(2) Crop coefficient

Crop coefficient should be locally obtained through field measurement by crops. For calculation of crop consumptive use, 10-day basis coefficients are averaged by four (4) crop growing stage as summarized below on the basis of the recommended crop coefficient by MPO.

Name of Crop	Initial Stage	Crop Develop.	Mid Season	Late Season
HYV Aus	1.10	1.10	1.03	0.85
HYV Aman	1.10	1.10	1.08	0.90
HYV Boro	1.10	1.12	1.27	1.06
LT Aman	1.10	1.10	1.10	0.95
LT Boro	1.10	1.16	1.27	0.98
HYV Wheat	0.59	1.05	1.10	0.69
Potato	0.58	1.12	1.13	0.92
Pulses	0.64	1.07	1.11	0.86
Mustard	0.56	1.14	1.14	0.92
Vegetables	0.55	1.00	1.00	0.98

(3) Consumptive use and on-farm irrigation requirement

Effective rainfall is also estimated based on an empirical formula recommended by FAO; the rainfall data in the fourth drought year for recent 20 years is applied for this estimate in consideration of drought frequency for irrigation plan. About 68 % of annual rainfall is effective for crop cultivation, but mostly concentrated during the monsoon season; the effective rainfall during the dry winter season is almost negligibly small. The crop consumptive use is then balanced by effective rainfall to get on-farm irrigation requirement for upland crops during the dry-winter season (Rabi).

With regards to the on-farm irrigation requirement for paddy crops, the crop consumptive use is further balanced by percolation, requirement for land preparation and that for nursery treatment before transplanting. The following assumptions are made in advance of calculation of the on-farm irrigation requirement for paddy cultivation:

i) Nursery : 10 % of transplanting field,
ii) Land preparation : 180 mm
iii) Land preparation period : 20 days
iv) Percolation rate in paddy : 3.0 mm.

The estimated annual on-farm requirement for paddy crop ranges from 1,014 mm for Boro crop during the dry-winter season to 331 mm for Aus crop during the monsoon season. While, that for Rabi crop ranges from 324 mm for potato to 237 mm for mustard.

Peak on-farm requirement for paddy crop is usually caused by land preparation in pre-transplanting period; it ranges from 14.7 mm for Boro crop during the dry-winter season to 9.9 mm for Aman crop during the monsoon season. Meanwhile, the peak on farm requirement for Rabi crop ranges from 4.6 mm for pulses to 3.3 mm for potato.

(4) Composite water requirement by cropping intensity

Seasonal on-farm irrigation requirement by crop would be composed by weighting cropping intensity in accordance with the proposed cropping calendar. Table 6.2.1 shows a composite sheet for the irrigation water requirement. The following equation is applied for the computation:

$$IRc = Lg \times Ac \times IRo$$

where,
- IRc : Composite requirement (mm/day)
- Lg : Percent of land grade (%)
- Ac : Percent of cropped area (%),and
- IRo : 10-day basis on-farm requirement by crop.(mm/day).

Peak consumptive use of 5.67 mm occurs in the middle of March. This is caused mainly by land preparation for Boro crops, development stage of Rabi crops, high evapotranspiration, and very few effective rainfall.

(5) Unit field irrigation requirement and unit diversion requirement

Application efficiency (Ea) of 0.62 is applied for getting a field requirement, taking level border irrigation practice for paddy cultivation and furrow irrigation practice for upland crops (Rabi) into account. As shown in Table 6.1.1, the peak field requirement of 9.14 mm/day for the proposed cropping pattern occurs in the middle of March.

Distribution efficiency (Ed) is composed of multiplication of field canal efficiency (Eb) and conveyance efficiency (Ec), or Ed = Eb x Ec. The distribution efficiency of 0.64 is applied making reference to FAO publication in order to obtain unit diversion requirement. As shown in Table 6.2.1, the peak unit diversion requirement for the Project,

which occurs in mid. March, is estimated to be 14.29 mm/day or 1.65 l/sec/ha. The annual unit diversion requirement for the overall crop intensity of 224 % amounts to 2,206 mm.

6.1.3 Irrigable area by surface water resources

Irrigable area by surface water resources would be determined dividing the minimum available water resources of 30 m^3/sec by the peak unit diversion requirement of 1.65 l/sec/ha in mid. March. The irrigable area is estimated to be 18,180 ha.

6.1.4 Irrigable area by groundwater resources

(1) Selection of groundwater exploitation mode

Groundwater development will be made by farmers at private initiative. Groundwater resources can be developed for irrigation through different modes like HTW/DTW/STW. Although selection of development mode should be the farmer's option, STW is tentatively selected to estimate a potential irrigable area by groundwater. The proposed project will include the establishment of demonstration farms where various modes of groundwater development will be demonstrated and tested. The demonstration farms will provide the farmers with appropriate technologies suited to their specific needs.

(2) Groundwater dependent area

Agricultural land which should be irrigated by groundwater is balanced at 13,530 ha, as shown below :

Items / Area	Classification of Project Area			Total Area (ha)
	Northwest (ha)	Central (ha)	South (ha)	
(1) Farmland	10,340	26,290	6,170	42,800
(2) Existing Irrigation Area				
1) by DTW	660	3,000	910	4,570
2) by STW	1,460	3,250	520	5,230
3) Total	2,120	6,250	1,430	9,800
(3) Existing Rainfed Area, (1) - (2)	8,220	20,040	4,740	33,000
(4) Surface Irrigation Area	0	18,180	0	18,180
(5) Project area by FAP-9A	0	1,290	0	1,290
(6) Groundwater Dependent Area (3) - (4) -(5)	8,220	570	4,740	13,530

(3) Assumptions for estimation of irrigable area by STW

The following criteria is adopted for STW development :

1) Pumping capacity of STW

A standard 0.5 csc (14.16 l/sec) mixed-flow pump would be installed for the proposed STWs.

2) Irrigation period and consumptive use

Irrigation period is assumed from 2nd January to 1st May or 120 days a year. Total consumptive use during the dry season of 120 days is 457 mm and the peak consumptive use is 5.67 mm per day in the middle of March (Table 6.1.1).

3) Operation hours and irrigation efficiency

Operation hours of STWs are assumed at 10 hours/day according to the current operation. Irrigation efficiency is assumed to be 62% for application and 90% for distribution.

4) Pumping duty

Pumping duty is obtained from 10 hour operation a day, peak consumptive use of 5.67 mm, application efficiency of 0.62 and distribution efficiency of 0.90.
5.67 / 0.62 / 0.90 x 10,000 x 24 / 10 / 86,400 = 2.823 l/sec/ha

5) Unit irrigable area by STW

Unit irrigable area per STW = Pumping capacity / Pumping duty
14.16 / 2.823 = 5.0 ha / well

6) Allowable spacing of DTW /STW

The present spacing rule given by BADC is as follow :

for DTW :	760 m	(2,500 ft)
for STW :	244 m	(800 ft)

Thus, one DTW can be installed in every 58 ha (760 m x 760 m), and STW in every 6 ha (244 m x 244 m) in principle.

(4) Estimation of irrigable area by STW

Irrigable area by STW is estimated under the assumptions mentioned above, to be 7,940 ha in total, including 570 ha in the central area as shown below :

Items / Area		Classification of Project Area			Total Area
		Northwest	Central	South	
(1) Nos of Existing DTW / STW					
1) by DTW	(nos)	34	155	47	236
2) by STW	(nos)	365	813	130	1,308
(2) Allowable Spacing					
1) DTW	(ha)	58	58	58	(58)
2) STW	(ha)	6	6	6	(6)
(3) Catchment Area of Existing STW / DTW, (1) x (2)					
1) DTW	(ha)	1,970	8,990	2,730	13,690
2) STW	(ha)	2,190	4,880	780	7,850
3) Total	(ha)	4,160	13,870	3,510	21,540
(4) Total Farmland	(ha)	10,340	26,290	6,170	42,800
(5) Remaining Catchment Area for Additional STW, (4) - (3)	(ha)	6,180	12,420	2,660	21,260
(6) Proposed Nos. of STW, (5) / (2)	(nos)	1,030	114*	444	1,588
(7) Unit Irrigable Area per STW	(ha)	5	5	5	(5)
(8) Estimated Irrigable Area, (6) x ((7)	(ha)	5,150	570	2,220	7,940

* : Nos of STW required for irrigating 570 ha are given, because groundwater dependent area in the central area is limited and no shortage of groundwater supplies is expected.

(5) Justification of proposed groundwater exploitation

Total pumping capacity should not exceed "available recharge" for STW in order to keep safe-yield of the groundwater. The estimated irrigable area by STW is smaller than the potential command area except South Tract in view of development potential of groundwater as shown below.

Items / Area		Classification of Project Area			Total Area
		Northwest	Central	South	
(1) Groundwater Dependent Area	(ha)	8,220	570	4,740	13,530
(2) Remaining Catchment Area for Additional DTW	(ha)	6,180	12,420	2,660	21,260
(3) Available Recharge	(mm)	407	343	303	(357)
(4) Consumptive Use	(mm)	457	457	457	(457)
(5) Potential Command Area* (2) x (3) / (4)	(ha)	5,500	9,320	1,760	16,580
(6) Estimated Irrigable Area	(ha)	5,150	570	2,220	7,940
(7) Balance, (5) - (6)	(ha)	370	8,750	-460	8,640
(8) Proposed Irrigable Area smaller (5) or (6)	(ha)	5,150	570	1,760	7,480

* : Potential command area (ha) = Potential catchment area for STW (ha) x Available Recharge (mm) / Consumptive use (mm)

In the South Tract, the potential command area by STW is calculated to be 1,760 ha which is smaller than the estimated irrigable area of 2,220 ha. It means that groundwater

resources is rather limited in the South Tract to allow the present spacing rule of 800 feet (244 m). Therefore, irrigable area in the South Tract will be limited to 1,760 ha of the potential command area as the maximum, which makes the proposed total irrigable area by STWs to be 7,480 ha.

6.1.5 Total irrigable area by conjunctive use

A total of 18,180 ha will be exploited by surface water irrigation and the farmlands of 7,480 ha will be irrigated by STW. The total project area including the existing STW/DTW schemes (9,800 ha) will therefore aggregate 35,460 ha. The following table shows the breakdown of the proposed development areas by conjunctive use:

Development Mode	Classification of Project Area			Total Area (ha)
	Northwest	Central	South	
(1) Without Project				
i) STW	1,460	3,250	520	5,230
ii) DTW	660	3,000	910	4,570
Total	2,120	6,250	1,430	**9,800**
(2) With Project				
(a) Groundwater (STW)	5,150	570	1,760	7,480
(b) Surface water	0	18,180	0	18,180
Total	5,150	18,750	1,760	**25,660**
Total Project Area	7,270	25,000	3,190	**35,460**
Rainfed Area	3,070	1,290	2,980	7,340
Total Farm Land	10,340	26,290	6,170	**42,800**

6.1.6 Irrigation facilities plan

(1) General layout of irrigation canal networks

(a) Layout of irrigation diagram

Irrigation diagram for Central Tract would be illustrated conjunctively with surface water irrigation canal system and tube-well system. The surface water irrigation canal system would be networked following the existing drainage canals, and would be sprawled to the maximum extent depending on the available surface water resources. The remaining irrigable area which can not be covered by surface water resources would be irrigated by ground water resources. Fig.6.1.2 shows the proposed irrigation

diagram. Northwest and South Tract would be irrigated exclusively by tubewells irrigation system, and no irrigation diagram is therefore prepared for both tracts.

(b) Surface water supply system

Intake facilities

Run-off river type intake is proposed to divert discharge of 30 m^3/sec from the Dharla river. A slight erosion site near Bunka village, northmost of the Kurigram South Unit, is selected for the location of the intake facilities in consideration of stable off-take function. About 270 m of intake channel would be excavated at flooding stage in front of the polder dike. In order to keep stability, the channel would be fully lined with concrete blocks, and its front would be protected with ripraps. An intake regulator would be proposed on the polder dike in order to regulate intake water.

Main canals and their related structures

Main canals are aligned along the existing creeks, drainage channels and swamps. These existing creeks, channels and drains are deepened by manpower in order to distribute irrigation water to expanded area during the low water season in the Dharla river, and are re-shaped as trapezoidal section for increase of conveyance capacity.

There are a number of related structures such as control structures and crossing structures. The major control structures consist of check gates and regulating structures; the check gates would function maintaining water level during irrigation period, and the regulating structure would function to control discharge in the irrigation canals throughout the year.

The major crossing structures consist of newly proposed and renewed bridges;almost all the existing crossing structures along the creeks and channels would be renewed due to deepening and re-shaping of the existing creeks and channels in conformity with section of the proposed irrigation canals.

Command area development with low lift pumping (LLP)

A number of low-lift pumping units are installed on both banks of the main and secondary canals to boost hydraulic head of irrigation flow in the canals and to distribute irrigation water to command area. Field canal extending from LLP, therefore, directly supplies irrigation water to command area; this canal should be extended as long as possible (at least, one km) to expand irrigation area; this results in increase of scale of LLP. In conformity with averaged command area and in

consideration of domestic procurement of pumping units,two sets of engine-driven pump with a bore of 150 mm and a delivery of 50 l/sec would be proposed for each LLP stations All the field canals are brick-lined to save conveyance losses in the canal.

(c) Groundwater supply system

Groundwater supply will be made by STW. The criteria authorized by BADC and the empirical formula recommended by BWDB are as given in Section 6.1.4. The following is a recaptulating of the criteria :

Pump	Delivery	Operation	Mutual Interval	Command Area	Irrigable Area
STW	14.16 l/sec	10.0 hrs	244 m	6.0 ha	5.0 ha

Ground water is mechanically pumped out and supplied to farm land by simple field channel. Pumping unit applied for STW is of low-lift mixed-flow or centrifugal type with a vertical shaft. The field canals for STW are brick-lined for saving conveyance losses in the canal; the canal extends to terminal irrigation field of one ha, and in the terminal field, irrigation water is supplied plot to plot. STW scheme is developed by farmers initiatives under the assistance of the Authorities concerned.

(2) Proposed Irrigation Practice

Proposed cropping pattern includes both paddy and upland crops. The paddy is irrigated by ordinary impounding irrigation practice in paddy plots; the upland crops are irrigated by furrow irrigation practice. Irrigation water supply for both paddy and upland crops during dry winter season should be made by one week rotation for effective use of limited water resources.

6.2 Drainage Improvement Plan

6.2.1 Assessment of present drainage condition

(1) Drainage basin and present drainage condition

The study area of 59,400 ha enclosed by flood protection dike is divided into eight drainage blocks in accordance with geography, topography, drainage canal networks, and drainage outlet. The drainage blocks are bordered by road, railway, or natural levee. The blocks are not completely isolated each other, because drainage channels in respective blocks are connected each other without any regulating facilities.

Eight (8) drainage blocks would be assumed as an independent or completely isolated mini-compartment in view of drainage improvement plan. On the basis of a concept of mini-compartmentarization, all runoff water in each drainage block should be drained into external river through their exclusive outlet or regulator at their own risk and should never be released into neighbouring lowlying drainage blocks.

(2) Assessment of Present Drainage Condition

In order to assess the present drainage condition in the Study area, drainage calculation is made on the following procedures and assumptions :

(i)	Calculation period :	Recent 8 years from 1983 to 1990 during May to October (the Monsoon season)
(ii)	Calculation step :	One (1) day,
(iii)	Rainfall data :	Nearby five (5) rainfall gauging stations, such as Lalumonirhat, Chilmari, Kaunia, Ulipur, and Kurigram.
(iv)	Rainfall losses :	Evaporation from bare ground and water body, Evapotranspiration from farm land and greens, Percolation from paddy field, channels, and swamps, and storage in paddy field and water bodies.
(v)	Data on external water level :	Data in the Kurigram and Talukshimulbari stations along the Dharla river; data in the Kaunia stations along the Teesta river; data in the Chilmari and Noonkawa.stations along the Burhamaputra river

(vi) Inundation area (H-A) and volume (H-V) curve : Prepared on topo map of 4" to a mile scale with a contour interval of 1 ft.

(vii) Continuous equation :

$$[\{Q_{i(t-1)} + Q_{i(t)}\}/2 - \{Q_{o(t-1)} + Q_{o(t)}\}/2]*t = S \text{ ,and}$$

$$S = V_t - V_{t-1},$$

whereas,

t	:	denote time (one day)
Q_i	:	inflow (runoff) discharge m^3/sec,
Q_o	:	outflow = $C*A*N*2g \sqrt{(Wl_i - Wl_o)}$,
C	:	flow coefficient (0.85),
A	:	sectional area of gate vent (1.52 m^2),
N	:	number of gate vent,
S	:	storage volume,
V_t, V_{t-1}	:	retained water volume,
Wl_i	:	internal water level,
Wl_o	:	external water level.

The drainage calculation is carried out to grasp the present drainage condition prevailing over the study area according to the assumption and procedures mentioned above. The calculation clarifies that the Monsoon season in 1987 is the most severe in terms of the drainage condition during the recent eight (8) years in the study area. Table 6.2.1 shows summary of all the calculation by blocks and by years. The following is the summary of the outcomes in 1987.

Drainage Block	Rainfall (6 months) (mm)	External WL at Outlet (m)	Inundated Area (ha)	Inundated Depth (m)	Inundated Period (day)
(1) Ratnai	2,543	30.37	1,774 (26.5%)	4.02	69
(2) Palashbari	1,708	27.45	1,461 (58.4%)	3.38	68
(3) Malbhanga	1,708	25.75	3,107 (24.1%)	3.51	48
(4) Bamni	1,601	25.26	4,101 (55.9%)	2.39	44
(5) Chilmari	1,601	24.80	4,579 (56.6%)	3.09	62
(6) Ghar'danga	2,402	29.58	1,530 (76.9%)	2.94	111
(7) Kishorpur	2,402	27.96	4,388 (51.6%)	2.56	63
(8) Harichari	1,797	25.07	6,339 (77.7%)	2.84	89

As summarized in the above table, the Harichari and Gharialdanga blocks are much serious as far as inundation ratio and period are concerned ; the Ratnai and Malbhanga blocks are rather gentle in terms of inundation ratio in the drainage block.

6.2.2 Proposed drainage system

(1) Basic consideration

Basically, two drainage systems can be envisaged for drainage improvement, namely one block system and multi-block system. In case of the one block system, all the drainage canals in the study area would be networked without any internal control facilities, and all the excess runoff would be conveyed and concentrated in lowlying area through drainage channels . Such a deep inundation in the lowlying area may compel inhabitants therein to drastically change their current land use. This system must be proposed at sacrifice of the inhabitants in the lowlying area and may cause serious sociological issues among the inhabitants.

In order to attain equitable drainage improvement without any regional sacrifices, all the excess runoff caused in a certain basin should be drained on that basin's risk in principle. Following this concept, the multi-block system with the so-called mini-compartmentarization concept would be proposed for the drainage improvement in this area.

(2) Drainage mode

There are two (2) modes of drainage, i.e , by pumping and by gravity. In comparison with the water level fluctuation of the Dharla and Teesta rivers during the monsoon season and the topographic slant and elevation of the study area, construction of additional regulators at respective outlets will never bring remarkable increase of outgoing discharge through respective regulators. In this view,project economy permitting, pumping drainage would be essential for full drainage improvement in the study area.

In the meantime, the pumping drainage is economically infeasible in spite of the remarkable improvement due to anticipated low benefits which will be accrued only from crop damages and extremely high installation and O/M costs for pumping units. Even if all the inhabitants in the study area have a strong intention for substantial drainage improvement, the introduction of pumping drainage would not be realistic in the study area at this moment.

As mentioned above, by-gravity drainage is not so effective as pumping drainage. In order to decrease inundation area, depth, and period under the by-gravity drainage mode, it is tried to excavate bottom of swamps and existing drainage channels as much as possible in order to increase retention volume for excess runoff water. The increased volume is,

actually however, rather small compared with the excess runoff water inundated in the study area. In spite of low cost measures, this mode is also technically not attractive.

Judging from the drainage calculation under the existing condition, specific drainage requirement in four (4) drainage blocks such as Chilmari,Bamni, Malbhanga,and Ratnai is assessed to be rather reasonable; it is equivalent to about 1.0 $m^3/sec/km^2$, more or less. That in the remaining four (4) drainage blocks such as Palashbari, Harichai, Kishorpur, and Gharialdanga, is far less than 1.0 $m^3/sec/km^2$. The drainage condition in these four (4) drainage blocks would be possibly improved by increase of their regulator's sluice capacity and retention volume.

(3) Drainage Calculation

According to the results of the calculation under the existing condition, the drainage condition in the study area in 1987 is the most serious during the period of the recent eight (8) years. Taking the frequency of flooding into account, the calculation for the drainage plan would be made based on the hydrological condition during the period of the monsoon season (May to October) in 1987.

At the first step of the calculation, four (4) drainage regulators such as Palashbari,Harichai,Kishorpur,and Gharialdanga are selected for the improvement of sluice capacity in the light of the specific drainage capacity under the present condition. The following is a summary of the additional installation for the said four regulators.

