5.4 Irrigation Plan

5.4.1 Source of Irrigation Water

This project aims at protecting the project area from the flood damages caused by raising water levels of both the Meghna and the Sitalakhya Rivers during the monsoon season by constructing embankment all around the area, the runoff from the local rainfall would be drained out of the area by use of pumps to minimize inundation which is the biggest constraint for agricultural development there. The pumps provided for drainage purpose during the monsoon season can also be used for irrigation purpose in the project area. Therefore, the Meghna and the Sitalakhya Rivers flowing along both banks of the project area are the sources of irrigation water.

(1) River Water Discharge

The project area is located within the tidal comportment of Bangladesh and in its neighbourhood, there are two hydrometery stations, one at Demra for the Sitalakhya River and the other at Bhairab Bazar for the Meghna River (see Fig. 5-5).

The observation of the river water discharges by these two hydrometery stations has been limited during June and October when the flows of the Meghna and the Sitalakhya Rivers would rise high enough to overcome the influences of the tidal levels of the Bay of Bengal as is the case in tidal comportment during November through May. The data on the river water discharges made available during this specific period of a year are given in Table 5-19 for Bhairab Bazar and in Table 5-20 for Demra.

Yet, to work out an irrigation plan which depends upon the Meghna and the Sitalakhya Rivers as exclusive sources of irrigation water, it si imperative to grasp their river water discharges during the dry season. As far as the Sitalakhya River is concerned, we can place our hand on one record of Qmin=113 cusecs which was observed on February 19, 1962 at Mymensingh which, however, is too far upstream of the project area and, moreover, completely free from the influences of the tidal levels of the Bay of Bengal, combined with those from the confluencing of three major rivers of the Ganges, Jamuna and Meghna. The river water discharges

around the project area are believed to be affected more by the backwater of the three rivers' confluencing than by the own discharges of the Meghna and the Sitalakhya Rivers during the dry season. Therefore, our irrigation plan would have no difficulty in obtaining enough water from the said two rivers during the dry season.

(2) Water Quality

Since the project area is located within the tidal comportment, the water levels of both the Sitalakhya and the Meghna Rivers flowing around the project area are affected by the tidal levels of the Bay of Bengal during the dry season, though not during the monsoon season. As the three major rivers of the Meghna, Ganges and Jamuna are met in confluence about 30 mi downstream of the project area, the saline water from the Bay of Bengal can be checked in its much further upstream. Accordingly, the river water along the Sitalakhya and the Meghna Rivers would have no disputable quality for irrigation purposes around the project area. Salinity density in the Lower Meghna River has been observed at different stations shown in Fig. 5-5 and their values are given in Table 5-21.

Fig. 5-5 TIDAL COMPORTMENT IN BANGLADESH

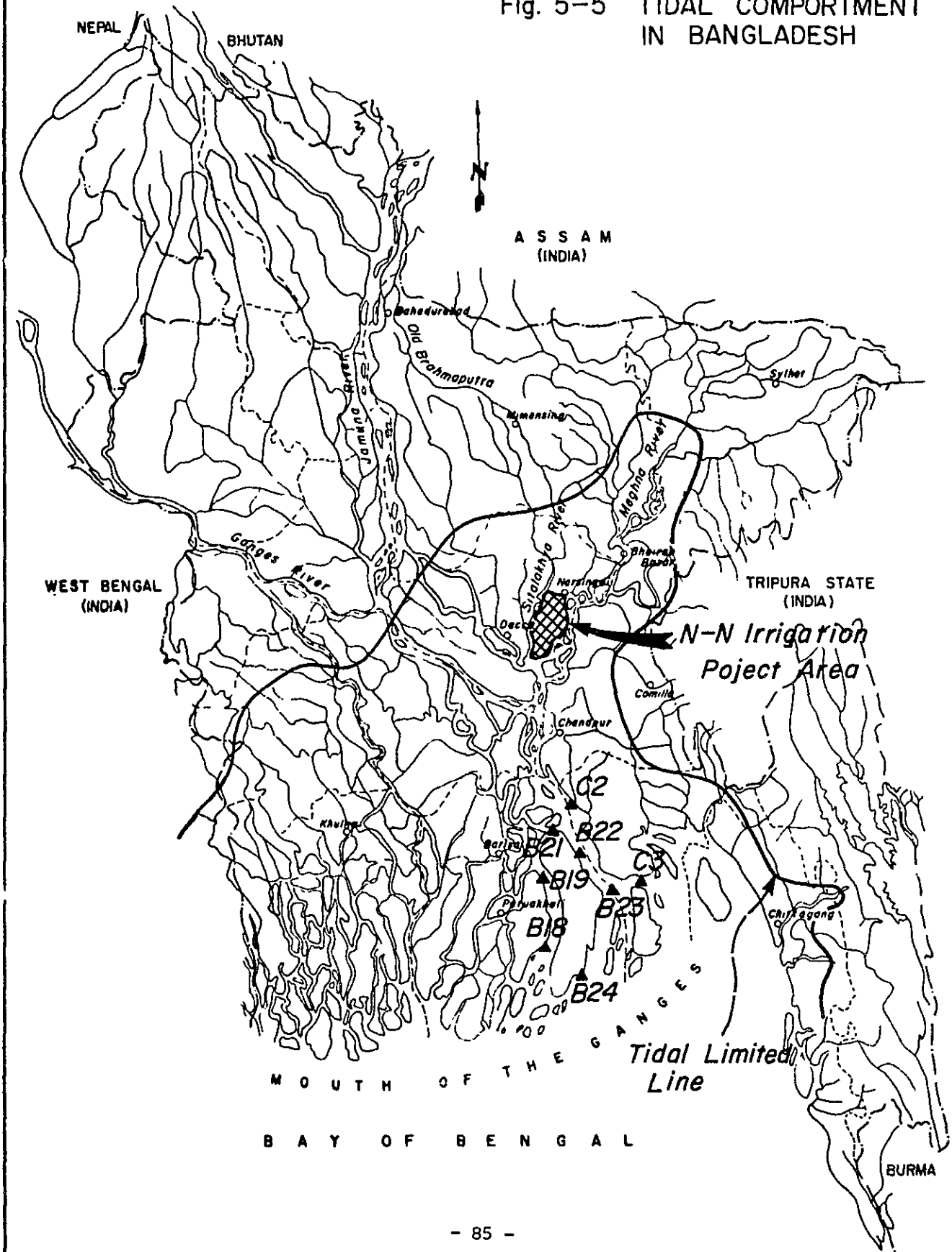


Table 5-19 Discharge Data of Maqhna River

Station: Bhairab Bazar (Unit: Cusecs)

Month	Item \ Year	1964/65	1967/68	1969/70	1970/71	1972/73	Average
Jun.	Q max	256,000	195,000	243,000	309,800	335,000	
	Q mean			168,179	195,100	170,000	
	Q min	96,100	168,000	113,000	116,000	123,000	
Jul.	Q max	393,000	450,000	326,000	443,600	360,000	
	Q mean	324,000	321,000	292,284	357,671	305,000	
	Q min	262,000	197,000	245,800	303,400	262,000	
Aug.	Q max	435,000	410,000	404,000	487,000	406,000	
	Q mean	401,000	328,000	335,419	452,400	358,600	
	Q min	354,000	287,000	295,000	392,400	290,000	
Sep.	Q max	372,000	287,000	406,000	389,200	295,000	
	Q mean	353,000	271,000	348,833	348,760	261,000	
	Q min	321,000	238,000	273,000	319,800	207,000	
Oct.	Q max	318,000	287,000	268,000	378,600	201,000	
	Q mean	273,000	230,000	191,871	328,129	150,000	
	Q min	223,000	140,000	127,000	245,400	109,000	
Nov.	Q max	218,000	145,000				
	Q mean	133,000					
	Q min	61,300	100,000				
Dec.	Q max	68,400					
	Q mean						
	Q min	29,200					
Annual	Q max	435,000	450,000	406,000	487,000	406,000	437,000
"	Q min						

Table 5-20 Discharge Data of Sitalakhya River

Station: Demra (Unit: Cusecs)

Month	Item \ Year	1967/68	1969/70	1970/71	1972/73	Average
Jun.	Q max		53,700		51,100	
	Q mean					
	Q min		17,700		19,000	
Jul.	Q max	62,000	63,500		49,000	
	Q mean	52,000				
	Q min	39,300	50,000		47,900	
Aug.	Q max	63,000	73,300	(15,300)	65,100	
	Q mean	51,500				
	Q min	39,800	54,900	(14,000)	41,400	
Sep.	Q max	44,500	68,300	(11,500)	48,200	
	Q mean	39,000				
	Q min	35,800	55,000	(7,470)	34,200	
Oct.	Q max	49,300	46,200	(11,500)	35,300	
	Q mean	38,600				
	Q min	19,500	16,800	(5,090)	21,000	
Nov.	Q max					
	Q mean					
	Q min					
Dec.	Q max					
	Q mean					
	Q min					
Annual	Q max	63,000	73,300	(15,300)	65,100	67,100
	Q min					

Table 5-21 Discharge and Salinity at Stations in the Lower Meghna River

Month	Discharge at Bhagyakul (cfs)	Estimated 1/ Discharge at Chandpur (cfs)	Conductivity of Water Samples in Micromhos							
			Station No.							
			C3	B24	B23	B22	C2	B21	B19	B18
Dec.'66	288,000	320,000	22,000	3,500	1,550	250	455	200	200	195
Jan.'67	215,000	233,000	2/	2/	3/	3/	8,000+	n	215	220
Feb.'67	224,000	245,000	2/	2/	8,000+	2,800	5,000	260	3/	3/
Mar.'67	239,000	265,000	2/	2/	8,000+	2,450	1,100	540	370	300
Apr.'67	323,000	360,000	2/	2/	8,000+	2,100	3/	430	440	330
May '67	422,000	500,000	2/	2/	2,800	240	1,300	150	3/	3/

1/ Discharge at Bhagyakul Station 93.5 on Padma River augmented by inflow in the Upper Meghna estimated from average monthly data

2/ Station dropped from further study

3/ Sample not taken during month

Source: IBRD/IDA Technical Report, Information on conductivity obtained from "Operation and Maintenance Manual for the Coastal Embankment" by Leedshill-Delew Engineers.

5.4.2 Identification of the Irrigable Area and Its Allocation among Different Cropping Patterns

The results obtained from the comparative studies on pumping capacity and its effectiveness through our previous drainage analysis suggested that the cropping pattern would be made relatively more effective by being based on light rainfall than on heavy rainfall. Therefore, the cropping patterns proposed under the project have been based on the 10th rainfall of the past ten years; irrigable areas under different cropping patterns are shown in Table 5-22.

Table 5-22 Project Area by Proposed Cropping Pattern

		Whole Area	Phase I Area	Phase II Area
Gross Area		111,600 Ac = 45,198 ha	71,600 Ac = 28,998 ha	40,000 Ac = 16,200 ha
Irrigable Area (Net Area)	Cropping Pattern A Area	2,700 Ac = 1,093 ha	2,700 Ac = 1,093 ha	0 Ac = 0 ha
	" " B "	70,300 " = 28,471 " ∿ 10.80 ft	49,400 " = 20,007 " ∿ 11.00 ft	20,900 " = 8,464 "
	" " C "	12,900 " = 5,225 ha 10.80 ∿ 8.75 ft	4,350 " = 1,762 ha 11.00 ∿ 8.85 ft	8,550 " = 3,463 ha
	" " D "	2,300 Ac = 932 " 8.75 ∿ 7.50 ft	550 Ac = 223 " 8.85 ∿ 7.50 ft	1,750 " = 709 "
	Total	88,200 Ac = 35,721 ha	57,000 Ac = 23,085 ha	31,200 Ac = 12,636 ha
Remarks		Pump Capacity 110 m^3/s H.W.L 11.75 ft	Pump Capacity 70 m^3/s No.1 No.2 }Pumping Station H.W.L 11.85 ft	Pump Capacity 40 m^3/s No.3 Pumping Station

Extension Area; Net - 8,600 Ac(3,483 ha)
Gross-11,300 Ac(4,576 ")

5.4.3 Calculation of Irrigation Requirements

(1) Definition

The following terminological definitions would be made in calculating irrigation water requirements:

(a) Evapotranspiration = Evaporation + Transpiration

(b) Crop Water Requirement = Evapotranspiration + Percolation

(c) Irrigation Requirement = Crop Water Requirement + Farm Waste - Effective Rainfall

(d) Diversion Requirement = Irrigation Requirement + Conveyance Losses + Diversion Losses

However, in irrigation requirement calculation with upland crops, the following formula would be used:

(a) $$\text{Irrigation Requirement} = (\text{Evapotranspiration} - \text{Effective Rainfall}) \times \frac{100\%}{\text{Irrigation Efficiency}}$$

(2) Selection of Base Year for Irrigation Plan

It is considered desirable to work out an irrigation plan based on the drought year which might occur once during ten years or so. According to the duration curve obtained from the annual rainfall records from 1906 to 1977 at Dacca station, 90% frequency rainfall is 59.5 in and 80% frequency is 66.5 in.

Among the last ten year's records (1967-1976) but for 1971's, that of 1969 with the figure of 65.66 in is the minimum. Although 90% frequency rainfall during the last 70 years was 59.5 in, no equivalent rainfall took place during the last 10 years. Hence, 1969 has been selected as the base year for the proposed irrigation plan.

Table 5-23 Annual Rainfalls in the Last 10 Years

(Unit: inches)

Year	Annual Rainfall	Total Rainfall during Dry Season (Nov.-Apr.)
1967	73.48	10.19
1968	74.40	9.95
1969	65.66	7.32
1970	81.05	4.82
1971	-	-
1972	67.52	10.72
1973	94.40	14.06
1974	86.98	10.44
1975	80.75	7.55
1976	83.36	6.50

(3) Effective Rainfall

Once 1969 has been selected as the base year, the effective rainfall during that year needs to be computed for calculating the water requirements under the proposed irrigation plan. In estimating an effective rainfall, 80% of monthly rainfall has often been taken (for paddy), for instance, in the case of Chenchuri Beel Project; however, such method might bring values higher than those in actual case in the country like Bangladesh where rain falls in much intensity. In our case, effectiveness of rainfall would be computed on daily rainfall basis and aggregated as a half-a-month unit as follows:

(a) For Paddy

Daily Rainfall	Effective Rainfall
less than 0.2 in	negligible
between 0.2 and 3.0 in	(R - 0.2) x 100%
more than 3.0 in	

where R represents daily rainfall.

