 5.2
	Range =	0.2 ~ 0.3	Range =	0.0 ~ 0.10

(6) Longitudinal Profile of Meghna, Titas and Dakatia Rivers Flood Peaks and Low Flow Periods (Approximately)

Section	Distance	H.W.L. (Sep)	L.W.L. (Feb)	Slope of H.W.L.	Slope of L.W.L.
	Km	m	m		
Nabinagar		7.34	0.70		
|	60			I=1/56,000	I=1/158,000
Daudkandi		6.27	0.32		
Daudkandi		6.27	0.32		
|	45			I=1/42,000	Level
Chandpur		5.20	0.35		
Dakatia		5.30	0.60		
|	30			I=1/500,000	I=1/120,000
Chandpur		5.24	0.35		

The detail data are shown in Table. F.1.7~1.10 and Figure. F 1.2.

1.4 Geology

The floodplain, the essential product of stream deposition, covers the largest area of Bangladesh. An alluvial plains of Quaternary Sediments laid down by the Ganges, Brahmaputra, Meghna and other streams. However, the recent deposits of Bangladesh, which are in general characterized by typically dark, loose compacted materials with a high water content and with variable but considerable quantities of organic materials, are composed of the combined deltaic masses and flood plains of Ganges, Brahmaputra and Meghna rivers.

Late Pleistocence to early recent sediments occupy slightly more elevated land in the central and eastern parts of the Old Comilla district. Older Pleistocence alluvial deposits fringe the extreme eastern parts adjacent to the Indian border.

The formation of younger alluvial deposit consists of clay, silt, fine sand/medium sand etc. The main streams which were usually active for the deposit of the sediments in the study area are the Meghna, Gumti, Titas, Danagoda, Dakatia rivers. The upper part of the area generally consists of clay, silt and very fine sand with low to very low permeability. The main aquifer is interbeded by a layer of clay, silt sand and medium coarse sand materials.

1.5 Groundwater

1.5.1 General

Groundwater is an important resource of Bangladesh and extensively used for both domestic and agricultural water needs. There is a fairly extensive aquifer at a very shallow depth of 6~12m below ground level which is generally drawn by the hand tubewells of ø 40 mm dia with a hand operated pump and the water is used for domestic as well as agricultural purposes. A deeper aquifer at about 60-~120 m depth has also been identified in large parts of the country, particularly the north, east and western regions.

Those tubewells are used to irrigated about 20~24 ha (50~60 acre) of land each, particularly during the dry winter season which allows an extra crop of high yielding rice or wheat to be grown. Over the past 20 years, many shallow tubewells and deep tubewells has been widely sunk all over the country. Although the groundwater aquifer is substantial there are concerns that limit of exploitation of the groundwater reserves may be approaching soon.

At present about 80 percent in the Study Area is cultivated, but agricultural productivity is constrained by flooding in the monsoon season, and shortage of irrigation in the dry season.

1.5.2 Ground Water Recharge

Recharge to ground water aquifer reservoir in the study area occurs mainly by percolation of rain water and influence of river stages. Actually groundwater recharge of the Old Comilla District various 121 mm to 191 mm from south-western part to south-eastern part and on the north-eastern part to western part actual recharge varies 96 mm to 160 mm. Available recharge is measured on the basis of 60% of the potential recharge.

With the beginning of the monsoon season, groundwater levels are rapidly restored to full field capacity. Vertical transfer of water due to monsoon season infiltration and dry season capillary rise dominate the groundwater flow system.

The ground water table starts rising from May to July and after attaining the maximum level it starts declining from October and continues upto April.

1.5.3 Ground Water Quality

Ground water quality of an area is mainly dependent on condition of deposit of sediments and geologic condition rather than depth of water bearing strata. Ground water qualities were analysed on the basis of three major components consisting of Iron, Chloride and Total Dissolved Solids (TDS).

The surface water salinity at lower Meghna (at Chandpur) tends to increase salinity (250 - 260 ppm) during February and March whereas at the advent of monsoon the salinity decreases (160 - 180 ppm) due to flushing of rain water.

Large Scale tubewell irrigation could not gain momentum due to higher chloride content upto the economic depth etc.

Small tubewells of BADC became abandoned in Barura, Kachua and Saharasti Upazilas because of higher chloride contents. The reasons for well failure are mostly in lack of proper maintenance, improper use of materials improper designing or sinking of wells.

Ground water quality data indicate a generally low total dissolved solids which is good quality for irrigation water. The data indicate slightly elevated salinity in the deep qualifier, and at shallow depth near the Meghna river towards the end of the dry season.

Ground water development zone, characteristic, potential and chemical concentration are shown in Figure. F.1.3~1.6 and Table. F 1.11 ~1.12.

(Source : Hydrogeological Map of Greater Comilla District - BWDB Water Supply Paper 489, groundwater Circle II June 1987).

2. IRRIGATION AND DRAINAGE CONDITION

2.1 Irrigation Condition

2.1.1 Background of Minor Irrigation System

Mechanized minor irrigation practices in Bangladesh had been progressed already in about 30 years old started with DTW, STW, LLP and HTW.

Thana Irrigation Programme (TIP) were executed in 1986 by BADC, and then Comilla District Integrated Rural Development Board (CDIRDP) now BRDB under Ministry of Local Government, Rural Development and Co-operatives and the Department of Agricultural Extension (DAE) under Ministry of Agriculture. The Programme was launched nationwide to create momentum to expand minor irrigation through the use of DTW and LLP. BADC having control over tubewell and LLP distribution, was assigned the responsibility for installation and commissioning of equipment. Integrated Rural Development Programme (IRDP) for organizing farm groups and DAE to provide extension services in irrigation and on farm water management.

In the mid 1970's STW were included in the minor irrigation sector and spread very rapidly among the farmers because of their favourable cost, low capacity (14 to 201/s), command area (4.6 ha), and case of installation and maintenance.

The Bangladesh Medium Term Food Production Plan (MTFPP) set a goal to attain food self sufficiency by 1985 through increasing land irrigated by the mechanized minor irrigation divices from a 1979/80 level of 0.96 million hectares to 1.5 million hectares by 1984/85 and increased 2.5 million hectares in 1989/90.

The plan involved a significant increase in the number of tubewells and LLP in use in the country, but the food self-sufficiency could not attain in the end. (Table. F.2.1 and 2.3)

Until 1983, BADC had a virtual monopoly over procurement and distribution of agro-chemicals, certified seeds and minor irrigation equipment. In recent years, progressively larger parts of the trade in these commodities have been taken over by the private sector. The corporation continues, however, to retain monopoly control over the supply of DTW equipment DTW remain in public ownership by BADC for rental to farmer groups. But it is now government policy that they should be sold off to the private sector.

The end of dry season groundwater supply is becoming increase due to decline water level. The facilities will be offered to investors throughout the country where aquifer conditions are suitable and water quality is not a constraint. Therefore the coastal zone (beginning the Chandpur district and a part of Comilla district gradually) will be excluded for water quality limitations.

Form the consideration of the based on the concept of potential recharge and groundwater quality, the surface Water Development would be utilized for providing irrigation facilities to minor schemes, mainly through low lift pump (single lift system) and low lift pump pass through the primary supplies from a larger river / stream using pontoon mounted pumps (double lift system). The minor irrigation system's prevailing situation of Comilla, Chandpur and Brahmanbaria Districts are shown in Table. F 2.2 and 2.4.

2.1.2 Study Area

(1) Irrigated Area

Irrigated area in the whole agricultural land is now about 38 percents with almost the same level of 4 Upazila.

Command area in the area that can be irrigated by an irrigation unit. normally this is determined by the irrigation water requirement in a critical period expressed in hectare per unit discharge. However, under the existing condition of Bangladesh the command area is influenced by other physical, social and economic constraints. Command area per unit pump equipments are varied with DTW of 50 - 80 acre (20 - 32 ha), STW of 12 - 16 acre (5 - 6 ha) and LLP of 30 - 40 acre (11 - 16 ha). (Table. F.2.5 - 2.7).(Figure. F.2.1)

(a) Spacing and Interferences of DTW.

With increase demand on tube-wells BADC, the agency responsible for installation and commissioning of DTW made a condition of at least 1,500 feet (450 m) and now it is 2,500 feet (760 m) between two DTWs. The 2,500 feet (760 m) spacing meant that a DTW must have at least 57 ha (760 m x 760 m) of area under its command actual command area of excluding home steads, canals roads and water body, etc must have about 46 ha due to supply of effective DTWs development. Considering 70% efficiency of the irrigation system and 18 - 20 hours per day a 2 cfs (571/s) DTW might cover a maximum area of 100 acre (40 ha.)

(b) Basic Standard of Pump

- DTW
. Planed Discharge Q = 2 cfs = 57 l/s
. Served Area A = 60 acre (24 ha)
. Well Dia = ø 350 mm
. Turbine Pump : ø 150 - 200 mm, 25 HP (17.5 - 22.5 KW)

- STW
. Planed Discharge Q = 0.5 - 0.75 cfs = 14 ~ 21 l/s
. Served Area A = 12 acre (5 ha)
. Centrifugal Pump : ø 75 - ø 100 mm, 5HP (5.5 - 7.5 KW)

- LLP
. Planed Discharge Q = 1 or 2 cfs = 28 l/s or 57 l/s
. Served Area A = 20 acre (8 ha) or 40 acre (16 ha)
. Centrifugal Pump : ø 150 - ø 200 mm, 15 HP (11.5 KW - 15 KW)

- The DTWs were financed under the Rural Works Programme. An average command area of 60 acre (24 ha) per DTW (57 l/s) has been adopted in the National Water Plan (NWP) as representing existing conditions. DTW is sold to the group/society farmers at a subsidized rate Tk 175,000. (About 70% subsidy rate of total construction cost).

- The STW programme was introduced by the BADC during the 1971 - 72. The BADC sells STWs to the farmers at a price fixed by the Government. Since 1974, the Bangladesh Krishi Bank (BKB) has been providing loan for the purchase of STW by the farmers. Individual farmers or the groups of farmers can purchase STW and LLP unit either on cash payment or through bank loans.

- The LLP extract directly surface water for irrigation from rivers, khals and beels. With major irrigation project (BWDB), LLPs use as secondary lifting pumps.

(2) Farmers Distribution and Water Charge

Table. F.2.8 give information on the number of farmers and area served per well , by type of pump. There had been some difference in coverage under the each pump types.

Irrigation water charge is different area. The reason are:

- Land type (high land, medium high land and low land)
- Soil texture (porous and no porous soil condition)

Diesel operated wells are costlier than electrically operated ones. (fuel cost, electricity cost and different durable life old diesel pump and motor pump)

The water charge included as below items:

- Interest on capital required for installation of pumps construction of pucca distribution channel.

- Operating cost (including cost of maintenance, fuel oil/electricity salary of operator)

- Management cost (salary of persons engaged for distribution of water, construction and maintenance of field channels)

- Over head and some rebate charge

- Depreciation cost.

The water charge is decided depending upon the marketing price's basis. According to the consideration of the experience, the life of diesel engines averaged about 7 years and life of motor average more than 15 years. The life of a pump unit used in surface water lifting is more susceptible to damage as compared to those used in tubewell. The construction cost and water charge by using various types of pump equipment are shown in Table. F.2.9 - 2.10.

(3) Problem Points

The problem points of Minor Irrigation Systems are summarized below:

- Limited daily working hour

  Spare parts and mechanical services are not always available farmers are hesitant to pump long hours in order to increase the area under irrigation by serving others farmers (especially DTW for high cost of spare parts and operation)

- Lack of the technical assistance

  The potential command area is never defined in quantity or location. The command area maps and design of distributing network systems are not available. The design should be utilized by using the existing contour maps. The channel's network, water control and outlet structure, farmers in the far reaches of the boundary are not encouraged even to try to expand the system to their plot of land.

- Lack of proper organizational management.

  The leadership of pump groups is generally regarded as a social services to the community, little incentive exists to expand the command area beyond a certain size since the status of the leader does not increase proportionately.

- Inefficient method of distribution

  The pumping equipment is owned by the private and group farmers who have adopted some type of co-operative arrangement for full purchase and transport, field channel excavation, operation and maintenance of the distribution system.

  The pump discharge into a network of channels that are divided until the stream sizes are a fraction of the pump discharge, each farmer simultaneously trying to receive water in spite of supplying water of the location irrigation system.

From the above mentioned points, IMP (Irrigation Management Programme) must be strengthened to prevail the better irrigation management by assistance, training and co-operation system of farmer groups.

2.2 Drainage Condition

2.2.1 Relationship between Flood Water Level and Inundation Area in the Study Area

The macro-zoning of inundation conditions are important to assess the rational land use of the study area. However, the current land use is more governed by the micro-limnological and micro-topographic conditions. Therefore it is not appropriate to adopt the cropping systems according to the above-mentioned land type classification without assessment of micro-limnological and micro-topographic conditions. In fact, by selecting crops as well as crop varieties, local farmers have adopted their cropping patterns and farming practices for their individual farmlands and overcome indigenous unfavorable conditions, i.e. poor drainage and recurrent floods. The JSARD also identified in its study area, i.e. eight (8) villages nation widely selected, as a general feature, that the prevailing cropping patterns are highly location specific governed by micro-topography and hydrological conditions. The JSARD emphasized the extreme importance of crop research and extension directed problem-oriented on the basis of land type classification at village level for selection of cropping patterns and farming practices.