Regulator	Existing Regulator (No. of Vent	Increased Ratio (%)	Improved Regulator (No. of Vent)
1) Palashbari	2	100	4
2) Harichai	12	66	20
2) Kishorpur	12	100	24
4) Gharialdanga	2	100	4

Furthermore,water level - inundation area (H - A) curve and water level - retention volume (H - V) curve for all the drainage blocks are modified based on the retention capacity increased through excavation of drainage channels, creeks, and swamps According to the same calculation procedures used for the assessment of the existing condition, the improvement of the drainage condition for each drainage block is assessed under revision of the sluice and retention capacities.

Table 6.2.2 summarizes the calculation under the improvement plan for eight (8) drainage blocks Further details are given in ANNEX -XI. The following is recapitulating the calculation in terms of the effectiveness of the drainage improvement :

Drainage Block	Decreased Inundated area (ha)	Decreased Inundated depth (cm)	Decreased Inundated period (day)
(1) Ratnai	3	1	4
(2) Palashbari	76	4	4
(3) Malbhanga	0	0	2
(4) Bamni	21	1	1
(5) Chilmari	8	0	0
(6) Gharialdanga	284	26	27
(7) Kishorpur	554	24	3
(8) Harichai	102	7	8

As shown above, the drainage condition in Ratnai,Malbhanga,and Chilmari drainage block is hardly improved. The selected area such as Palashbari, Gharialdanga, Bamni, Chilmari, and Kishorpur drainage blocks have been considerably improved in terms of inundation area ; as far as inundation depth and period are concerned, no remarkable improvement has been expected in all the drainage blocks.

(4) Improvement measures

It is clarified through various examination for drainage improvement that, from hydrological condition of the external flow and lowlying topographic condition of the study area, there is no attractive way to improve the drainage condition in the area without introduction of huge power pumping units. In the light of the drainage calculation mentioned above, the following two (2) improvement measures would be envisaged in the project area in due consideration of the project economy:

(i) Increase of four (4) regulator's sluice capacity, and
(ii) Increase of retention capacity for all the drainage blocks through excavation of channels, creek and beels

6.2.3 Drainage facilities plan

As previously mentioned,the existing channels,creeks ,and swamps would be deepened and re-shaped for dual purposes i.e,irrigation and drainage. All the proposed irrigation canal system would also function as drainage canal system. In addition, the existing swamps would be de-silted for increase of their retention capacity All the canals are connected to the existing eight (8) regulators which are improved, re-constructed and/or

rehabilitated ; the Ratnai and Harichari regulator would be re-constructed and rehabilitated, respectively, and the Palashbari, Harichai, Kishorpur, and Gharialdanga regulators would be improved for sluice capacity.

Furthermore, the Ratnai river which flows into the study area across the existing dike and causes habitual inundation in the northern tract,would be diverted directly into the Dharla river by excavating new diversion channel along the outside of the protection dike and by closing the existing breach.

6.3 Flood Protection Plan

Most of the flood protection plan for the Kurigram South Unit has been substantially completed by constructing the existing flood protection dike which is about 108 Km long. Since then,the dike has been partly eroded by river flow and winds,and also partly broken by inhabitants for use of homesteads. Furthermore,the dike is sporadically breached by local people for urgent drainage. In due consideration of such an existing condition,flood protection works would be limited to the following rehabilitation works :

(1) Closing works for the abandoned breaches, and
(2) Re-shaping and hightening of the eroded and slender portion of the embankment

6.4 Agricultural Development Plan

6.4.1 Future land use pattern

The existing cultivated land in the Study area (42,800 ha) is composed of 9,800 ha of irrigated land and 33,000 ha of rainfed land. After implementation of the Project, 25,700 ha of the existing rainfed land will be irrigated by use of both surface and groundwater resources. The remaining rainfed land (7,300 ha) will not be benefitted by the Project due to the limited water availability. The existing irrigated land of 9,800 ha will be under irrigated condition through improvement of operation and maintenance. As a result, it is proposed that 35,500 ha in total will be be irrigated as the Project area as shown below :

	Proposed	Existing	Difference
1. Total Farmland in the Study area	42,800 ha	42,800 ha	-
2. Irrigation Area	35,500 ha	9,800 ha	21,800 ha
Existing irrigated area	9,800 ha	9,800 ha	-
Surface water by LLP	18,200 ha	0 ha	18,200 ha
DTW newly constructed	7,500 ha	0 ha	7,500 ha
3. Rainfed Area	7,300 ha	33,000 ha	-21,800 ha

The present and proposed cropped area within 35,500 ha of the Project area are shown in Table 6.4.1. The total cropped area will expand from 68,300 ha to 79,500 ha, and cropping intensity will increase from 192% to 224%:

Item	Present Condition			Proposed
	Irrigated (ha)	Rainfed (ha)	Total (ha)	Irrigated Area (ha)
Total Land Area	9,800	25,700	35,500	35,500
Total Cropped Area	20,400	47,900	68,300	79,500
Cropping intensity	208%	186%	192%	224%

6.4.2 Proposed farming practices

The proposed farming practices are formulated through modification of the existing data and information collected. Most of farming practice will be carried out by labours and draft animals, as same as the present farming practice.

For rice crops, the nursery period will be 30 days after seeding at the seed rate of 30 kg/ha. Land preparation is carried out by animal power 20 days before transplanting. Fertilizer requirement of HVY rice would be about 200 kg of urea, 100 kg of TSP and 30kg of potash to achieve maximum potential yield. Fertilizers are applied in basal for land preparation and several top-dressings. Manure, if available, is applied as basal for land preparation. Plant protection should be made as required and minimize to use agro-chemicals. Dry land crops in the rabi season also requires proper application of fertilizer and farm management.

6.4.3 Anticipated yields and production

Anticipated crop yield is estimated on the basis of the proposed farming practices. The cultivated areas, crop yields and production in the Project area under the present condition and proposed condition are estimated in Table 6.4.2 and summarized below :

Crop	Present condition			Proposed condition			Increase (ton)
	Area (ha)	Yield (ton/ha)	Production (ton)	Area (ha)	Yield (ton/ha)	Production (ton)	
Rice	56,400	2.64	149,000	38,000	4.40	167,500	18,500
Jute	3,500	1.48	5,200	9,000	1.57	14,100	8,900
Rabi crops	6,900	3.16	21,800	32,500	6.73	218,800	197,000

Increased production under the project will be consumed in the Project area, and marketable surplus will be traded out of the Project area. This will contribute improvement of income of farmers and nutrient condition of the local people. It is estimated at several thousand tons of rice, potatoes and vegetables will be transported to North West region and other region of the country.

6.4.4 Agricultural support services and cooperative development

Improved farming practices under the irrigated condition using surface water irrigation as well as ground water will be required for increase in crop productivity. Agricultural extension activities done by Block Supervisors under Tana Agricultural Extension Officers, DAE should be strengthened at the command areas of the LLPs in the study area. The Project Implementation Office (PIO) is needed to coordinate with the on-going "marginal and small farm systems crop intensification project (MSFSCIP)" and other NGOs' irrigation programs using STWs and DTWs in the Project area. The results of crop development and researches under MSFSCIP will be utilized for the extension of appropriate crop production technologies, especially to marginal and small farmers both under ground water and surface water irrigation activities.

6.5 Inland Fisheries Development

6.5.1 Fisheries development potential

In the Study area, production of culture and capture fishery is estimated at 546 ton from 2,176 ha of pond and open water bodies, as shown below;

	Culture fishery	Capture fishery Beels	Capture fishery Revers	Total
Area	180 ha	256 ha	1,740 ha	2,176 ha
Unit production	928 kg/ha	84 kg/ha	205 kg/ha	-
Annual Production	167 ton	22 ton	357 ton	546 ton

Above 265 ha of existing open water bodies (except rivers such as Brahmaputra, Teesta and Dharla) will be improved and expanded as irrigation and drainage canal under the Project. As a result, approximately 920 ha of canal will be perenial water body and can be used for fishery production. However, the existing pond for culture fishery and capture fishery in the large rivers will not be improved by the Project.

6.5.2 Proposed fishery development system

Systems of culture fisheries may include 1) pond culture, 2) pen and cage culture, 3) fish culture in borrow pits or retarding ponds, 4) paddy-cum-fish culture, and 5) integrated farming (duck-cum-fish farming).

The paddy-cum-fish culture cannot be applied in the project, since HYV varieties will be introduced using agro-chemicals and intensive farm mangement. Pond culture will be intensified by application of the improved semi-intensive and intensive culture systems. Pen and cage culture sytem and integrated farming using fish and ducks or chickens seems to be appropriate for the Project, however those systems are under development in Bangladesh at present. Although a number of borrow pits and retarding basins can be used as nurseries for major carps as well as fish culture, those water bodies will not be insured as perenial water surface. The project would not include complete structures and facilities for each culture fishery system, therefore, a semi-intensive culture system modified with other systems mentioned above is considered as a project componet to utilize the irrigation and drainage canals.

It is assumed that about 50% of 920 ha would be applied the semi-intensive culture fishery by the Project, and this will increase the fishery production to attain per capita local

consumtion to the same as the current national level. Production from the remaining 50% of the area might increase by the effect of culture fishery, however, its production would not be considered as compensation for the adverse effect of the captured fishery by the Project. The future production is estimated as follows:

Item	Present			Proposed Condition			Difference
	Pond	River	Beels etc.	Pond	River	Canal	
Production system	Extensive culture fishery	Capture fishery	Capture fishery	Extensive culture fishery	Capture fishery	Semi-intensive culture fishery	-
Area (ha)	180	1,740	256	180	1,740	920	664
Production area (ha)	180	1,740	256	180	1,740	460	204
Unit production (kg/ha)	928	205	84	928	205	5,900	-
Annual production (ton)	167	357	22	167	357	2,714	2,692
Total Production (ton)		546			3,238		2,692

Total production of 3,238 ton is equivalent to 4.4 kg/person of the current national average. Production in the canals will be achieved by proper management to use materials, preparation and necessary inputs. For implementation of fishery development, institutional coordination will be required with BWDB and other government agencies concerned, and biological management and conservation include restrictive licensing, close seasons, restriction on gear and net mesh sizes, control on collection of wild spawn and fry.

CHAPTER VII PROPOSED PROJECT WORKS

7.1 Irrigation Development

7.1.1 Headworks (Intake Regulator)

(1) Intake discharge and water level

Drought discharge with a return period of 10 years for the Dharla river is 49 m^3/sec, out of which 60% or 30 m^3/sec will be diverted for irrigation. Intake water level is computed at 27.15 m, which is the lowest water level with a return period of 10 years on the basis of data from the Talukshimulbari gauging station.

(2) Main feature of headworks

Headworks are composed of intake mouth, intake canal and intake regulator. The main features of the headworks are as follows :

Intake mouth:	intake velocity	0.3 m/sec
	width of mouth	100 m
	water depth	1.0 m
Intake canal	canal length	265 m
	width of canal	100 -- 25 m
	water depth	1.0 -- 2.0 m
Intake regulator	size of vent	1.52 m (W) x 1.83 m (H)
	nos. of vent	12 vents
	size & nos. of sluice gate	1.52 m (W) x 1.83 m (H) x 12 gates
	elevation of gate sill	El.25.45 m
	top of embankment	El.33.41 m
	high water level	El.32.51 m

(3) Water level at beginning point of main channel

Water level at beginning point of main channel is set at WL.27.00 m.

7.1.2 Irrigation canal system

(1) Division of irrigation area

Irrigation network based on the existing rivers and drainage channels is shown on Fig.7.1.1. The project area is divided into three areas, north-west, central and south

tracts. Only the central area will be covered by the surface irrigation network and the rest of the area will be irrigated through groundwater development as shown below :

	Surface irrigation with LLPs	STW	Total
North-west area	0 ha	5,150 ha	5,150 ha
Central area	18,180 ha	570 ha	18,750 ha
South area	0 ha	1,760 ha	1,760 ha
Total	18,180 ha	7,480 ha	25,660 ha
Existing Irrigated Area			9,800 ha
Total Irrigation Area with Project			35,460 ha

(2) Irrigation canals and related structures

Most of irrigation canals are the existing river and drainage channels. The relation of main channels between existing rivers is as follows :

Main channel A	Ratnai river - Kalua nadi - Irrigation canal - Bamni river
Main channel B	Deola bil - Buri Teesta river
Main channel C	Upper Bamni river
Main channel D & E	Irrigation canal and drainage channels

Layout of irrigation canals and related structures are shown on Fig.7.1.2, and main features of the canals and related structures are listed in Table 7.1.1. The proposed canal length and number of related structures are as follows :

Main channel A	64.4 km
Main channel B	55.9 km
Main channel C	35.9 km
Main channel D	13.2 km
Main channel E	10.0 km
Main channel F	7.9 km
Total	187.3 km
Irrigation Canal Regulator	24 nos.
Check gate	7 nos.

(3) Irrigation canal section

The existing drainage channels and creeks have a gradient of 1/20,000. Lower canal gradient will be better for irrigation with use of LLPs because it will keep water

level higher which makes operation of LLPs economical. Considering these factors as well as land acquisition problems for canal construction and expected flow velocity, gradient of the proposed irrigation canals are determined to be 1/20,000. The proposed sections are determined in due consideration of the design discharges of each canal as shown in Table 7.1.2.

(4) Irrigation canal regulators and check gates

Irrigation canal regulators will be constructed to divert the irrigation water and/or to regulate the water level in the canal. Two (2) types of regulators are proposed; closed type and open type. The closed type will be installed at the boundaries between the drainage blocks so that the existing drainage system will not be drastically changed even if drainage channels in different blocks are connected. The closed type regulators will be equipped with sluice gates of 1.52 m (W) x 1.83 m (H), same as those of the existing drainage sluice (regulator), and will be manually operated. The open type regulators will also be manually operated but have larger sluice gates of 3.0 m (W) x 2.5 m (H). The check gates will be of open type and be installed to control the water level at the end of the irrigation canal near the existing drainage sluices (regulators). The proposed number of irrigation canal regulators and check gates are as follows:

	Closed type	Open type	Check gate	Total
Main channel A	3	3	2	8
Main channel B	5	1	1	7
Main channel C	3	4	1	8
Main channel D	1	1	1	3
Main channel E	1	1	1	3
Main channel F	1	0	1	2
Total	14	10	7	31

7.1.3 Command area development with LLPs

(1) Selection of LLP size

Command area development (CAD) with LLPs will be made by farmer groups at private initiative, and therefore selection of LLP size should be their option. The GOB will assist the farmer groups by demonstrating or making trials on O&M on various types of LLPs at the demonstration farms.

(2) Facility plan of LLPs

The LLPs should be selected among those available and widely used by the farmer groups in Bangladesh. In this sense, medium size of LLP with a capacity of 2.0 cusecs (56 l/sec) is tentatively selected only for planning of CAD with LLPs. It is recommended that two (2) units of LLPs be installed at one site for fail-safe. Command area will be 70 ha per site on an average. Total number of LLPs required for the irrigation area of 18,180 ha is 268 sites. Main features of pump facilities are as follows :

Pump capacity	56 l/sec (2.0 cusecs) x 2 units
Pump type	Centrifugal pump
Pump bore	150 mm
Total head	7 m
Prime mover	Diesel engine, 15.5 HP x 2 nos.
Others	Manual pump

7.1.4 Groundwater development with STWs

Groundwater development for irrigation will be made by farmer groups at private initiative, and actual selection of development modes should be left to their option. In this Study, however, STW is tentatively selected as most appropriate development mode only for planning purpose. Pump facilities for STW should be selected among those available and widely used in Bangladesh, and in this sense, the following pump with a capacity of 1/2 cusec (14 l/sec) was tentatively selected :

Pump capacity	14 l/sec (1/2 cusecs)
Pump type	Centrifugal pump
Pump bore	dia. 80mm
Total head	7 m
Prime mover	Diesel engine : 6 HP

Total number of STWs required for the irrigation area of 7,480 ha is as follows :

North-west area	5,150 ha	1,030	nos.
Central area	570 ha	114	nos.
South area	1,760 ha	352	nos.
Total	7,480 ha	1,496	nos.

7.1.5 Demonstration farms

The demonstration farms will be established at the following three (3) locations mainly to assist farmer groups in selecting development modes of tubewell and LLPs:

Locations	Thana	Area (ha)	Development Mode
Banagram	Lalmonirhat	101.0 ha	LLP / DTW / STW
Pratap	Kurigram	69.3 ha	LLP / DTW / STW
Narikelbari	Ulipur	88.9 ha	LLP / STW x 3 units

In order to demonstrate and/or make trials on different modes of water distribution in CAD, the facility plan of each demonstration farm is proposed as follows :

Locations	Proposed facilities
Banagram	Mortar lined canals and/or earth canal up to terminal blocks of 5 ha
Pratap	Pumping up again from LLP to elevated land and distributing water through open channels up to terminal blocks of 5 ha
Narikelbari	Buried pipe system to minimize land loss for water distribution

7.2 Drainage Improvement

7.2.1 Diversion of the Ratnai river

The Ratnai river originates in the Indian territory, having a total catchment area of 163 km^2. The Ratnai river will be closed off by the flood embankment. The catchment area outside the embankment is 115 km^2. The diversion works intend to drain the floods occurred in the outside catchment of 115 km^2 safely to the Dharla river. The design discharge is 88.6 m^3/sec which is equivalent to the flood with a return period of 20 years. Major features of the diversion channel are as follows :

Length :	3.3 km
Canal gradient :	1 / 3,500
Base width of channel :	10 m
Slope :	1 : 2
Water depth :	4 m

In addition to the excavation works of the diversion channel, bridges will be newly constructed at four (4) locations along the diversion channel to conserve the existing rural transportation network.

7.2.2 Rehabilitation of drainage regulators

There are three (3) main natural drains in the area; namely the Ratnai, Bamni and Buri Teesta rivers. In addition to these main drains, a number of small streams are running in the area. All these drains are finally connected with the existing regulators at 11 sites for draining out the internal excess water. Two regulators at Ratnai and Harichari, out of 11 regulators, will need re-construction and/or rehabilitation works. The Ratnai regulator was completely destroyed by the 1988 flood, and Horichari regulator is facing to serious erosion. In addition, increase of in number of vents will be needed for the improvement of drainage condition at regulators in drainage blocks of Palashubari, Harichari, Kishorpur and Gharialdanga.

(1) Reconstruction of Ratnai regulator

The regulator will be re-constructed with the following original design :

Gate sill elevation :	El. 25.38 m
Dimension of gates :	1.52 m (W) x 1.83 m (H)
Nos. of vents :	8 vents
Design high water level :	El. 30.48 m
Crest height of embankment :	El. 31.38 m

(2) Rehabilitation of Harichari Regulator

The connecting portion (riprap) of the Harichari regulator with drainage channel has been seriously scoured by the river flow. Rehabilitation works of rip-rap will be envisaged under the Project. Extent of the works will be as follows :

Country side :	12.0 m
River side :	22.5 m

(3) Construction of Additional Regulators

Additional regulators will be constructed at Paleshubari, Harichari, Kishorpur and Gharialdanga to increase the drainage capacity (see Section 6.2.2 of Chapter VI). The principal features of the additional regulators are as follows:

Items	Palashubari	Harichari	Kishorpur	Gharialdanga
Gate sill elevation	22.85	20.12	22.77	24.38
Dimension of gates	1.52 x 1.83	1.52 x 1.83	1.52 x 1.83	1.52 x 1.83
Nos. of vents	2	8	12	2
Design high water level	18.60	25.77	27.14	29.89
Crest height of embankment	29.50	26.67	28.04	30.79
Existing Regulators (Nos. of vents)	2	12	12	2

7.2.3 Desilting works of the existing drainage channels

The existing drainage system was designed and constructed for the flood with return period of 5 years. The some portion of the existing drainage channels have been heavily silted up. The widening and dredging of these portion will be carried out under the Project. The Ratnai, the Buri Teesta, the Bamni and other small drainage channels will be used as the irrigation canals. The locations of the desilting works are shown on Fig. 7.2.1. Extent of the desilting works are as follows :

Mathailer Chhara	8.0 km
Harichari Khal	6.5 km
New drainage channel(Harichari reg.)	4.5 km
Total	19.0 km

7.3 Flood Control and Erosion Protection Works

7.3.1 Rehabilitation of flood embankment

The existing embankment was constructed, to withstand the floods with return period of 50 years, in 1973 - 1984. The embankment is sufficient in height for the design water level and has successfully resisted against the large floods in recent years. Although there are some damaged portions, the embankment has been somehow functioning to date even

under poor operation and maintenance. Therefore, the rehabilitation works is limited to only damaged portion of the embankment. At the Joykumar and Mogolbasha sites in the damaged portion, the set-backed embankments were constructed in the dry season of 1992. The damaged portion of the embankment to be rehabilitated under the Project are identified as follows :

Location	Length
Durakuti (closure of embankment at Ratnai river)	92 m
Bumka	170 m
Char Khatamari	284 m
Ratnai regulator site	133 m
Pangula	64 m
Joykumar	350 m
Total	1,093 m

The design criteria of the embankment to be rehabilitated is as follows :

Items	Dharla/Teesta River	Brahmaputra River
Crest height	design high water level plus free board	
	(design high water level = flood level with return period of 50 years)	
Free board	0.90 m	1.50 m
Crest width	4.20 m	7.20 m
Slope (river side)	1 : 3	1 : 3
Slope (country side)	1 : 3	1 : 3

7.3.2 Embankment protection works

Protection works for the embankment will be carried out upstream and downstream of the proposed structures. The proposed sites under the Project are identified as follows :

Location	Length
Durakuti closure site	200 m
Intake regulator	Upstream : 300 m Downstream : 300 m
Ratnai regulator	200 m

The location of the proposed rehabilitation of embankment and protection sites are shown on Fig. 7.2.1. Erosion protection works where serious river erosion is anticipated, are described in Appendix-X, though they are not included in the project works.