(b) For Upland Crops

Daily Rainfall	Effective Rainfall
less than 0.1 in	negligible
between 0.1 and 2.0 in	(R - 0.1) x 80%
more than 2.0 in	2.0 in

Effective rainfalls in the base year (1969) obtained by the above method are shown in Table 5-24.

Table 5-24 Effective Rainfall in the Base Year (1969)

(Unit: inches)

Month	Period	Rainfall	Effective Rainfall for Paddy	Effective Rainfall for Other Crops
Jan.	I	0	0	0
	II	0	0	0
Feb.	I	0.05	0	0
	II	0	0	0
Mar.	I	0	0	0
	II	2.60	1.60	2.06
Apr.	I	0	0	0
	II	3.39	2.44	2.89
May	I	1.64	1.04	1.34
	II	2.08	0.89	1.35
Jun.	I	5.84	4.09	4.89
	II	3.97	2.43	3.05
Jul.	I	5.55	3.88	4.26
	II	6.37	3.51	2.67
Aug.	I	11.04	8.95	9.84
	II	9.91	7.92	7.62
Sep.	I	1.89	0.90	1.27
	II	6.01	4.74	5.34
Oct.	I	4.04	2.98	3.38
	II	0	0	0
Nov.	I	1.28	1.03	1.13
	II	0	0	0
Dec.	I	0	0	0
	II	0	0	0
Annual Total		65.66	46.40	51.09

(4) Irrigation Efficiency and Losses

In order to calculate the irrigation requirement, such items as the percolation, the water requirement for puddling, the irrigation efficiency, and the conveyance losses should be taken into consideration on and above the crop water requirements. Percolation is an important factor for calculating water requirement in paddy field and irrigation efficiency, for that of upland crops.

(i) Water Requirement for Puddling or Land Preparation

Water requirements for puddling have been determined as follows:

Boro cultivation	7.0 in
Aman and Aus cultivation	5.0 in

For land preparation of upland field, 3.0 in would be required.

(ii) Percolation

Percolation varies with soil texture and groundwater level, but it would be assumed to be 5.0 in per month under the project.

(iii) Irrigation Efficiency

Irrigation efficiency, which is used in estimating irrigation requirement for upland crops, has been assumed to be 50% in our case, although it should vary with irrigation methods and water duties.

(iv) Conveyance and Diversion Losses

The losses due to conveyance and diversion have been estimated at 30% of the total irrigation requirements on the ground that all the canals including the main canals are of earth type in the project area.

(5) Calculation of Crop Water Requirement and Unit Irrigation Requirement

(i) Evapotranspiration Index

In calculating crop water requirements in reference to the available meteorological data, Blarey-Criddle Method, Penman Method and a variety of other methods can be used. Nevertheless, the Blarey-Criddle Method would be inappropriate for this purpose in Bangladesh.[/1]

The modified Penman Method has been adopted as given below for calculating evapotranspiration index in the project area.

[Modified Penman Method]

$$ETo^* = W \cdot Rn + (1 - W) \cdot f(u) \cdot (ea - ed)$$

$$ETo^* = C \cdot ETo^*$$

where ETo^* : reference Evapotranspiration Index, mm/day (not adjusted)

ETo : adjusted Evapotranspiration Index, mm/day

W : temperature-related weighting factor

Rn : net radiation in equivalent evaporation, mm/day

$f(u)$: wind-related function

$(ea - ed)$: difference between the saturation vapour pressure at mean air temperature and the mean actual vapour pressure of the air, both in mbar

C : adjusting coefficient

Evapotranspiration indexes, as shown in Table 5-25, have been calculated by adopting the modified Penman Method in reference to the last 10-year meteorological data (1967-1976) obtained at Dacca station.

/1 : "Technical Guideline, Crop Consumptive Use Requirements", East Pakistan, Dec. 1970, WPDA

(ii) Calculation of Crop Water Requirements

Crop water requirements have been calculated by the following formula:

$$ET(Crop) = ETo \times Crop\ Factor$$

where ET(Crop): Evapotranspiration
ETo : Evapotranspiration Index

Crop factors used for this procedure follow the figures indicated in the Report "Bangladesh, Land and Water Resources Sector Study", IBRD, 1972, Vol. VII. They are shown in Table 5-26.

(iii) Calculation of Unit Irrigation Requirement

As represented in Table 5-27, unit irrigation requirements have been calculated for each individual crop on the basis of its crop water requirements obtained by taking into consideration effective rainfall, parcolation and water requirement for land preparation (or puddling).

(6) Calculation of Irrigation Requirement per 1,000 ac

Irrigation requirements per 1,000 ac have been computed for farmland allocated among different cropping patterns, as per Table 5-28.

(7) Calculation of Diversion Requirement for Phase I Area

Diversion Requirement Calculation has been made in Tables 5-29 and 5-30.

Table 5-25 Evapotranspiration Index
(Modified Penman Method)

Jan.	2.1 inches/Month
Feb.	2.8
Mar.	4.7
Apr.	5.8
May	5.9
Jun.	4.4
Jul.	4.3
Aug.	4.5
Sep.	3.7
Oct.	3.5
Nov.	2.5
Dec.	2.0
Total	46.2 inches/Month

Table 5-26 Crop Factors

Crops	Growing Period	Remarks	1		2		3		4		5		6		7		8		11		12	
			I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
	days																					
Boro	120	HYV	1.20	1.25	1.25	1.30	1.40	1.45	1.50	1.35												
	135	HYV	1.20	1.25	1.25	1.30	1.35	1.40	1.45	1.50	1.30											
T. Aus	105	HYV	1.20	1.25	1.30	1.40	1.45	1.50	1.35													
	120		1.20	1.25	1.25	1.30	1.40	1.45	1.50	1.35												
	135	Local	1.20	1.25	1.25	1.30	1.35	1.40	1.45	1.50	1.30											
T. Aman	105	HYV	1.20	1.25	1.30	1.40	1.45	1.50	1.35													
	150	Local	1.20	1.25	1.25	1.30	1.35	1.35	1.40	1.45	1.50	1.30										
Wheat	105		0.50	0.60	0.70	1.00	1.15	1.25	1.00													
Jute	120		0.50	0.65	0.95	1.15	1.50	1.40	1.40	1.40												
Pulses	90		0.50	0.70	0.95	1.10	1.10	0.95														
Oilseed	90		0.50	0.65	0.95	1.10	1.10	0.95														
Others	90	Winter Veg.	0.40	0.50	0.80	0.90	0.90	0.70														
"	90	Summer Veg.	0.40	0.65	0.80	0.90	0.95	0.85														
Sugar Cane	12 Months		0.60	0.80	0.90	1.00	1.20	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30			1.30	1.25	1.20	0.95
B. Aman																						

Table 5-27 Unit Irrigation Requirement

(Unit : inches)

Crops \ Month		Jan.		Feb.		Mar.		Apr.		May		Jun.		Jul.		Aug.		Sep.		Oct.		Nov.		Dec.	
		I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
Boro	HYV 135d	4.45	4.60	4.25	4.29	5.63	4.14	6.65	4.35	5.59	2.90	0													
Boro	" 120d	4.45	4.60	4.25	4.29	5.67	4.26		4.21	2.84	0														
T. Aus	" 105d					0.15	3.68	0.55	5.09	5.37	1.38	3.22	1.80	2.06	0										
T. Aus	Local 135d							0.17	0	2.94	4.58	1.16	2.89	1.48	1.96	0	0	4.19	0	0					
T. Aman (A)	HYV 105d														0	0	0	3.88	0.13	1.88	5.00	3.32	4.29	1.93	
T. Aman(B.C)	" "														0	0	0	3.94	0.13	1.88	5.00	3.32	4.29	2.55	0.63
T. Aman	Local 150d											0	0	0	0.36	0	0	4.06	0.26	1.94	5.00	3.32	4.25	2.52	0.63
B. Aman	" 195d									0.21	2.24	0	2.80	1.33	1.77	0	0	4.10	0.28	1.85	4.97	3.28	4.29	2.91	0.96
Wheat (A)	105d	1.78	2.26	3.36	3.16	2.36	0															0	1.82	1.57	1.30
" (B)	"	1.78	2.26	3.36	3.30	2.36																0.37	2.12	1.10	1.30
Jute	120d					1.50	0	3.36	0	3.40	5.14	0	0.06	0	0										
Pulses (A)	90d	2.02	1.26	2.32	2.88	5.78	0.72	2.78																	1.50
Pulses(B,C,D)	"	1.78	0.90	1.98	2.60	4.98	0.86	4.36	0																1.50
Oilseed	90d	0.86	1.44	2.54	2.96	4.98	0	1.40																1.50	1.76
Summer Vegtable	90d						0	2.66	0	1.62	2.32	0	0	0											
Winter Vegtable	90d	1.72	0.70	1.54	2.10	4.14	0	3.36	0																1.50
Sugar Cane		2.42	2.60	3.62	3.64	6.12	2.00	7.54	1.96	5.00	4.98	0	0	0	0.26	0	0	2.20	0	0	3.90	0	2.66	1.80	2.08

Table 5-28 Irrigation Requirement for 1,000 Ac. on Proposed Cropping Pattern

(Unit: Ac-ft)

Cropping Pattern \ Month	Jan.		Feb.		Mar.		Apr.		May		Jun.		Jul.		Aug.		Sep.		Oct.		Nov.		Dec.		Annual
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	
A	150.0	158.4	246.9	253.7	357.4	29.8	318.8	24.6	276.4	362.4	38.1	93.5	49.2	67.9	0	0	200.3	5.9	57.3	182.5	99.6	232.3	163.8	132.3	3,501.1
B	313.1	317.6	316.5	327.6	455.2	274.8	504.8	272.7	290.8	125.6	0	0.3	0	5.7	0	0	302.5	11.9	143.5	382.5	253.0	334.0	209.4	193.0	5,034.7
C	296.5	295.4	302.1	318.3	454.0	259.0	480.4	250.1	326.2	206.3	29.0	72.3	37.0	49.0	0	0	334.6	7.6	109.7	291.7	193.7	250.3	164.8	182.1	4,910.1
D	326.4	321.7	316.3	329.3	461.0	298.3	525.4	280.7	206.8	186.7	0	233.3	110.8	147.5	0	0	341.7	23.3	162.5	414.2	273.3	357.5	246.5	225.7	5,788.9
E	326.4	321.7	316.3	329.3	461.0	298.3	525.4	280.7	189.3	0	0	0	0	0	0	0	0	0	0	0	0	0	4.0	145.7	3,198.1

Table 5-29 Calculation of Diversion Requirements for Phase I Area

Cropping Pattern \ Month			Jan.		Feb.		Mar.		Apr.		May		Jun.		
			I	II	I	II	I	II	I	II	I	II	I	II	
A	I.R. per 1000 A		150.0	158.4	246.9	253.7	357.4	29.8	318.8	24.6	276.4	362.4	38.1	93.5	
2,700Ac	I.R. Ac·ft		405.0	427.7	666.6	685.0	965.0	80.5	860.8	66.4	746.3	978.5	102.9	252.5	
B	I.R. per 1000 A		313.1	317.6	316.5	327.6	455.2	274.8	504.8	272.7	290.8	125.6	0	0.3	
49,400Ac	I.R. Ac·ft		15,467.4	15,689.4	15,635.1	16,183.4	22,486.9	13,575.1	24,937.1	13,471.4	14,365.5	6,204.6	0	14.82	
C	I.R. per 1000 A		296.5	295.4	302.1	318.3	454.0	259.0	480.4	250.1	326.2	206.3	29.0	72.3	
4,350Ac	I.R. Ac·ft		1,289.8	1,285	1,314.1	1,384.6	1,974.9	1,126.7	2,089.7	1,087.9	1,419	897.4	126.2	314.5	
D	I.R. per 1000 A		326.4	321.7	316.3	329.3	461.0	298.3	525.4	280.7	206.8	186.7	0	233.3	
550Ac	I.R. Ac·ft		179.5	176.9	174.0	181.1	253.6	164.1	289.0	154.4	113.7	102.7	0	128.3	
Total	I.R. Ac·ft		17,341.4	17,579	17,789.8	18,434.1	25,680.4	14,946.8	28,176.6	14,780.1	16,644.5	8,183.2	229.1	710.1	
57,000Ac	Diversion R.	Ac·ft	22,543.8	22,852.7	23,126.7	23,964.3	33,384.5	19,430.3	36,629.6	19,214.1	21,637.9	10,638.2	297.8	923.1	
		Cusecs	757.7	768.1	777.3	805.4	1,122.1	653.1	1,231.1	6,458	727.2	357.5	10.0	31	
		m^3/Sec.	21.5	21.8	22	22.8	31.8	18.5	34.9	18.3	20.6	10.1	0.3	0.9	

Cropping Pattern \ Month			Jul.		Aug.		Sep.		Oct.		Nov.		Dec.		Annual Total
			I	II	I	II	I	II	I	II	I	II	I	II	
A	I.R. per 1000 A		49.2	67.9	0	0	200.3	5.9	57.3	182.5	99.6	232.3	163.8	132.3	3,501.1
2,700Ac	I.R. Ac·ft		132.8	183.3	0	0	540.8	15.9	154.7	492.8	268.9	627.2	442.3	357.2	9,453
B	I.R. per 1000 A		0	5.9	0	0	302.5	11.9	143.5	382.5	253.0	334.0	209.4	193.0	5,034.7
49,400Ac	I.R. Ac·ft		0	291.5	0	0	14,943.5	587.9	7,088.9	18,895.5	12,498.2	16,499.6	10,344.4	9,534.2	248,714.2
C	I.R. per 1000 A		37.0	49.0	0	0	334.6	7.6	109.7	291.7	193.7	250.3	164.8	182.1	4,910.1
4,350Ac	I.R. Ac·ft		161	213.2	0	0	1,455.5	33.1	477.2	1,268.9	842.6	1,088.8	716.9	792.1	21,358.9
D	I.R. per 1000 A		110.8	147.5	0	0	341.7	23.3	162.5	414.2	273.3	357.5	246.5	225.7	5,788.9
550 Ac	I.R. Ac·ft		60.9	81.1	0	0	187.9	12.8	89.4	227.8	150.3	196.6	135.6	124.1	3,183.9
Total	I.R. Ac·ft		354.7	769.1	0	0	17,127.7	649.7	7,810.2	20,885	13,760	18,412.2	11,639.2	10,807.6	282,710
57,000Ac	Diversion R.	Ac·ft	461.1	999.8	0	0	22,266.0	844.6	10,153.3	27,150.5	17,888	23,935.9	15,131	14,049.9	367,523
		Cusess	15.5	33.6	0	0	748.4	28.4	341.3	912.5	601.2	804.5	508.6	472.2	12,352.4
		m^3/sec.	0.4	1.0	0	0	21.2	0.8	9.7	25.8	17.0	22.8	14.4	13.4	349.8