In order support the farmers' efforts, Bangladesh Rice Research Institute (BRRI) has set up its research strategy on problem-oriented basis. To achieve increased rice productivity, BRRI identifies major regional, physical and technical problems to develop more site-specific technologies. In its long-term strategy, BRRI is to develop varieties with faster seedling growth and taller plant height to compete uncontrolled water conditions. Agronomic approach, e.g. shifting and shortening of cropping periods, will be more important for mitigation of drainage and flood problems by selection.

To avoid the serious damage by earlier and deep flooding as well as pest and disease infestation, farmers should have wide range of rice varieties including modern and local ones in terms of tolerance to flood depth, growing period and photoperiod-sensitivity. This enables farmers to appropriate variety selection based on location-specific adoption.

The following table shows the land types and their extent on the basis of inundation depth in the study area by the Counter Map (S=1/15,840).

Inundation Condition in the Study Area

Inundation Depth (m)	Bancharampur			Nabinagar			Debidwar			Kachua		
	Area	%	Duration	Area	%	Duration	Area	%	Duration	Area	%	Duration
	ha		month	ha		month	ha		month	ha		month
Fo (<0.3)	0	0	-	600	2	0 ~ 1.2	9600	49	0 ~ 1.3	3300	17	0 ~ 2.0
F1 (0.3 ~ 0.9)	500	3	1.2 ~ 3.6	1400	5	1.2 ~ 3.8	4800	24	1.3 ~ 2.3	2800	15	2.0 ~ 4.0
F2 (0.9 ~ 1.80	2800	15	3.6 ~ 5.0	3000	11	3.8 ~ 4.8	5200	27	2.3 ~ 3.4	9700	51	4.0 ~ 5.7
F3 (1.8 ~ 3.0)	8000	43	5.0 ~ 6.7	9600	35	4.8 ~ 6.8	0	0	-	3300	17	5.7 ~ 7.5
F4 (3.0<)	7200	39	6.7~	12800	47	6.8~	0	0	-	0	0	-
Total (Net Cultivated Area)	ha 18500	% 100		ha 27400	% 100		ha 19600	% 100		ha 19100	% 100	

The drainage problems are often focused in connection with road construction in the study area. As a result of blockade of water channels by new road construction, drainage conditions are often worsened. The road construction should be planned taking simple but well-functioning drainage structures into consideration. Actually, no particular measures are applied for improvement of poor drainage and flood damage in the study area.

The flood control measures are often planned in combination with major irrigation development. In the Chandpur irrigation scheme, for instance, the large-scale polder was constructed for protecting a gross area of 53,000 ha empoldered by the dykes of 100 km long. They are largely improving drainage conditions and controlling frequent floods in the area.

Relationship between acreage and ground elevation in the study area are shown in Figure. F.2.2 and Table. F.2.11.

2.2.2 Flood Control, Drainage and Irrigation Plan in the Study Area (Gumti Phase II Sub-Project under BWDB)

(1) Introduction

The Gumti Phase II Sub-Project Feasibility Study commenced on 1st January 1988. Originally scheduled to take two years, the study period has been extended to 31st March 1990 to allow the team to study the additional work necessary to extend the irrigation supply to the Gumti Phase I area.

The Terms of Reference for this study list the primary objectives as :

(a) reduction in crop losses due to flooding and impeded drainage;

(b) increase in the area of transplanted rice cultivation in the aman season, the reduction of the area under broadcast deep water rice as a result of reduced inundation, and, by supplementary irrigation and improved water management, increasing the aman yields;

(c) increase in the area of boro and rabi cultivation as a result of improved irrigation facilities;

(d) expansion of the area under improved rice (and wheat) varieties following the control of flood and improved water management;

(e) the development of fisheries; and

(f) improvement of agricultural, institutional and physical infrastructure, such as access roads, navigational facilities, etc. necessary to materialise the above objectives.

While improvement to the aus rice crop is not specifically mentioned in the above list of objectives, it can be implied from (a) and (d) above.

(2) Development Proposal

(a) Flood Control

Flood control works will consists the main perimeter embankment, the Salda-Buri river double embankment, the Guhunger and Bijni river left embankments and a total of 13 drainage regulator (for drainage and irrigation purpose). The embankment elevations are designed on the basis of the 1:20 year peak flood levels.

(b) Drainage

The area is divided into three main polders :

Drainage Block	Area (Gross)	Remarks
South and West	103,019 ha	
North Buri Nadi	24,082 ha	
Bijni	10,529 ha	
Total	137,630 ha	

(c) Irrigation

Irrigation supplies are provided by 4 Main Pumping Stations and 5 Re-lifting pumping stations.

- Irrigation Pumping Capacity = 104.5 m3/sec
- Irrigated Area = 97,100 ha
- Tubewell Area = 10,000 ha
- Total Area = 107,000 ha

Main Pump Station (Reversible)						Relift Pump Station (Revisable)				
Name	Gross Area	Pump Size	Pump Op + Standby	Total Flow	Main Pump	Name	Gross Area	Pump Size	Pump Op + Standby	Total Flow
	ha	m^3/sec		m^3/sec			ha	m^3/sec		m^3/sec
Mohanpur	5,000	2.25	2 + 1	4.5	Homna	Arsi	2,800	1.0	4 + 1	4.0
						Oder Khal	2,800	1.0	4 + 1	4.0
Homna	40,500	6.25	8 + 1	50.0		Jamna	7,700	3.0	4 + 1	12.0
Nabinagar West	79,000	6.25	5 + 1	31.25						
						Bijni	10,000	3.0	4 + 1	12.0
Nabinagar East		6.25	3 + 1	18.75	Nabinagar					
						Ghungar	10,000	3.0	3 + 1	4.0
	ha			m^3/sec			ha			m^3/sec
Total	124,500	-	-	104,50	Total		33,300	-	-	41.0

Note : Supplying pumped irrigation water to 97,100 ha of the total irrigable area of 107,100 ha and 10,000 ha through groundwater source by DSSTWs and DTWs (Existing Wells and Additional Wells).

In addition to the pumping stations and their associated structures, there are a large numbers of other irrigation structures controlling the flows and levels of the irrigation water supplies.

The controlling structures are irrigation Offtakes, Irrigation inlets and Check Structures. All these pumping stations and control structures are intended to supply water to the existing system of streams within the area. Water will then be re-lifted to the fields by LLPs, owned and operated by the farmers.

- Primary and Secondary Irrigation

  All irrigation water is conveyed by the existing drainage channels. some of these will be enlarged and embanked for drainage and the irrigation proposals have taken advantage of the opportunities these present for more controlled irrigation supplies.

- Tertiary Irrigation

  It is intended that this will be undertaken by the farmers themselves, acting as cooperatives or informal groups. This system is currently used with LLPs. In general, the beneficiary farmers elects a management committee which fixes the area to be irrigated and the water rate for the entire season. The area to be irrigated is divided into several blocks and a main canal from the LLP is dug with a network of smaller canals to

connect individual plots. Water is supplied as required by the crop to each lock in turn, the inlets to the other blocks being closed to ensure even distribution.

The proposed work and project map of Gumti Phase II Sub-Project are shown in Table. F, 2.12 and Figure. F.2.13.

3. IRRIGATION AND DRAINAGE DEVELOPMENT PLAN

3.1 Water Source Potential

3.1.1 Surface Water

At present, by the result of the hydrology analysised the available discharge and the low water level at the Meghna and Gumti rivers in the dry season are shown in the following table. (Refer to 1.3 Hydrology).

(1) Discharge in the Dry Season (Ten Daily Average)

Unit : m^3/sec

Station Name		Discharge Frequency	February			March			Remarks
			(1~10)	(11~20)	(21~28)	(1~10)	(11~20)	(21~28)	
273	Bhairab Bazar (Meghna)	Mean	260	230	253	287	307	394	Period of record Use : 1970~1989 NA: 1977 ~ 1984
		1/5 Year	125	98	102	147	228	255	
110	Comilla (Gumti)	Mean	21	20	19	19	18	23	- do -
		1/5 Year	15	12	12	12	10	10	1970 ~ 1990
114	Jibanpur (Gumti Bridge Point)	Mean	18	16	16	17	17	19	- do -
		1/5 Year	10	10	9	9	7	7	1970 ~ 1990

(2) Water Level in the Dry Season

a) Tidal River

Unit : M in PWD

Station Name		W.L.	February		March		Remarks	
			H.W.L	L.W.L	H.W.L	L.W.L		
298 (Titas)	Nabinagar	Max	1.93	1.10	2.50	1.60	Period of Record Use: Relative Upazila: Nabinagar, Bancharmapur	
		Min	1.60	0.70	2.12	1.08		
79	Matlab Bazar (Dhanagoda)	Max	2.33	1.00	2.54	0.97	- do -	: 1978~1990
		Min	1.5	0.38	2.23	0.58	Relative Upazila	: Kachua
58	Hajiganj (Dakatia)	max	1.92	0.87	2.37	0.98	- do -	: 1978~1990
		Min	1.52	0.61	1.65	0.43	Relative Upazila	: Kachua

b) Non Tidal River Unit : m in PWD

Station Name		W.L	March	April	Remarks
114	Jibanpur (Gumti Bridge point)	Max	6.77	6.99	Period of Record Use : 1978 ~ 1990
		Min	3.51	3.41	Relative Upazila : Debidwar

From the above tables, the available discharge (Probable 5 year) in the dry season are Q (Meghna) = 98 approximately 100 m3/sec and Q (Gumti) = 7~10 m^3/sec respectively. Also the minimum water level for irrigation by the LLPs are 0.7~1.6m at the Nabinagar and Bancharampur (Tidal range : 0.2~0.3m in the dry season), 0.4~1.0m at the Dhanagoda and Dakatia rivers (Tidal Range = 0.2 ~ 0.3 m in the dry season) and 3.4~3.5m of non tidal river at the Gumti Bridge point (Jibanpur 114).

The minimum flows in the Lower Meghan dry season are of the order of 5,000 m^3/sec. For example, the mean flow during the period 23 February to 9th March 1985 was 5,200 m3/sec made up as shown in the following table :

Flow in Lower Meghna (23 Feb~ 23 Mar 1985)

River Name	Flow (m^3/sec)
Ganges at Harding Bridge	885
Brahamaputra at Bhadurabad	4,040
Meghna at Azmiriganj	130
Tributaries	
Khowai, Boulai, Old Brahamaputra	
Lakhya and Gumti	165
Total	5,220

Source : Expert Studies Group, Halcrow, 1986

The abstraction of about 100 m^3/sec (Probable 5 year) from Meghna and Titas will be possible due to the backflows required from the Lower Meghna.

As showing the reference data, the abstracting discharge by the LLPs from the Meghna river at present will approximately suppose to be shown in the following table.

Relative Upazilas under Surface Water Using Discharge by LLPs from the Meghna River

Relative Upazilas under Surface Water Using Discharge by LLPs from the Meghna River.

Left bank Side of Meghna River		Right bank Side of Meghna River		Remarks
Upazila Name	Existing Irrigation Area by LLPs	Upazila Name	Existing Irrigation Area by LLPs	
	ha		ha	
Nabinagar	8,200	Raipura	3,900	
Bancharampur	4,700	Narshingdi	2,000	
Homna	700	Araihazar	900	
Daudkandi	10,000	Sonargaon	2,800	
		Bandar	2,900	
		Gazaria	1,000	
		Munshiganj	400	
		Matlab	3,500	
Total	*-1 ha 23,600	Total	*-2 ha 17,400	Ground ha Total = 41,000
Current Used Water (Q1) = 23,600 ha x 1.4 l/sec/ha = 33 m3/sec		Current Used Water (Q2) = 17,400 ha x 1.4 l/sec/ha = 24 m3/sec		Q = Q1 + Q 2 = 57 m3/sec

Note : * - 1 Upazila Information 1988, 1990
* - 2 Upazila Statistics 1985
- Water requiremetn was estimated by the basis of 1.4 l/sec/ha (714 ha/1 m3/sec.).