7.4 Rural Infrastructure Improvement

The existing bridges will be re-constructed at 52 locations due to re-excavation of the existing drainage channels and creeks. In addition, new bridges and culverts will be constructed at 39 locations due to construction of new irrigation canals connecting with the existing drainage channels. Total number of bridges to be constructed under the proposed project will be 91 as shown below :

Road Type	Bridges		Culvert	Total
	Re-construction	New Construction		
Railway	3	0	3	6
Asphalt-paved Road	1	0	3	4
Rural/Brick Road	48	30	3	81
Total	52	30	9	91

The bridges and culvert are classified into the following 10 types (see Table 7.4.1) :

	Types of Bridges	Width	Length	Nos. of Bridges/culverts
(1)	Railway Bridge A	3.0 m	38 m	1
(2)	Railway Bridge B	3.0 m	25 m	2
(3)	Metalled Road Bridge A	7.5 m	38 m	1
(4)	Rural/Brick Road Bridge A	3.0 or 4.5 m	38 m	12
(5)	Rural/Brick Road Bridge B	3.0 or 4.5 m	25 m	11
(6)	Rural/Brick Road Bridge C	3.0 or 4.5 m	17 m	16
(7)	Rural/Brick Road Bridge D	3.0 or 4.5 m	12 m	39
(8)	Culvert; Railway	5.0 m	7 m	3
(9)	Culvert; Metalled Road	7.5 m	7 m	3
(8)	Culvert; Rural/Brick Road	5.0 m	7 m	3
	Total			91

In addition to these bridges/culverts, the irrigation canal regulators that will be constructed at 30 locations, will also function as bridges.

7.5 Land Acquisition and Crop Compensation

Total land required for construction of the project facilities will be 806.7 ha, out of which 368.3 ha of land are privately owned and will have to be acquired. Another 438.4 ha of land are government owned land (mostly existing drainage channels) and will be subject to crop compensation, because most of the existing drainage channels are utilized for crop cultivation. During the course of the dredging works, crop compensation will be needed. Details of the land requirement for construction works are given in Table 7.5.1.

Private land to be acquired	368.3 ha
Government land (subject to crop compensation)	438.4 ha
Total	806.7 ha

CHAPTER VIII IMPLEMENTATION PLAN AND COST ESTIMATE

8.1 Project Construction Plan

8.1.1 Project components

Construction works of the proposed project will broadly consist of :

(1) Flood protection works
   a) Rehabilitation of existing embankment
(2) Drainage Improvement
   a) Diversion of Ratnai river
   b) Rehabilitation and improvement of existing Regulators
   c) Desilting works of drainage channels, creeks and beels
(3) Irrigation Development
   a) Irrigation Intake and irrigation canal system
   b) Command area development with LLPs
   c) Groundwater development
(4) Rural Infrastructure Improvement
   a) Re-construction of the existing bridges and construction of new bridges

BWDB will be responsible for construction of (1) flood protection works, (2) drainage improvement works and (3) - a) irrigation intake and canal system. BRDB and LGED will be responsible for (3) - b) command area development with LLPs and (3) - c) groundwater development under close coordination by BWDB.. Organizational set-up for implementation of the proposed project is discussed in Chapter IX (Organization and Management).

8.1.2 Work volume

The project works are described in Chapter VII. Work volumes of these project works are as follows (for details, see Table XIII-2.1, Page XIII-54, Volume II):

(1)	Earth works	14,720,000	m^3
(2)	Concrete works	55,700	m^3
(3)	Reinforced iron works	3,050	tons

8.1.3 Construction schedule

Construction schedule is prepared under the following assumptions:

(1) The proposed project facilities will be constructed by local contractors.
Work volumes of the proposed project facilities are rather large, but the kinds and natures of the required works are of those commonly executed by the local contractors in Bangladesh. Local contractors can undertake all kind of the construction works.

(2) Most of the construction works will be executed by manual labour.
Re-excavation of the existing drainage channels / creeks occupies major part of the construction works. Use of heavy equipment is not suitable for these works, because transportation of such equipment to the construction sites is difficult under the present road conditions, and also more land is required for temporary works at the construction sites which seems to be unpractical under the present land tenure condition. Manual execution is suitable for these works. It will contribute to creation of employment opportunity in the area.

(3) Construction period will be 10 years in total including 2 year period of detailed design and tendering procedures, in due consideration of work volumes and construction management capacity.

(4) Construction works will commence in the north with the diversion works of the Ratnai river, closing of the embankment, construction of irrigation intake structure and irrigation main canal-A, and construction sites will then move downwards from north to south.

(5) Command area development (CAD) with LLPs will be executed at private initiative immediately after the completion of the canal construction, and the farmers will start irrigation practices simultaneously

The proposed project construction schedule is shown on Fig. 8.1.1.

8.2 Project Cost Estimates

8.2.1 Assumptions

Project costs are estimated under the following assumptions:

(1) Unit costs for major construction works are based on the "Schedule Rate for Project VI" prepared by BWDB in October, 1989 and revised December, 1991.

(2) Unit prices of the items which are not included in the"Schedule Rate for Project VI" are estimated on the basis of the prevailing market prices as of September, 1992.

(3) The following exchange rates are used :

US$ 1.00 = Tk. 38.8 = ¥ 125, Tk.1.00 = ¥ 3.2

(4) Physical contingencies will be 15 % of the direct construction costs. Price contingency will be 10% for local currency portion and 7% for foreign currency portion per annum during the construction period.

(5) Land acquisition costs will be based on the latest actual compensation made by the BWDB's Kurigram office; i.e., Tk 110,000 per ha for private land and Tk. 50,000 per ha for crop compensation on government lands.

(6) O&M costs during the construction period will be included in the project costs.

8.2.2 Project costs

The project costs is estimated to be Tk. 2,280 million in total on a financial basis as of September, 1992 (for details, see Table 8.2.1):

(Unit: Tk million)

Items	LC	FC	Total
1. Construction Costs	728.7	339.3	1,068.0
1) Irrigation Development	581.9	247.5	829.5
a) Irrigation Intake	59.2	61.6	120.8
b) Irrigation Canals	273.6	51.9	325.5
c) LLP development	217.3	65.1	282.4
d) STW development	27.8	65.5	93.3
e) Demonstration farm	4.0	3.5	7.5
2) Drainage Improvement	38.2	24.0	62.2
3) Flood Control Works	8.6	3.9	12.5
4) Rural Infrastructure	100.0	63.8	163.8
2. Associated Costs	173.4	69.4	242.8
1) Land Acquisition	62.4	0	62.4
2) Administration	26.1	21.6	47.7
3) Consulting Services	60.9	47.8	108.7
4) O&M costs during construction period	24.0	0	24.0
3. Physical Contingency	109.3	50.9	160.2
4. Price Contingency	646.5	162.2	808.7
Total	1,657.9	621.8	2,279.7

The total project cost of Tk. 2,280 million comprises Tk. 1,658 million (72%) of local currency portion and Tk. 622 million (28%) for foreign currency portion. The total project

costs are divided into direct construction costs of 1,068 million (47%), indirect costs of 243 million (11%) and physical contingency of Tk 160 million (7%) and price contengency of Tk 809 million (35%).

8.2.3 Annual O&M costs

Annual operation and maintenance (O&M) costs are estimated to be Tk.6.8 million in total as shown below :

(Unit: Tk 1,000/year)

(1)	Irrigation facilities (intake and canal system)	2,037
(2)	Flood embankment	1,848
(3)	Drainage facilities (regulators and drainage channels)	153
(4)	Rural infrastructures (bridges)	294
(5)	Administration costs of BWDB's O&M circle	2,465
	Total	6,797

8.2.4 Annual fund requirements

Annual fund requirement for the construction period of 10 years will be as follows:

Year	Irrigation Area (ha)			Annual Fund Requirement (TK million)		
	LLP	STW	Total	LC	FC	Total
1st year	0	0	0	24.3	42.0	66.3
2nd year	0	0	0	24.3	15.5	39.8
3rd year	2,180	2,162	4,342	221.5	126.4	347.9
4th year	2,110	2,162	4,272	161.0	56.9	217.9
5th year	1,270	2,162	3,432	122.1	41.6	163.7
6th year	2,580	2,162	4,742	201.4	66.3	267.7
7th year	2,800	2,162	4,962	235.6	77.9	313.5
8th year	2,660	2,162	4,822	253.1	71.7	324.8
9th year	4,160	2,162	6,322	326.3	90.7	417.0
10th year	440	2,166	2,606	88.3	32.8	121.1
Total	18,200	17,300	35,500	1,657.9	621.8	2,279.7

CHAPTER IX ORGANIZATION AND MANAGEMENT

9.1 Existing Organizations related to Project Implementation and O&M

Various government agencies are expected to participate in the implementation and O&M of the proposed Project. Among other agencies, six (6) agencies (BWDB, BRDB, LGED, DAE, DOF and DOL) are expected to be directly involved. The proposed project requires inter-ministerial coordination because these agencies belong to different ministries and also have different functions and jurisdiction in government services. The prospective participating agencies are briefly described hereunder.

9.1.1 Bangladesh Water Development Board (BWDB)

The Bangladesh Water Development Board (BWDB), a semi-autonomous body under the Ministry of Irrigation, Water Development and Flood Control, is responsible for planning and execution of water resource development works, encompassing flood control, drainage improvement, irrigation, town protection and river training schemes. Only in the field of groundwater irrigation and minor surface irrigation with LLPs, a part of the responsibilities is shared with the Bangladesh Rural Development Board (BRDB) and the Local Government Engineering Department (LGED).

The BWDB has now a staff strength of more than 18,000 of which nearly 2,000 are engineers. The present organization of the BWDB is shown on Fig.9.1.1. In the project area, an Executive Engineer (EE) stationed at Kurigram and assisted by Sub-Divisional Engineers, is supervising the maintenance works of the existing FCD facilities (see Fig. 9.1.2). The Chief Engineer (CE), Project-IV, Implementation Division of BWDB, and the Superintendent Engineer (SE), Teesta Project Canal Circle-2, both stationed at Rangpur, have overall control. There is no O&M office in the project area. All the O&M activities are carried out by the EE's office at Kurigram with 49 staff in total.

The BWDB's annual development budget (ADP) is Tk 6,499 million in total for the financial year of 1991/92. However, not all the allocated funds are actually released mainly due to the regular adjustment made by the Government. It is widely recognized that the major constraints of BWDB are insufficient and irregular release of funds coupled with complicated and time-consuming land acquisition procedures consequently resulting in cost overruns. The implementation plan should therefore keep these realities in view.

9.1.2 Bangladesh Rural Development Board (BRDB)

The Bangladesh Rural Development Board (BRDB) was organized in December, 1982, to promote and strengthen the growth of UCCA/KSS/BSS/MSS system. BRDB has now more than 1,900 staff in total. The Thana Rural Development Officer and the Assistant Thana Rural Development Officer represent BRDB at the Thana level. In the project area, 28 such officers are engaged in the field operations. BRDB is now mainly engaged in two rural development projects in the project area; i.e., (1) the IDA-funded Rural Development II Project as the executing agency, and (2) the IFAD-funded Marginal and Small Farm Systems Crop Intensification Project as one of the participating agencies.

9.1.3 Local Government Engineering Department (LGED)

The Local Government Engineering Department (LGED) under the Ministry of Local Government, Rural Development and Cooperatives was established in 1984 to accelerate the rural and urban infrastructure development activities and to provide technical support to the local government. In addition, the LGED was recently empowered to carry out small scale irrigation development. The LGED has now 9,650 staff in total.

The Thana Engineer and his assistants represent the LGED at the Thana level and take responsibility for planning, design and implementation of rural infrastructures and the related civil works. In the project area, a total of 86 staff including 26 engineers are engaged in the rural infrastructure development. At present, the LGED are undertaking two (2) on-going projects in the project area. They are (1) the SIDA and NORAD assisted Rural Development Project -IV, (RD-IV) and (2) the EEC assisted Rural Development Project - VIII (RD-VIII).

9.1.4 Prospective supporting agencies

(1) Directorate of Agricultural Extension (DAE)

The Directorate of Agricultural Extension (DAE) is the largest government agency under the Ministry of Agriculture. The DAE was established in 1982. The prime objectives of the DAE is to enhance agricultural productivity through training and visits. The Deputy Director of DAE has been posted at Kurigram and supervises all activities pertaining the agricultural extension in the district. In the project area, the DAE is represented by the Thana Agricultural Officer at each Thana Parishad, and mainly engaged in the IFAD/German assisted "Marginal and Small Farm System Crop Intensification Project (MSSCIP)" since

1987. The DAE has developed a network of agricultural extension workers through the MSSCIP. The agricultural extension workers, in daily contact with farmers, can expect to play a significant role in encouraging the achievement of potential benefits from the proposed project.

(2) Directorate of Fisheries (DOF)

The Directorate of Fisheries (DOF) was established in 1972 under the Ministry of Fishery and Livestock. The primary objective of the DOF is to increase the production of fish for meeting the internal demand for home consumption from both fresh and saline water. Recently an inter-agency agreement have been developed to give the DOF's fisheries management responsibility in selected water bodies owned by BWDB. The total staff strength of the DOF is 3,783 persons at present, while that of the Kurigram district is 58 persons. The Thana Fishery Officer and his assistants represent the DOF at the Thana level.

(3) Directorates of Livestock (DOL)

The Directorate of Livestock (DOL) is also under the Ministry of Fishery and Livestock. The prime objective of the Directorate is to increase the poultry and livestock population of the country so as to meet the domestic nutritional demand and to increase the draught power which is fast declining. The Thana Livestock Officer and his assistants represent the DOL at the Thana level.

9.1.5 Local authorities

The District acts the focal point of all development activities in Bangladesh, and the Deputy Commissioner is cast in the role of Chief Coordinator.

The Thana Parishad, an elected local government body, is headed by the elected chairman (the chairman of the former Upazila Parishad was recently abolished) and comprises the elected chairmen of all the Union Parishads of the Thana and three (3) nominated female members. The officers of the development agencies working in the Thana are also members of the Parishad but they do not have any voting power. The Thana Nirbahi Officer (TNO), appointed by the Ministry of Establishment, acts as the principal coordinator of all administrative and development activities in the Thana administration. An organizational chart of the Thana Parishad is presented on Fig.9.1.3. The basic electoral unit of local government is the Union Parishad. The Union Parishad comprises three members representing each village and two female members nominated by the Government.

In recent years, coordination in development planning, designs and implementation at the Union level have been more and more emphasized by the Government.

9.2 Project Implementation

9.2.1 Executing agencies

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

(1) Rehabilitation of flood embankment and regulators,

(2) Re-excavation of the existing drains for drainage improvement as well as surface irrigation water supply,

(3) Construction of irrigation intake structure and irrigation canal systems, and

(4) Establishment of Demonstration Farms

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

(5) Command Area Development with LLPs (BRDB/LGED),

(6) Groundwater irrigation development (BRDB/LGED), and

(7) Rural infrastructure improvement (LGED)

Command area development (CAD) with LLPs will be made by private initiatives in view of the recent government policy shift to privatization and successful performance of private sector on small scale irrigation development. The BRDB will assist such private initiatives in terms of organizing farmer groups and arrangement of credit for them. The LGED will provide necessary engineering supports for CAD and O&M. LLPs will be supplied to farmer groups through private sector channels. Daily operation and maintenance of the installed LLPs will be made by the farmer groups at their own costs. Groundwater irrigation development will also be made by private initiatives on same reasons mentioned above.

In order to facilitate the private initiatives for CAD and minor tubewell irrigation, Demonstration Farms will be established as one of the project components. Possible development modes for CAD will be demonstrated and/or tested at the demonstration farms. The demonstration farms will be established by BWDB at three (3) locations with prime objectives of demonstrating and testing (a) institutional build-up and arrangement for CAD with LLPs and tubewells, (b) physical planning and designs of CAD and (c) irrigation water management for cultivation. BRDB will be responsible for institutional aspects of the demonstration farms. DAE will take charge of extension aspects on irrigation water management.

In addition to the above major activities, BRDB will be responsible for organizing the landless groups with the help of the NGOs as Landless Contracting Societies (LCSs). Such LCSs will be entitled to undertake 25% of the earth work during the implementation of the project. The LGED will be an executing agency for rural infrastructure improvement.

Though not executing agencies, three (3) other agencies are expected to play an important role under the overall coordination and responsibility of BWDB. The Department of Agricultural Extension (DAE) is expected to provide farmer groups with agricultural extension services, particularly for Boro cultivation. The Department of Fishery (DOF) is expected to provide necessary technical inputs and advises for the enhancement of inland fishery activities particularly during the Rabi season. The Department of Livestock (DOL) is expected to provide the same particularly for enhancement of duck raising.

The relationship between the proposed project components and executing agencies is summarized on Fig.9.2.1.

9.2.2 Project implementation arrangement

Close coordination among the above government agencies is crucial to the successful implementation of the proposed project. It is recommended that coordination committees consisting the representatives from the related agencies (BWDB, BRDB, LGED, DAE, DOF and DOL), will be established at the Central, District and Thana levels for the successful implementation of the proposed project. To ensure close coordination among the agencies, there should be clear and definite "Government Order" demarcating responsibilities of each agency. Follow-up actions should be regularly monitored at the central level. The proposed coordination structure for project implementation is illustrated on Fig. 9.2.2.

The BWDB will establish a Project Implementation Office (PIO) which will be headed by the Superintendent Engineer, the Teesta Project Canal Circle-2, as the Project Director, and one full-time Executive Engineer will be assigned to the field office at Kurigram. At the Central, District and Thana coordination committees, BWDB will be represented by the Member (Implementation), Project Director (SE), and Executive/Sub-divisional Engineers, respectively. During O&M stage, the BWDB will be represented by the Member (O&M).

Similarly, the required staff will be assigned from central to Thana level at BRDB, LGED, DAE, DOF and DOL

9.2.3 Beneficiary participation

The Project Implementation Office (PIO) should establish a Project Beneficiary Committee (PBC) in each of five (5) Thanas in the Project area, in order to facilitate close and uninterrupted interaction between the beneficiaries and the project executing agencies. The PBCs will consist of representatives from the government offices, Thana Nirbahi Officer (TNO) and members of the Union Parishad and others directly representing farmers, fisherman and the landless, and will also include the representatives from NGOs.

During the construction phase, various construction arrangements will be addressed at the PBCs to ensure close coordination with the local authorities and beneficiaries. The land acquisition process will also be monitored at PBCs to ensure the smooth implementation of the project. In the post construction phase, PBCs could also function as an effective benefit monitoring organization, extending its functions to ensure the sustained operation and maintenance (O&M) of the proposed project facilities.

9.2.4 Non-governmental organizations (NGOs)

In the Project area, approximately 170 NGOs are working in various sectors of development to improve the living standards of the rural poor. It is considered that the experiences and capabilities of such NGOs in organizing and mobilizing the landless and women at the grass-root level will provide an important role in implementing various components of the Project. The possible scope of cooperation with such NGOs should be kept as flexible as possible, and be examined during the initial phase of the project implementation.

9.2.5 Land acquisition process

Although the proposed project is planned with a view to minimizing land acquisition for the construction of the project facilities, it will still need about 370 ha of private land for canal construction in order to connect the irrigation intake with the existing drainage channels (see Table 7.5.1). Delays and difficulties in land acquisition are, in most cases, the most serious reason for overall delay in project implementation. In order to minimize such possible delays in land acquisition process, the following will be taken into account:

(1) Participation of the beneficiaries (joint monitoring of land acquisition process by PBCs and executing agencies);

(2) Adequate compensation in cash to farmers who are to lose their land as a result of the project's land acquisition;

(3) "Land for land" concept, whereby farmers are to become landless as a result of the project's land acquisition, will be provided with the alternative land which will be made available through re-adjustment of land among the project beneficiaries; and

(4) Disposal of excavated soils; the excavated soil will be spread over the adjacent land.

9.3 Operation and Maintenance (O&M) of Project Facilities

9.3.1 Current O&M problems

The operation and maintenance of FCD/I projects is a problem throughout the country. It is widely recognized that many of completed FCD/I projects become inoperative within a few years after completion mainly because the BWDB can not afford to finance and implement the required O&M works. Lack of adequate O&M has led to reduced benefits and as a consequence to little interest of the beneficiaries in the functioning of the projects. At present the readiness of the farmers to participate in the O&M of the projects is not virtually observed. The projects may be rehabilitated again, allowing the same process of inadequate O&M, but the project benefits will never reach their intended level due to consequent deterioration.

Such poor O&M have been recognized by the BWDB and numerous initiatives have been launched to find effective means of improving the current O&M. These initiatives include the System Rehabilitation Project (SRP), the Second Small Scale Flood Control, Drainage and Irrigation Project (SSSFCDIP), the Land Reclamation Project (LRP), the

Early Implementation Project (EIP), the Land Reclamation Project (LRP) and the Operation and Maintenance Study (FAP-13). Most of these are still at the exploratory or pilot testing stages, and none of the approaches have been proved most effective by this time.