Table 5-30 Calculation of Diversion Requirements for Phase I Area and Extension Area

Cropping Pattern	Month	Jan. I	Jan. II	Feb. I	Feb. II	Mar. I	Mar. II	Apr. I	Apr. II	May I	May II	Jun. I	Jun. II	
A 2,700Ac	I.R. per 1000Ac	150.0	158.4	246.9	253.7	357.4	29.8	318.8	24.6	276.4	362.4	38.1	93.5	
	I.R. Ac·ft	405.0	427.7	666.6	685.0	965.0	80.5	860.8	66.4	746.3	978.5	102.9	252.5	
B 49,400Ac	I.R. per 1000Ac	313.1	317.6	316.5	327.6	455.2	274.8	504.8	272.7	290.8	125.6	0	0.3	
	I.R. Ac·ft	15,467.1	15,689.4	15,635.1	16,183.4	22,486.9	13,575.1	24,937.1	13,471.4	14,365.5	6,204.6	0	14.8	
C 4,350Ac	I.R. per 1000Ac	296.5	295.4	302.1	318.3	454.0	259.0	480.4	250.1	326.2	206.3	29.0	72.3	
	I.R. Ac·ft	1,289.8	1,285	1,314.1	1,384.6	1,974.9	1,126.7	2,089.7	1,087.9	1,419	897.4	126.2	314.5	
D 550Ac	I.R. per 1000Ac	326.4	321.7	316.3	329.3	461.0	298.3	525.4	280.7	206.8	186.7	0	233.3	
	I.R. Ac·ft	179.5	176.9	174.0	181.1	253.6	164.1	289.0	154.4	113.7	102.7	0	128.3	
Extension 8,600Ac	I.R. per 1000Ac	326.4	321.7	316.3	329.3	461.0	298.3	525.4	280.7	189.3	0	0	0	
	I.R. Ac·ft	2,807	2,766.6	2,720.2	2,832	3,964.6	2,565.4	4,518.4	2,414	1,628	0	0	0	
Total 65,000Ac	I.R. Ac·ft	20,148.4	20,345.6	20,510	21,266.1	2,964.5	17,511.8	32,695.0	17,194.1	18,272.5	8,183.2	229.1	710.1	
	Diversion R. Ac.ft	26,192.9	26,449.3	26,663	27,645.9	38,538.5	22,765.3	42,503.5	22,352.3	23,754.3	10,638.2	297.8	923.1	
	Diversion R. Cusecs	880.3	889	896.1	929.2	1,295.3	765.1	1,428.5	751.3	798.4	357.5	10	31.0	
	Diversion R. m^3/Sec.	24.9	25.2	25.4	26.3	36.7	21.7	40.5	21.3	22.6	10.1	0.3	0.9	

Cropping Pattern	Month	Jul. I	Jul. II	Aug. I	Aug. II	Sept. I	Sept. II	Oct. I	Oct. II	Nov. I	Nov. II	Dec. I	Dec. II	Annual Total
A 2,700Ac	I.R. per 1000Ac	49.2	67.9	0	0	200.3	5.9	57.3	182.5	99.6	232.3	163.8	132.3	3,501.1
	I.R. Ac·ft	132.8	183.3	0	0	540.8	15.9	154.7	492.8	268.9	627.2	442.3	357.2	9,453
B 49,400Ac	I.R. per 1000Ac	0	5.9	0	0	302.5	11.9	143.5	382.5	253.0	334.0	209.4	193.0	5,034.7
	I.R. Ac·ft	0	291.5	0	0	14,943.5	587.9	7,088.9	18,895.5	12,498.2	16,499.6	10,344.4	9,534.2	248,714.2
C 4,350	I.R. per 1000Ac	37.0	49.0	0	0	334.6	7.6	109.7	291.7	193.7	250.3	164.8	182.1	4,910.1
	I.R. Ac·ft	161	213.2	0	0	1,455.5	33.1	477.2	1,268.9	842.6	1,088.8	716.9	792.1	21,358.9
D 550Ac	I.R. per 1000Ac	110.8	147.5	0	0	341.7	23.3	162.5	414.2	273.3	357.5	246.5	225.7	5,788.9
	I.R. Ac·ft	60.9	81.1	0	0	187.9	12.8	89.4	227.8	150.3	196.6	135.6	124.1	3,183.9
Extension 8,600Ac	I.R. per 1000Ac	0	0	0	0	0	0	0	0	0	0	4.0	145.7	3,198.1
	I.R. Ac·ft	0	0	0	0	0	0	0	0	0	0	34.4	1,253	27,503.7
Total 65,000Ac	I.R. Ac·ft	354.7	769.1	0	0	17,127.7	649.7	7,810.2	20,885	13,760	18,412.2	11,673.6	12,060.6	310,213.7
	Diversion R. Ac·ft	461.1	999.8	0	0	22,266.0	844.6	10,153.3	27,150.5	17,888	23,935.9	15,175.7	15,678.8	403,277.8
	Diversion R. Cusecs	15.5	33.6	0	0	748.4	28.4	341.3	912.5	601.2	804.5	510.1	527	
	Diversion R. m^3/sec.	0.4	1.0	0	0	21.2	0.8	9.7	25.8	17.0	22.8	14.4	14.9	

5.5 Plan for Installation of the Facilities Related to Irrigation and Drainage

5.5.1 Pumping Plan

(1) General

Pumping plants have to be equipped with satisfactory functions for both irrigation and drainage purposes. Capacity of the pump(s) serving for dual purposes needs to be determined by a workable balance maintained between irrigation and drainage. While 2,480 cusec (70 m^3/sec) would be appropriate for drainage purpose in Phase I area, irrigation of the Phase I area plus the extension area which belongs to Phase II would suggest the pumping capacity of about 1,430 cusec (40.5 m^3/sec) only. The pumping capacity based on irrigation requirement is apparently too large for drainage purpose. However, pumping operation for irrigation purpose takes much longer time and yet full operation (24-hour operation of all the pumps) is not desirable from the plant's O&M point-of-view. This problem is usually solved either by regulating the operation hours of all the pumps or through alternate operation of a number of pumps. The operating ratio of the pumping facilities determined from the drainage point-of-view would remain between 30 - 60% all through the irrigation period which is deemed almost appropriate. Therefore, the pumping capacity would be determined at 2,480 cusec. From the topographical as well as irrigation/drainage system view-points, two pumping stations would be built on the Sitalakhya River side.

(2) Pumping Capacity

Pumping capacity for Phase I Area as a whole is equal to the sum of 2,480 cusec (70 m^3/sec) for irrigation purpose and 1,429 cusec (40.5 m^3/sec) for drainage purpose. The total pumping capacity for Phase I Area can be divided into Pumping Stations No. 1 and No. 3 as follows:

Table 5-31 Pumping Capacity for Phase I Area

Case	No. 1 Pumping Station	No. 2 Pumping Station	Total
	cusec m^3/s	cusec m^3/s	cusec m^3/s
Drainage	1240 (35)	1240 (35)	2480 (70)
Irrigation	712 (20.17)	717 (20.33)	1429 (40.5)

As mentioned above, proposed pumping capacity has been determined at 1,240 cusec (35 m^3/sec) for both Pumping Stations No. 1 and No. 2.

(3) Pumping Facilities

The specifications as per Table 5-32 have been arrived at upon comparative studies of the following conditions:

(a) Minimum quantity and time and seasonal variation in the quantities of water to be dealt with;

(b) Equipment cost (pumping machinery, installation), operation and maintenance costs;

(c) Risk dispersion with facilities;

(d) Limits to pumping capacities;

(e) Loads and bearing power of the foundation; and

(f) Engineering and construction costs.

Those summarized in Table 5-32 are the justifiable results of the above techno-economic comparative studies.

Table 5-32 List of Pumping Facilities

Item			No. 1 Pumping Station	No. 2 Pumping Station
Type			Vertical Mixed Flow Pump	Vertical Mixed Flow Pump
Pump Bore			1650 mm	1650 mm
Nos. of Pump			6	6
Power			550 kw	550 kw
Head	Suction Water Level	Drainage	2.0 ft PWD	2.0 ft PWD
		Irrigation	1.0 " "	0.3 " "
	Delivery Water Level	Drainage	22.0 " "	22.8 " "
		Irrigation	21.0 " "	22.0 " "
	Actual Head	Drainage	20.0 ft	20.8 ft
		Irrigation	20.0 "	21.7 "
	Total Head	Drainage	23.0 "	23.8 "
		Irrigation	23.0 "	24.7 "
Structure of Pumping Station			Reinforcement Concrete. Two floor Type.	- do -

(4) Pumping Station Works

Pumping Stations No. 1 and No. 2 would be built along Tatkir Khal and Kendua Khal, respectively..

(i) Pumping Station No. 1

Pumping Station No. 1 would be located along the Dacca-Chittagong Road, approximately 0.5 mi away from the Sitalakhya River. It would measure 100 ft x 100 ft and of a double-floor type; it's irrigation-cum-drainage function would be operable by a gate system. With insufficient geological survey undertaken during the feasibility study, geological conditions of its site have been assumed from the data obtained from the D-N-D Irrigation Project adjacent to this project as well as from the ground surface observations made on the spot, as follows:

The ground level to a depth of 20 ft made up of soft silty clays and trace sands with a N-value of less than 5 (a N-value obtained from penetration testing), and the underlying layer made up of clays (with high plasticity) and trace sands showing a N-value of about 10. In the D-N-D Irrigation Project, no foundation treatment was made for construction of its pumping stations. Geological survey of its site is preferable at the detailed design stage. Sheet piles would be provided at both the upper and lower reaches so as to avoid piping caused by seepage pressures due to differences between the inside and outside water levels. A control office measuring 20 ft x 40 ft has been proposed.

(ii) Pumping Station No. 2

Pumping Station No. 2 would be located inside the new dike, 300 ft away from the Sitalakhya River. Its size is almost equivalent to that of Pumping Station No. 1, but its floor elevation would be 1 ft higher at 24.0 P.W.D.

(5) Power Transmission

Transmission lines within the project area are as illustrated in the Notes. Power supply facilities are to be provided by P.D.B. in general, but as it has difficulties in purchasing these facilities, their procurement costs would be appropriated by the project.

(i) Power Stations

Power for Pumping Station No. 1 would be supplied from Haripur S/S, while that for Pumping Station No. 2, from Kenghar S/S. Such would be feasible because each power station has spare bays. Since there are no two-way switch apparatus used for outgoing feeders from the power stations, they would be purchased under the project.

(ii) Transmission Lines

The distances between the power stations and the pumping stations would be connected with 33 KV overhead lines as follows:

HARIPUR - Pumping Station No. 1 L = 3 mi (4.8 km)
KANGHAR - Pumping Station No. 2 L = 2 mi (3.2 km)

5.5.2 Drainage Canals

(1) General

As has been discussed above, drainage system aims at draining rain water falling within a catchment area of 71,600 ac (29,000 ha) of Phase I Area, subject to no water inflow from outside the project area; therefore, optimum pump capacity for Phase I Area has been decided at 2,480 cusec (70 m^3/sec) with a specific discharge of 0.0346 cusec/ac (0.0024 m^3/sec/ha).

From the physical reasons such as topography and existing drainage systems, Phase I catchment area would be divided into 41,900 ac (17,000 ha) under the command of Pumping Station No. 1 and 29,700 ac (12,000 ha) under that of Pumping Station No. 2. However, as the pumping facilities are requested to serve for both drainage and irrigation,

catchment area of 4,900 ac belonging to Pumping Station No. 1 would be brought under the command of Pumping Station No. 2, as follows:

Table 5-33 Catchment Area

Pumping Station	Existing Catchment Area	Proposed Catchment Area
No. 1	41,900 ac (17,000) ha	37,000 ac (15,000) ha
No. 2	29,700 ac (12,000) ha	34,600 ac (14,000) ha

As Pumping Station No. 1 and No. 2 are connected with Sonakhali Khal which allows free flow of water between the two command areas, each pumping station would be equipped with the same capacity.

To facilitate for effective drainage within the project area, the main drainage canals leading to two pumping stations (Tatkir, Kendua and Sonakhali Khals) would be either widened in their width or newly constructed, and the same improvements would be made with the secondary canals.

(2) Canal Alignment and Capacities

Main drainage canals would have the following features:

Main Drainage Canal leading to Pumping Station No. 1

6.25 mi Tatkir Khal connecting the Old Brahmaputra River to the Sitalakhya River would be widened, re-shaped and put into the required cross section.

Main Drainage Canal leading to Pumping Station No. 2

A new 8.50 mi long drainage canal would be built between the Old Brahmaputra River and the Sitalakhya River through Sonakhali and Kendua Khals.

Discharge and lengths of the main canals are stated in Table 5-34.

Table 5-34 Discharges and Lengths of Drainage Canals

Canal Type	Discharge/1	Length
No. 1 Pumping Station	cusec	mile
P1 - 1	1240	0.75
- 2	1120	3.75
- 3	920	1.75
Sub-total		6.25
No. 2 Pumping Station		
P2 - 1	1240	3.00
- 2	950	1.00
- 3	380	2.25
- 4	270	2.25
Sub-total		8.50
Total		14.75

(3) Design Criteria

(i) Type of Canal

All drainage canals have been designed as being of unlined earth type.

(ii) Hydraulic Depth

Hydraulic depth of the drainage canals would have to be deeper than that of the irrigation canals and has been determined at 7 ft.