3.1.2 Groundwater

According to the BWDB study (water Supply paper 489, Ground Water Circle II June, 1987), groundwater development zone, characteristic and potential are shown in the following summarized table. (Refer to 1.5 Groundwater)

Groundwater Development Zone, Characteristic and Potential

Zone Type of Study Area	Identified Total Area (Km2)	Ground Water Resource (Million m3)/ Range (mm)/Average (mm) 1981-85			Remarks
		Actual Recharge on Existing develop - ment/Losses (from fluctuation)	Potential Recharge Rp	Average Recharge Ra =Rp x 60/100	
D2 (Nabinagar) (Bancharmapur)	1,237	240.6 (128 mm)	290.7 (235 mm)	174.4 (141 mm)	Nabinagar, Bancharampur : A = 565 km2 Available Recharge (Ra) Ra = 174.4 Mill m3 x 565/1,237 = 80 Million m3 (141 mm)
D1	365	47.0 (128 mm)	70.1 (192 mm)	42.1 (115 mm)	Debidwar : A = 239 km2 Available Recharge (Ra) Ra = 89.4 Mill m3 x 239/650 = 32.9 Million m3 (137 mm)
B1 (Debidwar)	285	35 (124 mm)	79 (276 mm)	47 (166 mm)	
Total	(650)			585 (137 mm)	
D1	365	47.0 (128 mm)	70.1 (192 mm)	42.1 (115 mm)	Kachua : A = 236 km2 Available Recharge (Ra) Ra = 585.3 Mill m3 x 236/4.324 = 31.9 Million m3 (135 mm)
D2	1,237	246.6 (144 mm)	290.7 (235 mm)	174.4 (141 mm)	
C1	1.074	113.8 (106 mm)	205.5 (191 mm)	123.3 (115 mm)	
C2	1.018	145.5 (142 mm)	223.9 (220 mm)	134.4 (132 mm)	
C3 (Kachua)	630	92.4 (147 mm)	185.2 (294 mm)	111.1 (176 mm)	
Total	(4.324)			585.3 (135 mm)	

From the analysis of the above mentioned table supposed approximately available groundwater sources of each Upazila in the study area are shown in the following table.

Available Ground Water Source of each Upazila

Upazila Name	Area	Available Groundwater volume	Available DTW Nos * - 1	Remarks
	Km^2	Million m^3	Nos	
Nabinagar	358	51	170	
Bancharampur	207	29	90	
Debidwar	239	33	110	
Kachua	236	32	100	

Note : *-1 Annual use water volume by DTW (2 cfs = 57 ^{l}/sec

v= 57 $^{l/sec}$ x 1,300 ^{hr} x 3,600 sec x ^{1}/1,000 = 266,760 → 300,000 m^{3}/year

At present RD-II, RD-8 and IDA Irrigation Project - 2 under IMP (Irrigation Management Program) are prevailing strongly through the national level.

The prevailing condition and plan in the study area are :

Project Wise and Years Wise List of Upazilas under IMP (Study Area Only)

Name of the Project	Name of the District	Year Wise Incorporation of Upazilas								1990-1991 Target			Land under each Machine (Acre/Unit)	
		83-84	84-85	85-86	86-87	87-88	88-89	89-90	90-91	Name of Upazila	No of Scheme DTW	STW/LLP	Cultivation in 1989-90	Target for 1990-91
													Acre/Unit	Acre/Unit
RD-II		Debidwar	Kachua							Kachua	5		62	75
RD-8			Bancha-rampur Nabinagar											
IDA Irrigation Project-2						Debidwar	Nabinagar Bancha-rampur			Nabinagar Debidwar Bancha-rampur	10 12 5		58	61 75 51

Source : Go for Extention of Irrigation through Co-operatives and organize Co-operatives on Irrigation" IMP Program/Action Plan

3.2 Irrigation and Drainage Development Plan

3.2.1 Basic Concept for Irrigation and Drainage Development

a) To increase HYV Boro production under irrigation by the expansion in the dry season.

b) To design and to implement the development plan quickly in order to make low investment cost per hectare through the minor irrigation system.

According to the above mentioned point, the irrigation should be carried out by the supply of LLPs for using the surface water.

- To select each available irrigation area through each area of the existing canals (khal) for the intake of water to be done as much as possible.

- To execute the re-excavation of the existing canals from the taking into consideration of the limited water source and the sedimented silt up condition. The present water sources have limited the areas applied for current LLPs.

- To improve the land area of the existing canal lots by the excavation.

c) To prevent beneficiary for the irrigation area presently using LLPs and DTWs.

d) To improve not only the irrigation but also the drainage through the re-excavation of the existing canals.

But the drainage measure during the monsoon period is not possible due to the high level at the Meghna river. Therefore the purpose of the drainage improvement will be considered only to prevent the drainage of crops during the pre-monsoon period (Apr-Mar) and the post monsoon period (Nov-Dec). During this period the low water level is keeping at the Meghna river, but Boro and Aman have been often damaged by the large rainfall occasionally.

3.2.2 Extension of the Irrigation Area for the Master Plan

From the above mentioned basic points, the irrigation development area of the each Upazila is shown in the following table and Figure. F.3.1.

Extension of Irrigation Area (Master Plan)

Bancharampur					Nabinagar					Kachua					Remarks
Rank	Canal (Khal) Name		Command Area	Canal Length	Rank	Canal (Khal) Name		Command Area	Canal Length	Rank	Canal (Khal) Name		Command Area	Canal Length	
			ha	km				ha	km				ha	km	
1	Kathalbari	1	70	9	1	Majikata	1	400	10	1	Bealjuri	P1	150	12.5	Control under BWDB
										2	Sachar	P2	-	(9.0)	"
2	Dulbanaga	2	600	13	2	Jafarpur	2	440	9	3	Sachar-Hajiganj	S1	250	16.0	
3	Dairarchar	3	300	8	3	Laur Fatbepur	3	200	8	4	Dhamala-Keylsin	S2	-	(3.5)	NA
										5	Kanaya-Raguaathpur	S3	100	6.0	
4	Munder	4	300	7	4	Bikhali	4	100	8	6	Nondda-Charalbanga	S4	100	12.0	
										7	Bitara-Aliara	S5	100	9.0	
5	Dariakandi Bara	5	70	4	5	Adalmanil Chat	5	100	7	8	Uzani-Tetulia	S6	50	4.0	On-going improve-
										9	Sachar-Baytk	S7	-	(3.5)	ment under BWDB
6	Nandelia	6	80	5	6	Bash	6	400	6	10	Modhupur-Baraiara	S8	-	(4.0)	"
										11	Amujau	S9	-	(6.0)	NA
7	Hasainpur	7	180	5	7	Binagan	7	380	5	12	Baichara	S10	100	3.5	
										13	Balasbar-Rahimanagar	S11	-	(7.0)	NA
8	Mandalia	8	400	5	8	Begdubar	8	300	5	14	Sreerampur-Kanya	S12	-	(4.5)	"
										15	Udara	S13	100	7.5	
9	Paharialandi	9	30	3	9	Dewjuri	9	260	12	16	Fatbepur	S14	-	3.0	NA
										17	Kajkamia-Komorkasba	S15	50	4.5	
10	Kalakandisena	10	70	3	10	Samegram	10	100	10	18	Bachsia	S16	50	3.5	
										19	Singua	S17	-	(3.0)	NA
11	Mara Titas	11	100	5	11	Rasullabad	11	360	10	20	Pala-Budhumda	S18	-	(2.5)	"
										21	Atishar	S19	50	2.0	
					12	Rasulpur	12	160	6	22	Akania-Nasirpur	S20	-	(5.0)	NA
										23	Mamigacha-Amujan	S21	-	(3.5)	"
										24	Jagatpur-Pepolkara	S22	-	(3.5)	"
	Total		ha 2200	km 67		Total		ha 3200	km 96		Total		ha 1100	km (55) 83.5 138.5	

Note: 1) Canal Ranking for Upazila Proposal.
2) Command area excluding the existing irrigated area by LLPs using.
3) NA = Not available for the gravity water use depending on the current low water level of the Dhanagoda and Dakatia rivers

The minor irrigation development should be based on the introduction of technologies proven to be more economical and effective under local condition considered. From the above concept and the reference of 3.1.2 Groundwater, the irrigation system should be prevailed by the LLPs using as much as possible the surface water source in these Upazilas. After the completion of irrigation by the LLPs, the development of the DTW and DSSTWs for using groundwater will be considered in these Upazilas.

3.2.3 Design Water Level for LLPs and Canal Standard Section for the Re-excavation.

At present, the irrigation by many using LLPs is done through the available surface water limits in the study area. This has been carried out mainly for the HYV Boro cultivation during the dry season. Therefore, in order to expand the irrigation area, the Re-excavation of the current canals (Khal) should be planned for the possible water sources from main rivers.

(1) Design Water Level of the Main River Source

According to the results of the hydrology analysis in the dry season (Feb-Mar), the design water levels for each Upazila are envisaged as follows :

- Nabinagar and Bancharampur
  Design Water Level = 1.10 m (PWD)
  [Based on the observed data at 298 Nabinagar (Titas River)]

- Kachua
  Design Water Level = 0.70 m (PWD)
  [Based on the observed data at 79 Matlab Bazar (Dhanagoda River) and
  58 Hajiganj (Dakatia River)]
  (Refer to 1.3 Hydrology)

(2) Standard Section for Re-excavation of Existing Canals.

Based on the current canal sections, the design forms were determined from the taking into consideration on the possible improvement of existing canal lots by excavation.

The canal standard sections and dimensions subjected to the improvement are shown in Figure. F.3.2.

3.2.4 Drainage Improvement by Re-excavation of Existing Canals.

The water level conditions in the pre-monsoon (Apr-May) and post-monsoon period (Nov-Dec) at the Titas, Dhanagoda, Dakatia River, also the cultivating land elevation of the each Upazila in the study area are shown in the following table

Unit : m in PWD

Station Name		H.W.L	Pre-Monsoon		Post-Monsoon		Cultivating Land Elevation and Area		
			Apr	May	Nov	Dec	Nabinagar		
							Land Type	E.L	Area
			m	m	m	m		m	ha
		Max	2.90	4.90	4.50	3.10	F4	1.5~3.0	12,800
298	Nabinagar	Mean	2.50	3.70	3.60	2.50	F3	3.2~4.4	9,600
	(Titas)	Min	2.12	2.61	2.76	2.08	F2	4.4~5.3	3,000
									(25,400)
							Bancharampur		
		Max	3.05	3.63	3.70	2.82	F4	1.5~3.0	7,200
79	Matlab Bazar	Mean	2.60	3.20	3.20	2.50	F3	3.0~4.2	8,000
	(Dhanagoda)	Min	2.30	2.82	2.89	2.29	F2	4.2~5.1	2,800
									(15,200)
							Kachua		
		Max	3.32	3.55	3.87	3.31	F4	-	-
58	Hajiganj	Mean	2.60	3.00	2.90	2.60	F3	2.4~3.0	3,000
	(Dakatia)	Min	2.03	2.56	2.03	1.94	F2	3.0~3.9	9,700
									(12,700)

Note : Refer to Figure. F.2.2

From the above table mentioning the relationship between the river water level and the cultivating land elevation, the improvement plan by re-excavation of current canals (Khal) would be reduce largely the production of the Boro and Aman during havesting periods.

3.3 Irrigation and Drainage Development for the Priority Project

3.3.1 Basic Concept for Irrigation and Drainage Development

The irrigation area by the master plan level had been taken up and the most beneficiary areas for irrigation are selected, based on the following items.

a) To expect the most benefit from the consideration on the relationship through the improvement of roads.

b) To obtain high effect on the present market conditions. Therefore, the irrigation areas should be located near the sites of the markets.

c) To expect the suitable operation and maintenance.

d) To obtain high effect on the present navigation systems.

3.3.2 Extension of the Irrigation Area for the priority Project

From the above mentioned points, the priority project area for irrigation and drainage of each Upazila is shown in the following table.

Bancharampur					Nabinagar					Kachua				
Rank	Canal (Khal) Name		Command Area	Canal Length	Rank	Canal (Khal) Name		Command Area	Canal Length	Rank	Canal (Khal) Name		Command Area	Canal Length
			ha	km				ha	km				ha	km
1	Kathakahali	1	70	9	1	Majikata	1	400	10	1	Sachar-Hajiganj	S1	250	16
2	Dulbanaga	2	600	13	2	Laur Fathepur	3	200	8	2	Karaya-Ragunathpur	S3	100	6
3	Murader	4	300	7	3	Adulmanil Chart	5	100	7	3	Uzani-Tatulia	S6	50	4
4	Nandalia	6	80	5	4	Birugan	7	380	5	4	Udara	S13	100	7.5
5	Pahariakandi	9	30	3	5	Begdubar	8	300	5	5	Kajkamta-Kamorkasha	S15	50	4.5
6	Kalakandiaona	10	70	3	6	Rasullabad	11	360	10					
Total			ha 1150	km 40	Total			ha 1740	km 45	Total			ha 550	km 38

4. OPERATION AND MAINTENANCE FOR LLP

4.1 Organization

The organization for the LLPs irrigation project will be aimed at its operation and maintenance. This operation and maintenance would be carried out by the so-called two tier cooperative system - UCCA and KSS - through the on-going Irrigation Management Programme (IMP) basis. In the meantime, the O&M of water source channels would be carried out by Upazila Parishad and Water Users Association(WUA). The Upazila Parishad would receive a part of charge for the maintenance of water source channels from the UCCA through the Food for Work Program.