9.3.2 Basic framework of proposed O&M

BWDB does not have sufficient financial resources to run the completed projects efficiently. After completion of the proposed project, annual O&M costs will be significantly increased. Our public consultation survey indicates that most of the beneficiaries think they can afford to pay additional taxes for the O&M works provided that the effectiveness of the project facilities can be visually confirmed in the field. To ease the increased financial requirement for O&M works, various alternative arrangements should be undertaken, taking two (2) related issues into account; namely, (a) involvement of beneficiaries (PBCs) and (b) mobilization of local financial resources.

Considering all the above, preliminary framework of the O&M plan is conceived hereunder. The plan is only indicative and will need full discussions at the field level with local administration and also a pilot testing during the project implementation stage.

(1) Components of O&M programme

The activities to be taken up under the O&M programme will include (i) routine operation and maintenance, (ii) periodic maintenance, (iii) emergency maintenance, and (iv) rehabilitation or re-construction.

(2) Responsibility for O&M

Considering that the North Unit of the Kurigram FCD/I project may be implemented simultaneously, O&M responsibility should be given to a circle with name and style as Kurigram O&M Circle stationed at Kurigram. One Executive Engineer for the South Unit and another Executive Engineer for North Unit, may be posted for the execution of the required O&M works under the existing O&M Office of North Western Zone at Rangpur, O&M Division of BWDB.

After completion of the project works, the project facilities will be officially transferred from the Project Implementation Office (PIO) to the Kurigram O&M Circle. The O&M circle will be responsible for not only routine and periodic maintenance of the project

facilities but also emergency maintenance and rehabilitation or reconstruction. Terminal irrigation facilities (LLPs and terminal canal systems) will be operated and maintained by water user's cooperatives at their own costs.

(3) Mobilization of local resources

For sustainable O&M, local resources should be mobilized. Water rate for irrigation will be collected from the beneficiaries through BWDB or appropriate agency as per decision of the Government. The collected water rate for irrigation will be exclusively utilized for O&M of the irrigation intake structures and irrigation / drainage canal systems. Land development tax (for improvement of flood embankment and regulators) is unlikely to be collected under present circumstances. There is a need to mobilize the local resources in this aspect not only to ease the burden of BWDB but also to ensure the long-term viability of the project. All possible means should be tested during the implementation of the project. At least, routine maintenance of flood protection facilities will be entrusted to Union administration with technical supports of BWDB.

(4) Institutional Framework for O&M

In order to improve inter-agency coordination, clear and definite "Government Order" with definite routine responsibilities is necessary, and participating agencies at the central government level must monitor their field activities as part of their routine duty. The BWDB's O&M Circle should ensure close cooperation with the related government offices and local authorities to provide adequate services and help to the beneficiaries in order to get them involved in the O&M. The PBCs is expected to serve as an effective benefit monitoring organization, extending its functions to ensure the sustained O&M of the project facilities.

Suggested demarcation of responsibilties of participating agencies for O&M is given on Fig. 9.3.1, and relationship between the Kurigram O&M Circle and other related agencies / public bodies under O&M stage is illustrated on Fig. 9.3.2.

(5) Irrigation Water Management

The Intake structure and main canal networks will be operated and maintained by BWDB, while O&M of the terminal blocks irrigated by LLPs will be made by farmer

groups. Coordination between BWDB and each farmer group will be indispensable for effective use of irrigation water for cultivation.

In the Study area, each Thana office has "Irrigation Management Committee (IMC)" to coordinate among the related agencies in development and O&M of irrigation schemes and also to make necessary guidance on irrigation practices to the farmers. Various agencies (DAE, LGED, BRDB, BADC) at Thana level are involved in the IMC. It is expected that after completion of the surface irrigation system, BWDB will also participate in the IMC together with the representatives of the Project Beneficiaries Committee (PBC) to discuss O&M issues and water management practices for cultivation.

CHAPTER X PROJECT JUSTIFICATION

10.1 Economic Evaluation

10.1.1 Basic assumption

Economic evaluation was basically made in accordance with the "Guidelines for Project Assessment" prepared by Flood Pan Coordination Organization (FPCO). The basic assumptions applied for the economic evaluation are summarized as follows :

(1) The economic useful life of the project is 30 years,

(2) All prices and costs are expressed in mid-1992 prices in Taka,

(3) The exchange rate of US$ 1.00 = Tk. 38.8 = ¥ 125 is applied,

(4) Economic prices of agricultural outputs and inputs are estimated applying the conversion factors prepared by the said Guidelines to the market prices in the project area , and

(5) Economic prices of project works for construction and engineering, O&M, and replacement are estimated same as the agricultural outputs and inputs.

(6) Economic prices for unskilled labour wage, conversion factor of 0.65 is applied for project works, while 0.75 is applied for agricultural inputs because of seasonal and competitive employment for crop production.

10.1.2 Economic benefits

Direct benefits by the Irrigation, Flood Control and Drainage (FCD) development accrue from the productivity increase in the following activities :

1) Crop production in the rainfed and existing irrigated land, and

2) Inland culture fishery in the main channels and beels.

Direct economic benefits could be estimated as incremental benefits between the future with (W) and without (WO) project conditions. In this study, the direct benefits are estimated as one development effects by both irrigation and FCD.

Crop production benefits accrue from the irrigation water supply to rainfed area, improvement of existing irrigation condition, alleviation of flood and water logging, and improvement of farming practices and productivity. Economic net crop production values (ENCPV) per ha under (WO) and (W) project conditions are estimated on the basis of the present and proposed cropping patterns, cropping intensities, and net crop production value per ha as shown in Table 10.1.1. The O&M and replacement costs for the LLP and STW

irrigation in the command area of 35,500 ha are accounted as a production cost in the crop budgets. Incremental ENCPVs may be estimated as follows :

Item	Project Area (ha)	Total ENCPV (Tk million)	Average ENCPV Per ha (Tk'000/ha)
1. Without Project Condition (WO)	35,500	684.1	19,270
- Rainfed area	25,700	412.2	16,040
- Irrigated area	9,800	271.9	27,740
2. With Project Condition/Irrigated (W)	35,500	1,259.9	35,490
3. Increment, (W) - (WO)	-	575.8	16,220
- Surface irrigation area	18,200	385.3	21,170
- Ground water irrigation area	7,500	190.5	11,010
- Rainfed area	-25,700	-	-

In addition to crop production, the project will increase the productivity of culture fishery using the increased water bodies of main channels and beels where year round and fresh water will be available. Economic net fish production values (ENFPV) per ha under (WO) and (W) project conditions are estimated on the basis of the future effective area of water body with 460 ha. Incremental ENFPV is estimated at Tk 204,900 per ha or Tk 94.3 million in total.

The farm land acquired for the project is estimated at around 799 ha for the surface water irrigation and 8 ha for the Ratnai diversion channel. The annual production foregone as negative benefit is defined as an annual net return under the future (WO) project condition in the farmland. The production foregone in the Ratnai diversion channel is allocated to the surface and STW irrigation components according to the proportion of respective irrigation area. Allocated production foregone at the full development stage is estimated at Tk 15.5 million for the surface irrigation and only Tk 0.08 million for STW irrigation.

Incremental development benefits comprising crop and fishery production will be expected to increase year by year according to the implementation schedule. It is assumed that the built-up period to achieve full benefit is five (5) years after the completion of physical works (first year 20% rising by 20% increment per year). The benefit flow in the project life of 30 years is prepared in Table 10.1.2 according to the annual development area.

10.1.3 Economic costs

The financial costs consisting of (1) construction cost for project works including personnel power, materials, equipment and land acquisition, (2) physical contingency, (3) engineering and administration costs, (4) operation and maintenance (O&M) cost, and (5) replacement cost are converted to the economic costs by applying specific conversion factors prepared by the Guideline for Project Assessment. The economic project costs for the surface and STW irrigation as well as FCD components are summarized as follows :

Item		Surface Irrigation	STW Irrigation	FCD Components	Total
1. Project Area	(ha)	18,200	17,300*	35,500	35,500
2. Project Cost	(Tk million)	893.2	67.8	82.0	1,043.0
- Construction		667.7	59.0	62.0	788.7
- Physical contingency		100.2	8.8	9.3	118.3
- Engineering & administration		125.3	0	10.7	136.0
3. Cost Per ha	(Tk'000)	49.1	9.0	2.3	29.4

Note : existing irrigated area of 9,800 ha is included.

The economic cost for FCD components is allocated to the surface water and ground water (STW) irrigation components according to the proportion of respective irrigation area. The annual economic cost flow is prepared on the basis of the implementation schedule as shown in Table 10.1.3.

10.1.4 Economic evaluation

Economic evaluation is made through the estimation of (1) Economic Internal Rate of Return (EIRR), (2) Net Present Value (NPV) and (3) Benefit - Cost Ratio (B/C) both at the discount rate of 12% as shown in Table 10.2.1. The surface water and STW irrigation components are evaluated taking the FCD benefit and cost into account. The evaluation result is summarized as follows :

Item		Surface Irrigation & FCD	STW Irrigation & FCD	Total
1. EIRR	(%)	24.0	63.9	28.5
2. NPV				
Benefit	(Tk million)	1,521	651	2,172
Cost	(Tk million)	602	67	670
3. Benefit-cost ratio		2.5	9.7	3.2

In order to evaluate soundness of the project against possible adverse changes in the future, sensitivity analysis is made as follows :

(Unit : %)

Case	Surface Irrigation	STW Irrigation	Total
Case 1:Project cost overrun by 20%	21.4	57.4	25.5
Case 2:Benefit decrease by 20%	20.5	55.8	24.6
Case 3:Delay in construction for 2 years	18.6	41.4	21.7
Case 4:Combination of Case 1 and 2	18.1	50.0	21.8
Case 5:Combination of Case 1 and 3	16.7	38.0	19.6
Case 6:Combination of Case 2 and 3	16.0	37.2	18.9
Case 7:Combination of Case 1, 2 and 3	14.3	34.0	17.0

10.2 Project Impact Analysis on Income Distribution

In order to evaluate the project from financial aspect of farmers, farm budgets for landless, small, medium, large and very large farmers were made under (W) and (WO) project conditions. Average operated land sizes for the respective groups under the different flooded conditions (F0, F1 and F2&3) in the Study area were clarified by the result of Socio-economic Baseline Survey. Farm budgets are prepared on incomes from agriculture and non-agriculture, and expenditures for agriculture and others including living expenditure. Project impact analysis on income distribution was made on the basis of the following changes in the respective household economy :

1) Increase in agricultural income through increase in agricultural productivity, employment as a farm labour ; agricultural employment income is estimated at Tk 400 /year for landless household,

2) Increase in non-farm income through project construction employment ; construction employment income is estimated at Tk 600/year for landless household during construction period of 12 years,

3) Increase in agricultural production cost for surface water and STW irrigation as well as farm inputs, and

4) Increase in living expenditure according to increase in the household income ; increase in living expenditure is estimated at 30% of the incremental net income for the respective group household.

For the project impact analysis on the respective groups, the development impact to the rainfed farmers to be irrigated using surface water (LLP) and ground water (STW) in the Study area are considered. The farmer beneficiaries under the surface water irrigation (LLP) will receive more irrigation benefit than the STW beneficiaries. The incremental net reserve of LLP beneficiaries will be 1.2 - 1.6 times to those of STW as follows :

(Unit : Tk/year)

Item	Landless (<0.2ha)	Small (0.20-0.5ha)	Medium (0.6-1.9ha)	Large (2.0-3.9ha)	Very Large (4.0ha<)	Total
(1) F0 Area						
(WO/Net reserve)	200	6,860	17,990	49,350	91,150	7,080
(W/Increment)						
- LLP	1,700	8,580	19,070	45,300	74,530	9,040
- STW	1,400	5,550	12,100	28,170	45,500	5,860
- Ratio	1.2	1.6	1.6	1.6	1.6	1.5
(2) F1 Area						
(WO/Net reserve)	270	2,250	10,970	29,310	64,970	4,170
(W/Increment)						
- LLP	1,620	4,500	11,850	25,870	46,250	5,920
- STW	1,400	3,390	8,600	18,420	32,130	4,380
- Ratio	1.2	1.3	1.4	1.4	1.4	1.4
(3) F2&3 Area						
(WO/Net reserve)	60	130	6,840	13,170	38,510	900
(W/Increment)						
- LLP	510	4,210	15,100	26,290	56,270	6,100
- STW	370	3,110	10,670	18,470	40,000	4,450
- Ratio	1.4	1.4	1.4	1.4	1.4	1.4
(4) Total Area/Average						
(WO/Net reserve)	250	3,770	13,890	35,540	73,610	4,910
(W/Increment)						
- LLP	1,150	5,690	13,680	31,500	54,060	6,480
- STW	940	4,010	9,020	20,930	34,770	4,420
- Ratio	1.2	1.4	1.5	1.5	1.6	1.5

The payment capacity of beneficiary farmers for the direct construction and O&M costs is assessed on the basis of their incremental net reserve between (WO) and (W) project conditions. It is concluded that the required water charge be supplemented by the less than 30% of incremental net reserves and be reasonable for the respective group as follows :

Item	Landless (<0.2ha)	Small (0.20-0.5ha)	Medium (0.6-1.9ha)	Large (2.0-3.9ha)	Very Large (4.0ha<)	Total
(1) Water Charge (Tk/year)						
F0 Area	165	1,636	3,575	9,232	15,654	1,719
F1 Area	206	1,060	3,108	7,112	13,483	1,472
F2&3 Area	123	978	3,963	6,988	14,543	1,472
Total Area	165	1,266	3,510	7,966	14,543	1,554
(2) Share of Water Charge (%) within Incremental Net Reserve						
F0 Area	10	19	20	20	21	19
F1 Area	13	24	26	27	29	25
F2&3 Area	24	23	26	27	26	24
Total Area	14	22	26	25	27	24

10.3 Social Impact Assessment

10.3.1 Increase in employment opportunity

The project implementation will increase employment opportunity at several phases in the Study area. The increase in agricultural productivity will require more farm labour inputs. Annual employment increased under the (W) project condition is estimated at around 1.8 million man-day. The project works will accrue construction labour employment from 0.9 to 2.0 million man-day during the 3rd to 9th year of the project life. The O&M activities will need 120,000 man-day /year. In addition, increased production will accelerate agro-based industries and marketing activities. The employment at industrial and service sectors will be also increased.

10.3.2 Increase in land value

Economic value of land will be increased by the project implementation through change of rainfed land to irrigated. It will increase the value of land assets as a mortgage and the larger land owners will have more monetary power in the future. On the contrary, marginal farmers such as landless and small farmers will be hard to acquire farm lands because of increase in land price. It is assumed that income imbalance between marginal and large farmer groups be enlarged without socio-economic incentives to the marginal farmers such as improvement of leasehold tenancy (change from present share tenancy to fixed rent), promotion of agrarian reform, especially to absentees' land, and increase in non-agricultural year-round employment.

10.3.3 Improvement of local transportation

Existing bridges over the proposed main channels in the Study area will be newly constructed and accessibility between right and left bank areas be improved. Improvement of rural road network linked with the bridges or between villages and local markets could be accelerated in the future.

10.4 Environmental Impact Assessment

Probable negative impacts on FCD/I development in the Study area are listed along with their ranks of maginitude as shown below :

	List of probable negative impacts and mitigation measures	Impact level
(1)	Environmental degradation from increased pressure on land: Mitigating meaures:Monitoring resettlement to balance with the carring capacities of land, increased productivity from agricultural lands.	low
(2)	Loss of land from inundation: Mitigating meaures:Increasing cultivation of HYV crops in irrigated and protected area to offset losses.	low
(3)	Water logging from irrigation water: Mitigating meaures:Number size and location of sluice gates as requirement to remove excess water quickly, proper operation of gates.	low
(4)	Salinization of soils from water logging:	none
(5)	Increased soil erosion:	none
(6)	Reduction in floodplain agriculture:	none
(7)	Clogging/choking of canals from sedimentation: Mitigating meaures:Monitoring sedimentation at critical or potential sites and overall management of canals to minimize sedimentation.	moderate
(8)	Changes in natural vegetation cover: Mitigating meaures:Afforestation on the embankments and encouragement to plant homestead trees, introduction of new species.	moderate
(9)	Loss of wildlife habitat: Mitigating meaures:Monitoring the increase of pests and rodents and devicing biological control of these by introduction of different animals or birds.	moderate
(10)	Adverse effect on fish habitat: Mitigating meaures:Provision of fish ladder and other passageways, protection of spawning grounds, alternate development of reservior fisheries.	moderate
(11)	Effect on human settlement pattern: Mitigating meaures:Due to the absence of flood, homestead may be built anywhere uncrouching valuable agricultural land. Effective land use zoning laws should be devised so that new homesteads are built toward the existing towns leaving the agricultural land.	low
(12)	Displacement of people due to canal construction: Mitigating meaures:Relocation in suitable land, comoensation in kind and cash, simultaneous provision for creating non-farm income generating opportunities.	low
(13)	Problem of resettlement of displaced population: Mitigating meaures:special provision for khas land distribution, compensation and simultaneous provision for creating non-farm income generating opportunities.	low
(14)	Problem in circulation network (roads, waterways): Mitigating meaures:Afforestration of roadsways by the programme such RDRS model utilising the labour from the villages for rural road maintenance.	low
(15)	Reduction of downstream navigation potentials:	none

(16)	Loss of historic and cultural ffeatures:	none
(17)	Deterioration of water quality: Mitigating meaures:Removal of stagnant water by more sluice gates and proper operation.	moderate
(18)	Increase in incidence of water related disease like malaria:	none
(19)	Increase in water born diseases like diarrhoea:	none
(20)	Sanitation/drainage & garbage disposal in urban areas:	none
(21)	Potential for structural failure: Mitigating meaures:Afforestrtion on the embankments, restriction on settlement on embankment, monitoring the physical condition of the embankments and river training.	moderate
(22)	Problem of downstream flooding: Mitigating meaures:Taking up of similar flood control projects in the affected area	low

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

CHAPTER XI RECOMMENDATIONS

11.1 Implementation Priority of the Project

The project area is one of the poorest districts in Bangladesh, and its economic performance has been stagnant. The situation would get worse with increasing population and decreasing per capita production level unless corrective measures are undertaken. The Kurigram FCD/I Project was initiated in 1969/71. Only flood embankment and drainage sluices were constructed, and irrigation component has been left undeveloped so far. According to our public consultation survey, farmers are anxious to have irrigation facilities among others to improve their agricultural activities. The proposed project is verified to be technically sound and economically feasible with overall EIRR of 27.6%, and considered eligible for early implementation.

However, since there are many other FCD/I projects throughout the country including those newly identified by the FAP studies, the implementation priority of the project should be examined in a long-term FCD/I development programme of BWDB.

11.2 Additional Survey and Detailed Design

For the successful implementation of the proposed construction works, various additional surveys and investigations should be made by the BWDB. These comprise geological and soil mechanical investigation at the proposed site of regulators and bridges, materials survey for embankment, canals, and related structures, topographic survey for designs of command area development (CAD) with LLPs, and groundwater potential survey by pumping test.

The topographic maps covering the project area are too old to use for the detail design of the project. Only the aerial photos which were taken in 1990, are available at present. In order to ensure the early commencement of the project, the photo mapping with a proper scale should be prepared as early as possible. It is recommended that detailed design should be undertaken based on the newly prepared photo maps. The financial arrangement for the detailed design including preparation of tender documents would be needed in advance of the commencement of the construction works.

11.3 Land Acquisition

According to FAP-15, land acquisition is the most time-consuming facotr for project implementation. Although special attention was paid to this in the project formulation, about 800 ha of land is still required for construction of the project facilities. The land acquisition should be commenced as early as possible in advance of the commencement of the construction works.

11.4 Flood Control and Erosion Protection Works

Serious river bank erosion is observed at Moglbasha, Chilmari and Kishorpur. However, the erosion protection works at these sites are not included in the proposed Project as agreed between BWDB and the Study Team (see Attachment-8), mainly because such works are rather urgently required and should not be delayed until the proposed project be implemented. The required erosion protection works are tentatively studied as described in Appendix-X. It is hoped that our suggestions for the erosion protection works would be useful for BWDB.

11.5 Drainage Improvement

The Rainai river diversion works will cause land acquisition problem for construction of the diversion channel (3.5 km). Much efforts should be made to solve the problem through a series of public consultation and focus group discussions. The drainage improvement works such as construction of additional regulators and re-excavation of the existing channels, creeks and beels should be made in parallel with construction of irrigation canal network, because most of the existing channels are connected with the existing regulators and will be utilized as irrigation canal.

In order to improve the existing drainage condition as much as possible, it is recommended that LLPs should be operated for dual purposes - irrigation and drainage - by interchanging suction pipe with delivery pipe. The LLP should be used for irrigation of rabi crops during the dry winter season, while used for drainage of excess water during the Monsoon season. This operation would contribute to the improvement of drainage in sporadically inundated area in particular. This should be tested at the proposed demonstration farms.