(iii) Freeboard

Freeboard has been decided at 2 ft.

(iv) Inside Slope

Inside slope has been determined to be 1.5 : 1, identical to that of the irrigation canals.

/1: Each discharge has been obtained from specific discharges.

(v) Bank Width

Bank widths of the drainage canals, which are identical to those of the irrigation canals, have been determined at 15 ft (4.5 m) and 5 ft (1.5 m), while those of secondary drainage channels, 12 ft (3.6 m) and 4 ft (1.2 m).

(vi) Flow Formula

The following flow formula, which is identical to that used for the irrigation canals, has been adopted for the drainage canals.

$$Q = A.V$$

$$V = \frac{1.486}{n} r^{2/3} s^{1/2}$$

S : Main canal 1/20,000

Secondary canal 1/10,000

(vii) Standard Cross Section

Seven types have been proposed for the main drainage canals, while three types, for the secondary drainage canals.

(4) Hydraulic Calculation

Standard cross sections of drainage canals belonging to different pumping stations have been calculated as per Table 5-35.

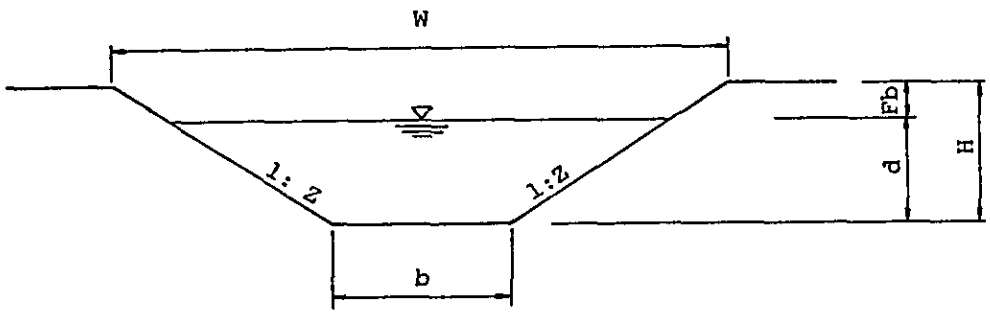
(5) Related Structures

Frap-gate is required to check back flow of the drainage water into the project area enclosed by dike when its level along the drainage canals rises higher than that inside the dike. Furthermore, bridges would be constructed with an interval of 1,000 ft.

Table 5-35 Hydraulic Calculation of Standard Cross Section for Main Drainage Canal

Pumping Station		Canal Type	1 cusec Qd	2 S	3 n	4 $\frac{1.486}{n}\sqrt{S}$	5 ft b	6 z	7 ft d	8 b/d	9 ft^2 A	10 ft P	11 $R=(\frac{A}{P})^{ft}$	12 $R^{2/3}$	13 ft/s V	14 cusec $Q_c=(A\cdot V)$	15 H^{ft}	16 Wft	17 Fb^{ft}	18 *mil L
Main Canal	No.1	1	1,240	1/20,000	0.025	0.420	114.0	1.5	7.0	16.286	871.50	139.242	6.259	3.396	1.426	1,242.8	9.0	141.0	2.0	0.75
		2	1,120	"	"	"	103.0	"	"	14.714	794.50	128.242	6.195	3.373	1.417	1,125.8	"	130.0	"	3.75
		3	920	"	"	"	84.0	"	"	12.000	661.50	109.242	6.055	3.322	1 395	922.8	"	111.0	"	1.75
	No.2	1	1,240	1/20,000	0.025	0.420	114.0	1.5	7.0	16.286	871.50	139.242	6.259	3.396	1.426	1,242.8	9.0	141.0	2.0	3.0
		2	950	"	"	"	87.0	"	"	12.429	682.50	112.242	6.081	3.332	1.399	954.8	"	114.0	"	1.0
		3	380	"	"	"	33.0	"	"	4.714	304.50	58.242	5.228	3.012	1.265	385.2	"	60.0	"	2.25
		4	270	"	"	"	22.0	"	"	3.143	227.50	47.242	4.816	2.852	1.198	272.5	"	49.0	"	2.25
Secondary Canal		1	920	1/20,000	0.025	0.420	84.0	1.5	7.0	12.000	661.50	109.242	6.055	3.322	1.395	922.8	9.0	111.0	2.0	2.70
		2	132	"	"	"	13.0	"	6.0	2.167	132.00	34.636	3.811	2.440	1.025	135.3	8.0	37.0	"	36.30

* L : Length of main canal



5.5.3 Irrigation Canals

(1) Canal Alignment

Irrigation canal routes have been selected by paying due attention to the following points:

(a) To locate the canal route along the highest possible altitude, keeping enough head for water distribution to the secondary irrigation canals;

(b) To avoid canal alignment through village settlements as far as possible; and

(c) To avoid the proposed canal bed to be made up of embankment as far as possible.

Main irrigation canals would be as follows:

(i) Main irrigation canal system belonging to Pumping Station No. 1

Two main irrigation canal systems would be arranged, the one in the east and another in the west, on both sides of the main drainage canal system.

(a) East Main Canal (P1-E)

This comprises of two routes of P1-E1 and P1-E2. The P1-E1 route has a total length of 15.5 mi. It starts from Pumping Station No. 1, running eastward along the D-C Road until it reaches the N-M Railway, wherefrom it runs along the western hem of the N-M Railway to Araihazar. The P1-E2 Route has a total length of 3.75 mi. It branches off from the P1-E1 route at the crossing point with the N-M Railway, and turns southward after passing underneath the D-C Road till it almost reaches the N-B Road. 6 types of cross section have been designed for the East Main Canal.

(b) West Main Canal (P1-W)

This comprises of two routes of P1-W1 and P1-W2. The P1-W1 route has a total length of 10.25 mi. It runs westward from Pumping Station No. 1 along the D-C Road till it reaches the D-N Road, where it branches off into P1-W1 and P1-W2. P1-W1 runs therefrom northward along the D-N Road till it reaches the Brahmaputra River. P1-W2 route has a total length of 6.75 mi. It branches off from P1-W1 at the D-N Road and runs northward along the Sitalakhya River till Mongalkhali. 5 types of cross section have been designed for the West Main Canal.

Total length of the main irrigation canals belonging to Pumping Station No. 1 is 36.25 mi (58.3 km).

(ii) Pumping Station No. 2

Main canal routes have been arranged in the south and north of the main drainage canal (Kendua Khal).

(a) South Main Canal (P2-S)

South main canal route, i.e. the P2-S route, has a length of 5.1 mi and starts running from Pumping Station No. 2 along the Sitalakhya River to Mongalkhali. One type of cross section has been designed for the South Main Canal.

(b) North Main Canal (P2-N)

North main canal is composed of three routes: P2-N1, P2-N2 and P2-N3. The P2-N1 route runs northward along the Sitalakhya River from Pumping Station No. 2 and turns eastward at Ghagra and runs in parallel with Ghagra Khal, with a length of 13.25 mi. It crosses the Brahmaputra River and the D-N Road.

The P2-N2 route runs eastward along the Danga-Srichandi Road after branching off from the P2-N1 main canal

route and crosses the D-N Road and the Brahmaputra River after passing through Srichandi, with a length of 6.5 mi.

The P2-N3 route also branches off from the P2-N1 main canal route and extends up to Chott Madhabdi after crossing the D-N Road and the Brahmaputra River, with a length of 9.45 mi.

The total length of the main irrigation canals belonging to Pumping Station No. 2 is 34.3 mi (55.2 km), for which 10 types of cross section have been proposed.

(iii) Secondary Canal

Secondary and tertiary canals have been so aligned as to make the entire area irrigable, by taking into consideration the topographical features of the project area. Secondary canal would have a unit irrigable area of about 500 ac (200 ha), and tertiary channel would have irrigable area smaller than that of the secondary canal.

(iv) Pump Irrigation of the Peripheral Parts of the Main Canals

The main irrigation canals fed by Pumping Station No. 2 (Routes P2-N1, P2-N2 and P2-N3) have some pocket areas which can not be irrigated by gravity system at their peripheral parts. These areas are scattered in small parcels at 5 to 10 feet higher levels, with 3,700 ac (1,500 ha) in gross and 2,700 ac (1,100 ha) in net irrigable areas (see Fig. 5-6). These areas would be fed with irrigation water by use of low-lift pumps installed along the main irrigation canals according to the following specifications:

Type	:	Vertical pump
Bore	:	10 in
Total Head	:	10 ft
Discharge	:	90 cu-ft/min (2.6 m^3/min)
Motor	:	3 P.S.

Table 5-36 Length and Type of Irrigation Canals

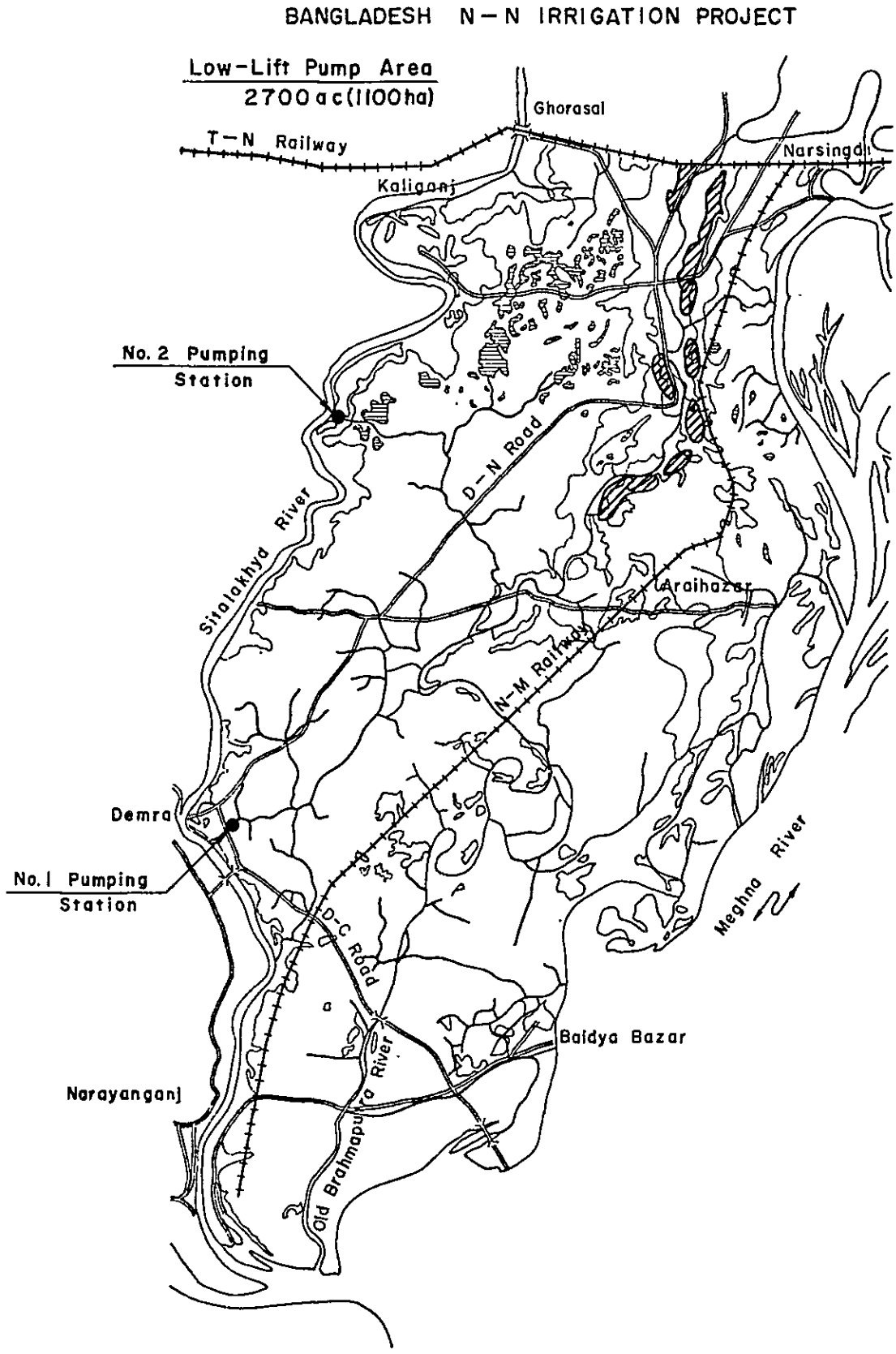
(I) Main Canal

Rout	Length (Mile)	Type (Nos.)
No.1 Pumping Station		
P_1 - E_1	15.50	4
P_1 - E_2	3.75	2
P_1 - W_1	10.25	3
P_1 - W_2	6.75	2
Sub total	36.25	
No.2 Pumping Station		
P_2 - S	5.10	1
P_2 - N_1	13.25	5
P_2 - N_2	6.50	2
P_2 - N_3	9.45	3
Sub total	34.30	
Total	70.55	

(2) Secondary Canal

Tipe / Pumping Station	Length (Mile)					
	Type 1	Type 2	Type 3	Type 4	Type 5	Total
No.1 Pumping Station			26.00	4.50	38.10	68.60
No.2 Pumping Station	10.70	6.80	11.90	7.40	45.00	81.80
Total	10.70	6.80	37.90	11.90	83.10	150.40

Fig. 5—6 LOCATION OF HIGH LAND AREA



Each pump would irrigate about 75 ac (30 ha) and the total number of pumps required would be 36.

(2) Canal Capacities

Judging from the results of the irrigation requirement calculation in the Section 5.4.3, the maximum diversion requirement for Phase I Area (covering 57,000 ac : 23,100 ha) has been determined at 1,231 ac (34.9 m^3/sec) and the unit diversion requirement at 0.0216 cusec/ac (1.511 l/sec/ha). On the other hand, the maximum diversion requirement for the sum of Phase I Area and Extension Area (implying a part of Phase II Area and covering 65,600 ac : 26,600 ha) has been determined at 1,429 cusec (40.5 m^3/sec) and the unit diversion requirement to be 0.0218 cusec/ac (1.523 l/sec/ha). However, since 24-hour water supply for the project area by full utilization of pumps for long period of time seems to be impossible, it is necessary to analyse the relationships between half-monthly water requirement and pump operation hour. From the results of the calculation of irrigation requirement, diversion requirement would reach its peak level of 1,429 cusec (40.5 m^3/sec) in the first half of April.