The UCCA would own all LLPs and lease them to the WUA composed by KSS/BSS and MSS/MBSS. The UCCA would collect the rental charge of these LLPs through the WUA and use this for the annual O&M and the renewal of LLP units in the future. The Upazila Parishad owns all existing water source channels used for the LLPs project, and takes the responsibility for their maintenance for the irrigation, drainage and navigation purposes.

The project will promote also the formation of formal farmers groups through the Water Users Association (WUA). This WUA will aim at a suitable O&M with the following objects, roles and responsibilities.

- In the name of the Association and on behalf of its members to mobilize resource, raise fund from members, and obtain loans for the execution and operation of irrigation system improvements.

- To participate in the construction of water distribution system and related infrastructure works, to operate/arrange the execution of these functions, and to maintain and manage the system in the command areas.

- To resolve problems and disputes among members concerning the use of water.

- To set and collect charges from members for the operation, maintenance and management of the irrigation and distribution system, loan repayment and member charges and to take necessary operational or appropriate action against members in default of payments due to the Association.

The Association should be participated by all landowners and tenants in the command area, as many as possible, such as NGO organized groups.

All farmers cultivating lands in the command area qualify for membership in the Association. For any new land brought into the command area, the Association shall motivate to the farmers and the member shall pay annual fees or charge for the Association. The project will undertake promotional activities through publicity, demonstration and technical advice to farmers.

4.2 Operation Flow

The work flow of the project is formulated in Figure.F.4.1 and the organization of the on-going Irrigation Management Programme (IMP) is shown in Figure. F.4.2.
The roles and responsibilities for O&M of the project indicate the following.

(1) BRDB

- Appointment of the Project Manager
- Project formulation and establishment of task force
- Preparation of "Operation Manual of the Project"
- Provision of administrative advise to UCCA including credit arrangement, staff training, etc.
- Budgetary arrangement for overhead cost of BRDB
- Internal auditing
- Coordination with other agencies concerned
- Monitoring and evaluation of the Project
- Record keeping
- Reporting to project sponsor, if any

(2) UCCA

- Arrangement of credit for procurement of pumps and other consumable to the Water Users Association (WUA) and its repayment
- Maintaining ownership of pumps
- Prevailing and assistance for the formation of the WUA
- Day-to-day management of the Project
- Resolve of problems and disputes among members of the WUA
- Assistance and advice to the WUA for the construction of the distribution canal

- Provision of technical guidance and staff training for pump operators and mechanics of the WUA
- Provision of O&M support, spare parts and repair services
- Accounting including set-up of rental charge, collection of rental charge from WUA
- Financial control for self-reliance in the project execution
- Record keeping
- Reporting to the PM of BRDB

(3) Water Users Association (WUA)

- Efforts for the irrigation area expansion
- Preparation of work schedule, meeting and arrangement for all members
- Construction of the distribution canal
- O&M for the pump and distribution canal
- O&M for the budget and ledger
- Instalment and pay back of credit
- Collection of the water charge from all members
- Payment to the UCCA for the rental charge of LLP
- Request to the UCCA for technical assistances and repair services of LLP
- Payment for repair services and spare parts for LLP
- Cooperation with Upazila Parishad for the maintenance of the water source channels under control by Upazila Parishad
- Record keeping
- Reporting to the UCCA

(4) Irrigation Management Programme (IMP)

a) Upazila Irrigation Committee

The Upazila Irrigation Committee is a very important organization in Upazila which is responsible for the following functions.

- To enforce spacing, zoning and setting criteria for irrigation equipments
- To register irrigation equipments
- To plan programmes of irrigation improvement
- To resolve disputes

- To organize farmers meetings

b) Upazila Implementation Team under IMP

The roles and responsibilities of this team will be executed in the field through following functions.

- To implement IMP as per guidelines of the IMP manual
- To train farmers and field workers
- To report on IMP

c) Scheme Irrigation Management Committees

The IMP Manual calls for the formation of an Irrigation Management Committee at each scheme, consisting of the KSS Chairman, the UCCA Inspector, the Block Leaders and the Scheme Manager. This committee is the executive body of the water user group responsible for the management of the scheme on behalf of the members.

d) Reporting on IMP

The responsibility for this reporting lies with BRDB and these functions are as follows.

- A weekly monitoring report submitted by the scheme manager to the UCCA
- An annual report from the scheme manager to the UCCA
- An annual report from the upazila to the District Team. And with the monthly report the same proforma was to be sued by the District to consolidate the upazila information for transmission to Head Quarters.

This reporting system aims at key indicators of (i) the total numbers of the group, (ii) the total numbers of KSS, (iii) estimated cropped areas of Boro rice, wheat, transplanted Aman, etc. and total cropped area, (iv) estimated yields, (v) irrigation charges for KSS and non-KSS members, and (vi) total operation hours and total days of pump breakdown.

4.3 Training

Training aims at providing the necessary training to the beneficiaries of the project to enable them to properly manage the irrigation facilities which they will procure. The following training concepts will be required.

- Farm management, water management and accounting training
- Minor irrigation facilities management
- Management and development of cooperative systems
- On-the-job training for pump operators and mechanics of the WUA

BRDB was established to promote the UCCA/KSS co-operative system and has provided training to the accountants who maintain the book of the co-operatives at the Upazila and village level. BRDB has a Training Materials Production Unit in Dhaka which could be used for the design and production of information and training materials for the project.

The pump suppliers will provide training to mechanics for servicing equipments. This training will also be targeted for pump operators, mechanics, irrigation group organizers and water user groups.

Potential groups (WUA) for the minor irrigation equipments will be identified by the irrigation group organizers who will visit the group in the field. To implement the activities planned under the project, an information dissemination campaign will be undertaken in areas targeted for development under the project. Irrigation group organizers will be encouraged to participate in the project to the maximum extent possible and will be involved in the formation of water user groups.

Training for WUA will include the following.

- How to obtain system design assistance, credit and agricultural advice
- Group organization and decision making
- Pump operation and repair services
- Book-keeping and financial management

a) Pump Operator Training at Farmer Level

- Duties of the operator
- General working of the diesel engine, drive mechanism
- Regular servicing and planned maintenance
- Importance of clean air, fuel, lubricants and coolants
- Safety measures
- Seasonal shut down procedures
- Record keeping

b) Mechanics Training

- Use of tools and workshop equipments
- Repair of engines and pump equipments
- Fault finding of pumping equipments
- Ordering of spare parts
- Introducing other farm machineries
- Basic book-keeping for running a small business

4.4 Workshop

The necessity of a mechanical workshop to be established at the Upazila level is based on the following concepts.

- For quickly repairing
- For supplying available spare parts
- For supplying quickly available technical personnel
- For training facilities

Points mentioned by farmers were indicated by (i) the lack of spare parts in BADC store, (ii) the insufficient training for operation, and (iii) the high cost for supervision.

The objectives of a workshop were based on the considerations that it would help quick repairing of machines, costs will be less, repairing time will be minimized, stores of spares can be maintained easily and the training activities for repairing, maintenance as well as motivation can be carried out very smoothly and efficiently.

4.5 Equipment & O.M. Costs and Revenues

(1) Expenditure

a) Equipment Cost for Workshop

Equipment for storage, transportation machinery of the LLPs/FPs, machinery and tools for the repair of pumps are as follows.

	Q'ty	Tk/unit	Tk
Mini-Track (2 ton)	1	750,000	750,000
Mini-Tractor (with trailer)	2	75,000	150,000
Motorcycle (125 cc)	2	40,000	80,000
Machine for Repair	1	L.P.	1,500,000
Miscellaneous	1	L.P.	520,000
Total			3,000,000

b) Personnel Cost

In order to perform administration managing, accounting, business forming and machinery jobs, the following staff and fee are required.

	Person	Tk/month/person	Tk/year
Project Administrator	1	5,000	60,000
Accountant	1	3,000	36,000
Mechanic Eng.	2	4,000	96,000
Machinery Staff	2	2,000	48,000
Assistant Staff	1	2,000	24,000
Driver	1	3,000	36,000
Total			300,000

c) O&M Cost for Workshop

	Tk/unit	Tk/year
Vehicle Repair	1.0 L.P.	100,000
Equipment Repair	"	30,000
Vehicle Fuel etc.	"	10,000
Spare Parts of LLPs	"	100,000
Office Supply	"	50,000
Miscellaneous	"	10,000
Total		300,000

d) Training Cost for LLPs

Total 130,000 Tk (for pump operators)

e) Maintenance Cost for Water Source Canals

The Upazila Parishad will charge the UCCA for the maintenance of water source canals (Upazila controled) from the UCCA's incomes through the Food for Work Programme. This charge to each Upazila UCCA will be determined, based on the construction cost for canals re-excavation.

O&M Cost for Canals Re-excavation

Total 250,000 Tk/year
(Bancharampur, Nabinagar and Kachua Upazila)

Total expenditure (Bancharampur, Nabinagar and Kachua Upazila)

-	Personnel Cost	300,000 Tk x 3 =	900,000	Tk/year
-	O&M Cost for Workshop	300,000 Tk x 3 =	900,000	"
-	Training Cost for LLPs		130,000	"
-	O&M Cost for Canal Re-excavation		250,000	"
	Total Expenditure (O&M)		2,180,000	Tk/year
	Equipment Cost for Workshop	3,000,000 Tk x 3 =	9,000,000	Tk

(2) Incomes

Incomes for the UCCA through the LLPs business are as follows.

- Rental Fee of LLPs from WUA	173 Nos x 11,000 Tk =	1,903,000	Tk/Year
- Repair Fee of LLPs from WUA	173 Nos x 2,000 Tk =	346,000	"
Total		2,249,000	Tk/year

(3) Financial Balance

Expenditure

Annual O&M Cost	2,180,000 Tk
Annual Income	2,249,000 Tk

This fund would be considered, based on the fee related to the income of LLPs rental charge/LLPs repair charge and the O&M cost of LLPs under the UCCA. At present, the LLPs are purchased directly by the individual farmers without the government subsidy.

In order to achieve fruitfully the development in rural areas, the GOB assistances to local peoples are very importance. From this viewpoint, the rental for WUA may be charged high as about 11,000 Tk/unit (550 Tk/ha). This, however, can be set with to farmer with 5,000 ~ 6,000 Tk/unit (250 ~ 300 Tk/ha) with the consideration of a half cost subsided by the GOB.

(4) Water Charge

The current water charge ranges 2,500 to 3,200 Tk/ha in 1990/91 according to upazila and BADC officers. Based on our calculation shown in below, the proposed water charge per ha of the LLPs project will be set with 2,500 Tk.

Items	Cost Tk/ha
1. Fuel	1,200
2. Personal and Labour cost	500
3. LLP rental charges	400
4. Water Source canal O & M	50
5. Work Shop O & M	100
6. Repair and Spare parts	150
7. Other	100
Total	2,500

This proposed water charge will be occupied about 23 % of the production cost for Boro HYV which is 11,000 Tk. per ha.

TABLES

Table F.1.1 Average Monthly and Annual Max/Min Temperature (℃)

Station Name		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Mean	Remarks
Comilla	Max	25.70	28.00	31.40	32.00	32.40	31.40	30.70	31.10	31.60	31.30	29.70	26.60	30.10	(Period of Record Use)
	Min	12.50	15.10	19.90	23.10	24.40	25.50	25.60	25.50	25.40	23.60	19.20	13.80	21.10	1969 - 1988
Chandpur	Max	25.10	27.60	31.60	32.90	32.90	32.10	30.90	29.10	31.70	31.40	29.10	25.60	30.00	1969 - 1987
	Min	13.40	15.60	20.40	23.30	24.30	25.70	25.80	25.70	25.70	24.00	19.80	14.80	21.60	
Dhaka	Max	25.30	28.10	32.50	34.20	32.90	31.30	31.00	30.90	31.30	30.70	27.90	25.80	30.20	1961 - 1980
	Min	11.90	14.80	20.00	23.50	24.60	25.80	26.20	26.10	25.90	23.60	18.40	13.40	21.20	

Table F.1.2 Average Monthly and Annual Humidity (%)

Comilla	73	70	73	79	81	85	87	86	85	82	78	74	79	(Period of Record Use) 1969-88
Chandpur	75	72	72	77	80	87	88.0	87	87	83	79	77	80	1969-1987
Dhaka	69	64	61	71	79	86	86.0	86	85	81	75	73	76	1961-1980

Table F.1.3 Average Monthly/Daily Evaporation (mm)

Station Name		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec	Remarks
Comilla	Monthly	53	67	117	116	109	82	77	85	84	75	65	51	(Period of Record Use)
	Daily	1.7	2.4	3.8	3.9	3.6	2.8	2.5	2.8	2.8	2.4	2.2	1.7	1976 - 1980
Dhaka	Monthly	60	65	108	107	88	77	78	85	77	74	71	62	1976 - 1979
	Daily	1.9	2.3	2.8	3.6	2.8	2.6	2.5	2.7	2.6	2.4	2.30	2	