11.6 Command Area Development (CAD)

Installation of tubewells for groundwater irrigation development should be made by private initiatives in view of the government policy shift to privatization and successful performance of private sector on tubewell development in recent years. Installation of LLPs for surface irrigation system should also be made by farmers groups on the same reason. For successful implementation of CAD, the government supports should be extended to the farmers in particular for organizing farmers groups, arrangement of credits and technical guidance in construction and O&M. These supports should be made by BRDB and LGED under close coordination with BWDB.

11.7 Establishment of Demonstration Farm

The command area development with tubewells / LLPs will be made by private initiatives, and development modes and pump size will be finally decided by the farmers themselves. In order to support such private initiatives, it is strongly recommended that demonstration farms be established in the Project area and operated jointly by BWDB/ DAE/BRDB. The "Demonstration Farm" should have the following objectives :

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

The demonstration farms will provide the farmers with appropriate technologies applicable for CAD in the area. The demonstration farms should be established gradually in parallel with the irrigation canal construction so that the farmers can utilize the surface water by their own responsibilities making reference to the demonstration farm operation.

11.8 Inter-Ministerial Coordination Committee

BWDB will be the lead executing agency for project implementation, and other agencies such as LGED, BRDB, DAE, DOF and DOL are expected to participate in the proposed Project. It is recommended that in order to ensure close coordination among the agencies, an inter-ministerial coordination committee comprising MIWDFC, MOLGRDC, MOA, MOFL Planning Commission and MOF be established, and the "Government Order" demarcating responsibilities of each agency in project implementation should be set out before the commencement of the construction works.

11.9 Inland Fisheries Development

The project will develop a vast perennial water body through the development of the surface water irrigation system and the improvement of the drainage system. It is clarified through the Study, that inland fisheries development is technically and economically sound; among the proposed development modes, duck-cum-fish culture is much attractive. In the early stage of the project implementation, both fisheries development should be tested and demonstrated as a pilot testing scheme in the project area..

11.10 Groundwater Resources in the Central Tract

Irrigation water resources in the Central Tract is mainly dependent upon surface water resources in the Dharla river, supplemented by groundwater resources. A considerable portion of the groundwater resources in the Central Tract remains potentially even after the commencement of the operation of the project. These resources should be reserved for the time being and further exploited for potable and cottage industrial water supplies in the future which are subject to high water quality.

11.11 Operation Rule of Regulators

The existing regulators have been operated mainly to drain excess runoff and to protect backflow from external rivers, and sometimes, have caused excess drainage due to mis-operation at the late monsoon season. After the completion of the project, all the regulators should be more severely operated for the dual purposes, irrigation and drainage. In particular, the gate operation during the late monsoon season should be made severely to use runoff water effectively for irrigation and to avoid excess drainage. In this view, it is recommended that the BWDB prepare the operation rule for each regulator and to train the employed gate keepers before the commencement of the project

TABLES

Table 1.2.1 List of Personnel Participated in the Study

BWDB offcial (including counterpart personnel)

(1)	Mr. Liaquat Hossain	Chief Engineer,Planning	
(2)	Mr. Md.Afazuddin	Chief Engineer,Design II	
(3)	Mr. Eman H. Khan	Director,Land and Water Use	
(4)	Mr. S.A.M.Rafiquzzaman	Directer,Planning (general)	(Counterpart)
(5)	Mr. A.K.M. Anisur Rahman	Superintending Engineer, Teesta Project Canal Circle - II	(Counterpart)
(6)	Mr. Y. Haroon	Executive Engineer,Planning (general)	(Counterpart)
(7)	Mr. Mohendra Chandra Dey	Economist,E.P.Directorate	(Counterpart)
(8)	Mr. Fakrul Islam	Dy. Chief Agronomist, Directorate of Planning (genaral)	(Counterpart)
(9)	Mr. Md. Akhtar Alam	Executive Engineer,F.P.C.O.,Dhaka	
(10)	Mr. Md. Raihan Ali Miah	Executive Engineer,WARPO(MPO),Dhaka	
(11)	Mr. Md. Aminul Haque	Executive Engineer,Negotiation Cell	
(12)	Mr. Mukhlesuzzaman	Executive Engineer,Design V	
(13)	Mr. Md. Quamruzzaman	Executive Engineer,Kurigram	
(14)	Mr. Ashraf Ali Khandokar	Soil Scientist	(Counterpart)
(15)	Mr. Minarul Islam	Soil Survey Officer	(Counterpart)
(16)	Mr. Anwar Hossain	Civil Engineer	
(17)	Mr. Md. Shahabuddin	Sub - Divisional Engineer	

JICA Advisory Committee

(1)	Shoichiro Nakagawa	Chairman,JICA Advisory Committee
(2)	Hideaki Sekioka	Irrigation / Drainage
(3)	Akira Ohtsuka	Agriculture

JICA Study Team

(1)	H. Yamamoto	Leader / Irrigation & Drainage
(2)	N. Ariga	Agricultural Economy / Institutional Planning
(3)	Y. Kobayashi	Meteorology / Hydrology
(4)	N.Morioka	Agriculture / Soil and Land Use
(5)	M.Tatebayashi	Soil Mechanics and Fundation
(6)	F. Tamura	Facility Plan - Headworks
(7)	Y. Inoue / J. Nakagawa	Facility Plan - Pumping Station
(8)	K. Tsumura	Topographic Survey
(9)	K.B.S. Rasheed	Environmental Assessment
(10)	M.A.L. Sarker	Inland Fishery
(11)	Y. Fukasaka	Project Evaluation

Table 3.5.1 10-day Mean Discharge at Kurigram (No.77)

(Unit : m3/sec)

		Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1973	1st	113.0	148.7	395.7	511.1	760.0	360.4	384.5	281.8	199.1	165.9	155.8	135.7
	2nd	112.3	252.8	615.2	394.9	651.0	565.1	434.1	246.5	184.0	164.5	148.1	132.2
	3rd	135.1	240.4	725.3	529.5	426.8	479.9	353.1	221.8	173.7	162.9	140.6	135.1
	Mean	120.1	214.8	578.8	480.1	606.6	468.5	389.3	250.0	185.2	164.4	148.7	134.4
1974	1st	104.7	316.8	770.5	2,771.6	3,008.6	2,495.0	1,481.3	310.5	165.0	138.1	106.4	92.5
	2nd	167.5	674.9	691.1	1,867.1	1,063.5	2,170.9	806.1	233.6	166.3	126.0	100.0	86.0
	3rd	197.8	428.9	1,762.8	2,636.1	1,005.3	2,009.6	959.6	193.3	152.8	116.9	94.6	82.0
	Mean	156.7	472.1	1,074.8	2,431.8	1,670.3	2,225.2	1,078.4	245.8	161.1	126.7	100.7	86.7
1975	1st	94.4	96.0	191.4	1,356.1	1,695.8	1,380.3	1,146.6	338.5	182.0	145.2	128.4	108.3
	2nd	91.4	120.7	383.9	1,068.8	799.0	1,424.1	719.5	234.1	170.6	135.8	121.9	102.2
	3rd	100.6	139.3	1,004.2	2,112.0	991.6	1,183.6	499.8	197.2	156.4	127.9	113.1	94.9
	Mean	95.5	119.3	526.5	1,531.6	1,156.6	1,329.3	779.3	256.6	169.2	136.0	121.4	101.6
1976	1st	97.4	198.7	410.8	1,723.6	1,198.5	686.3	412.7	164.6	142.0	96.8	73.9	60.2
	2nd	93.5	260.7	978.7	1,494.4	1,213.7	561.0	272.5	155.4	120.5	88.4	68.3	55.9
	3rd	109.7	247.8	767.0	983.1	1,145.3	502.2	199.4	141.9	107.0	80.0	64.3	53.4
	Mean	100.2	236.1	718.8	1,386.9	1,184.5	583.1	291.8	154.0	122.7	88.1	69.2	56.4
1977	1st	78.5	201.1	574.4	768.5	822.0	1,057.7	837.5	249.9	138.6	107.9	116.8	99.1
	2nd	130.6	140.2	851.3	1,078.9	1,491.6	725.0	578.2	209.7	121.0	124.0	112.5	93.6
	3rd	138.5	237.7	836.7	1,235.5	1,600.3	781.7	312.4	161.6	107.3	122.4	106.2	86.3
	Mean	115.9	194.4	754.2	1,034.3	1,314.1	854.8	567.5	207.1	121.8	118.2	112.2	92.8
1978	1st	79.5	97.5	218.9	838.5	961.0	572.4	603.7	294.2	206.5	170.2	144.4	124.6
	2nd	72.8	112.8	373.1	1,069.3	713.2	869.6	500.6	255.7	190.7	158.9	142.4	116.3
	3rd	104.2	235.7	749.7	1,096.4	607.0	927.7	346.5	239.2	179.4	151.2	132.2	108.8
	Mean	85.5	151.5	447.2	1,004.5	755.5	789.9	479.2	263.0	191.8	159.8	140.2	116.3
1979	1st	94.7	119.8	96.3	380.4	624.6	849.3	643.6	241.1	202.3	143.2	111.2	109.9
	2nd	97.6	157.3	132.5	438.7	434.1	795.6	590.3	211.7	173.9	126.7	106.1	97.3
	3rd	102.6	134.4	171.3	792.8	720.7	441.8	322.8	190.5	157.8	117.0	103.6	96.5
	Mean	98.3	137.1	133.4	545.5	597.3	695.6	512.5	214.4	177.3	128.6	107.1	101.1
1980	1st	178.6	229.1	647.4	1,695.1	4,182.2	3,030.1	2,066.7	582.7	280.5	172.8	136.8	96.1
	2nd	157.0	325.9	1,900.2	3,382.7	6,268.7	2,910.2	1,126.4	415.5	231.4	157.1	124.3	93.4
	3rd	172.6	462.9	2,370.1	4,477.7	4,331.1	2,585.9	915.0	339.5	199.6	148.7	106.4	83.8
	Mean	169.4	343.3	1,639.2	3,226.8	4,908.1	2,842.1	1,354.7	445.9	235.9	159.2	123.7	90.9
1981	1st	53.1	77.1	138.1	995.5	1,029.3	1,034.5	457.5	188.9	135.6	114.0	94.9	85.7
	2nd	51.9	124.4	148.1	830.9	901.6	895.2	290.6	166.8	133.1	107.3	93.0	82.8
	3rd	70.7	113.5	282.4	1,052.5	1,072.0	550.8	224.2	151.1	122.2	100.0	88.2	90.4
	Mean	58.5	105.3	189.5	962.7	1,003.2	826.9	320.9	168.9	130.0	106.9	92.3	86.4
1982	1st	75.7	97.9	139.3	1,292.1	1,291.5	539.8	451.8	229.0	150.5	113.8	93.2	80.7
	2nd	78.4	114.4	376.4	1,798.7	516.1	988.3	301.4	179.9	134.0	104.1	87.9	75.2
	3rd	98.4	95.9	829.0	1,817.0	490.8	1,075.6	280.3	163.3	123.6	97.9	88.7	80.8
	Mean	84.2	102.5	448.2	1,641.7	757.2	867.9	342.4	190.7	135.6	105.0	90.0	79.0
1983	1st	85.5	161.8	339.7	1,314.1	981.0	995.4	701.8	240.0	149.4	119.1	-999.9	77.1
	2nd	77.7	225.2	469.6	-999.9	664.8	1,605.6	534.5	199.3	135.1	113.2	89.0	72.2
	3rd	79.4	256.9	826.6	-999.9	953.5	1,308.7	367.9	168.8	128.6	-999.9	76.2	68.4
	Mean	80.8	216.0	545.3	-999.9	869.2	1,303.2	529.4	202.7	137.4	-999.9	-999.9	72.4
1984	1st	44.7	78.2	419.6	688.1	759.9	641.6	419.7	256.0	167.1	133.2	97.4	85.3
	2nd	42.0	137.7	712.0	1,055.5	366.6	1,080.8	309.5	216.2	155.6	116.7	98.7	80.6
	3rd	52.4	374.8	593.9	1,038.7	471.6	813.0	408.2	188.3	144.7	102.3	90.7	78.0
	Mean	46.3	202.7	575.2	931.0	530.7	845.1	380.1	220.1	155.4	116.9	96.0	81.2
1985	1st	89.0	123.2	851.6	1,320.5	1,060.9	1,270.2	696.0	244.8	145.6	148.1	101.3	81.6
	2nd	79.6	177.1	574.5	1,545.0	680.5	947.8	520.5	198.8	140.3	124.1	92.2	77.5
	3rd	116.9	227.3	874.6	1,965.8	982.1	886.6	412.5	165.2	147.9	114.6	86.8	71.4
	Mean	95.2	177.5	766.9	1,621.9	910.2	1,034.9	538.8	202.9	144.7	128.5	93.9	76.7
1986	1st	105.3	192.6	228.4	1,000.7	1,173.5	1,038.8	657.8	200.2	124.8	87.9	72.3	73.8
	2nd	111.1	187.6	427.7	941.9	518.8	1,217.4	628.1	166.4	111.7	80.3	69.7	86.1
	3rd	126.8	179.7	699.7	999.9	803.3	787.0	328.8	150.9	99.5	73.1	68.4	83.2
	Mean	114.4	186.4	451.9	981.4	830.9	1,014.4	531.5	172.5	111.6	80.2	70.3	81.1
1987	1st	72.7	136.8	215.9	1,659.9	1,691.5	1,038.9	834.1	237.2	127.2	88.0	71.6	71.9
	2nd	65.0	137.7	369.3	1,170.2	2,312.7	1,006.1	367.8	182.0	109.1	84.3	68.1	71.8
	3rd	86.6	125.8	840.6	1,553.7	786.2	1,011.5	430.1	151.8	96.2	78.8	73.4	64.4
	Mean	74.8	133.2	475.2	1,464.2	1,570.6	1,018.8	540.3	190.3	110.4	83.6	70.9	69.2
1988	1st	52.7	85.6	335.5	1,486.7	1,061.3	2,343.0	660.0	135.6	99.4	78.2	67.8	61.8
	2nd	59.2	145.6	354.1	1,473.5	1,644.9	1,441.6	380.9	111.6	95.8	70.2	66.5	59.9
	3rd	97.6	291.0	672.3	1,615.4	3,218.4	746.1	209.0	100.2	89.6	70.0	74.2	59.5
	Mean	69.8	177.8	453.9	1,528.1	2,015.0	1,510.2	409.9	115.8	94.8	72.7	69.2	60.3
1989	1st	54.3	63.5	625.6	1,397.1	745.0	1,106.4	860.8	216.4	109.7	87.8	73.4	68.0
	2nd	52.6	68.3	963.9	1,568.5	815.5	1,155.0	521.9	160.2	100.3	81.8	73.0	66.1
	3rd	52.2	322.7	794.3	1,079.1	1,019.0	1,314.0	332.6	133.0	97.1	78.4	70.0	65.8
	Mean	53.0	157.0	794.6	1,339.6	865.0	1,191.8	564.0	169.9	102.2	82.5	72.3	66.6
1990	1st	77.2	189.3	887.2	1,180.2	1,205.3	967.6	1,400.7	276.3	140.9	107.8	70.8	54.0
	2nd	101.7	294.4	998.8	1,589.2	1,474.9	1,247.2	1,039.0	207.0	115.9	87.1	62.4	49.0
	3rd	128.0	325.5	1,341.8	1,611.6	1,307.3	1,414.6	453.7	168.2	97.1	76.4	56.3	48.3
	Mean	102.3	271.5	1,075.9	1,465.2	1,328.5	1,209.8	948.0	217.1	117.3	90.0	63.6	50.4

Table 3.10.1 List of Existing Rural Infrastructure

Rural Infrastructures	Unit	Kurigram	Rajarhat	Ulipur	Chilmari	Lalmonirhat
1. Road						
Metaled	km	49	18	30	10	32
Unmetaled	km	170	216	200	263	205
Total	km	219	234	230	273	237
2. Market						
Category A	nos	7	3	2	2	2
Category B	nos	0	14	0	0	0
Category C	nos	14	4	32	4	28
Total	nos	21	21	34	6	30
3. Education						
Primary School	nos	70	74	117	63	76
Secondary School	nos	20	15	29	8	33
College	nos	3	1	3	1	3
Madrasha	nos	101	30	135	54	23
Total	nos	194	120	284	126	135
4. Health						
Hospital/Thana Health Complex	nos	1	1	1	1	2
Union Health Care Centre	nos	3	2	1	1	4
Medical Asst. Training Centre	nos	1	0	3	0	0
Family Planning Clinic	nos	6	2	8	6	8
Veterinary	nos	6	2	1	1	1
Total	nos	17	7	14	9	15
5. Library	nos	2	1	1	0	2
6. Community Centre	nos	1	1	1	0	2
7. Post Office (Telegram)	nos	10	9	25	7	11
8. Cinema Hall	nos	4	1	1	2	3
9. Water Supply`						
Deep Tube Well	nos	3	0	0	0	2
Overhead Tank	nos	2	0	0	0	0
Piped System	km	23.2	0	0	0	6.3
Shallow(Hand) Tube Well	nos	1,375	1,324	1,000	1,047	1,200
Tora DSP Pump	nos	128	4	20	23	15
10. Electrification (Nos.of Consumer)	nos	3,020 (Kurigram + Rajarhat)		931	483	3,482

Table 3.11.1 Existing Drainage System

(1) Existing Drainage Regulator

	Name	River	Vent		
			Number	Size (m)	Sill level (m)
I.	Dharla River Side				
	1. Ratnai	Ratnai River	8	1.52 x 1.83	25.38
	2. Siramari	Ratnai River	3	1.52 x 1.83	23.75
	3. Palashbari	Deserhater Chhara	2	1.52 x 1.83	22.85
II.	Brahmaputra River Side				
	4. Malbhanga	Irrigation Canal	16	1.52 x 1.83	21.80
	5. Bamni	Bamni River	12	1.52 x 1.83	21.45
	6. Bamni Add.	Bamni River	3	1.52 x 1.83	21.36
	7. Magurabeel	Buri Teesta River	3	1.52 x 1.83	21.03
	8. Chilmari	Buri Teesta River	10	1.52 x 1.83	21.03
III.	Teesta River Side				
	9. Harichari	Mathailer Chhara	12	1.52 x 1.83	20.12
	10. Kishorpur	Buri Teesta River	12	1.52 x 1.83	22.77
	11. Gharialdanga	Buri Teesta River	2	1.52 x 1.83	24.38

(2) Existing Pipe Sluice

Location	Dimensions			Remarks
	Diameter	Length	Type	
1. Char Modajdzajasara	1.1m	18.7m	RC Pipe, Flap Gate	Good Condition
2. Bhelakopa	1.0m	23.0m	RC Pipe, Stop Log	To be included in Secondary Town Protection Project
3. Hingul Ray	1.0m	19.0m	RC Pipe, Stop Log	- ditto -
4. Dalan	1.2m	18.8m	RC Pipe, Stop Log	To be rehabilitated to Flap Gate
5. Raniganj	1.2m	20.5m	RC Pipe, Stop Log	- ditto -
6. Chasler Bil	1.2m	31.8m	RC Pipe, Stop Log	- ditto -
7. Hokadanga	1.0m	20.0m	RC Pipe, Stop Log	- ditto -
8. Karpura	1.0m	20.0m	RC Pipe, Flap Gate	Good Condition
9. Rati	1.0m	20.0m	RC Pipe, Stop Log	To be rehabilitated to Flap Gate
10. Chatura	1.0mx 5 nos.	20.0m	Steel Pipe, Open	To be reconstructed
11. Lakhlarpara (proposed)	1.0m	20.0m	RC.Pipe,Flap Gate	To be constructed

Table 4.1.1 SUMMARY OF PREVIOUS FEASIBILITY STUDIES ON KURIGRAM FCD/I PROJECT (SOUTH UNIT)