Optimum pump capacity for Phase I Area has been decided at 2,470 cusec (70 m^3/sec) based on calculation of drainage requirements. 14-hour operation by full use of pumps would be enough to irrigate Phase I Area. In this case, unit discharge becomes larger and cross sections of irrigation canals and related structures need to be correspondingly enlarged, thus resulting in increase in the project costs.

In order to solve such a problem, restricted number of pumps would be put in 24-hour operation in alteration, and the cross sections of irrigation canals would be so designed as to admit the maximum diversion requirement of 1,429 cusec (40.5 m^3/sec). Seasonal pump operation hours computed on such basis are shown in Table 5-36. 15 days 24-hour operation and 15 days 22-hour operation are proposed as required during the dry season when 15-hour operation per day would be enough. Pumping operation during the monsoon season would be around 5 hours per day.

Table 5-37 Operation Time

		Jan.		Feb.		Mar.		Apr.		May		Jun.		Jul.		Aug.		Sep.		Oct.		Nov.		Dec.	
		I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
Diversion R	Acft	26,193	26,449	26,663	29,646	38,539	22,765	42,504	22,352	23,754	10,638	298	923	461	1000	0	0	222.66	845	10,153	27,151	17,888	23,936	15,176	15,679
	CuSec	880	889	896	929	1,295	765	1,429	751	798	358	10	31	16	34	0	0	748	28	341	913	601	805	510	527
	m^3/s	24.9	25.2	25.4	26.3	36.7	21.7	40.5	21.3	22.6	10.1	0.28	0.88	0.44	0.95	0	0	21.2	0.8	9.7	25.8	17	22.8	14.4	14.9
Operation time (hr)		15	15	15	16	22	13	24	13	13	6	0.2	0.5	0.3	0.6	0	0	13	0.5	6	15	10	14	9	9

The maximum and unit diversion requirements for each pumping station are shown in Table 5-38.

Table 5-38 List of Diversion Requirements

Pumping Station		Max. Diversion Requirement	Unit Diversion Requirement
No. 1	cusec	712	0.022
	m^3/sec	20.17	0.00153
No. 2	cusec	717	0.0216
	m^3/sec	20.33	0.00151
Total	cusec	1429	0.00218
	m^3/sec	40.5	0.00152

Capacities of the canals aligned to each pumping station are given in Tables 5-39 and 5-40.

(3) Canal Lining and Design

(i) Canal Lining

Canals would be of excavation-without-timbering type and unlined. The proposed cross sections would be obtained through cutting or embanking. The gradient of the canal would have to be made very gentle because of the topographic characteristics of the project area itself. Accordingly, the velocity of flow would be about 1 ft/sec far too slow to cause washing-out of the canals. This would rather make frequent weeding necessary to assure smooth flow of irrigation water.

(ii) Design

Standard cross section has been designed as trapezoid one.

Table 5-39 Sectional Discharge and Type and Length of Main Canals

No. 1 Pumping Station ΣQ = 712 cusec (20.17 m^3/s)
ΣA = 32.400 ac (13.150 ha)

Canal	Turnout	Main Canal				Turnout	
		Irrigation Area	Discharge	Canal Type	Length	Irrigation Area	Discharge
		ac	cusec		mile	ac	cusec
	Pumping						
P_1-E_1	Station	19,570	435	E_1-A			
	E_1-1	17,770	396	"		1,800	39
	2	12,340	271	E_1-B		5,430	125
	3	10,910	240	"		1,430	31
	4	10,340	228	"		570	12
	5	8,940	196	"		1,400	32
	6	7,190	157	E_1-C		1,750	39
	7	5,930	129	"		1,260	28
	8	5,240	113	"		690	16
	9	3,790	82	"		1,450	31
	10	2,340	51	E_1-D		1,450	31
	11	570	13	"		1,770	38
	End			"		570	13
					(15.5)		
P_1-E_2	E_1-2	5,430	125	E_2-A			
	E2-1	3,750	86	"		1,680	39
	2	2,000	46	E_2-B		1,750	40
	End			"		2,000	46
					(3.75)		
	Pumping						
P_1-W_1	Station	12,830	277	W_1-A			
	W_1-1	7,990	173	W_1-B		4,840	104
	2	6,810	147	"		1,180	26
	3	5,820	126	"		990	21
	4	4,540	98	W_1-C		1,280	28
	5	3,850	83	"		690	15

(to be continued)

Canal	Turnout	Main Canal				Turnout	
		Irrigation Area	Discharge	Canal Type	Length	Irrigation Area	Discharge
		ac	cusec		mile	ac	cusec
	W_1-6	3,360	73	W_1-C		490	10
	7	1,790	39	"		1,570	34
	End					1,790	39
					(10.25)		
P_1-W_2	W_1-1	4,840	104	W_2-A			
	W_2-1	4,100	89	"		740	15
	2	2,470	54	W_2-B		1,630	35
	End					2,470	54
					(6.75)		
Total		32,400	712 (20.17 m^3/s)		36.25 (58.3 km)		

Unit requirement Phase 1 0.0216 CuSec (1.511 ℓ/sec/ha)
Phase 2 0.023 " (1.60 ")
Ave 0.022 " (1.534 ")

Table 5-40 Sectional Discharge and Type and Length of Main Canals

No. 2 Pumping Station ΣQ = 717 CuSec (20.33 m^3/s)

ΣA = 33.200 ac (13,450 ha)

Canal	Turnout	Main canal				Turnout	
		Irrigation Area	Discharge	Canal Type	Length	Irrigation Area	Discharge
		ac	cusec		mile	ac	cusec
	Pumping						
P2-S	station	2,960	64	S-A			
	S-1	1,970	43	"		990	21
	2	740	16	S-B		1,230	27
	End			"		740	16
					(5.10)		
	Pumping						
P2-N1	station	30,240	653	N1-A			
	N1-1	28,140	608	"		2,100	45
	2	16,840	364	N1-B		11,300	244
	3	10,050	217	N1-C		6,790	147
	4	8,200	177	"		1,850	40
	5	6,100	132	N1-D		2,100	45
	6	4,130	90	"		1,970	42
	7	2,280	50	N1-E		1,850	40
	8	620	14	"		1,660	36
	End			"	(13.25)	620	14
P2-N2	N1-3	6,790	147	N2-A			
	N2-1	5,680	123	"		1,110	24
	2	4,080	88	"		1,600	35
	3	1,610	35	N2-B		2,470	53
	4	670	15	"		940	20
	End			"	(6.50)	670	15
P2-N3	N1-2	11,300	244	N3-A			
	N3-1	9,570	207	"		1,730	37
	2	8,950	194	"		620	13
	3	5,620	122	N3-B		3,330	72
	4	2,440	53	N3-C		3,180	69

(to be continued)

Canal	Turnout	Main canal				Turnout	
		Irrigation Area	Discharge	Canal Type	Length	Irrigation Area	Discharge
		ac	cusec		mile	ac	cusec
	N_3-5	1,060	23	N_3-C		1,380	30
				"		1,060	23
	End				(9.45)		
Total		33,200	717 (20.33 m^3/s)		34.30 (55.2km)		
Unit requirement			0.0216 CuSec/ac (1.511 ℓ/Sec/ha)				

Fig. 5－7

No. I PUMPING STATION CANAL NET WORK AND DISCHARGE ASSIGNMENT

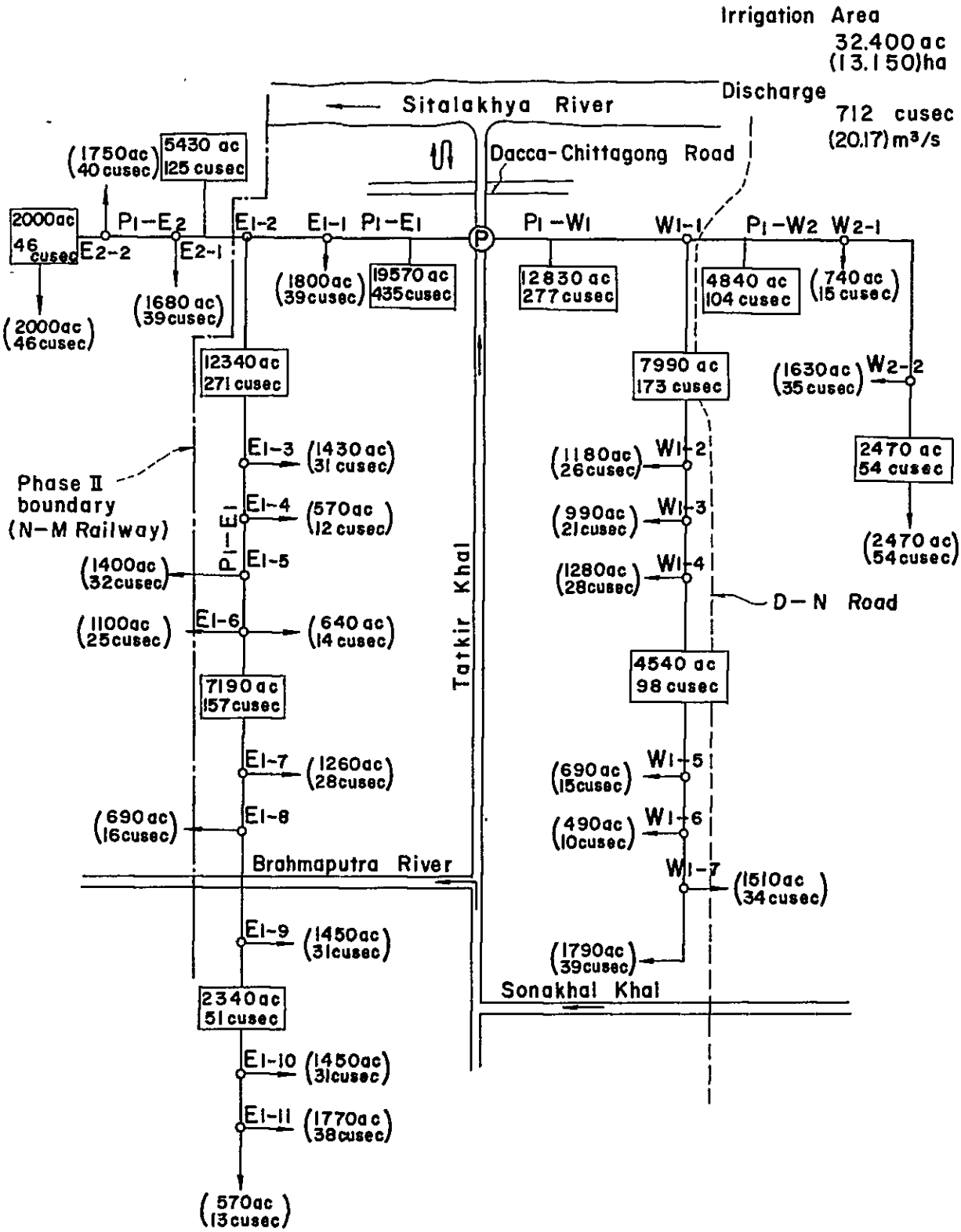
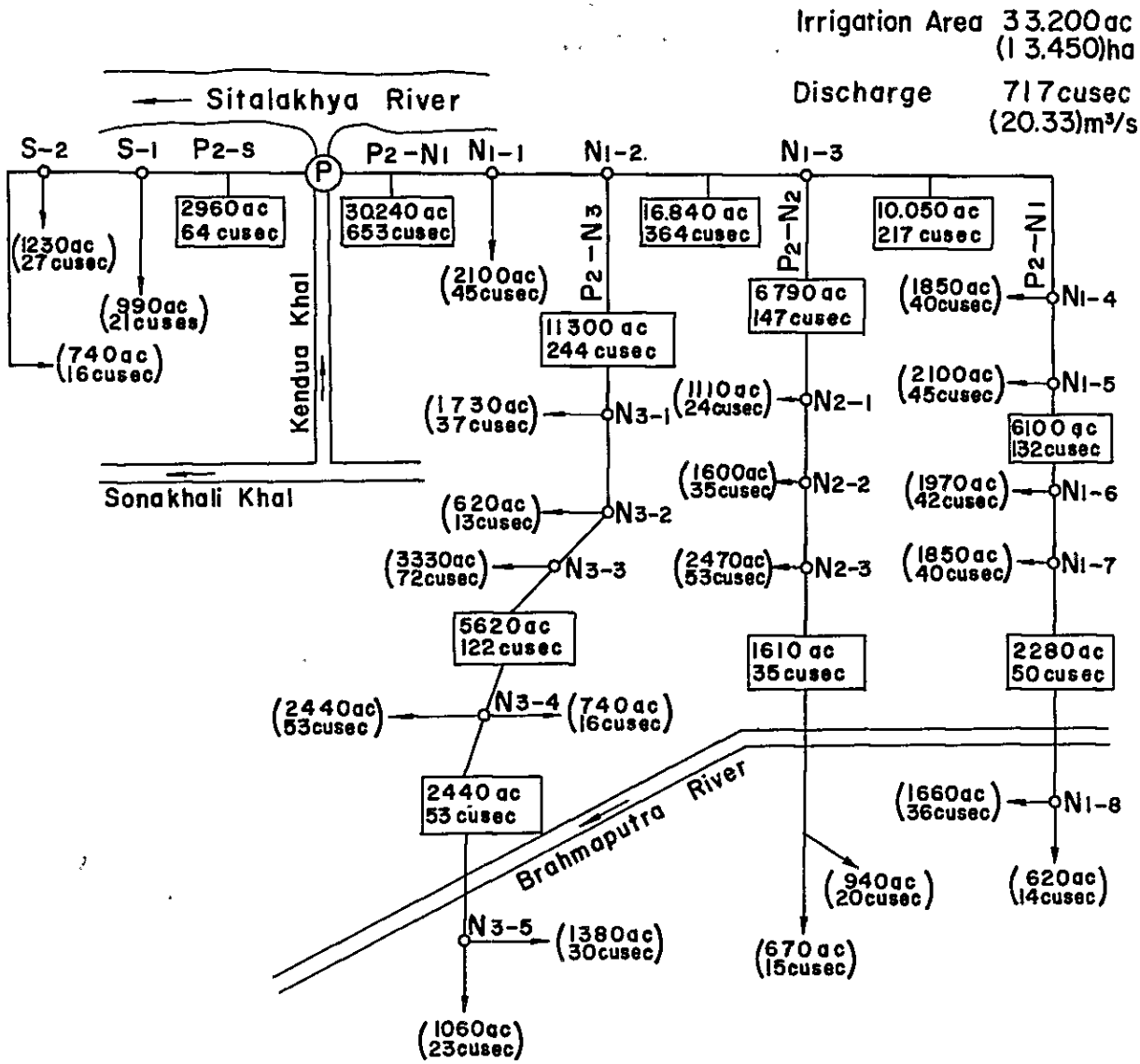


Fig. 5 – 8

No. 2 PUMPING STATION CANAL NET WORK AND DISCHARGE ASSIGNMENT



(a) Hydraulic Depth

Standard hydraulic depth of irrigation canal usually ranges from 5 to 7 ft. In our case, main and secondary canals would have the hydraulic depths of 5 to 6 ft and 3 to 4 ft, respectively.