Table F.1.4 Average Monthly and Annual Wind Speed

Station Name	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual	Remarks
Comilla	4	4	5	7	6	6	6	6	5	4	4	4	5	(Period of Record Use) 1969 - 1988
Chandpur	3	3	5	5	4	4	4	4	3	4	3	3	4	1969 - 1987
Dhaka	3	3	5	6	5	5	5	5	5	4	3	3	4	1961 - 1980

Note : 1 Knot = 1,853 Km/hr

Table F.1.5 Average Monthly and Annual Rainfall

Station Name	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual	Remarks
Comilla	5	17	45	162	325	336	413	336	232	138	47	4	2058	(Period of Record Use) 1969 - 1988
Chandpur	8	8	59	220	344	553	507	394	284	113	50	10	3153	1969 - 1987
Daudkandi	11	34	108	234	345	544	585	440	341	184	56	23	3219	1965 - 1982

Table F.1.6 Maximum Two-Day Rainfall/Ten-Day Rainfall

(Unit : mm)

Station Name	Days	2.33 Year	5 Year	10 Year	20 Year
BMD Comilla	2 days	199	256	300	341
	10 days	403	469	509	539
103 Brahmanbaria	- do -	226	263	288	308
	- do -	411	488	542	587
351 Bancharampur	- " -	186	233	268	301
	- " -	379	457	511	558
367 Nabinagar	- " -	203	241	267	290
	- " -	371	429	471	507
366 Muradnagar	- " -	158	203	231	253
	- " -	300	388	446	494
357 Daudkandi	- " -	201	236	262	285
	- " -	467	550	606	653
360 Hajiganj	- " -	184	236	278	317
	- " -	349	404	440	468
354 Chandpur	- " -	192	247	286	323
	- " -	342	421	482	537
363 Laksham	- " -	205	246	274	298
	- " -	474	564	629	684
352 Barura	- " -	178	223	262	301
	- " -	355	430	490	546
R76 Narshindi	- " -				
	- " -	220	254	279	301
		418	501	573	638

Source : MPO Report

Table F.1.7 Flood Peak Frequency

(Flood Peak (m3/Sec)

Station Name	River	Drainage Area (Km2)	Period of Record Use	2.33 Year	5 Year	10 Year	20 Year	Highest Flood Level
230.1 Bhairab Bazar Railway Bridge	Old Brahmaputra	2,960	1969-70 1972-82	677	848	985	1,120	-
273 Bhairab Bazar	Meghna	80,200	1964-74	12,900	14,500	16,200	18,000	19,800(11.7.1988)
114 Jibanpur	Gumti	246	1965-70 1972-78	290	384	462	500	617 (3.7.1976)
110 Comilla	Gumti	2,210	1965-70 1972-82	474	572	637	689	1,160 (6.8.1983)

Source : MPO Report

Table F.1.8 Maximum One-Day Average Flood Level of Selected Recurrence Intervals

(Unit : Meters in PWD)

Station Name	River	Period of Record Use	2.33 Year	5 Year	10 Year	20 Year	50 Year	Highest Flood Level
297 Gokarnaghat	Titas	1960, 1962, 1968-74 & 1978-80	6.48	6.84	7.09	7.30	7.53	7.42 (12.9.1988)
298 Nabinagar	Titas	1959-60, 1962-63, 1968-74, 1978-79 & 1981	6.33	6.63	6.87	7.09	7.36	7.34 (10.9.1988)
275 Baidyer Bazar	Meghna	1960-61, 1969-82	5.42	5.65	5.82	5.98	6.16	6.98 (4.9.1988)
115 Daudkindi	Gumti	1957, 1959-61, 1963-64 &1971-82	5.38	5.61	5.79	5.94	6.14	6.27 (3.9.1988)
276 Satual	Meghna	1951-61 & 1962-82	5.18	5.40	5.57	5.72	5.90	6.04 (3.9.1988)
79 Matlab Bazar	Danagoda	1959-64, 1968-77 & 1979-80	5.13	5.33	5.47	5.60	5.76	NA
277 Chandpur	Meghan	1956-60 & 1969-82	4.80	4.96	5.08	5.18	5.31	5.16 (29.8.1988)
58 Hajiganj	Dakatia	1958-60 & 1970-82	4.64	4.85	5.03	5.21	5.44	5.52 (9.9.1988)

Source : MPO Report

Table F.1.9 Minimum Discharge Frequency (Ten Daily Average Discharge)

(Unit : M3/Sec)

	Station Name	Discharge Frequency	February			March			April			Remarks
			1 (1~10)	2 (11~20)	3 (21~28)	1 (1~10)	2 (11~20)	3 (21~31)	1 (1~10)	2 (11~20)	3 (21~30)	
273	Bhairab Bazar	Max	474	478	523	576	501	816	1250	2140	3050	Period of Record Use :
		Mean	260	230	253	287	307	394	719	1293	1547	
		Min	64	47	42	63	207	211	342	878	595	
	(River = 102	1/5 Probable	125	98	102	147	228	255				1970 ~ 1989
	Surma-Meghna	1/10 "	82	63	62	102	208	210				NA =
		1/20 "	51	40	35	69	196	181				1977 ~ 1984
110	Comilla	Max	36	35	36	32	34	97	80	86	70	Period of Record Use :
		Mean	21	20	19	19	18	23	25	30	32	
		Min	7	6	6	6	5	5	5	4	7	
	(River = 43	1/5 Probable	15	12	12	12	10	10	11	18	15	1970 ~ 1990
	Gumti-Burinadi)	1/10 "	12	10	9	9	8	7	7	9	11	
		1/20 "	9	8	7	7	6	5	5	7	8	
114	Jibanpur	Max	31	28	28	33	49	79	54	109	68	
	(Gumti Bridge)	Mean	18	16	16	17	17	19	19	28	28	
		Min	5	4	4	4	4	3	2	3	3	- do -
	(River = 43	1/5 Probable	10	10	9	9	7	7	7	10	12	
	Gumti-Burinadi)	1/10 "	8	7	6	6	5	4	4	7	8	
		1/20 "	6	5	5	4	4	3	2	5	5	

Table F.1.10 Minimum Surface Water Level (Dry Season)

Unit : Meters in PWD

Station Name / Month	W.L	January		February		March		Remarks
		L.W.L	H.W.L	L.W.L	H.W.L	L.W.L	H.W.L	
298 Nabinagar	Max	1.94	1.18	1.93	1.10	2.50	1.60	Period of Record Use
(River : 108 Titas)	Min	1.70	0.96	1.60	* 0.70	2.12	1.08	1977 ~ 1990
297 Gokarnaghat	Max	2.02	1.24	1.96	1.18	2.47	1.29	1978 ~ 1990
(River : 108 Titas)	Min	1.72	0.98	1.60	* 0.67	1.80	0.91	NA: 1979-1981
272 Bhairab Bazar	Max	2.12	1.28	1.98	1.14	2.61	1.28	1981 ~ 1990
(Rver : 102 Surma-Meghna)	Min	1.79	0.99	1.68	* 00.74	1.92	1.00	
274 Narsingdi	Max	2.13	1.22	1.98	1.05	2.42	1.25	1970 ~ 1990
(Rver : 102 Surma-Meghna)	Min	1.67	0.98	1.54	* 0.64	1.66	0.78	NA: 1981~1982
275 Baidyer Bazar	Max	2.48	1.42	2.37	1.17	2.55	1.26	1970 ~ 1990
(Rver : 102 Surma-Meghna)	Min	1.51	0.47	1.25	* 0.14	1.52	* 0.14	Na: 1978~1981 and 1988
275.5 Meghna Ferry Ghat	Max	2.19	1.02	2.11	0.93	2.37	1.10	1978 ~ 1990
(Rver : 102 Surma-Meghna)	Min	1.87	0.73	1.69	0.49	1.78	* 0.20	NA: 1979-1981
276 Satual/Matlab	Max	2.31	0.80	2.14	0.83	2.79	0.79	1982 ~ 1990
(Rver : 102 Surma-Meghna)	Min	1.22	0.66	1.74	0.39	1.68	* 0.07	
277 Chandpur	Max	2.44	1.04	2.25	0.81	2.58	0.80	1970 ~ 1990
(Rver : 102 Surma-Meghna)	Min	1.81	0.47	1.83	* 0.35	2.00	0.37	
58 Hajiganj	Max	2.07	1.16	1.92	0.87	2.37	0.98	1970 ~ 1990
(River : 27 Dakatia)	Min	1.58	0.66	1.52	0.61	1.65	* 0.43	NA: 1981~1983
79 Matlab Bazar	Max	2.56	1.05	2.33	1.00	2.54	0.97	1978 ~ 1990
(River : 34 Dhanagoda)	Min	2.00	0.73	1.95	0.38	2.23	0.58	NA: 1979~1982

(Gumti River)

Unit : Meters in PWD

Station Name / Month	W.L	Jan.	Feb.	Mar.	Apr.	Remarks
110 Comilla	Min	8.45	8.41	10.37	10.15	Periods of Record Use:
	Min	7.13	7.13	7.07	*7.01	1970 ~ 1990
113 Kangsanagar	Min	6.99	6.90	7.80	9.34	1980 ~ 1990
	Min	4.69	4.18	4.10	*3.96	
114 Jibanpur	Min	5.21	5.15	6.77	6.99	1978 ~ 1990
(Gumti Bridge)	Min	3.64	3.55	3.51	*3.41	NA : 1980 ~ 1981

Table F.1.11 Ground Water Development Zones, Characteristics and Potentials

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Identified A		Percentage of Coarser Material (Study Depth 105 m)	Identified Area	Specific Yield Calculated from Bore-log up to 15 m	Maximum Depth to Ground Water Table from Land Surface	Actual Water Table Fluctuation	Maximum Fluctuation Attained/ Expected	Ground Water Resource (Million M3)/ Rang(mm)/Average(mm) 1981~85			Thickness of Upper Silt and Clay	Depth to Top of Main Aquifer	Thickness of Main Aquifer at Various Depth	Aquifer Characteristic Derived from Aquifer Test			Chemical Qualities			
Zone	Sub-Zone	%	(Km2)	(m)	(m)	(m)		Actual Recharge on Existing Development/ Losses (from Fluctuation)	Potential Recharge Rp	Average Recharge Ra=Rpx60 100	(m)	(m)	(m)	Transmiss-ibility of Main Aquifer SQ (m/day)	Storage Co-efficient	Specific Capacity (l/S/m)	Total Dissolved solids (TDS) PPM (Depth Range (27 ~ 106m)	Iron (Fe) PPM (27 ~ 106m)	Chloride (Cl) PPM (27 ~ 106m)	DEVELOPMENT POTENTIALS
B	B1	50 ~ 75	285.00	0.046	2.5 ~ 6.0	2.5~4.5	6.0	35.40 (124 mm)	78.80 (276 mm)	47.30 (166 mm)	1.0~6.0	15 ~ 70	50 ~ 80	400 ~670	0.01 ~ 0.08	2.2 ~ 9.6	174 ~ 213	5.0 ~ 10.0	8 ~ 18	Area is suitable for further development of shallow/deep tube-well (sinking of STW/DTW side by side within the same area is not advisable).
	B2		325.00	0.034		1.0~3.5	6.0	31.70 (98 mm)	66.30 (204 mm)	39.80 (122 mm)	10 ~ 29	15 ~ 45		315~470	0.01~0.05	4.5 ~ 9.5	240 ~ 275	6.5 ~ 19.2	11 ~ 12	
	B3		589.00	0.045	3.5 ~ 6.0	3.5 ~ 4.5	6.0	104.90 (178 mm)	160.30 (272 mm)	96.20 (163 mm)	1 ~ 10			315 ~ 900	0.001~0.05	3.1~17.0	116 ~ 240	4.5 ~ 21.0	8 ~ 18	Most of the area has good water qualities.
	B4		322.00	0.033	3.5 ~ 6.0	2.5 ~ 6.5	7.0	36.40 (113 mm)	65.40 (203 mm)	39.20 (122 mm)	1 ~ 28			470 ~ 553	0.01~ 0.13	2.2 ~ 9.5	174 ~ 219	5.0 ~ 21.0	8 ~ 13	
C	C1	25 ~ 50	1.074	0.043	2.5 ~ 3.5	1.0 ~ 3.5	4.5	113.80 (106 mm)	205.50 (191 mm)	123.30 (115 mm)	1 ~ 10	15 ~ 70	25 ~ 80	200 ~ 1000	0.01~0.05	4.5 ~ 9.5	240 ~ 1100	1.0 ~ 19.2	12 ~ 735	Area is moderately suitable for further development of Shallow/deep tube- well (sinking of STW/DTW side by side whithin the same area is not advisable). Installation of well within the range of 30m to 106 m depth is not advisable in the salinity problem area like Chandpur, Kachua, barura, Saharasti.
	C2		1.018	0.044	3.5 ~ 6.0	1.0 ~ 4.5	5.0	145.50 (142 mm)	223.90 (220 mm)	134.40 (132 mm)		15 ~ 45		200 ~ 750		2.8 ~ 7.0	145 ~ 1.100	1.0 ~ 7.0	3 ~ 735	
	C3		630.00	0.042		3.5 ~ 4.5	7.0	92.40 (147 mm)	185.20 (294 mm)	111.10 (176 mm)		15 ~ 70	50 ~ 80	325 ~ 750	0.01~0.04	2.8 ~ 6.7	145 ~ 339	1.0 21.0	3 ~ 390	
	C4		431.00		6.0 ~ 15.0	4.5 ~ 6.5	9.5	111.30 (258 mm)	172.00 (399 mm)	103.20 (239 mm)	6 ~ 28	15 ~ 45		325 ~ 450	0.04~0.05	2.8 ~ 3.9	174 ~ 347	8.0 ~ 10.0	8 ~ 18	Area is suitable for further development of DTW. Water quality is suitable for irrigation.
D	D1	0 ~ 25	365.00	0.046	2.5 ~ 6.0	1.0 ~ 4.5	5.0	47.00 (128 mm)	70.10 (192 mm)	42.10 (115 mm)	1 ~ 6	15 ~ 70	15 ~ 80	498 ~ 670	0.01~0.13	2.2 ~ 9.6	174 ~ 1.105	1.2 ~ 21.0	8 ~ 60	Area moderately suitable for further development of Shallow/deep tube-well (sinking of STW/DTW side by side within the same area is not advisable). Installation of well within the range of 30m to 106m depth is not advisable in the salinity problem area like Kachua, Matlab, Daudkandi.
	D2		1.237	0.047	3.5 ~ 6.0		5.0	240.60 (194 mm)	290.70 (235 mm)	174.40 (141 mm)			15 ~ 25	450 ~ 670	0.001~0.023	3.7 ~ 6.8	164 ~ 1.235	1.2 ~ 21.0	10 ~ 28	
	D3		240.00	0.038	2.5 ~ 3.5	1.0 ~ 3.5	4.0	24.20 (101 mm)	36.50 (152 mm)	21.90 (91 mm)	10 ~ 28	45 ~ 70		550 ~ 670	0.01~0.023	6.0 ~ 7.0	213 ~ 339	1.0 ~ 5.0	13 ~ 38	Area is moderately suitable for further development of shallow/deep tube- well (sinking of STW/DTW side by side within the same area is not advisable). Most of the area has good water quality than other parts of the district.
	D4		120.00	0.031	3.5 ~ 6.0	3.5 ~ 4.5	5.5	14.80 (123 mm)	20.10 (167 mm)	12.50 (104 mm)	1 ~ 28	15 ~ 70	15 ~ 80	450 ~580	0.01 ~ 0.13	2.2 ~ 9.6	174 ~ 339	1.0 ~ 5.0	8 ~ 39	