	Items	Original F/S in 1969/71	Revised and Updated F/S in 1975	Revised and Updated F/S in 1982
1	Feasibility Report	vol. 1: Main Report vol. 2: Appendix vol. 3: Special Alternative Studies (not available) (The 1969 report was incomplete and finalized in 1971.)	vol. 1: Main Report vol. 2: Appendix vol. 3: Drawings (not available)	Main Report only
2	Consultant/Executing Agency	Pakistan Techno-Consult Limited	Techno Consult Eastern Limited	Task Force Team of BWDB
3	Proposed Project Features			
	(1) Gross Area	157,500 acres (63,740 ha), 70 ft. - 110 ft.	157,500 acres (63,740 ha), 70 ft. - 110 ft.	157,500 acres (63,740 ha), 70 ft. - 110 ft.
	(2) Net Irrigation Area	121,500 acres (49,170 ha)	127,905 acres (51,760 ha)	121,500 acres (49,170 ha)
	by Pump	48,600 acres (19,670 ha)	No irrigation by pump was proposed.	No irrigation by pump was proposed.
	by Gravity (barrage)	72,900 acres (29,500 ha)	76,600 acres (31,000 ha)	70,000 acres (28,330 ha)
	by Tubewell	not considered	51,300 acres (20,760 ha)	51,500 acres (20,840 ha)
	(3) Flood Embankment			
	Length	64.2 mile (103.3 km)	66.0 mile (106.2 km)	63.0 mile (101.4 km)
	Average Height	9.5 feet (2.9 m)	10.0 feet (3.0 m)	10.0 feet (3.0 m)
	Crest Width	14 ft. - 24 ft. (4.3 m - 7.3 m)	14 ft. - 24 ft. (4.3 m - 7.3 m)	14 ft. - 24 ft. (4.3 m - 7.3 m)
	Slopes	3:1 (riverside), minimum 3:1 (countryside)	3:1 (riverside), minimum 3:1 (countryside)	3:1 (riverside), minimum 3:1 (countryside)
	Free Board	3 ft. - 5 ft. (0.9 m - 1.5 m)	3 ft. - 5 ft. (0.9 m - 1.5 m)	3 ft. - 5 ft. (0.9 m - 1.5 m)
	(4) Pumping Plant	Purpose: Irrigation	No pumping plant was proposed.	No pumping plant was proposed.
	Irrigation Capacity	1,430 cfs (40 m3 /sec)		
	(5) Dhalra Barrage	Purpose: Irrigation & Railway/Roadway Bridge	Purpose: Irrigation & Railway/Roadway Bridge	Purpose: Irrigation & Railway/Roadway Bridge
	Max. Flood Dischage	250,000 cfs (7,075 m3/sec)	250,000 cfs (7,075 m3/sec)	250,000 cfs (7,075 m3/sec)
	Total Length	1,866 ft. (569 m)	1,866 ft. (569 m)	1,866 ft. (569 m)
	Normal Pool Elevation	98 ft. (full supply level at canal head: 96.2 ft.)	98 ft. (full supply level at canal head: 96.2 ft.)	98 ft. (full supply level at canal head: 96.2 ft.)
	Design Intake Capacity	Full Supply Discharge: 2,165 cfs (61.0 m3 /sec)	Full Supply Discharge: 1800 cfs (50.9 m3 /sec)	Full Supply Discharge: 1800 cfs (50.9 m3 /sec)
	(6) Tubewell Development	No tubewell development was proposed.	364 tubewells with an average capacity of 3 cfs (85 l/sec)	DTW (2 cfs: 57 l/sec): 436, STW (0.5 cfs:14 l/sec): 308
	(7) Length of Irrigation Canal			
	Main Canal	39.04 miles (62.8 km)	39.04 miles (62.8 km)	39.04 miles (62.8 km)
	Branch Canal	43.05 miles (69.3 km)	43.05 miles (69.3 km)	43.05 miles (69.3 km)
	Laterals	127.15 miles (204.6 km)	120 miles (193.1 km)	120 miles (193.1 km)
	(8) Drainage System			
	Drainage Sluice/pumping plant	Drainage Sluice: 5 nos.	Drainage Sluice: 5 nos, Drainage pumping plant : 5 units	Drainage Sluice: 9 nos (no drainage pump was proposed.)
	Drainage Channels	96 miles (154.5 km)	96 miles (154.5 km)	96 miles (154.5 km)
	(9) Transmission line	11 kV transmission line, 7.25 miles (11.7 km) (for pumping plant)	33 kV: 108 miles (173 km), 0.44 kV: 146 miles (235 km) (for tubewell development)	33 kV: 108 miles (173 km), 0.44 kV: 146 miles (235 km) (for tubewell development)
4	Agricultural Development			
	Cropping Intensity	to be increased from 174% to 250%	to be increased from 174% to 273%	to be increased from 196% to 223%
	Unit Yield of T. Aman	to be increased from 1.46 to 2.49 tons/ha	to be increased from 1.46 to 3.69 tons/ha	to be increased from 2.20 to 3.76 tons/ha
5	Project Economy			
	Exchange Rate	US$1.00 = Rs. 4.76 (1968/69)	US$1.00 = Tk. 8.547 (1972/73)	US$1.00 = Tk.20.0 (1981)
	Capital Cost	Rs.232,457,100 (Dhalra Barrage: Rs.60,195,300)	Tk.640,110,800 (Dhalra Barrage: TK.118,698,600)	Tk.1,533,630,000 (Dhalra Barrage: TK.426,260,000)
	US$ equivalent	US$ 48.84 million (Dhalra Barrage: US$ 12.67 million)	US$ 74.89 million (Dhalra Barrage: US$ 13.88 million)	US$ 76.68 million (Dhalra Barrage: US$ 21.31 million)
	per ha Cost	US$ 993/ha (Dhalra Barrage: US$ 429/ha)	US$ 1,447/ha (Dhalra Barrage: US$ 448/ha)	US$ 1,560/ha (Dhalra Barrage: US$ 752/ha)
	Annual O&M Cost	Rs.14,874,000 (6.4% of the Capital Cost)	Tk.52,154,000	Tk.43,610,000
	US$ equivalent	US$3.12 million (US$ 63.6/ha)	US$6.10 million (US$ 117.8/ha)	US$2.18 million (US$ 44.3/ha)
	Primary Project Benefits	Rs.50,212,000	Tk.331,602,000	Tk.983,802,000
	US$ equivalent	US$ 10.55 million (US$ 215/ha)	US$ 38.80 million (US$ 750/ha)	US$ 49.19 million (US$ 1,000/ha)
	Internal Rate of Return	11.41%	38.90%	56.21%

Table 6.1.1 Irrigation Water Requirement

Land Type	Name of Crop	Cropped Area (%)	Jan.			Feb.			Mar.			Apr.			May			Jun.			Jul.			Aug.			Sep.			Oct.			Nov.			Dec.			Requirement (mm)
			1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
F0 Area 39%	Mustar/Onion	17.95	2.57	2.88	3.24	3.59	3.75	3.74																												1.53	1.52	1.97	253
			0.18	0.20	0.23	0.25	0.26	0.26																										0.11	0.11	0.14	18
	T.Boro/T.Aus	17.95						2.56	10.75	14.65	7.88	8.04	8.03	4.89	0.39	0.00	0.00	1.59	3.45	1.18	0.00																	642
								0.18	0.75	1.03	0.55	0.56	0.56	0.34	0.03	0.00	0.00	0.11	0.24	0.08	0.00																	45
	T.Aman	17.95																			1.95	8.08	8.66	2.20	3.48	1.64	0.00	0.00	0.00	3.80	7.20	6.36	5.19	3.91					541
																					0.14	0.57	0.61	0.15	0.24	0.11	0.00	0.00	0.00	0.27	0.50	0.45	0.36	0.27					38
	T.Boro	15.38		2.40	10.16	13.17	6.81	7.24	7.95	8.76	8.64	8.96	8.90	5.62	1.04	0.00	0.00	0.00																				915
				0.14	0.61	0.79	0.41	0.43	0.48	0.53	0.52	0.54	0.53	0.34	0.06	0.00	0.00	0.00																				55
	T.Aman	15.38																			1.95	8.08	8.66	2.20	3.48	1.64	0.00	0.00	0.00	3.80	7.20	6.36	5.19	3.91					541
																					0.12	0.48	0.52	0.13	0.21	0.10	0.00	0.00	0.00	0.23	0.43	0.38	0.31	0.23					32
	Mustard	12.82	2.86	2.88	3.08	3.07																												1.83	1.85	2.16	2.52	2.83	237
			0.14	0.14	0.15	0.15																												0.09	0.09	0.11	0.13	0.14	12
	T.Aus	12.82										2.66	10.81	11.83	0.13	0.00	0.00	1.07	3.54	2.34	0.73	0.00	0.00	0.00															331
												0.13	0.54	0.59	0.01	0.00	0.00	0.05	0.18	0.12	0.04	0.00	0.00	0.00														17
	Mustard	17.95	1.99	2.59	3.24	3.59	3.94	4.18	4.24																													1.38	1.53	272
			0.14	0.18	0.23	0.25	0.28	0.29	0.30																													0.10	0.11	19
	Jute	17.95								0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00																		0
										0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00																		0
	T.Aman	17.95																				1.80	8.40	9.89	3.48	1.67	0.00	0.00	0.00	3.80	7.20	6.97	6.14	4.98	3.66				597
																						0.13	0.59	0.69	0.24	0.12	0.00	0.00	0.00	0.27	0.50	0.49	0.43	0.35	0.26				42
	Mustard	17.95	2.57	2.88	3.24	3.59	3.75	3.74																													1.53	1.52	1.97	253
			0.18	0.20	0.23	0.25	0.26	0.26																													0.11	0.11	0.14	18
	Boro	17.95						2.56	10.75	14.65	7.88	8.04	8.03	4.89	0.39	0.00	0.00	1.59	3.45	1.18	0.00																			642
								0.18	0.75	1.03	0.55	0.56	0.56	0.34	0.03	0.00	0.00	0.11	0.24	0.08	0.00																			45
	T.Aman	17.95																			1.95	8.08	8.66	2.20	3.48	1.64	0.00	0.00	0.00	3.80	7.20	6.36	5.19	3.91					541
																					0.14	0.57	0.61	0.15	0.24	0.11	0.00	0.00	0.00	0.27	0.50	0.45	0.36	0.27					38
	Pulses	17.95	1.80	2.21	2.93	3.50	3.84	4.28	4.57	4.40																												1.57	1.59	311
			0.13	0.15	0.21	0.25	0.27	0.30	0.32	0.31																												0.11	0.11	22
	T.Aus	17.95								2.68	10.79	14.42	7.91	4.63	0.00	0.00	0.00	1.00	3.54	1.95	0.00	0.00																		480
										0.19	0.76	1.01	0.55	0.32	0.00	0.00	0.00	0.07	0.25	0.14	0.00	0.00																	34
	T.Aman	17.95																				1.80	8.40	9.89	3.48	1.67	0.00	0.00	0.00	3.80	7.20	6.97	6.14	4.98	3.66				597
																						0.13	0.59	0.69	0.24	0.12	0.00	0.00	0.00	0.27	0.50	0.49	0.43	0.35	0.26				42
Sub-Total		271.80	0.77	1.03	1.65	1.94	1.48	1.91	2.60	3.07	2.38	2.81	2.75	1.94	0.12	0.00	0.00	0.35	0.91	0.42	0.43	1.87	2.91	1.82	1.18	0.56	0.00	0.00	0.00	1.29	2.45	2.25	1.90	1.57	0.60	0.32	0.55	0.64	475
F1 Area 51%	Wheat/Potato	33.33	2.78	2.81	3.15	3.33	3.30	3.24																															324
			0.47	0.48	0.54	0.57	0.56	0.55																															55
	LT. Aman	33.33													1.48	7.71	1.31	9.24	3.87	2.66	1.04	0.00	0.61	2.20	3.48	1.67	0.00	0.00	0.00	1.27									362
															0.25	1.31		1.57	0.66	0.45	0.18	0.00	0.10	0.37	0.59	0.28	0.00	0.00	0.00	0.22									62
	Mustard/Onion	33.33	2.51	2.53	2.84	3.14	3.42	3.77																															299
			0.43	0.43	0.48	0.53	0.58	0.64																															51
	T.Boro	33.33							2.63	10.93	14.31	8.01	7.91	4.83	0.58	0.00	0.00	2.18	4.68	3.44	1.14	0.00	0.00																621
									0.45	1.86	2.43	1.36	1.34	0.82	0.10	0.00	0.00	0.37	0.80	0.58	0.19	0.00	0.00																106
	Pulses	33.33	2.78	2.81	3.15	3.30	3.19																											2.09	1.92	1.96	2.15	2.56	265
			0.47	0.48	0.54	0.56	0.54																											0.36	0.33	0.33	0.37	0.44	45
	Jute	33.33											0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00																0
													0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00																0
Sub-Total		199.98	1.37	1.39	1.55	1.66	1.68	1.19	0.45	1.86	2.43	1.36	1.34	0.82	0.10	0.25	1.31	1.94	1.45	1.04	0.37	0.00	0.10	0.37	0.59	0.28	0.00	0.00	0.00	0.22	0.00	0.00	0.34	0.98	0.98	1.11	1.20	1.33	318
F2 Area 7%	Wheat/Potato	28.57	2.78	2.81	3.15	3.33	3.30	3.24																										2.01	1.89	1.89	2.16	2.47	2.76	324
			0.06	0.06	0.06	0.07	0.07	0.06																										0.04	0.04	0.04	0.04	0.05	0.06	6
	HYV.Boro	11.43							2.63	10.93	14.31	8.01	7.91	4.83	0.58	0.00	0.00	2.22	4.73	3.44	1.14	0.00	0.00																622
									0.02	0.09	0.11	0.06	0.06	0.04	0.00	0.00	0.00	0.02	0.04	0.03	0.01	0.00	0.00																5
	Jute	5.71										0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00																0
												0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00																0
	Mustard/Onion	28.57	2.86	2.88	3.08	3.07																												1.83	1.85	2.16	2.52	2.83	237
			0.06	0.06	0.06	0.06																												0.04	0.04	0.04	0.05	0.06	5
	HYV. Boro	17.14						2.56	10.75	14.65	7.88	8.01	8.07	5.15	0.89	0.00	0.00	2.18	4.68	2.78	0.08	0.00																685
								0.03	0.13	0.18	0.09	0.10	0.10	0.06	0.01	0.00	0.00	0.03	0.06	0.03	0.00	0.00																8
	Jute	5.71									0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00																	0
											0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00																	0
	Pulse	42.86	2.78	2.65	2.62																																		267
			0.08	0.08	0.08																													2.36	2.22	2.34	2.62	2.81	2.73	2.76	8
	HYV.Boro	34.29				2.48	10.40	13.79	7.81	8.32	8.03	8.48	8.72	5.62	1.04	0.00	0.00	1.51	2.93	0.51																				804
						0.06	0.25	0.33	0.19	0.20	0.19	0.20	0.21	0.13	0.02	0.00	0.00	0.04	0.07	0.01																				19
	Jute	8.57							0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00																				0
									0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00																				0
Sub-Total		182.85	0.20	0.19	0.20	0.19	0.32	0.43	0.34	0.46	0.40	0.36	0.37	0.24	0.04	0.00	0.00	0.08	0.16	0.07	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.11	0.14	0.15	0.17	0.18	0.19	52
F3 Area 3%	HYV.Boro	100.00	10.03	12.63	6.12	6.46	6.90	7.58	8.47	9.20	8.79	8.96	8.90	4.93	0.00	0.00																							2.40	1,031
			0.30	0.38	0.18	0.19	0.21	0.23	0.25	0.28	0.26	0.27	0.27	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	31
Sub-Total		100.00	0.30	0.38	0.18	0.19	0.21	0.23	0.25	0.28	0.26	0.27	0.27	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Consumptive Use (mm)		223.80	2.64	2.98	3.59	3.98	3.69	3.75	3.64	5.67	5.47	4.80	4.73	3.14	0.26	0.25	1.31	2.37	2.53	1.53	0.81	1.87	3.01	2.20	1.77	0.85	0.00	0.00	0.00	1.51	2.45	2.32	2.35	2.70	1.74	1.60	1.93	2.23	875
Field Requirement (mm)	Field Application Efficiency	Ea=0.62	4.25	4.81	5.79	6.43	5.94	6.05	5.87	9.14	8.83	7.74	7.63	5.07	0.42	0.41	2.11	3.82	4.07	2.47	1.30	3.01	4.86	3.55	2.86	1.36	0.00	0.00	0.00	2.43	3.95	3.74	3.78	4.35	2.81	2.59	3.11	3.59	1,412
Unit Diversion Requirement (mm)	Distribution Efficiency	Ed=0.64	6.65	7.52	9.05	10.04	9.29	9.46	9.17	14.29	13.80	12.10	11.93	7.92	0.66	0.63	3.30	5.97	6.36	3.85	2.03	4.71	7.59	5.54	4.47	2.13	0.00	0.00	0.00	3.80	6.17	5.84	5.91	6.79	4.39	4.04	4.87	5.62	2,206
ditto	(l/sec/ha)		0.77	0.87	1.05	1.16	1.07	1.10	1.06	1.65	1.60	1.40	1.38	0.92	0.08	0.07	0.38	0.69	0.74	0.45	0.24	0.54	0.88	0.64	0.52	0.25	0.00	0.00	0.00	0.44	0.71	0.68	0.68	0.79	0.51	0.47	0.56	0.65	
Diversion Requirement	M3/sec		13.98	15.83	19.03	21.13	19.54	19.91	19.29	30.06	29.03	25.45	25.10	16.66	1.39	1.33	6.95	12.55	13.39	8.11	4.28	9.91	15.97	11.66	9.41	4.48	0.00	0.00	0.00	8.00	12.98	12.30	12.44	14.30	9.24	8.51	10.24	11.82	

Table 6.2.1 Existing Drainage Condition

Station	Year	External Water Level [Max.] (m/PWD)	External Water Level [Min.] (m/PWD)	Rain fall (mm)	Innundation [Max.] W.L. (m/PWD)	Innundation [Max.] Area (sq. km)	Innundation [Max.] Area (%)	Innundation [Max.] Depth (m)	Period (days)
CHILMARI	1983	24.36	19.36	906	23.98	19.15	23.7	2.02	43
	1984	24.54	19.62	1,415	24.20	23.22	28.7	2.24	71
Area (sq. km)	1985	24.24	20.19	1,026	24.35	26.08	32.3	2.39	50
80.8	1986	23.80	20.00	1,300	23.80	15.67	19.4	1.84	42
	1987	24.80	19.79	1,601	25.05	45.79	56.7	3.09	62
	1988	25.42	19.57	1,700	24.65	34.42	42.6	2.69	84
	1989	23.91	19.67	1,555	24.55	31.55	39.0	2.59	48
	1990	23.96	20.27	1,252	24.54	31.25	38.7	2.58	58
BAMNI	1983	24.86	20.22	906	24.60	15.12	20.6	1.42	9
	1984	25.00	20.19	1,415	24.63	15.67	21.3	1.45	37
Area (sq. km)	1985	24.80	20.81	1,026	24.96	22.56	30.7	1.78	19
73.4	1986	24.38	20.53	1,300	24.32	9.96	13.6	1.14	5
	1987	25.26	20.32	1,601	25.57	41.01	55.9	2.39	44
	1988	26.04	20.15	1,700	25.30	32.69	44.5	2.12	45
	1989	24.45	20.32	1,555	25.09	26.17	35.7	1.91	22
	1990	24.45	20.82	1,252	25.11	26.72	36.4	1.93	12
MALBHANGA	1983	25.40	21.11	1,287	25.92	23.06	17.9	2.74	30
	1984	25.50	20.80	1,500	25.82	20.63	16.0	2.64	41
Area (sq. km)	1985	25.39	21.24	1,256	25.75	18.89	14.7	2.57	33
128.8	1986	25.00	21.08	1,237	25.54	14.50	11.3	2.36	21
	1987	25.75	20.87	1,708	26.69	31.07	24.1	3.51	48
	1988	26.69	20.74	1,699	26.77	31.21	24.2	3.59	52
	1989	25.02	21.00	1,573	26.08	26.72	20.7	2.90	22
	1990	24.98	21.40	1,477	25.93	23.08	17.9	2.75	26
PALASHBARI	1983	26.57	22.62	1,287	26.75	7.43	29.7	2.96	68
	1984	27.33	22.67	1,500	26.82	8.14	32.6	3.03	82
Area (sq. km)	1985	26.70	22.65	1,256	26.78	7.74	31.0	2.99	67
25.0	1986	25.87	22.72	1,237	26.33	3.45	13.8	2.54	58
	1987	27.45	22.52	1,708	27.17	14.61	58.4	3.38	68
	1988	27.35	22.33	1,699	26.99	11.25	45.0	3.20	54
	1989	26.23	22.17	1,573	26.74	7.33	29.3	2.95	69
	1990	25.87	22.69	1,477	26.52	5.22	20.9	2.73	55
HARICHAI	1983	24.61	19.76	861	23.12	18.43	22.6	1.16	20
	1984	24.80	20.10	1,460	23.85	40.69	49.9	1.89	105
Area (sq. km)	1985	24.46	20.60	845	23.60	32.90	40.3	1.64	41
81.6	1986	23.99	20.51	1,284	23.77	38.26	46.9	1.81	48
	1987	25.07	20.32	1,797	24.80	63.39	77.7	2.84	89
	1988	25.53	20.09	1,558	23.92	42.76	52.4	1.96	103
	1989	24.11	20.10	1,490	23.80	39.01	47.8	1.84	72
	1990	24.21	20.75	1,275	23.88	41.57	50.9	1.92	39
RATNAI	1983	29.87	25.95	1,121	29.66	8.21	12.3	2.82	60
	1984	30.29	26.31	2,060	30.56	15.02	22.5	3.72	87
Area (sq. km)	1985	29.68	26.45	1,596	30.02	10.34	15.5	3.18	77
66.9	1986	29.13	26.32	1,267	29.75	8.70	13.0	2.91	43
	1987	30.37	26.07	2,543	30.86	17.74	26.5	4.02	69
	1988	29.77	25.93	1,699	30.38	13.50	20.2	3.54	48
	1989	29.39	25.71	1,228	29.35	6.45	9.6	2.51	56
	1990	28.98	26.21	1,553	29.20	5.93	8.9	2.36	48
KISHORPUR	1983	27.46	24.42	1,129	27.54	29.97	35.3	1.92	23
	1984	27.60	24.32	1,818	27.78	34.94	41.1	2.16	74
Area (sq. km)	1985	27.46	24.78	1,593	27.69	33.01	38.8	2.07	48
85.0	1986	26.90	24.67	1,106	27.20	22.51	26.5	1.58	44
	1987	27.96	24.59	2,402	28.18	43.88	51.6	2.56	63
	1988	28.05	24.45	1,214	27.74	34.23	40.3	2.12	42
	1989	27.16	24.27	1,402	27.29	24.50	28.8	1.67	48
	1990	27.27	24.84	1,247	27.43	27.55	32.4	1.81	50
GHARIALDANGA	1983	29.11	26.98	1,129	28.97	8.09	40.7	2.13	71
	1984	29.16	26.64	1,818	29.32	10.24	51.5	2.48	123
Area (sq. km)	1985	29.12	26.96	1,593	29.26	9.76	49.0	2.42	130
19.9	1986	28.80	26.96	1,106	28.72	6.67	33.5	1.88	62
	1987	29.58	26.92	2,402	29.78	15.30	76.9	2.94	111
	1988	29.58	26.78	1,214	29.13	8.99	45.2	2.29	107
	1989	28.95	26.57	1,402	28.89	7.61	38.2	2.05	140
	1990	29.05	27.05	1,247	28.76	6.90	34.7	1.92	82