(b) Freeboard

As the irrigation canals proposed under the project are solely meant for conveyance of the pumped-up water, an inflow of outside water being unimaginable, there should be no need for a sizeable freeboard. Taking example from the similar projects, it has been decided at 1.5 ft.

(c) Inside Slope

Pending on the results of soil tests with material earth obtainable along the canal routes, inside slopes have been tentatively determined as follows:

Main canal	1.5 : 1
Secondary canal	1.5 - 1 : 1

(d) Bank Width

Width of the main canal banks would be 15 ft (4.5 m) on O & M side and 5 ft (1.5 m) on the other. The bank width of secondary canals would be 12 ft (3.6 m) on O & M side and 4 ft (1.2 m) on the other side.

(e) Flow Formula

The following Manning formula is used in the Bangladesh design standard: "Hydrological and Hydraulic Design Procedures":

$$Q = A \cdot V$$

$$V = \frac{1.486}{n} r^{2/3} \cdot s^{1/2}$$

where Q : design discharge ft^3/sec

A :	cross sectional area	ft^2
V :	Velocity of water	ft/sec
r :	Hydraulic radius	ft
s :	Average loss of head	
n :	Roughness coefficient	0.025

As s stands for a flat profile:

Main canal	1/20,000
Secondary canal	1/10,000

(f) Standard Cross Section

As for the standard cross section, 22 types are proposed for the main canals and 5 types for the secondary canals.

Main canal	Pumping Station No. 1	11 types
Main canal	Pumping Station No. 2	11 types
Secondary canal		5 types

The results of hydraulic calculation with different standard cross sections are shown in Tables 5-41 through 5-43.

(4) Related Structures

(i) Crossings

Crossing structures are required at the intersections of the canals and branch rivers, roads and drainage channels. Bridges and culverts are planned at the intersections of the canals and roads, and aqueducts at the intersections of the canals, branch rivers and drainage channels. Concrete pipe would do at the intersection of the existing minor drainage channels and the proposed canals. Main canal crossings are categorized in Table 5-44.

(a) Bridges

Three types of bridge have been proposed, respectively for (i) Highway, (ii) Farm Road, and (iii) O & M Road.

Table 5-41 Hydraulic Calculation of Standard Cross Section for Main Irrigation Canal No. 1 Pumping Station

Canal	Type	1 cusec Qd	2 S	3 n	4 $\frac{1.486}{n}\sqrt{I}$	5 ft b	6 Z	7 d ft	8 b/d	9 ft^2 A	10 ft P	11 ft $R=(\frac{A}{P})$	12 $R^{2/3}$	13 ft/s V	14 cusec $Q_c=(A\cdot V)$	15 ft H	16 ft W	17 ft Fb	18 *mil L
P_1-E_1	1	435	1/20,000	0.025	0.420	51.0	1.5	6.0	8.500	360.00	72.636	4,956	2,907	1.221	439.6	7.5	73.50	1.5	2.75
	2	271	"	"	"	31.0	"	"	5.167	240.00	52.636	4,540	2,750	1.155	277.2	"	53.50	"	4.79
	3	157	"	"	"	16.0	"	"	2.667	150.00	37.636	3,986	2,514	1.056	158.4	"	38.50	"	2.52
	4	51	"	"	"	5.0	"	5.0	1.000	62.50	23.030	2,714	1,946	0.817	51.1	6.5	24.50	"	5.44
P_1-E_2	1	125	"	"	"	19.0	"	"	3.800	132.50	37.030	3,578	2,339	0.982	130.1	"	38.50	"	0.81
	2	46	"	"	"	5.0	"	"	1.000	62.50	23.030	2,714	1,946	0.817	51.1	"	24.50	"	2.94
P_1-W_1	1	277	"	"	"	31.0	"	6.0	5.167	240.00	52.636	4,560	2,750	1.155	277.2	7.5	53.50	"	0.56
	2	173	"	"	"	18.0	"	"	3.000	162.00	39.636	4,087	2,556	1.074	174.0	"	40.50	"	4.18
	3	98	"	"	"	9.0	"	"	1.500	108.00	30.636	3,525	2,316	0.973	105.1	"	31.50	"	5.51
P_1-W_2	1	104	"	"	"	15.0	"	5.0	3.000	112.50	33.030	3,406	2,264	0.951	107.0	6.5	34.50	"	2.09
	2	54	"	"	"	6.0	"	"	1.200	67.50	24.030	2,809	1,991	0.836	56.4	"	25.50	"	4.66

*L: Length of main canal

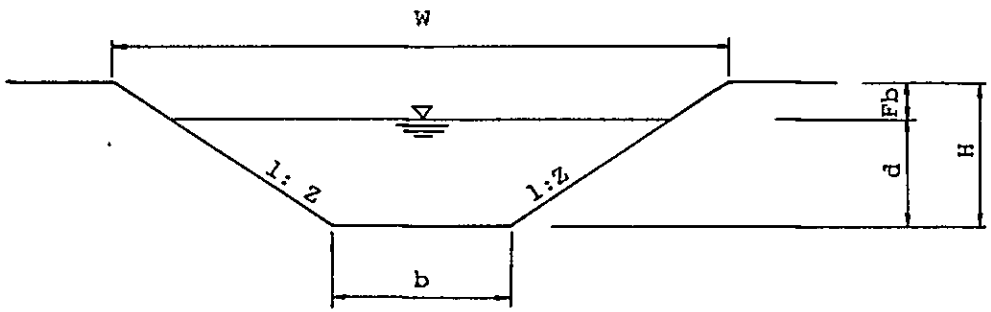


Table 5-42 Hydraulic Calculation of Standard Cross Section for Main Irrigation Canal No.2 Pumping Station

Canal Type		1 cusec Qd	2 S	3 n	4 $\frac{1.486}{n}\sqrt{I}$	5 ft b	6 z	7 ft d	8 b/d	9 ft^2 A	10 ft P	11 ft $R=(\frac{A}{P})$	12 $R^{2/3}$	13 ft/s V	14 cusec $Q_c=(A\cdot V)$	15 ft H	16 ft W	17 ft Fb	18 *mil L
P_2-N_1	1	653	1/20,000	0.025	0.420	78.0	1.5	6.0	13,000	522.00	99.636	5.239	3.016	1.267	661.4	7.5	100.50	1.5	2.86
	2	364	"	"	"	42.0	"	"	7,000	306.00	63.636	4.809	2.849	1.197	366.3	"	64.50	"	1.54
	3	217	"	"	"	24.0	"	"	4,000	198.00	45.636	4.339	2.660	1.117	221.2	"	46.50	"	3.89
	4	132	"	"	"	13.0	"	"	2,167	132.00	34.636	3.811	2.440	1.025	135.3	"	35.50	"	2.92
	5	50	"	"	"	5.0	"	5.0	1,000	62.50	23.030	2.714	1.946	0.817	51.1	6.5	24.50	"	2.04
P_2-N_2	1	147	"	"	"	22.0	"	"	4,400	147.50	40.030	3.685	2.386	1.002	147.8	"	41.50	"	5.00
	2	35	"	"	"	6.0	"	4.0	1,500	48.00	20.424	2.350	1.768	0.743	35.7	5.5	22.50	"	1.50
P_2-N_3	1	244	"	"	"	39.0	"	5.0	7,800	232.50	57.030	4.077	2.552	1.072	249.2	6.5	58.50	"	3.83
	2	122	"	"	"	18.0	"	"	3,600	127.50	36.030	3.539	2.322	0.975	124.3	"	37.50	"	1.47
	3	53	"	"	"	6.0	"	"	1,200	67.50	24.030	2.809	1.991	0.836	56.4	"	25.50	"	4.15
P_2-S		64	"	"	"	8.0	"	"	1,600	77.50	26.030	2.977	2.069	0.869	67.3	"	27.50	"	5.10

*L: Length of main canal

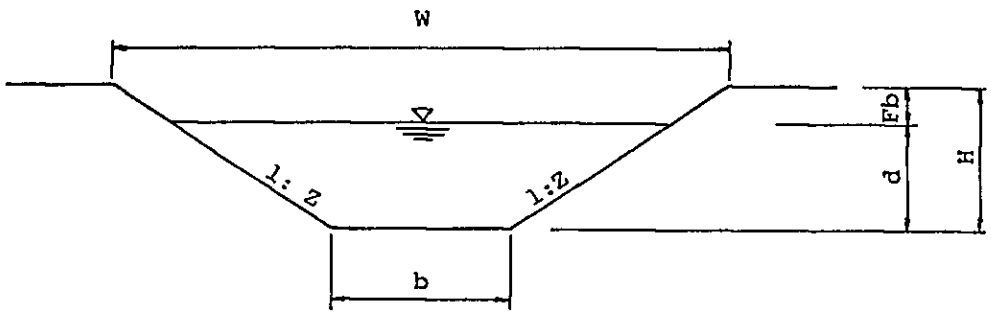


Table 5-43 Hydraulic Calculation of Standard Cross Section for Secondary Canal

Canal Type	1 cusec Qd	2 I	3 n	4 $\frac{1,486}{n}\sqrt{I}$	5 ft b	6 z	7 ft d	8 b/d	9 ft^2 A	10 ft P	11 ft $R=(\frac{A}{P})$	12 2/3 R	13 ft/s V	14 cusec Qc=(A·V)	15 ft H	16 ft W	17 ft Fb	18 *mil L
70∿51 1	70	1/10,000	0.025	0.594	10.0	1.5	4.0	2,500	64.00	24,424	2,620	1,901	1.129	72.3	5.5	26.5	1.5	
50∿41 2	50	"	"	"	6.0	"	"	1,500	48.00	20,424	2,350	1,768	1.050	50.4	"	22.5	"	
40∿31 3	40	"	"	"	5.0	"	"	1,250	44.00	19,424	2,265	1,725	1.025	45.1	"	21.5	"	
30∿21 4	30	"	"	"	8.0	1.0	3.0	2,667	33.00	16,485	2,002	1,588	0.943	31.1	4.0	16.0	1.0	
20∿ 5	20	"	"	"	5.0	"	"	1,667	24.00	13,485	1,780	1,469	0.873	21.0	"	13.0	"	

*L: Length of main canal

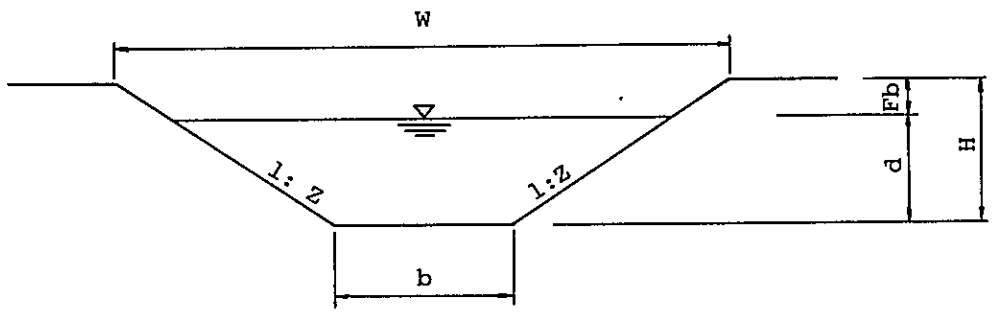


Table 5-44 List of Proposed Irrigation Facilities

Canal Type	Turn-out (T.O)	Check-Gate (C.G)	Aqueduct	Bridges	Siphon	Regulating Gate
No.1 Pumping Station						
$P_1 - E_1$	11	1	2	85	4	
$P_1 - E_2$	2	1	1	21		1
$P_1 - W_1$	7	1	12	65		
$P_1 - W_2$	2	1		37		
Total	22	4	15	208	4	1
No.2 Pumping Station						
$P_2 - N_1$	8	2	2	75		
$P_2 - N_2$	4	1	3	36	1	
$P_2 - N_3$	6	1	3	52		
$P_2 - S$	2			27		
Total	20	4	8	190	1	

Irrespective of its types, the bridge would have brick abutment and concrete body.

(b) Aqueducts

Two types are being proposed, one is for crossing the Old Brahmaputra River and the other for main drainage canals. Both would have brick abutments.

(c) Culverts

(ii) Turnouts

Turnouts would be provided at all places where secondary canals branch off from the main canals. Proposed intake would be regulated by gate operation. Each turnout would have a control hut for a watchman who is permanently stationed there to assure appropriate water distribution. Out of three types of the turnout, Types I and II would be the combination of two gates and a concrete box, and Type III, the combination of one gate and a concrete pipe.

(iii) Checks

Two types of check gate are proposed to facilitate diversion of the water from the main canal to the secondary canals. Each comprises of a fixed overflow weir and a gate, which is to be operated for maintenance of main canal water level as required.

(iv) Water Measurement Facilities

Installation of water gauge has been proposed along the main canal or secondary canal for effective distribution of water.