Notes :

1. Composite Aquifer : Comprises of the layer from the bottom of the upper silte and clay up to the top of main aquifer, a finer aquifer exists consisting of very fine sand interbedded and mixed with fine sand and silt and clay. Thickness of such aquifer varies from 13m to 63m (with few exception). Hand tube wells and dug wells are generally tapping water from this aquifer limited supply.

2. Main Aquifer : is situated below the composite aquifer which is a layer of medium sand with some fine sand. The thiskness of this aquifer varies from 15m to 20m (with few exceptions) STWs/DTWs are generally developmed in this zone.

3 (a) Zone : Bangladesh has been classifed into 4-broad zones based on percent thickness of coarser materials (main aquifer) Viz, A = 75 to 100%, B = 50 to 75%, C = 25 to 50% and D = 0 to 25%.

3 (b) Sub-Zone : is based on maximum depth to water table from land-surface water table fluctuation, thickness of upper silt and clay depth to top of main aquifer.

4. The study is based on available hydrogeological data, may be improved with availability of more data.

5. The spacing of tube well may be based on actual and/or potential recharge (Col. 9 to 11), aquifer characteristic (Col. 15 to 17) and existing Govt. policies.

6. Normally development of ground water by shallow and hand tube well by suction lift pumps is possible approximately up to 6 meter depth from land surface. For existing ground water below this depth up to expected potential recharge (Rp) limit upto approximately 8 to 9 meters, deep tube weel with turbine/submersible pump will be necessary.

7. Available recharge has been considered as 60% of potential recharge which means 40% of water has been lost before starting of the irrigation season in January as revealed from ground water level hydrographs.

8. Potential recharge has been calculated on the basis of maximum fluctuation attained or expected to attained.

9. Chemical Qualities : (MRL : Maximum Recommended Limit) << For drinking water and irrigation water >>

   (a) Iron (Fe) : 1 PPM Bangladesh Standard.
   0.1 PPM WHO Standard.

   (b) Chloride (Cl) : 600 PPM Bangladesh Standard.
   200 PPM WHO Standard

   (c) TDS : 1500 PPM Bangladesh Standard
   500 PPM WHO Standard

Table F.1.12 Concentration of Iron(Fe), Chloride(Cl) and TDS in PPM

LOCATION (Upazila)	Depth : 0 ~ 30 m			Depth : 30 ~ 60 m			Depth : 61 ~ 110 m			Depth : Above 100 m		
	Iron (Fe) PPm	Chloride (Cl) PPm	TDS PPm	Iron (Fe) PPm	Chloride (Cl) PPm	TDS PPm	Iron (Fe) PPm	Chloride (Cl) PPm	TDS PPm	Iron (Fe) PPm	Chloride (Cl) PPm	TDS PPm
BARURA	1.0 ~ 4.0	-	-	1.45	45	487	0.50	20 ~ 357	175	-	-	-
CHANDPUR	2.1	200	1,170	2.1	450	2,030	7.3 ~ 7.8	171 ~ 347	442 ~ 776	3.0 ~ 7.7	35 ~ 135	250 ~ 549
DAUDKANDI	0.2 ~ 3.5	56 ~ 275	375~1235	0.2 ~ 7.3	36 ~ 56	375 ~ 386	1.1 ~ 4.5	68 ~ 125	277 ~ 715	-	-	-
HAJIGANJ	-	-	-	-	-	-	3.2 ~ 7.8	111 ~ 230	394 ~ 637	-	-	-
HAIMCHAR	-	-	-	-	-	-	2.2	240	313	5.6	-	-
HOMNA	-	-	-	-	-	-	2.7	12	163	-	-	-
KACHUA	-	-	-	-	-	-	0.2 ~ 4.5	26 ~ 595	402 ~ 1105	-	-	-
LAKSAM	2.6 ~ 7.3	12 ~ 38	193 ~ 343	-	-	-	0.3 ~ 4.8	16 ~ 25	130 ~ 641	-	-	-
MATLAB	-	-	-	9.0	16	80	0.90	61 ~ 237	351 ~ 780	2.5	16.0	312.0
MURADNAGAR	-	-	-	1.4 ~ 5.9	18 ~ 52	348 ~ 440	4.10	8	183	-	-	-
SAHARASTI	-	-	-	-	-	-	1.5 ~ 2.5	375 ~ 610	1332~1570	3.80	79	312

1) IRON (Fe)
MRL (Maximum Recommended Limit)
IPPM Bangladesh Standard
1 PPM WHO Standard

2) Chloride (Cl)
MRL
600 PPM Bangladesh Standard
200 PPM WHO Standard

3) TDS (Total Dissolved Solids
MRL
1500 PPM Bangladesh Standard
500 PPM WHO Standard

Table F.2.1 Mechanized Minor Irrigation Devices in Bangladesh

Devices	Number's in Operation (x 1,000)				Irrigatied Area (x 1,000) ha				Increase Ratio of Irrigated area (x 1,000)			
	1974/75	1979/80	1984/85	1989/90	1974/75	1979/80	1984/85	1989/90	1974/75	1979/80	1984/85	1989/90
DTW	2.7	9.8	20.3	28.5	47.7	235.8	428.5	604.6	100	494	898	1268
STW	4.0	23.1	121.0	199.4	14.2	113.0	588.0	904.2	100	796	4141	6368
LLP	35.5	37.4	50.7	58.2	526.7	606.2	459.9	942.8	100	115	87	179
Total	42.2	70.3	192.0	286.1	588.6	955.0	1476.4	2451.6	100	162	251	417
Irrigated Area (%)					% 6.5	% 10.6	% 16.3	% 27.1	-	-	-	-

Total area in Bangladesh A = 14,340 x 1,000 ha (143,400 km2)

Net Area of Cultivated Land A = 9,030 x 1,000 ha (90,300 km2) (1989/90)

Table F.2.2 Mechanized Minor Irrigation Devices in Comilla, Chandpur and Brahmanbaria Districts
(Old Comilla District)

Devices	District Name	Nubmbers in Equipment (x 1,000)			Irrigatied Area (x 1,000 ha)			Increase Ratio of Irrigated Area		
		1979/80	1984/85	1989/90	1979/80	1984/85	1989/90	1979/80	1984/85	1989/90
								%	%	%
DTW	Comilla	0.90	1.26	1.23	22.9	31.7	32.0	100	138	140
	Chandpur	0.03	0.10	0.08	0.7	2.5	1.9	"	-	-
	Brahmanbaria	0.18	0.47	0.82	4.7	11.2	70.0	"	238	426
STW	Comilla	2.98	3.46	3.96	13.5	11.9	16.4	"	88	121
	Chandpur	0.03	0.06	0.19	0.1	0.2	0.8	"	-	-
	Brahmanbaria	0.93	1.37	2.41	4.0	5.0	10.2	"	125	255
LLP	Comilla	1.72	2.08	2.82	25.1	28.4	36.5	"	113	145
	Chandpur	1.32	1.73	2.20	18.7	25.2	31.3	"	135	167
	Brahmanbaria	1.79	2.20	2.65	26.2	29.3	36.5	"	112	139
Total	Comilla	5.60	6.80	8.01	61.5	72.0	84.9	"	117	138
	Chandpur	1.38	1.89	2.47	19.5	27.9	34.0	"	143	174
	Brahmanbaria	2.90	4.04	5.88	34.9	45.5	66.7	"	130	191
GRAND TOTAL		9.9	12.7	16.4	115.9	145.4	185.6	100	125	160
					%	%	%			
Comilla	Irrigated Area (%)				21	24	28	-	-	-
Chindpur	"				13	19	24	-	-	-
Brahmanbaria	"				19	26	36	-	-	-
					%	%	%			
GRAND TOTAL	Irrigated Area (%)				19	23	30	-	-	-

- District Area : Comilla A = 309.3 x 1,000 ha
  Chandpur A = 170.4 x 1,000 ha 671.3 x 1,000 ha
  Brahmanbaria A = 191.6 x 1,000 ha (6,713 km2)

- Agriculture Land Area : Comilla A = 299.1 x 1,000 ha
  Chandpur A = 144.7 x 1,000 ha 620.8 x 1,000 ha
  Brahmanbaria A = 185.0 x 1,000 ha (6,208 km2)

Table F.2.3 (a) Minor Irrigation DTW, STW and LLP (Total Bangladesh)

Year	No. of DTW	Total Area Irrigated (Acre)	Average Command Area		Remarsk
			Acre	Ha	
1967-68	102	4,117	40.4	16.4	
1968-69	380	16,080	42.30	17.10	
1969-70	980	32,070	32.70	13.20	
1970-71	796	32,070	40.30	16.30	
1971-72	906	29,330	32.40	13.10	
1972-73	1,237	37,776	30.50	12.30	
1973-74	1,494	61,456	41.10	16.60	
1974-75	2,699	117,854	43.70	17.70	
1975-76	3,828	153,747	40.20	16.30	
1976-77	4,461	164,198	36.80	14.90	
1977-78	7,453	338,474	45.40	18.40	
1978-79	9,329	504,340	54.10	21.90	
1979-80	9,795	582,298	63.0	25.5	
1980-81	12,400	925,183	60.3	24.4	
1981-82	12,810	704,550	55.0	22.3	
1982-83	11,721	839,097	57.0	23.1	
1983-84	16,438	1,002,718	61.0	24.7	
1984-85	20,348	1,058,096	52.0	21.1	
1985-86	22,393	1,254,008	56.0	22.7	
1986-87	23,481	1,361,898	58.0	23.5	
1987-88	24,657	1,134,222	46.0	18.6	
1988-89	26,443	1,401,479	53.0	21.5	
1989-90	28,485	1,492,735	51.0	20.6	

Source : BRDB, BADC

Table F.2.3 (b) Minor Irrigation DTW, STW and LLP (Total Bangladesh)