Table 6.2.2 Drainage Implovement Plan on Basic Year (1987)

[Existing]

Station	Area	External Water Level [Max.]	External Water Level [Min.]	Rain fall	Innundation [Max.] W.L.	Innundation [Max.] Area		Innundation [Max.] Depth	Period
	(sq.km)	(m/PWD)	(m/PWD)	(mm)	(m/PWD)	(sq. km)	(%)	(m)	(days)
CHILMARI	80.8	24.80	19.79	1,601	25.05	45.79	56.7	3.09	62
BAMNI	73.4	25.26	20.32	1,601	25.57	41.01	55.9	2.39	44
MALBHANGA	128.8	25.75	20.87	1,708	26.69	31.07	24.1	3.51	48
PALASHBARI	25.0	27.45	22.52	1,708	27.17	14.61	58.4	3.38	68
HARICHAI	81.6	25.07	20.32	1,797	24.80	63.39	77.7	2.84	89
RATNAI	66.9	30.37	26.07	2,543	30.86	17.74	26.5	4.02	69
KISHORPUR	85.0	27.96	24.59	2,402	28.18	43.88	51.6	2.56	63
GHARIALDANGA	19.9	29.58	26.92	2,402	29.78	15.30	76.9	2.94	111

[Proposed]

Station	Area	External Water Level [Max.]	External Water Level [Min.]	Rain fall	Innundation [Max.] W.L.	Innundation [Max.] Area		Innundation [Max.] Depth	Period
	(sq.km)	(m/PWD)	(m/PWD)	(mm)	(m/PWD)	(sq. km)	(%)	(m)	(days)
CHILMARI	80.8	24.80	19.79	1,601	25.05	45.71	56.6	3.09	62
BAMNI	73.4	25.26	20.32	1,601	25.56	40.80	55.6	2.38	43
MALBHANGA	128.8	25.75	20.87	1,708	26.69	31.07	24.1	3.51	46
PALASHBARI	25.0	27.45	22.52	1,708	27.13	13.85	55.4	2.34	64
HARICHAI	81.6	25.07	20.32	1,797	24.73	62.37	76.4	2.77	81
RATNAI	66.9	30.37	26.07	2,543	30.85	17.71	26.5	4.01	65
KISHORPUR	85.0	27.96	24.59	2,402	27.94	38.34	45.1	2.32	60
GHARIALDANGA	19.9	29.58	26.92	2,402	29.52	12.46	62.6	2.68	84

Table 6.4.1 Cropped Area under Present and Proposed Condition in the Project Area

Item	Present Condition: Irrigated Area (ha)	(%)	Rainfed Area (ha)	(%)	Total Area (ha)	(%)	Proposed Irrigated Area (ha)	(%)
Total Land Area	9,800	(28)	25,700	(72)	35,500	(100)	35,500	(100)
Total Cropped Area	20,400		47,900		68,300		79,500	
Cropping intensity	208%		186%		192%		224%	
Rice	17,400	(178)	39,000	(152)	56,400	(159)	38,000	(107)
B./L.T. Aus	-	-	3,400	(13)	3,400	(10)	-	-
HYV Aus	-	-	15,200	(59)	15,200	(43)	4,200	(12)
L. T. Aman	700	(7)	4,200	(16)	4,900	(14)	6,000	(17)
HYV Aman	6,900	(70)	15,100	(59)	22,000	(62)	12,000	(34)
L. T. Boro	-	-	800	(3)	800	(2)	-	-
HYV Boro	9,800	(100)	300	(1)	10,100	(28)	4,900	(14)
Late Boro/Early Aus	-	-	-	-	-	-	10,900	(31)
Jute	100	(1)	3,400	(13)	3,500	(10)	9,000	(25)
Sugarcane	-	-	1,500	(6)	1,500	(4)	-	-
Rabi	2,900	(30)	4,000	(16)	6,900	(19)	32,500	(92)
Wheat	800	(8)	2,100	(8)	2,900	(8)	8,400	(24)
Oil Seed	500	(5)	600	(2)	1,100	(3)	4,600	(13)
Pulses	400	(4)	500	(2)	900	(3)	3,000	(8)
Potatoes	600	(6)	400	(2)	1,000	(3)	9,700	(27)
Spices	300	(3)	200	(1)	500	(1)	3,400	(10)
Vegetables	300	(3)	200	(1)	500	(1)	3,400	(10)

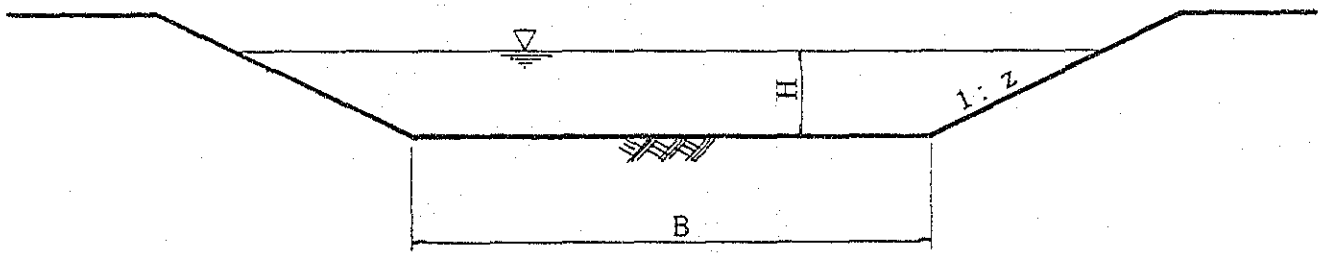
Table 6.4.2 Crop Production under Present and Proposed Condition in the Project Area

Crop	Present Condition			Proposed Condition			Production Increase
	Area (ha)	Yield (ton/ha)	Production (ton)	Area (ha)	Yield (ton/ha)	Production (ton)	(ton)
Total Production			176,000			400,400	224,400
Rice	56,400	-	149,000	38,000	-	167,500	18,500
B./L.T. Aus	3,400	1.25	4,300	-	-	-	-4,300
HYV Aus	15,200	2.40	36,500	9,600	4.30	41,300	4,800
L. T. Aman	4,900	1.75	8,600	6,000	2.80	16,800	8,200
HYV Aman	22,000	2.77	60,900	12,000	4.70	56,400	-4,500
L. T. Boro	800	1.84	1,500	-	-	-	-1,500
HYV Boro	10,100	3.68	37,200	10,400	5.10	53,000	15,800
Jute	3,500	1.48	5,200	9,000	1.57	14,100	8,900
Sugarcane	1,500	27.00	40,500	-	-	-	-
Rabi	6,900	-	21,800	32,500	-	218,800	197,000
Wheat	2,900	2.03	5,900	8,400	3.25	27,300	21,400
Oil Seed	1,100	0.60	700	4,600	1.40	6,400	5,700
Pulses	900	0.74	700	3,000	1.20	3,600	2,900
Potatoes	1,000	9.05	9,000	9,700	13.00	126,100	117,100
Spices	500	4.84	2,400	3,400	5.70	19,400	17,000
Vegetables	500	6.18	3,100	3,400	10.60	36,000	32,900

Table 7.1.1 Number of Irrigation Canal Regulator of Each Main Channel

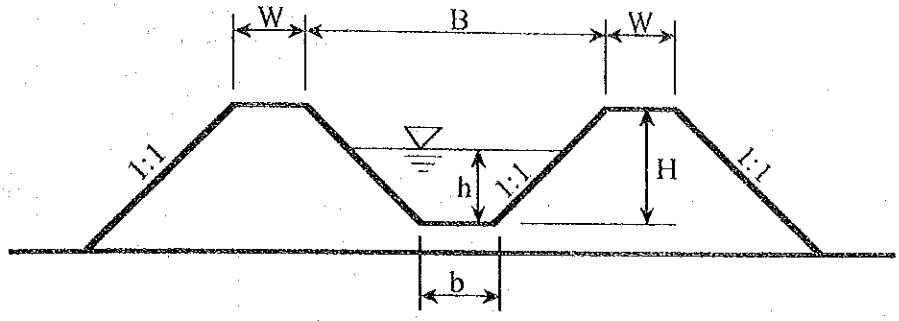
Type		Road Width (w)	Main Channel						Total
			A	B	C	D	E	F	
Closed Type	A	4.5	2	--	--	--	--	--	2
	B	4.5	--	2	--	--	--	--	2
	C-1	3.0	--	--	1	--	--	--	1 :
	C-2	4.5	--	1	--	--	--	--	1 : 2
	D-1	3.0	1	--	--	1	--	2	4 :
	D-2	4.5	--	1	1	--	1	--	3 : 7
	E-1	3.0	--	1	--	--	--	--	1 :
	E-2	4.5	--	--	1	--	--	--	1 : 2
Sub-Total			3	5	3	1	1	2	15
Open Type	A	4.5	1	--	--	--	--	--	1
	B	4.5	1	--	--	--	--	--	1
	C	4.5	--	--	1	--	--	--	1
	D	4.5	--	1	--	--	--	--	1
	E	4.5	--	--	2	--	--	--	2
	F	3.0	--	--	--	1	--	--	1
	G	3.0	--	--	--	--	2	--	2
	H	4.5	3	--	--	1	--	--	4
	I-1	3.0	--	1	--	--	--	--	1 :
	I-2	4.5	--	--	1	--	--	--	1 : 2
	J	--	--	--	1	--	--	--	1
Sub-Total			5	2	5	2	2	0	16
	Total		8	7	8	3	3	2	31

Table 7.1.2 Cross Section of Irrigation Channel



Type	Discharge Q (cu.m)	Slope 1 : z	Canal Slope I	Bed width B (m)	Water Depth H (m)	Velocity V (m/s)	Length of Channels (m)						
							A	B	C	D	E	F	Total
I	30.00 ~ 26.84	1 : 2.5	1/20,000	25.0	2.28 ~ 2.15	0.430 ~ 0.416	27,630	-	-	-	-	-	27,630
II	24.50	1 : 2.5	1/20,000	23.0	2.14	0.412	3,995	-	-	-	-	-	3,995
III	16.55	1 : 2.0	1/20,000	14.0	2.23	0.405	-	8,100	-	-	-	-	8,100
IV	8.03 ~ 6.05	1 : 2.0	1/20,000	6.0	2.18 ~ 1.88	0.332 ~ 0.359	11,820	23,080	14,430	-	-	-	49,330
V	4.64 ~ 3.94	1 : 2.0	1/20,000	4.0	1.90 ~ 1.76	0.304 ~ 0.316	-	12,220	5,470	2,200	-	-	19,890
VI	2.90 ~ 1.02	1 : 1.5	1/20,000	3.0	1.76 ~ 1.01	0.221 ~ 0.294	20,977	12,476	15,948	11,000	10,000	7,832	78,233
						Total (m)	64,422	55,876	35,848	13,200	10,000	7,832	187,178

Table 7.1.3 Cross Section of Field Canal



Type	Q	Gradient	Lining	b	B	h	H	W
	(l/sec.)			(m)	(m)	(m)	(m)	(m)
A	56-112	1/1,500	Brick, Mortal	0.20	1.20	0.27-0.37	0.5	0.30
B	15-56	1/1,500	Brick, Mortal	0.15	0.95	0.15-0.29	0.4	0.30
C	0-15	1/1,000	Unlining	0.15	0.75	0.2	0.3	0.15

Table 7.4.1 Number of Bridge and Culvert of Each Main Channel

Type		B (m)	Main Channel A	B	C	D	E	F	Ratnai Div. Canal	O/M Road for Regulator	Total
Rural / Brick Road Bridge	A	3.0	3	--	--	--	--	--	--	--	3 :
	A	4.5	9	--	--	--	--	--	--	--	9 : 12
	B	3.0	--	3	--	--	--	--	4	--	7 :
	B	4.5	--	2	1	--	--	--	--	1	4 : 11
	C	3.0	--	4	1	--	--	--	--	--	5 :
	C	4.5	--	4	7	--	--	--	--	--	11 : 16
	D	3.0	3	2	4	1	3	3		--	16 :
	D	4.5	2	9	7	3		2		--	23 : 39
Metal Road Bridge	MA	7.5	1	--	--	--	--	--	--	--	1 :
Culvert	CA	7.5	1	1	1	--	--	--	--	--	3 : 4
	CB	5.0	1	1	1	--	--	--	--	--	3 :
	CC	5.0	--	1		--	2	--	--	--	3 : 6
Railway Bridge	RA	3.0	1	--	--	--	--	--	--	--	1 :
	RB	3.0	--	1	1	--	--	--	--	--	2 : 3
	Total		21	28	23	4	5	5	4	1	91

Table 7.5.1 Land Acquisition and Crop Compensation

Project Works	Private Land	Government Land	Total
Ratnai Diversion Channel	8.2	0	8.2
Intake Canal	3.2	0	3.2
Main Channel A	90.8	84.8	175.6
Main Channel B	136.1	18.0	154.1
Main Channel C	83.0	7.6	90.6
Main Channel D	23.6	1.2	24.8
Main Channel E	13.7	1.3	15.0
Main Channel F	7.4	0	7.4
Secondary Channels	0	325.5	325.5
Demonstration Farm	2.3	0	2.3
Total	368.3	438.4	806.7

Table 8.2.1 Project Cost

Work	Total			Phase-I			Phase-II		
	L.C.	F.C.	Total	L.C.	F.C.	Total	L.C.	F.C.	Total
I. Construction Cost									
I-1 Irrigation Development									
(1) Head Work Construction	59,235	61,600	120,835	59,235	61,600	120,835	0	0	0
(2) Irrigation Canal									
a. Main Channel A	73,408	15,274	88,682	73,408	15,274	88,682	0	0	0
b. Main Channel B	54,755	9,685	64,440	0	0	0	54,755	9,685	64,440
c. Main Channel C	40,812	11,501	52,313	0	0	0	40,812	11,501	52,313
d. Main Channel D	16,175	5,355	21,530	16,175	5,355	21,530	0	0	0
e. Main Channel E	22,750	8,886	31,636	22,750	8,886	31,636	0	0	0
f. Main Channel F	3,139	1,204	4,343	3,139	1,204	4,343	0	0	0
g. Secondary Channels & Bils Desilting works	62,544	0	62,544	31,272	0	31,272	31,272	0	31,272
h. Sub-Total	273,583	51,905	325,488	146,744	30,719	177,463	126,839	21,186	148,025
(3) LLP Development	217,292	65,106	282,398	97,185	29,118	126,303	120,107	35,988	156,095
(4) STW Development	27,800	65,461	93,261	13,900	32,732	46,632	13,900	32,729	46,629
(5) Demonstration Farm	3,946	3,508	7,454	2,725	1,679	4,404	1,221	1,829	3,050
(6) Sub-Total of Irrigation Development	581,856	247,580	829,436	319,789	155,848	475,637	262,067	91,732	353,799
I-2 Drainage Improvement									
(1) Ratnai River Diversion Canal	1,944	0	1,944	1,944	0	1,944	0	0	0
(2) Ratnai Regulator Construction	9,084	6,103	15,187	9,084	6,103	15,187	0	0	0
(3) Harichai Regurator Rehabilitation	599	1,347	1,946	0	0	0	599	1,347	1,946
(4) Add. Regulators Construction	16,964	15,412	32,376	0	0	0	16,964	15,412	32,376
(5) Pipe Sluices Rehabilitation	2,331	1,164	3,495	0	0	0	2,331	1,164	3,495
(6) Desilting Works of Existing Drainage Channelcs	7,301	0	7,301	0	0	0	7,301	0	7,301
(7) Sub-Total of Drainage Improvement	38,223	24,026	62,249	11,028	6,103	17,131	27,195	17,923	45,118
I-3 Flood Protection Works									
(1) Ratnai River Closure at Durakuti	2,458	1,408	3,866	2,458	1,408	3,866	0	0	0
(2) Breached Embankment	4,882	2,464	7,346	4,882	2,464	7,346	0	0	0
(3) Flood Embankment Rehabilitation	1,284	0	1,284	0	0	0	1,284	0	1,284
(4) Sub-Total of Flood Protection Works	8,624	3,872	12,496	7,340	3,872	11,212	1,284	0	1,284
I-4 Rural Infrastructure Improvement	99,999	63,787	163,786	53,332	34,020	87,352	46,667	29,767	76,434
I-5 Total of Construction Cost	728,702	339,265	1,067,967	391,489	199,843	591,332	337,213	139,422	476,635
II Land Aquisition	62,427	0	62,427	38,887	0	38,887	23,540	0	23,540
III Consurting Survice	60,963	47,767	108,730	44,276	47,767	92,043	16,687	0	16,687
IV Administration	26,093	21,573	47,666	17,321	14,677	31,998	8,772	6,896	15,668
V Maintenance Cost during Construction Period	20,224	0	20,224	5,653	0	5,653	14,571	0	14,571
VI O&M Cost of Demonstration Farm	3,741	0	3,741	2,631	0	2,631	1,110	0	1,110
Sub-Total (II-VI)	173,448	69,340	242,788	108,768	62,444	171,212	64,680	6,896	71,576
VII Phisical Contiguency	109,300	50,885	160,185	58,720	29,974	88,694	50,580	20,911	71,491
Sub-Total (I-VII)	1,011,450	459,490	1,470,940	558,977	292,261	851,238	452,473	167,229	619,702
VIII Price Escalation	646,469	162,272	808,741	195,772	56,340	252,112	450,697	105,932	556,629
GRAND TOTAL	1,657,919	621,762	2,279,681	754,749	348,601	1,103,350	903,170	273,161	1,176,331

Table 10.1.1 Economic Net Crop Production Value per Ha

Item	Present/Without Project Condition					
	Rainfed			Irrigated (Ground Water/STW)		
	Net Production Value per ha by Crop (Tk/ha)	Cropping Intensity (%)	Net Production Value per ha at Project Area (Tk/ha)	Net Production Value per ha by Crop (Tk/ha)	Cropping Intensity (%)	Net Production Value per ha at Project Area (Tk/ha)
(1) Rice						
B/L.T Aus	3,720	13.2	490	0	0	0
HYV Aus	8,370	59.2	4,960	0	0	0
L.T Aman	7,700	16.3	1,260	9,830	7.1	700
HYV Aman	8,960	58.8	5,270	13,560	70.4	9,550
L.T Boro	6,860	3.1	210	0	0	0
HYV Boro	8,290	1.2	100	13,820	100.0	13,820
(2) Jute	10,300	13.2	1,360	10,300	1.0	100
(3) Sugarcane	19,770	5.8	1,150	0	0	0
(4) Rabi						
Wheat	8,840	8.2	720	14,320	8.2	1,170
Oil Seed	2,620	2.3	60	3,860	5.1	200
Pulses	5,290	1.9	100	7,250	4.1	300
Potato	9,210	1.6	150	12,060	6.1	740
Spices	22,270	0.8	180	31,730	3.1	980
Vegatables	3,170	0.8	30	5,830	3.1	180
Total		186.4	16,040		208.2	27,740
	(For 25,700 ha : Tk		412,228,000)	(For 9,800 ha : Tk		271,852,000)
	Average at Project Area per ha (rainfed ; 72.394%, irrigated; 27.606%)				:	19,270
					(For 35,500 ha :	684,080,000)

Item	With Project Condition (Ground Water/STW) Irrigated			With Project Condition (Surface Water/LLP) Irrigated		
	Net Production Value per ha by Crop (Tk/ha)	Cropping Intensity (%)	Net Production Value per ha at Project Area (Tk/ha)	Net Production Value per ha by Crop (Tk/ha)	Cropping Intensity (%)	Net Production Value per ha at Project Area (Tk/ha)
(1) Rice						
B/L.T Aus	0	0	0	0	0	0
HYV Aus	14,150	27.0	3,820	16,210	27.0	4,380
L.T Aman	11,620	16.9	1,960	13,170	16.9	2,230
HYV Aman	17,580	33.8	5,940	19,900	33.8	6,730
L.T Boro	0	0	0	0	0	0
HYV Boro	16,410	29.3	4,810	19,070	29.3	5,590
(2) Jute/Rainfed	10,300	25.4	2,620	10,300	25.4	2,620
(3) Sugarcane	0	0	0	0	0	0
(4) Rabi						
Wheat	15,700	23.7	3,720	17,100	23.7	4,050
Oil Seed	9,770	13.0	1,270	10,790	13.0	1,400
Pulses	8,830	8.5	750	9,980	8.5	850
Potato	16,650	27.3	4,550	18,050	27.3	4,930
Spices	33,810	9.5	3,210	34,830	9.5	3,310
Vegatables	10,800	9.5	1,030	11,810	9.5	1,120
Total		223.9	33,680		223.9	37,210
	(For 17,300 ha : Tk		582,664,000)	(For 18,200 ha : Tk		677,222,000)
	Average at Project Area per ha (STW ; 48.732%, LLP; 51.268%)				:	35,490
					(For 35,500 ha :	1,259,886,000)