5.5.4 Road System

The road network is currently in very poor conditions as is shown in Table 5-45. Except the D-N Road and the D-C Road which are passable for traffic throughout the year, most roads are often submerged by flood water during the monsoon season. Poor road network is partly due to the costlieness of construction and maintenance of roads which need 10 - 15 ft embankment to keep themselves above the flood water which inundates the project area as a whole during every monsoon season. The traffic and transport services are almost completely replaced by countless boats which cater between village settlements and unsubmerged main roads. Construction of all-season roads would become very much easier and less costly upon completion of the pumping stations and the inundation area restricted to the minimum. Apart from the new dike which affords motor traffic on its crest, the irrigation/drainage canals criss-crossing the project area would have O&M roads with 12 - 15 ft width. Hence the total length of roads would be extended as follows:

Table 5-46 Proposed Road Network

Item	Length
1. New Dike	21.50 miles
2. Irrigation Main canal	70.55 "
" Secondary canal	150.40 "
Sub-total	220.95 "
3. Drainage Main canal	14.75 "
" Secondary canal	39.00 "
Sub-total	53.75 "
4. Existing Road	552.60 "
Total	848.80 miles (25 ft/ac = 37 m/ha)

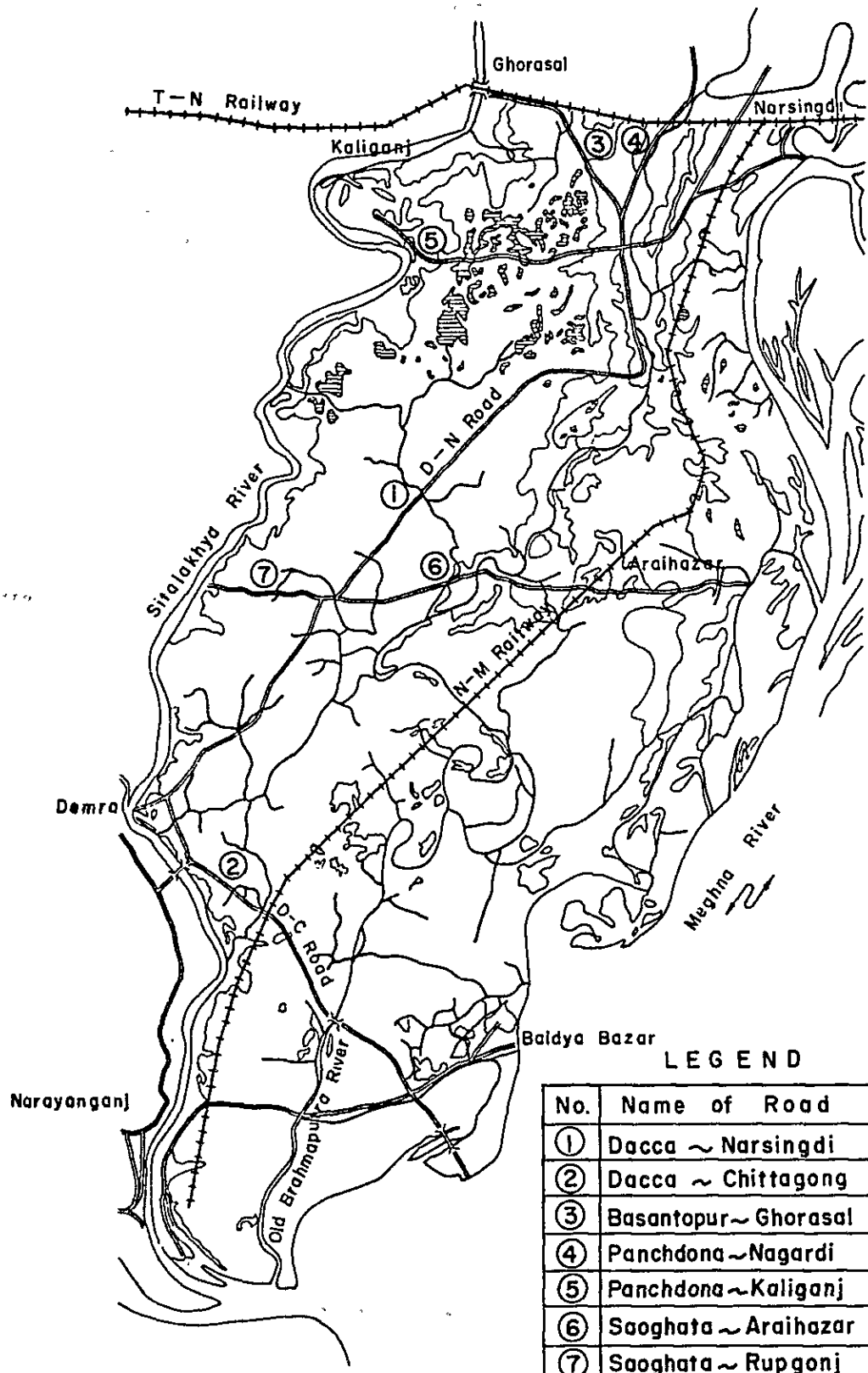
The road network would be brought to completion by being equipped with farm road network as will be discussed in the following section.

Table 5-45 Existing Road

Name	Route	Remarks			
		Length	Width	Pavement	Classification
		mile	ft		
D-N Road	Dacca ∿ Narsingdi	23.03	37.0	Asphalt	National Road
D-C "	Dacca ∿ Chittgong	10.59	40.0	"	National Road
N-G "	Nagar Ponghdono ∿ Ghorasal	3.84	20.0	"	Car passable
N-R "	Nagar Ponghdono ∿ Roghabdi	2.95	12.0	Non	Car passable in dry season
S-K "	Srichandi ∿ Koliganj	7.18	"	Brick	Car passable
S-A "	Saoghata ∿ Araihazar	9.64	"	"	"
S-R "	" ∿ Rupgonj	2.56	"	"	"
B-N "	Baidyer Bazar ∿ Narayanganj	1.77	"	"	"

Fig. 5-9 EXISTING ROAD

BANGLADESH N-N IRRIGATION PROJECT

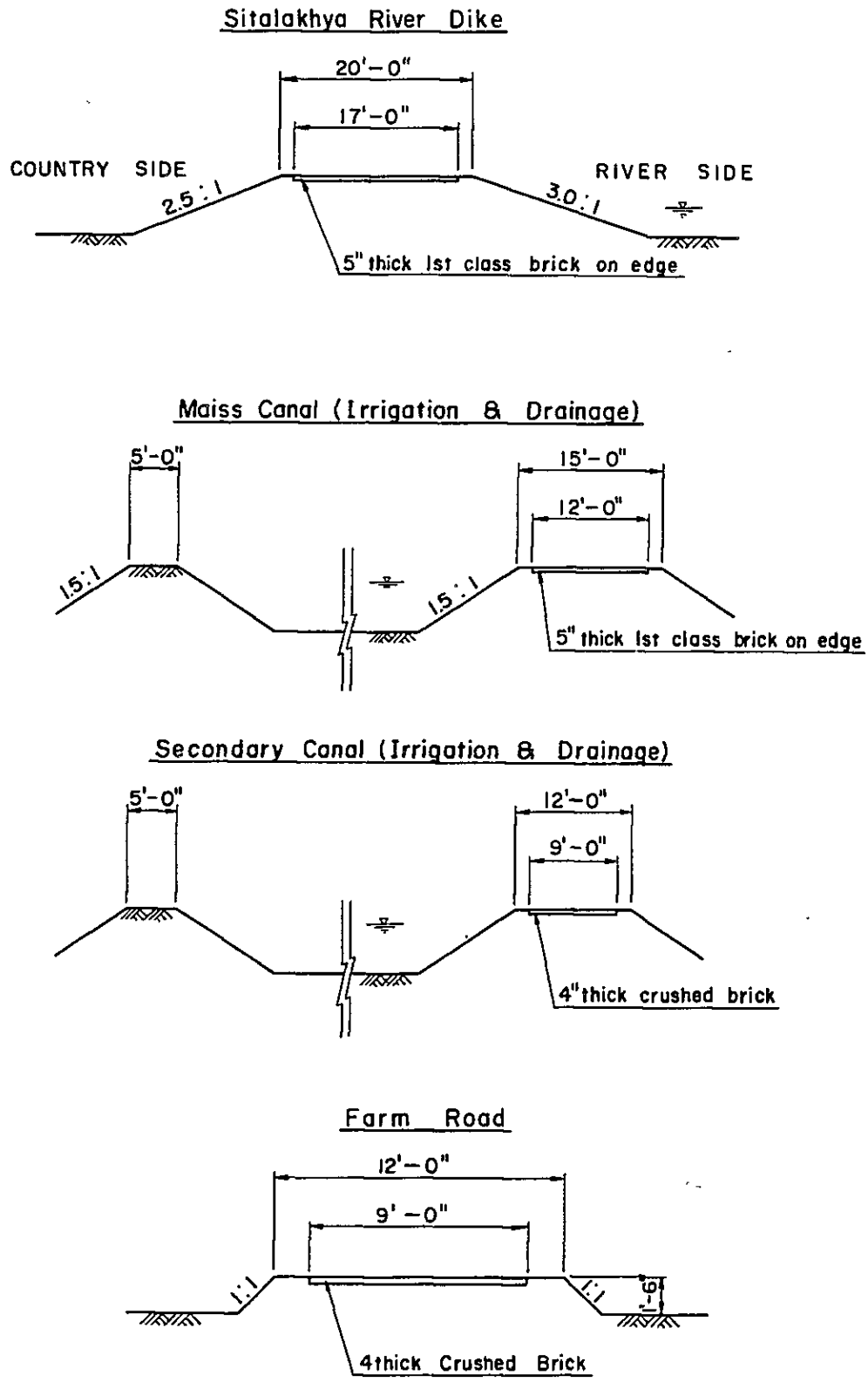


LEGEND

(mile)

No.	Name of Road	Length
①	Dacca ~ Narsingdi	23.0
②	Dacca ~ Chittagong	3.4
③	Basantopur ~ Ghorasal	3.8
④	Panchdona ~ Nagardi	3.0
⑤	Panchdona ~ Kaliganj	7.2
⑥	Saoghata ~ Araihazar	9.6
⑦	Saoghata ~ Rupgonj	2.6
	Total	52.6

Fig. 5-10 PROPOSED CROSS SECTION OF MAINTENANCE ROAD



5.5.5 Farm Network

In peripheral farms, the following facilities would be provided in view of forming effective farming pattern and thereby increase the economic benefits.

(1) Tertiary Channel and Farm Ditch

Tertiary channel which branches off from the secondary canal would have a command area of about 120 ac (50 ha); the smaller units would be irrigated by farm ditches. Density of irrigation canal would be 53 ft/ac (40 m/ha). Its outlay is illustrated in Fig. 5-11.

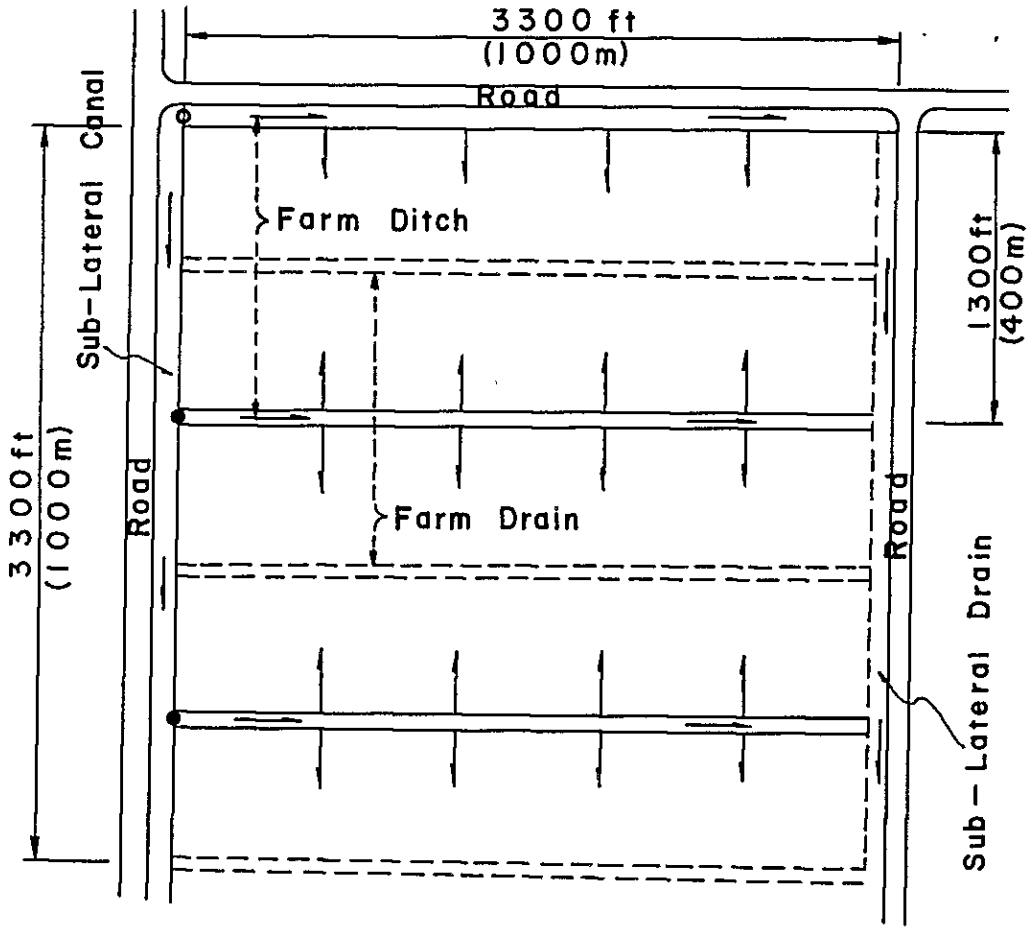
(2) Lateral Drain and Farm Drain

Sub-lateral drains would be provided at an interval of 3,300 ft (1,000 m) and farm drains at an interval of 1,300 (400 m) for efficient drainage of the peripheral farm (see Fig. 5-11). Density of drainage canal would be 53 ft/ac (40 m/ha).

(3) Farm Roads

Farm roads would be provided as per Fig. 5-11. Farm road density would be 40 ft/ac (30 m/ha).