Year	No. of STW	Total Area Irrigated (Acre)	Average Command Area		Remarsk
			Acre	Ha	
1971-72	685	NA	-	-	
1972-73	1,324	NA	-	-	
1973-74	1,252	NA	-	-	
1974-75	4,029	35,052	8.70	3.50	
1975-76	5,179	31,074	6.00	2.40	
1976-77	5,402	31,332	5.80	2.30	
1977-78	12,325	112,158	9.10	3.70	
1978-79	17,036	180,582	10.70	4.30	
1979-80	23,061	279,038	21.1	4.9	
1980-81	26,735	321,497	12.0	5.9	
1981-82	41,300	462,560	11.2	4.5	
1982-83	64,290	752,193	11.7	4.7	
1983-84	98,440	1,082,840	11.0	4.5	
1984-85	120,980	1,451,760	12.0	4.9	
1985-86	145,322	1,655,631	11.4	4.6	
1986-87	158,899	1,779,669	11.2	4.5	
1987-88	176,232	2,114,784	12.0	4.9	
1988-89	185,742	2,191,756	11.8	4.8	
1989-90	199,358	2,232,809	11.2	4.5	

Source : BRDB, BADC

Table F.2.3 (c) Minor Irrigation DTW, STW and LLP (Total Bangladesh)

Year	No. of LLP	Total Area Irrigated (Acre)	Average Command Area		Remarsk
			Acre	Ha	
1967-68	6,558	317,903	48.5	19.60	
1968-69	10,852	430,052	39.60	16.00	
1969-70	17,846	642,752	36.00	14.60	
1970-71	24,483	889,809	36.30	14.70	
1971-72	24,243	883,941	36.50	14.80	
1972-73	32,917	1,218,766	37.00	15.00	
1973-74	35,343	1,330,810	37.70	15.30	
1974-75	35,534	1,300,507	36.60	14.80	
1975-76	36,382	1,312,577	36.10	14.60	
1976-77	28,224	1,034,328	36.60	14.80	
1977-78	36,730	1,300,000	35.40	14.30	
1978-79	35,895	1,436,212	40.00	16.20	
1979-80	37,389	496,802	40.00	16.20	
1980-81	36,049	1,370,421	38.00	15.40	
1981-82	41,354	1,461,700	35.00	14.20	
1982-83	43,039	1,365,840	32.00	13.00	
1983-84	43,615	1,031,395	24.00	9.70	
1984-85	50,661	1,135,600	22.00	8.90	
1985-86	51,242	1,229,953	24.00	9.70	
1986-87	37,489	927,760	24.90	10.10	
1987-88	40,554	1,001,643	24.70	10.00	
1988-89	50,103	1,753,605	35.00	14.20	
1989-90	58,200	2,328,000	40.00	16.20	

Source : BRDB, BADC

Table F.2.4 (a) Minor Irrigation DTW, STW and LLP (District Level))

Year	1. Comilla District				2. Chandpur District				3. Brahmanbaria District			
	No. of DTW	Total Area Irrigated (Acre)	Average Command Area		No. of DTW	Total Area Irrigated (Acre)	Average Command Area		No. of DTW	Total Area Irrigated (Acre)	Average Command Area	
			Acre	ha			Acre	ha			Acre	ha
1979-80	899	56637	63.0	25.5	27	1674	63.0	25.1	183	11529	63.0	25.5
1980-81	981	61803	63.0	25.5	51	3060	60.0	24.3	197	12214	62.0	25.1
1981-82	1053	64233	61.0	24.7	64	3904	61.0	24.7	221	13481	61.0	24.7
1982-83	1197	77805	65.0	26.3	73	4599	63.0	25.5	357	22491	63.0	25.5
1983-84	1235	72865	59.0	23.9	87	5307	61.0	24.7	409	23722	58.0	23.5
1984-85	1263	78306	62.0	25.1	103	6077	59.0	23.9	468	27612	59.0	23.9
1985-86	1269	79947	63.0	25.5	107	6099	57.0	23.1	489	27873	57.0	23.1
1986-87	1295	77700	60.0	24.3	101	6060	60.0	24.3	487	29220	60.0	24.3
1987-88	.1) 1335	74700	56.0	22.7	.2)108	5832	54.0	21.9	.3) 466	24698	53.0	21.5
1988-89	1409	76086	54.0	21.9	116	6032	52.0	21.1	689	35828	52.0	21.1
1989-90	1234	78976	64.0	26.0	80	4800	60.0	24.3	821	49260	60.0	24.3

The figure incluids DTW sunk under rental basis as follows :
.1) : 844, .2) : 51, .3) : 271
Source : BRDB

Table F.2.4 (b) Minor Irrigation DTW, STW and LLP (District Level))

Year	1. Comilla District				2. Chandpur District				3. Brahmanbaria District			
	No. of STW	Total Area Irrigated (Acre)	Average Command Area		No. of STW	Total Area Irrigated (Acre)	Average Command Area		No. of STW	Total Area Irrigated (Acre)	Average Command Area	
			Acre	ha			Acre	ha			Acre	ha
1979-80	2980	33376	11.2	4.5	30	330	11.0	4.5	927	9919	10.7	4.3
1980-81	2999	29990	10.0	4.0	37	370	10.0	4.1	1092	11138	10.2	4.1
1981-82	3152	30574	9.7	3.9	45	441	9.8	4.0	1187	11277	9.5	3.8
1982-83	3203	29467	9.2	3.7	49	475	9.7	3.9	1201	11650	9.7	3.9
1983-84	3392	28492	8.5	3.4	52	484	9.3	3.8	1290	11997	9.3	3.8
1984-85	3455	29367	8.9	3.6	57	519	9.1	3.7	1367	12440	9.1	3.7
1985-86	3495	28659	8.2	3.3	76	676	8.9	3.6	1674	14731	8.8	3.6
1986-87	3639	28748	7.9	3.2	91	746	8.2	3.3	1509	12977	8.6	3.5
1987-88	3452	37520	10.0	4.0	116	858	7.4	3.0	1231	8863	7.2	2.9
1988-89	3819	37808	9.9	4.0	167	1635	9.9	4.0	1368	13680	10.0	4.1
1989-90	3964	40432	10.2	4.1	185	1942	10.5	4.3	2414	25106	10.4	4.2

Source: BRDB

Table F.2.4 (c) Minor Irrigation DTW, STW and LLP (District Level))

Year	1. Comill District				2.Chandpur District				3. Brahmanbaria District			
	No. of LLP	Total Area Irrigated (Acre)	Average Command Area		No. of LLP	Total Area Irrigated (Acre)	Average Command Area		No. of LLP	Total Area Irrigated (Acre)	Average Command Area	
			Acre	ha			Acre	ha			Acre	ha
1979-80	1719	61884	36.0	14.6	1322	46270	35.0	14.1	1794	64584	36	14.6
1980-81	1813	63455	35.0	14.1	1427	51372	36.0	14.6	1877	66070	35.2	14.3
1981-82	1897	64877	34.2	13.9	1501	52535	35.2	14.3	1908	68688	36	14.6
1982-83	1936	65824	34.0	13.8	1598	55770	34.9	14.1	2087	66993	32.1	13.0
1983-84	1999	72163	36.1	14.7	1687	59045	35.0	14.1	2103	72133	34.3	13.9
1984-85	2078	70236	33.8	14.1	171	62316	36.0	14.6	2195	72435	33	13.3
1985-86	2291	71479	31.2	12.6	1951	72382	37.1	15.0	2215	77525	35	14.1
1986-87	2187	65172	29.8	12.1	2112	80678	38.2	15.5	2102	75672	36	14.6
1987-88	2004	48497	24.2	9.8	2240	69440	31.0	12.6	2042	57176	28	11.3
1988-89	2309	69270	30.0	12.1	2239	8321	9.0	11.7	2329	69870	30.0	2.1
1989-90	2816	90112	32.0	13.0	2197	77334	35.2	14.3	2654	90236	34	13.8

Source : BRDB

Table F.2.5 Total Irrigated Area of Minor Irrigation Practices

(Year : 1989/90)
Unit : ha

Items / Upazila	Uupazla Total Area (A)	Agriculture Land				Irrigated Area (C)	B/A (%)	C/B (%)	Cropping Intensity (%)
		Single Crop Area	Double Crop Area	Triple Crop Area	Total (B)				
KACHUA	23,600	11,400	6,500	1,200	19,100	6,800 (5,400)	81	36 (28)	147
DEBIDWAR	23,900	800	11,900	6,900	19,600	8,200 (8,200)	82	42 (4)	231
BANCHARAMPUR	20,700	3,400	11,500	3,600	18,500	7,400 (7,300)	89	40 (39)	201
NABINAGAR	33,500	7,200	16,000	4,200	27,400	10,000 (9,700)	82	36 (35)	189
TOTAL	101,700	22,800	45,900	15,900	84,600	32,400 (30,600)	83	38 (36)	192

- Exclude in Khas land,River Canal,Pond,Home stead,water body and Road etc.
- Value of ( ) exclude the mannual type irrigated area.

Table F.2.6 Irrigated Practices by Equipment Type(Year 1989/90)

a) DTW, STW, LLP

Area : Acre (ha)

Items / Upazila	DTW			STW			LLP			Total
	Number	Total Irri-Area	Average Irri-Area	Number	Total Irri-Area	Average Irri-Area	Number	Total Irri-Area	Average Irri-Area	Irri-Area
		Acre	Acre		Acre	Acre		Acre		Acre
KACHUA	61	4,200 (1,700)	70 (28)	13	200 (80)	15 (6)	293	8900 (3,600)	30 (12)	13300 (5,380)
DEBIDWAR	92	5,900 (2,400)	64 (26)	428	6,900 (2,800)	16 (6)	192	7,400 (3,000)	38 (15)	18,800 (8,200)
BANCHARAMPUR	16	1,300 (520)	80 (32)	440	5,200 (2100)	12 (5)	350	11,600 (4700)	32 (13)	18100 (7320)
NABINAGAR	26	1,300 (530)	50 (20)	173	2,500 (1000)	15 (6)	540	20,300 (800)	37 (15)	24100 (9730)

b) Mannual Type

Items / Upazila	Swing Basket			Dhoon			Rower Pump			Total
	Number	Total Irri-Area	Average Irri-Area	Number	Total Irri-Area	Average Irri-Area	Number	Total Irri-Area	Average Irri-Area	Irri-Area
					Acre	Acre		Acre		Acre
KACHUA	-	-	-	1,169	3,500 (1400)	3 (1.2)	-	-	-	3500 (1400)
DEBIDWAR	-	-	-	-	-	-	-	-	-	-
BANCHARAMPUR	-	-	-	-	-	-	730	240 (100)	0.3 (0.1)	240 (100)
NABINAGAR	245	500 (200)	2 (0.9)	72	300 (120)	5 (2)	-	-	-	800 (320)

source : Information form Upazila and BADC Officer

Table F.2.7 Supplied Equipment Type Numbers of Each Year

a) DTW Q = 2 cf = 57 l/s

Items / Upazila	Type	>1986	1987	1988	1989	1990	Total
KACHUA	Diesel	23	23	33	52	65	
	Electric	3	4	6	8	8	73
DEBIDWAR	Diesel						
	Electric			N A			
BANCHARAMPUR	Diesel	-	-	-	-	16	
	Electric	-	-	-	-	-	16
NABINAGAR	Diesel	13	13	13	23	35	
	Electric	1	1	1	1	1	36

b) STW

Items / Upazila	Discharge	Type	>1986	1987	1988	1989	1990	Total
KACHUA	0.5~ Q=0.75 cfs =14~211/s	Diesel	12	12	12	12	12	
		Electric	-	-	-	-	1	13
DEBIDWAR	- do -	Diesel	382	384	388	408	408	
		Electric	5	7	11	20	20	428
BANCHARAMPUR	0.5~ Q=0.75 cfs =14~211/s	Diesel					334	
		Electric	NA	NA	NA	NA	6	440
NABINAGAR	0.5~ Q=0.75 cfs =14~211/s	Diesel	125	147	171	204	222	
		Electric	-	-	-	-	-	222

c) LLP

Items / Upazila	Discharge	Type	>1986	1987	1988	1989	1990	Total	
KACHUA	Q=0.5 cfs = 14 1/s	Diesel	68	120	184	186	186		
		Electric	0	0	0	0	20	206	
	Q=1 cfs = 28 1/s	Diesel	52	50	55	56	74		293
		Electric	13	13	13	13	13	87	
DEBIDWAR	Q=1 cfs = 28 1/s	Diesel	45	48	53	68	68		
		Electric	2	2	4	9	9	77	
	Q= 2 cfs = 57 1/s	Diesel	74	82	94	103	103		192
		Electric	12	12	12	12	12	115	
BANCHARAMPUR	Q=1 cfs = 28 1/s	Diesel					150		
		Electric	NA	NA	NA	NA	-	150	
	Q= 2 cfs = 57 1/s	Diesel					150		350
		Electric	NA	NA	NA	NA	28	200	
NABINAGAR	Q=1 cfs = 28 1/s	Diesel	151	153	142	160	180		
		Electric	-	-	-	-	-	180	
	Q= 2 cfs = 57 1/s	Diesel	274	282	290	320	295		540
		Electric	24	30	38	40	65	360	