Item	Without Project Condition			With Project Condition	Increment
	Rainfed	Irrigated	Total	Irrigated	
(1) STW Project Area					
Area (ha)	7,500	9,800	17,300	17,300	0
Net Production Value					
- Per ha (Tk/ha)	16,040	27,740	22,670	33,680	11,010
- Total (Tk'000)	120,300	271,852	392,152	582,664	190,512
(2) LLP Project Area					
Area (ha)	18,200	0	18,200	18,200	0
Net Production Value					
- Per ha (Tk/ha)	16,040	0	16,040	37,210	21,170
- Total (Tk'000)	291,928	0	291,928	677,222	385,294
(3) TotalProject Area					
Area (ha)	25,700	9,800	35,500	35,500	0
Net Production Value					
- Per ha (Tk/ha)	16,040	27,740	19,270	35,490	16,220
- Total (Tk'000)	412,228	271,852	684,080	1,259,886	575,806

Table 10.1.2 Economic Annual Benefit Flow for Crop and Fishery Production

(1) Annual Development Area (ha)

Year	Surface Irrigation Development								STW Irrigation	Crop Area Total
	Crop Production Area by Channel							Fish Culture		
	A	B	C	D	E	F	Total			
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	2,180	0	0	0	0	0	2,180	50	2,162	4,342
4	2,110	0	0	0	0	0	2,110	50	2,162	4,272
5	820	0	0	450	0	0	1,270	35	2,162	3,432
6	0	0	0	560	980	1,040	2,580	40	2,162	4,742
7	0	2,800	0	0	0	0	2,800	75	2,162	4,962
8	0	2,660	0	0	0	0	2,660	75	2,162	4,822
9	0	0	4,160	0	0	0	4,160	75	2,162	6,322
10	0	0	440	0	0	0	440	60	2,166	2,606
11	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0
Total	5,110	5,460	4,600	1,010	980	1,040	18,200	460	17,300	35,500

(2) Annual Benefit (Tk'000)

Year	Surface Irrigation Development			STW Irrigation	Total Irrigation	Production Foregone			Net Benefit		
	Crop Production	Fish Culture	Total			Surface Irrigation	STW Irrigation	Total	Surface Irrigation	STW Irrigation	Total
1	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	2,309	77	2,386	-2,309	-77	-2,386
3	0	0	0	0	0	4,446	77	4,523	-4,446	-77	-4,523
4	9,230	2,049	11,279	4,762	16,041	6,087	77	6,164	5,192	4,685	9,877
5	27,394	6,147	33,541	14,285	47,826	7,602	77	7,679	25,939	14,208	40,147
6	50,934	11,679	62,613	28,570	91,183	9,888	77	9,965	52,725	28,493	81,218
7	85,399	18,851	104,250	47,616	151,866	12,156	77	12,233	92,094	47,539	139,633
8	131,720	29,098	160,818	71,424	232,242	15,468	77	15,545	145,350	71,347	216,697
9	180,072	40,368	220,440	95,232	315,672	15,468	77	15,545	204,972	95,155	300,127
10	237,105	52,663	289,768	119,040	408,808	15,468	77	15,545	274,300	118,963	393,263
11	290,623	65,982	356,605	142,856	499,461	15,468	77	15,545	341,137	142,779	483,916
12	333,217	77,662	410,879	161,912	572,791	15,468	77	15,545	395,411	161,835	557,246
13	363,956	86,268	450,224	176,205	626,429	15,468	77	15,545	434,756	176,128	610,884
14	383,432	91,800	475,232	185,738	660,970	15,468	77	15,545	459,764	185,661	645,425
15	385,294	94,260	479,554	190,512	670,066	15,468	77	15,545	464,086	190,435	654,521
16	385,294	94,260	479,554	190,512	670,066	15,468	77	15,545	464,086	190,435	654,521
17	385,294	94,260	479,554	190,512	670,066	15,468	77	15,545	464,086	190,435	654,521
18	385,294	94,260	479,554	190,512	670,066	15,468	77	15,545	464,086	190,435	654,521
19	385,294	94,260	479,554	190,512	670,066	15,468	77	15,545	464,086	190,435	654,521
20	385,294	94,260	479,554	190,512	670,066	15,468	77	15,545	464,086	190,435	654,521
21	385,294	94,260	479,554	190,512	670,066	15,468	77	15,545	464,086	190,435	654,521
22	385,294	94,260	479,554	190,512	670,066	15,468	77	15,545	464,086	190,435	654,521
23	385,294	94,260	479,554	190,512	670,066	15,468	77	15,545	464,086	190,435	654,521
24	385,294	94,260	479,554	190,512	670,066	15,468	77	15,545	464,086	190,435	654,521
25	385,294	94,260	479,554	190,512	670,066	15,468	77	15,545	464,086	190,435	654,521
26	385,294	94,260	479,554	190,512	670,066	15,468	77	15,545	464,086	190,435	654,521
27	385,294	94,260	479,554	190,512	670,066	15,468	77	15,545	464,086	190,435	654,521
28	385,294	94,260	479,554	190,512	670,066	15,468	77	15,545	464,086	190,435	654,521
29	385,294	94,260	479,554	190,512	670,066	15,468	77	15,545	464,086	190,435	654,521
30	385,294	94,260	479,554	190,512	670,066	15,468	77	15,545	464,086	190,435	654,521

Table 10.1.3 Economic Annual Cost Flow for Project Works

(Unit : Tk'000)

Year	Surface Water (LLP) Irrigation Development									STW Construction Cost
	Construction Cost							O&M Cost	Replace-ment Cost	
	Head Work	Main Channel	Rural Infra.	LLP	Demo. Farm	Consultant & Administration	Total			
1	0	0	0	0	0	53,143	53,143	0	0	0
2	0	0	0	0	1,540	20,222	21,762	0	0	0
3	106,303	34,769	11,852	30,960	1,967	7,665	193,516	325	0	8,478
4	0	34,769	19,054	29,966	0	7,130	90,919	515	0	8,479
5	0	26,290	19,054	18,037	0	5,525	68,906	1,059	0	8,479
6	0	46,704	19,054	36,641	0	5,755	108,154	1,222	0	8,479
7	0	32,158	19,054	39,765	2,430	7,188	100,595	847	0	8,479
8	0	32,156	19,054	37,777	0	7,035	96,022	1,265	0	8,479
9	0	48,295	19,054	59,080	0	6,653	133,082	1,566	0	8,479
10	0	6,288	9,522	6,245	0	5,049	27,104	1,863	0	8,479
11	0	0	0	0	0	0	0	1,608	0	0
12	0	0	0	0	0	0	0	1,608	0	0
13	0	0	0	0	0	0	0	1,608	6,064	0
14	0	0	0	0	0	0	0	1,608	1,600	0
15	0	0	0	0	0	0	0	1,608	4,365	0
16	0	0	0	0	0	0	0	1,608	8,333	0
17	0	0	0	0	0	0	0	1,608	1,525	0
18	0	0	0	0	0	0	0	1,608	2,598	0
19	0	0	0	0	0	0	0	1,608	5,785	0
20	0	0	0	0	0	0	0	1,608	0	0
21	0	0	0	0	0	0	0	1,608	0	0
22	0	0	0	0	0	0	0	1,608	0	0
23	0	0	0	0	0	0	0	1,608	6,064	0
24	0	0	0	0	0	0	0	1,608	1,600	0
25	0	0	0	0	0	0	0	1,608	4,365	0
26	0	0	0	0	0	0	0	1,608	8,333	0
27	0	0	0	0	0	0	0	1,608	1,525	0
28	0	0	0	0	0	0	0	1,608	2,598	0
29	0	0	0	0	0	0	0	1,608	5,785	0
30	0	0	0	0	0	0	0	1,608	0	0
Total	106,303	261,429	135,698	258,471	5,937	125,365	893,203	40,822	60,540	67,831

Year	FCD Development						Allocated LLP Irrigation			Allocated STW Irrigation		
	Construction Cost				O&M Cost	Replace-ment Cost	Total Construction Cost	O&M Cost	Replace-ment Cost	Total Construction Cost	O&M Cost	Replace-ment Cost
	FCD	Rural Infra.	Consultant & Administration	Total								
1	0	0	4,502	4,502	0	0	55,453	0	0	2,192	0	0
2	0	0	1,735	1,735	0	0	22,652	0	0	845	0	0
3	4,984	7,194	658	12,836	5	0	200,101	328	0	14,729	2	0
4	19,328	0	612	19,940	13	0	101,148	522	0	18,190	6	0
5	0	0	474	474	1,288	0	69,149	1,720	0	8,710	627	0
6	0	0	493	493	1,288	0	108,407	1,883	0	8,719	627	0
7	18,512	0	617	19,129	1,288	0	110,408	1,508	0	17,795	627	0
8	12,255	0	604	12,859	1,300	0	102,619	1,932	0	14,741	633	0
9	7,932	0	571	8,503	1,309	0	137,444	2,238	0	12,620	637	0
10	1,101	0	433	1,534	1,380	0	27,891	2,571	0	9,226	672	0
11	0	0	0	0	1,380	5,580	0	2,316	2,863	0	672	2,717
12	0	0	0	0	1,380	0	0	2,316	0	0	672	0
13	0	0	0	0	1,380	0	0	2,316	6,064	0	672	0
14	0	0	0	0	1,380	595	0	2,316	1,905	0	672	290
15	0	0	0	0	1,380	0	0	2,316	4,365	0	672	0
16	0	0	0	0	1,380	0	0	2,316	8,333	0	672	0
17	0	0	0	0	1,380	1,190	0	2,316	2,135	0	672	580
18	0	0	0	0	1,380	888	0	2,316	3,054	0	672	432
19	0	0	0	0	1,380	0	0	2,316	5,785	0	672	0
20	0	0	0	0	1,380	0	0	2,316	0	0	672	0
21	0	0	0	0	1,380	5,580	0	2,316	2,863	0	672	2,717
22	0	0	0	0	1,380	0	0	2,316	0	0	672	0
23	0	0	0	0	1,380	0	0	2,316	6,064	0	672	0
24	0	0	0	0	1,380	595	0	2,316	1,905	0	672	290
25	0	0	0	0	1,380	0	0	2,316	4,365	0	672	0
26	0	0	0	0	1,380	0	0	2,316	8,333	0	672	0
27	0	0	0	0	1,380	1,190	0	2,316	2,135	0	672	580
28	0	0	0	0	1,380	888	0	2,316	3,054	0	672	432
29	0	0	0	0	1,380	0	0	2,316	5,785	0	672	0
30	0	0	0	0	1,380	0	0	2,316	0	0	672	0
Total	64,112	7,194	10,699	82,005	35,471	16,506	935,272	59,022	69,008	107,767	17,271	8,038

Note : Cost for FCD component is allocated according to the proportion of project area of LLP (18,200ha) and STW (17,300ha).

Table 10.2.1 Economic Cost and Benefit Stream for Economic Evaluaion

(1) Surface Irrigation Development & FCD (Tk'000)

Year	Cost				Benefit	Balance
	Const-ruction	O&M	Replace-ment	Total		
1	55,453	0	0	55,453	0	-55,453
2	22,652	0	0	22,652	-2,309	-24,961
3	200,101	328	0	200,429	-4,446	-204,875
4	101,148	522	0	101,670	5,192	-96,478
5	69,149	1,720	0	70,869	25,939	-44,930
6	108,407	1,883	0	110,290	52,725	-57,565
7	110,408	1,508	0	111,916	92,094	-19,822
8	102,619	1,932	0	104,551	145,350	40,799
9	137,444	2,238	0	139,682	204,972	65,290
10	27,891	2,571	0	30,462	274,300	243,838
11	0	2,316	2,863	5,179	341,137	335,958
12	0	2,316	0	2,316	395,411	393,095
13	0	2,316	6,064	8,380	434,756	426,376
14	0	2,316	1,905	4,221	459,764	455,543
15	0	2,316	4,365	6,681	464,086	457,405
16	0	2,316	8,333	10,649	464,086	453,437
17	0	2,316	2,135	4,451	464,086	459,635
18	0	2,316	3,054	5,370	464,086	458,716
19	0	2,316	5,785	8,101	464,086	455,985
20	0	2,316	0	2,316	464,086	461,770
21	0	2,316	2,863	5,179	464,086	458,907
22	0	2,316	0	2,316	464,086	461,770
23	0	2,316	6,064	8,380	464,086	455,706
24	0	2,316	1,905	4,221	464,086	459,865
25	0	2,316	4,365	6,681	464,086	457,405
26	0	2,316	8,333	10,649	464,086	453,437
27	0	2,316	2,135	4,451	464,086	459,635
28	0	2,316	3,054	5,370	464,086	458,716
29	0	2,316	5,785	8,101	464,086	455,985
30	0	2,316	0	2,316	464,086	461,770

(2) Ground Water Irrigation Development and FCD (Tk'000)

Year	Cost				Benefit	Balance
	Const-ruction	O&M	Replace-ment	Total		
1	2,192	0	0	2,192	0	-2,192
2	845	0	0	845	-77	-922
3	14,729	2	0	14,731	-77	-14,808
4	18,190	6	0	18,196	4,685	-13,511
5	8,710	627	0	9,337	14,208	4,871
6	8,719	627	0	9,346	28,493	19,147
7	17,795	627	0	18,422	47,539	29,117
8	14,741	633	0	15,374	71,347	55,973
9	12,620	637	0	13,257	95,155	81,898
10	9,226	672	0	9,898	118,963	109,065
11	0	672	2,717	3,389	142,779	139,390
12	0	672	0	672	161,835	161,163
13	0	672	0	672	176,128	175,456
14	0	672	290	962	185,661	184,699
15	0	672	0	672	190,435	189,763
16	0	672	0	672	190,435	189,763
17	0	672	580	1,252	190,435	189,183
18	0	672	432	1,104	190,435	189,331
19	0	672	0	672	190,435	189,763
20	0	672	0	672	190,435	189,763
21	0	672	2,717	3,389	190,435	187,046
22	0	672	0	672	190,435	189,763
23	0	672	0	672	190,435	189,763
24	0	672	290	962	190,435	189,473
25	0	672	0	672	190,435	189,763
26	0	672	0	672	190,435	189,763
27	0	672	580	1,252	190,435	189,183
28	0	672	432	1,104	190,435	189,331
29	0	672	0	672	190,435	189,763
30	0	672	0	672	190,435	189,763

(3) Total Development (Tk'000)

Year	Cost				Benefit	Balance
	Const-ruction	O&M	Replace-ment	Total		
1	57,645	0	0	57,645	0	-57,645
2	23,497	0	0	23,497	-2,386	-25,883
3	214,830	330	0	215,160	-4,523	-219,683
4	119,338	528	0	119,866	9,877	-109,989
5	77,859	2,347	0	80,206	40,147	-40,059
6	117,126	2,510	0	119,636	81,218	-38,418
7	128,203	2,135	0	130,338	139,633	9,295
8	117,360	2,565	0	119,925	216,697	96,772
9	150,064	2,875	0	152,939	300,127	147,188
10	37,117	3,243	0	40,360	393,263	352,903
11	0	2,988	5,580	8,568	483,916	475,348
12	0	2,988	0	2,988	557,246	554,258
13	0	2,988	6,064	9,052	610,884	601,832
14	0	2,988	2,195	5,183	645,425	640,242
15	0	2,988	4,365	7,353	654,521	647,168
16	0	2,988	8,333	11,321	654,521	643,200
17	0	2,988	2,715	5,703	654,521	648,818
18	0	2,988	3,486	6,474	654,521	648,047
19	0	2,988	5,785	8,773	654,521	645,748
20	0	2,988	0	2,988	654,521	651,533
21	0	2,988	5,580	8,568	654,521	645,953
22	0	2,988	0	2,988	654,521	651,533
23	0	2,988	6,064	9,052	654,521	645,469
24	0	2,988	2,195	5,183	654,521	649,338
25	0	2,988	4,365	7,353	654,521	647,168
26	0	2,988	8,333	11,321	654,521	643,200
27	0	2,988	2,715	5,703	654,521	648,818
28	0	2,988	3,486	6,474	654,521	648,047
29	0	2,988	5,785	8,773	654,521	645,748
30	0	2,988	0	2,988	654,521	651,533

(4) Calculation

Item	EIRR (%)	NPV (Tk million) Cost	NPV (Tk million) Benefit	B-C	B/C
(1) Surface	24.0	602	1,521	919	2.5
(2) STW	63.9	67	651	584	9.7
(3) Total	28.5	669	2,172	1,503	3.2

Note :

EIRR	;	Economic Internal Rate of Return
NPV	;	Net Present Value at discount rate of 12%
B - C	;	Benefit minus cost
B / C	;	Benefit cost ratio

FIGURES

Fig. 1.2.1 WORK SCHEDULE

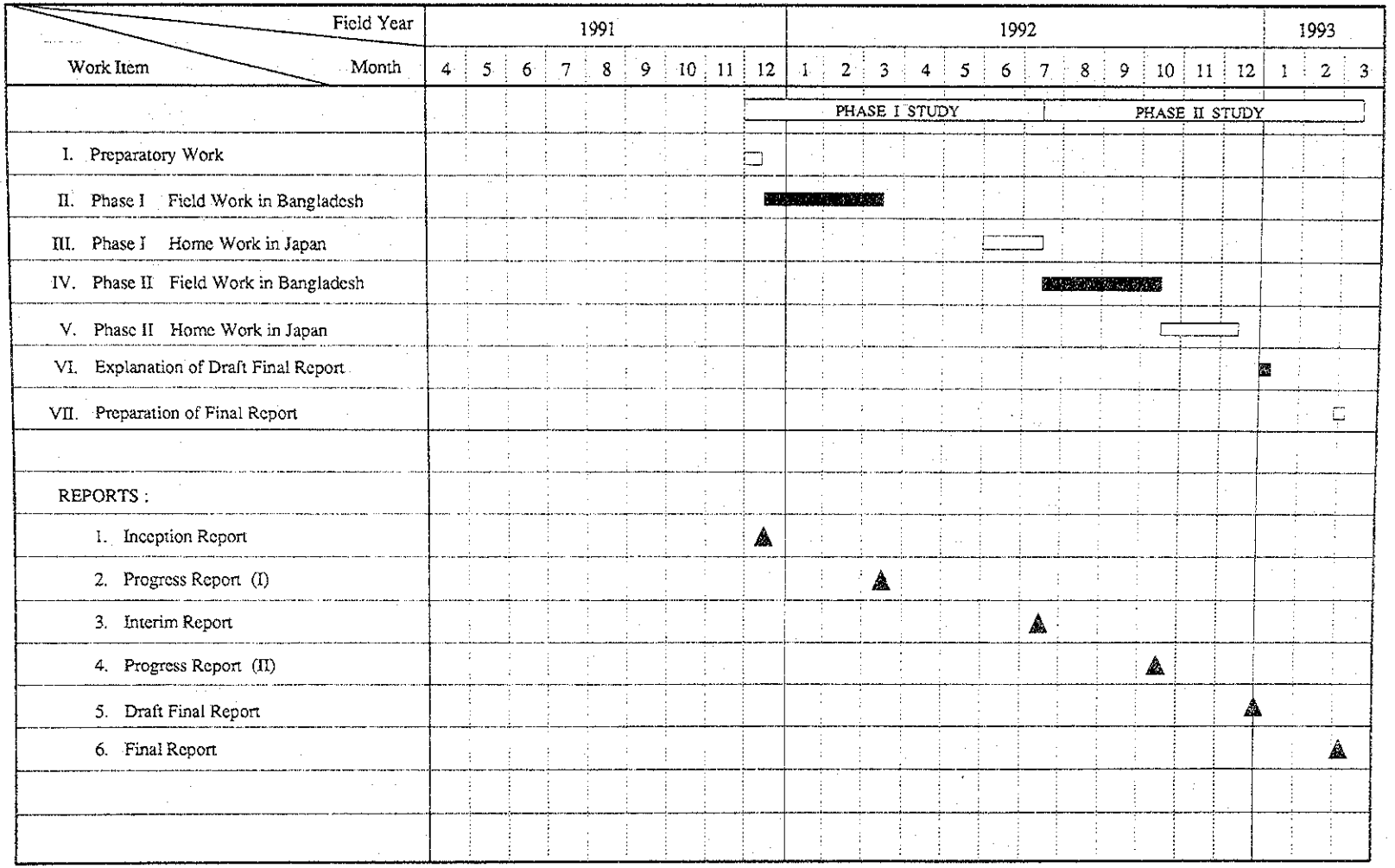


Fig. 1.3.1 ASSIGNMENT SCHEDULE OF THE JICA STUDY TEAM