Source : Information from Upazila and BADC officer

Table F.2.8 Area Served and Farmers Distribution per Pump (1989/90)

a) DTW Q = 2 cf = 57 l/s

Items / Upazila	Average Served Area	Number of Farmer	Number of Operated well	Average Irri-Area Per farmer (ha/farmer)	Not Operated Well	Remarks
KACHUA	Area 60 ~ 80 (24~32 ha)	70 ~ 100	61	0.3	12	Not Operated well : -Pump Trouble -Not Operated Covered Area A = 1,700 ha Two crop = Boro, T Aman, wheat
DEBIDWAR	Area 50 ~ 70 (20~28 ha)	70 ~ 80	92	0.3	15	Not Operated well : -Pump Trouble 7 - Abandoned 2 (Sand deposit) - Not Opeated 6 Covered Area A = 2,400 ha
BANCHARAMPUR	Acre 80 (32 ha)	100~175	16	0.2	-	Covered Area A = 520 ha (One Crop = Boro)
NABINAGAR	Acre 25(10 ha)	8 60~165	1 5	0.1	10	Not Operated well : -Pump Trouble 3 - Abandoned 2 (gas Trouble) - Not Operated 5 Covered Area A = 530 ha (One Crop = Boro)
	Acre 60 (24 ha)	75~165	20	0.2		

b) STW (Q=0.5 ~ 0.75 cfs = 14 l/s ~ 21 l/s)

Items / Upazila	Average Served Area	Number of Farmer	Number of Operated well	Average Irri-Area Per farmer (ha/farmer)	Total Covered Area	Not Operated Well	Remarks
KACHUA	Acre 12 ~ 17 (5 ~ 7 ha)	15~30	13	0.2	80 ha Two Crop : Boro, T. Aman, wheat	-	
DEBIDWAR	Acre 12 ~ 15 (5 ~ 6 ha)	15~20	428	0.3	2,800 ha Two Crop : Boro, T. Aman, wheat	-	
BANCHARAMPUR	Acre 10 ~ 15 (4 ~ 6 ha)	20~40	440	0.2	2100 ha One Crop (Boro)	-	
NABINAGAR	Acre 5~10 (2~4 ha) 11~15 (4.1~6) 11~15 (4.1~6) 11~15 (4.1~6) 16~20 (6.1~8)	 20 ~30 20 ~30 31 ~40 41 ~60 50 ~70	 12 10 33 21 97 Total 173	0.1	1,000 ha One Crop (Boro)	49	Not Operated Well: -Engine Trouble 18 - Abandoned 31 (gas Trouble)

c) LLP

Items / Upazila	Discharge	Average Served Area	Number of Farmer well	Average Irri-Area Per farmer (ha/farmer)	Number of Operated Pump	Total Pump Numbers	Total Covered Area
KACHUA	Q=0.5cfs (14 l/s)	Acre 8~12 (3~5 ha)	10~12	0.4	32		3600 ha Two Crop : Boro, T. Aman Wheat
	Q=1 cfs (28 l/s)	Acre 20~30 (8~12 ha)	20 ~ 30	0.4	174	293	
	Q=2 cfs (57 ls)	Acre 40~60 (16~24 ha)	50 ~ 70	0.3	87		
DEBIDWAR	Q=1 cfs (28 l/s)	Acre 20~30 (8~12 ha)	20 ~ 30	0.4	77		3,000 ha Boro, T. Aman Wheat
	Q=2 cfs (57 ls)	Acre 40~50 (18~20 ha)	45 ~ 50	0.4	115	192	
BANCHARAMPUR	Q=1 cfs (28 l/s)	Acre 20~30 (8~12 ha)	30 ~ 50	0.3	150		4700 ha One Crop (Boro)
	Q=2 cfs (57 ls)	Acre 30~50 (12~20 ha)	50 ~ 125	0.2	200	350	
NABINAGAR	Q=1 cfs (28 l/s)	Acre	30 ~ 40	0.3	23		8200 ha One Crop (Boro)
		20~30 (8~12 ha)	50 ~ 70	0.2	157	180	
		30~40 (8~16)	50 ~120	0.2	39		
	Q=2 cfs (57 ls)	40~50 (16-0)	50 ~120	0.2	316		
		50~60 (20~29)	50 ~120	0.3	10	360	
						540	

Source : Information form Upazila and BADC Officer

Table F.2.9 Construction Cost and Water Charge of DTW, STW and LLP

Items / Upazila	Discharge	Average Depth of Well	Average Served Area	Total Construction Cost (Tk)	Cost per Acre (ha) Tk/Acre (ha)	Remarks
DTW	Q = 2 cfs = 57 l/s	90 m	Acre 60 (24 ha)	with steel screen 650,000 with PVC screen 550,000	10,800 (27,000)	
STW	Q = 0.5 ~ 0.75 cfs = 14~21 l/s	40 m	12 Acre (5 ha)	50,000	4,200 (10,000)	
LLP	Q = 1 cfs = 28 l/s	-	20 Acre (8 ha)	60,000	3,000 (7,500)	
	Q = 2 cfs = 57 l/s	-	40 Acre (16 ha)	90,000	2,300 (5,600)	

- Actual construction cost of DTW is Tk. 175,000 for about 70% of Govt. subsidy.

Items / Upazila	Upazila	Water Charge (Tk/Acre) 1989/90	1988/89	1987/88	Average Water Charge 1989/90	Remarks
DTW	KACHUA	1,300	1,300	1,300	(TK/ACRE)	
	DEBIDWAR	1,350	1,350	1,350		
	BANCHARMPUR	1,500	1,500	1,500		
	NABINAGAR	1,500	1,500	1,500	1,400	
STW	KACHUA	1,300	1,300	1,300		
	DEBIDWAR	1,800	1,650	1,650		
	BANCHARMPUR	1,500	1,500	1,400		
	NABINAGAR	1,800	1,800	1,700	1,500	
LLP	KACHUA	1,200	1,200	1,200		
	DEBIDWAR	1,200	1,200	1,200		
	BANCHARMPUR	1,200	1,200	1,100	1,200	
	NABINAGAR	900	900	850		

Source : Information form Upazila and BADC Officer

Table F.2.10 Annual Working Hours of DTW, STW and LLP

(One Crop : Boro Season Only)

Items / Upaazila	Upazila	Working Hours per Day (Average) Plant Period	Working Hours per Day (hr/day) Other Period	Annual Operation Hours (hr)	Average Operation Hours (hr)	Remarks
DTW	KACHUA	10	8	1,000		
	DEBIDWAR	14	12	1,400		
	BANCHARMPUR	16	12	1,600		
	NABINAGAR	15	8	1,200	1,200	
STW	KACHUA	12	10	1,200		
	DEBIDWAR	14	10	1,400		
	BANCHARMPUR	16	12	1,600		
	NABINAGAR	15	8	1,200	1,200	
LLP	KACHUA	14	10	1,400		
	DEBIDWAR	12	10	1,200		
	BANCHARMPUR	16	12	1,600	1,300	
	NABINAGAR	15	8	900		

Source : Information form Upazila and BADC Officer

Table F.2.11 Relationship between Ground Elevation and Land Area

(1) Bancharampur

Elevation (Meter in PWD)	Gross Area		Net Cultivated Area		Gross Area	Net Cultivated Area
	Area	Accumulation	Area	Accumulation	%	%
m	ha	ha	ha	ha		
0 ~ 1.5	1,200	1,200	-	-	6(0)	0(0)
1.5 ~ 2.1	800	2,000	800	800	10(4)	4(4)
2.1 ~ 3.0	6,300	8,300	6,300	7,100	40(30)	38(32)
3.0 ~ 4.0	6,800	15,100	6,800	13,900	73(33)	15(37)
4.0 ~ 4.6	3,600	18,700	3,100	17,000	90(17)	92(17)
4.6 ~ 5.5	2,000	20,700	1,500	18,500	100(10)	100(8)

(2) Nabinagar

Elevation (Meter in PWD)	Gross Area		Net Cultivated Area		Gross Area	Net Cultivated Area
	Area	Accumulation	Area	Accumulation	%	%
m	ha	ha	ha	ha		
0 ~ 1.5	2,200	2,200	-	-	7(7)	0(0)
1.5 ~ 2.1	3,400	5,600	3,400	3,400	17(10)	12(12)
2.1 ~ 3.0	7,600	13,200	7,600	11,000	39(22)	40(28)
3.0 ~ 4.0	8,800	22,000	8,800	19,800	66(27)	72(32)
4.0 ~ 4.6	5,400	27,400	3,700	23,500	82(16)	86(14)
4.6 ~ 6.5	6,100	33,500	3,900	27,400	100(18)	100(14)

(3) Kachua

Elevation (Meter in PWD)	Gross Area		Net Cultivated Area		Gross Area	Net Cultivated Area
	Area	Accumulation	Area	Accumulation	%	%
m	ha	ha	ha	ha		
0.5 ~ 2.4	400	400	-	-	2(2)	-(-)
2.4 ~ 3.0	3,600	4,000	3,600	3,600	17(15)	19(19)
3.0 ~ 3.7	9,200	13,200	8,300	11,900	56(39)	62(43)
3.7 ~ 4.6	5,800	19,000	4,400	16,300	81(25)	85(23)
4.6 ~ 5.5	4,600	23,600	2,800	19,100	100(19)	100(15)

(4) Debidwar

Elevation (Meter in PWD)	Gross Area		Net Cultivated Area		Gross Area	Net Cultivated Area
	Area	Accumulation	Area	Accumulation	%	%
m	ha	ha	ha	ha		
1.0 ~ 3.2	200	200	-	-	1(1)	-(-)
3.2 ~ 3.7	1,200	1,400	1,200	1,200	6(5)	6(6)
3.7 ~ 4.6	8,900	10,300	7,600	8,800	43(37)	45(39)
4.6 ~ 6.1	13,600	23,900	10,800	19,600	100(57)	100(55)

Table F.2.12 Schedule of Proposed Works of Gumti Phase II Sub-Project

Item		Unit	Quantity		Description	Sill Level
			FCD	FCDI		
1.	Embankments				Height :	
1.1	Titas/ Meghna	Km.	112.0	112.0	1.75 - 6.74 m	
1.2	Salda/ Buri	Km.	40.8	40.8	0.20 - 6.44 m	
1.3	Bijni	Km.	20.0	20.0	0.49 - 5.25 m	
1.4	Ghungur	Km.	25.4	25.4	0.00 - 4.65 m	
2.	Drainage Regulators				Height x Width	
2.1	Colonel Bazar	No. of gates	1	1	0.91m x 0.91m	7,16
2.2	Bijni	No. of gates	7	7	3.04m x 3.04m	0.50
2.3	Shibnagar	No. of gates	2	2	0.91m x 0.91m	0.50
2.4	Nat Ghat	No. of gates	2	2	0.91m x 0.91m	0.50
2.5	Chandai ghat	No. of gates	2	2	0.91m x 0.91m	0.50
2.6	N.W Polder at N'Nagar	No. of gates	6	-	3.04m x 3.04m	0.50
2.7	Buri	No. of gates	4	4	4.50m x 9.14m	0.50
2.8	W. Polder at N'nagar	No. of gates	6	-	3.04m x 3.04m	0.50
2.9	Mukta Rampur	No. of gates	2	2	1.82m x 1.52m	0.50
2.10	Homna	No. of gates	5	-	4.50m x 9.14m	0.50
2.11	Batakandi	No. of gates	2	2	1.82m x 1.52m	0.50
2.12	Lalpur	No. of gates	2	2	1.82m x 1.52m	0.38
2.13	Mirpur	No. of gates	2	-	0.91 x 0.91m	0.50
3.	Primary Pump Stations					
3.1	Nabinagar East	m^3/s	-	18.75	3 @ 6.25	- 3.50
3.2	Nabinagar West	m^3/s	-	31.25	5 @ 6.25	- 3.50
3.3	Homna	m^3/s	-	50.0	8 @ 6.25	- 4.00
3.4	Mohanpur	m^3/s	-	4.50	2 @ 2.25	- 3.30
4.	Re-lift Pump stations					
4.1	Ghungur	m^3/s	-	9.00	3 @ 3.00	1.18
4.2	Bijni	m^3/s	-	4.00	4 @ 1.00	1.18
4.3	Arshi Nadi	m^3/s	-	4.00	4 @ 1.00	1.06
4.4	Oder Khal	m^3/s	-	12.00	4 @ 3.00	1.63
4.5	Jamuna	m^3/s	-	12.00	4 @ 3.00	0.76
5.	Check Structures					
5.1	Major Checks	No.	2	9	From 2.62 to 0.38	
5.2	Checks/ irr. controls	No.	-	6	From 3.50 to 2.00	
5.3	Minor checks	No.	-	27		
6.	Irrigation offtakes					
6.1	Inlet-cum-aqueduct	No.	-	6	3.00	
6.2	Inlets	No.	-	2	2.00	
6.3	Irrigation Offtakes	No.	-	9	-	
7.	Roads					
7.1	Roads on Embankments	Km.	85	92.8		
7.2	New Roads	Km.	7.7	48.9		