Fig. 5-11 DENSITY OF CANALS AND ROADS



Sub-Lateral Canal	$\frac{3300ft}{247ac}$	= 13 ft/ac	
Farm Ditch	$\frac{9900ft.}{247ac}$	= 40 ft/ac	
Irrigation Canal Density		= 53 ft/ac (40 m/ha)	
Sub-Lateral Drain	$\frac{3300ft}{247ac}$	= 13 ft/ac	
Drain Ditch	$\frac{9900ft}{247ac}$	= 40 ft/ac	
Drainage Canal Density		= 53 ft/ac (40 m/ha)	
Road	$\frac{9900ft}{247ac}$	= 40 ft/ac	
Road Density		40 ft/ac (30 m/ha)	

5.6 Agricultural Production

5.6.1 Agriculture

(1) Expansion of the Cropped Area

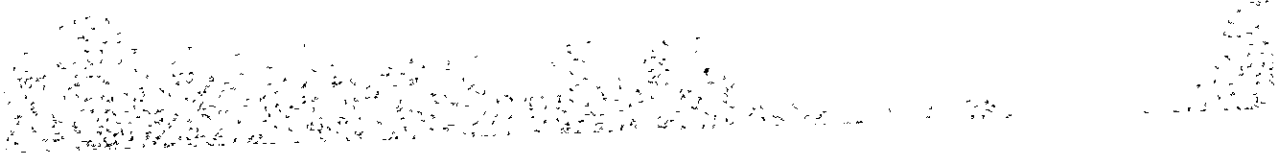
Of a toal gross land area of 71,600 ac, 77% (55,300 ac) are cultivated. The present total cropped area is 73,200 ac, giving 128% cropping intensity. The prospect of further expansion of cultivable land is limited. After the completion of the basic infrastructure such as flood-protection embankment, pumping stations, irrigation-cum-drainage canals and on-farm facilities, the total cultivable area would be expanded to 113,965 ac (cropping intensity 200%). On and above this 113,965 ac which would be brought under year-round irrigation in the Phase I area, 8,600 ac belonging to Phase II area would also be supplied with irrigation water during dry season only by Pumping Station No. 1. Hence, the total irrigable area during dry season would become 122,565 ac.

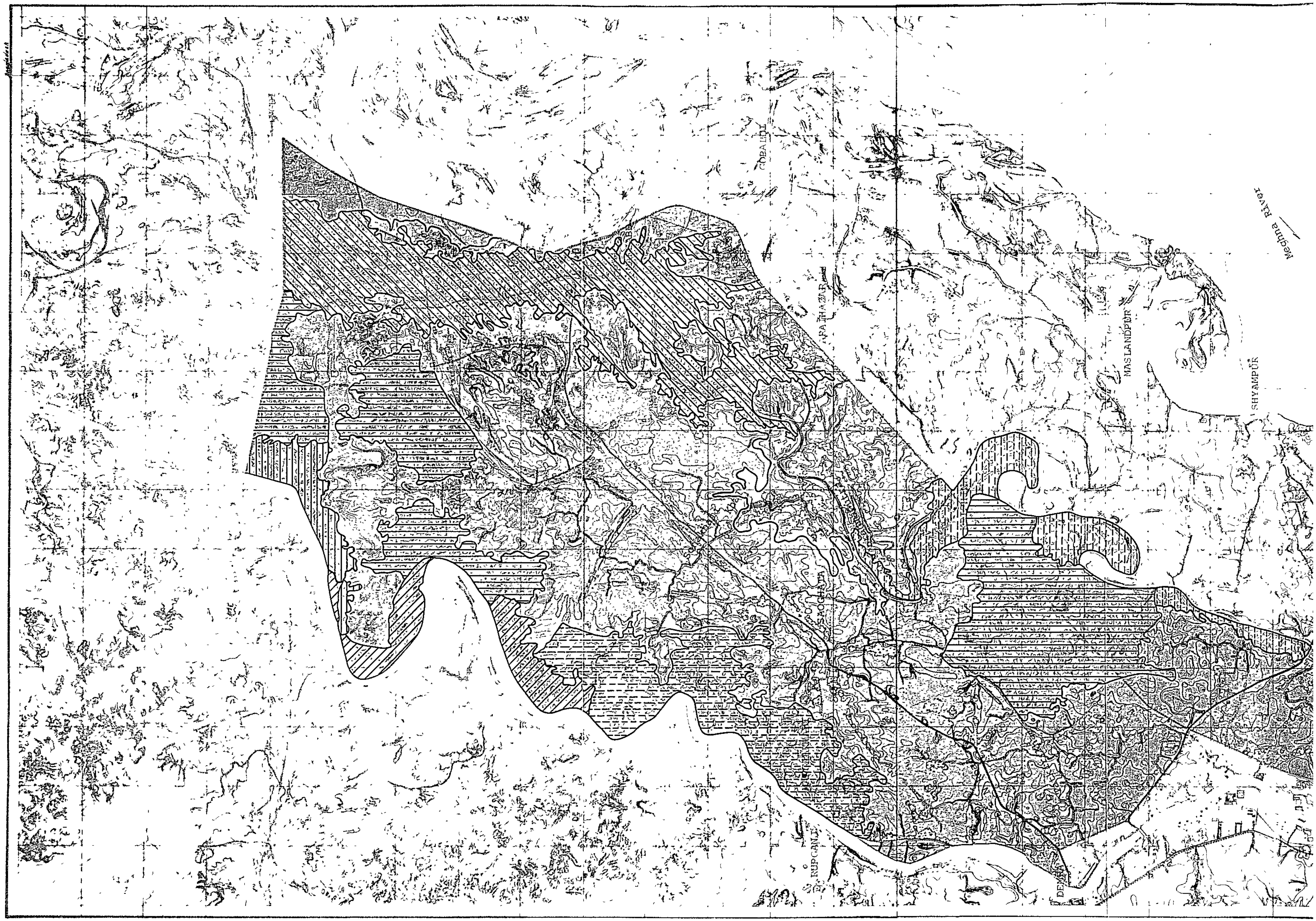
(2) Selection of Crops

The cropping patterns have been prepared in five typical models of A, B, C, D and E, by taking into consideration the topography and profile or inundation water levels during monsoon season and the soil conditions prevailing in each levels of the land. A, B, C and D are for year-round irrigable land inside Phase I area and E is for 8,600 ac of Phase II area. Each of the four cropping patterns in Phase I area is meant for 5 year rotation and its crop combination has been made according to the following principles:

(i) While giving top priority to rice in view of attaining self-sufficiency in the people's staple food supply, production of jute should attract proper attention as an important foreign exchange earner, side by side with that of wheat, vegetables, oil seeds, pulses and sugar cane;

(ii) To accelerate the replacement of local variety by local improved variety (LIV) and HYV, in rice and jute cultivation;




GOBALDI
ARAIHAZAR
MASLANDPUR
SHYAMPUR
Meghna River
RUPGANJ

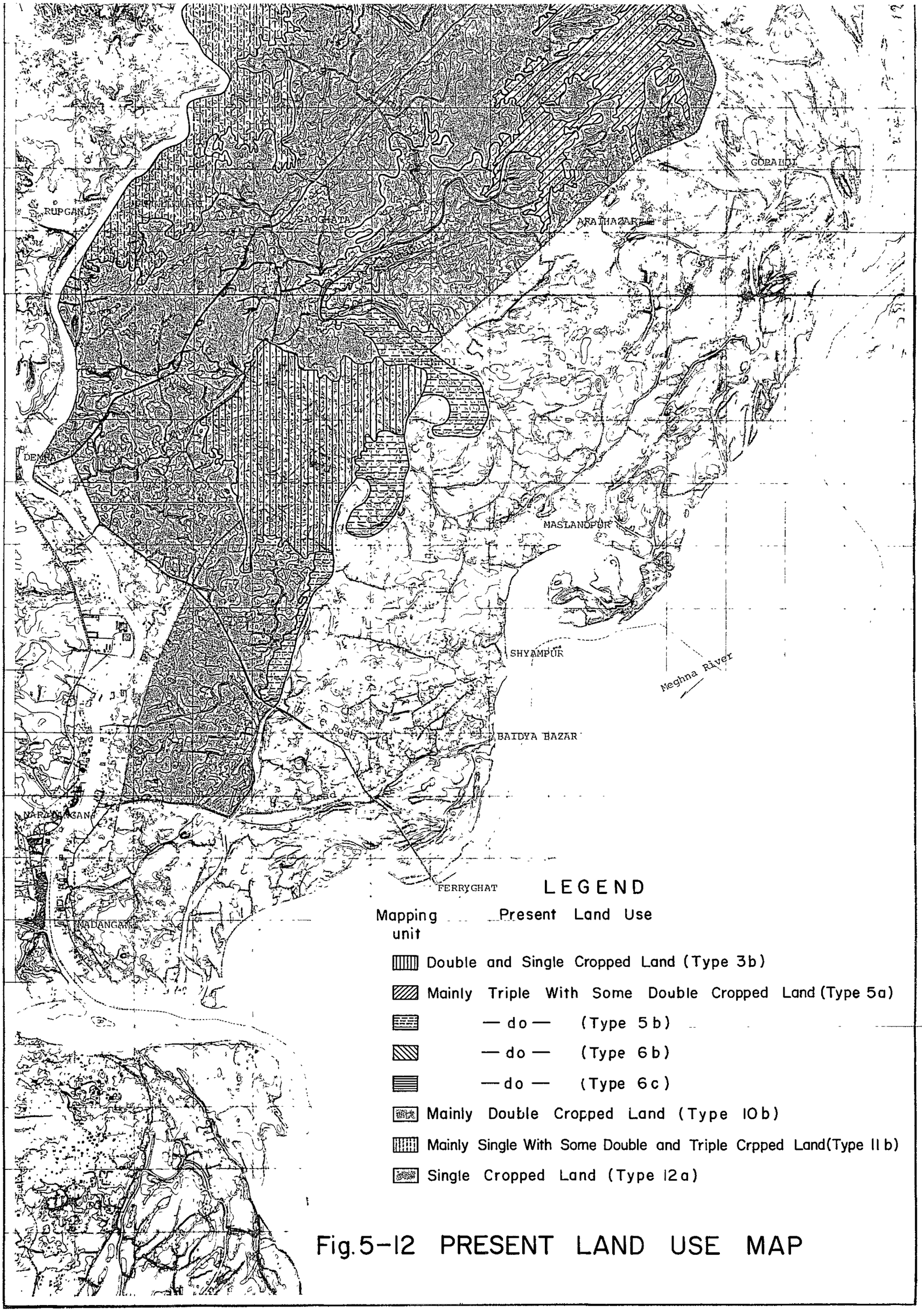
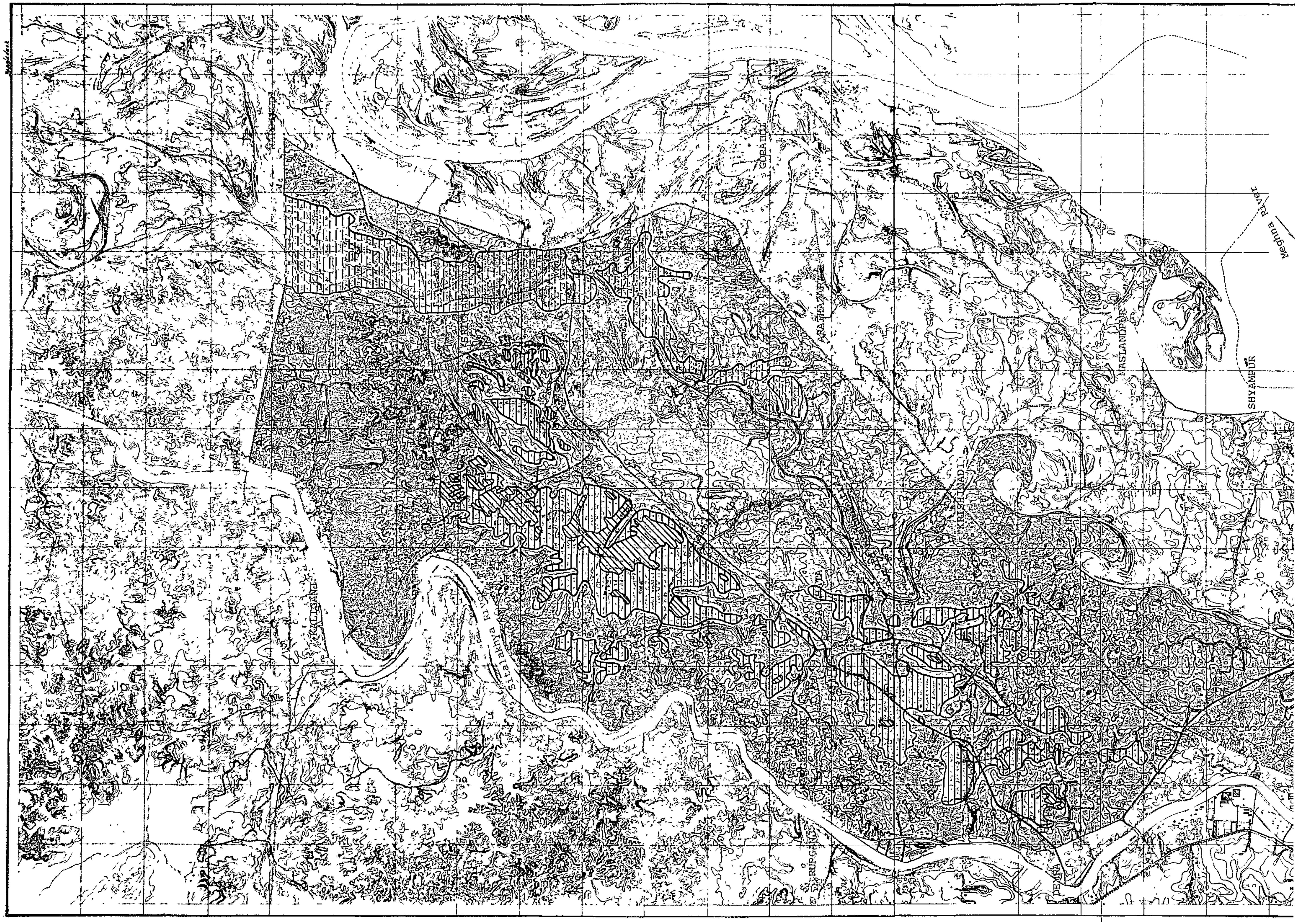


Fig.5-12 PRESENT LAND USE MAP


Meghna River
SHYAMPUR
Sitalakhya River

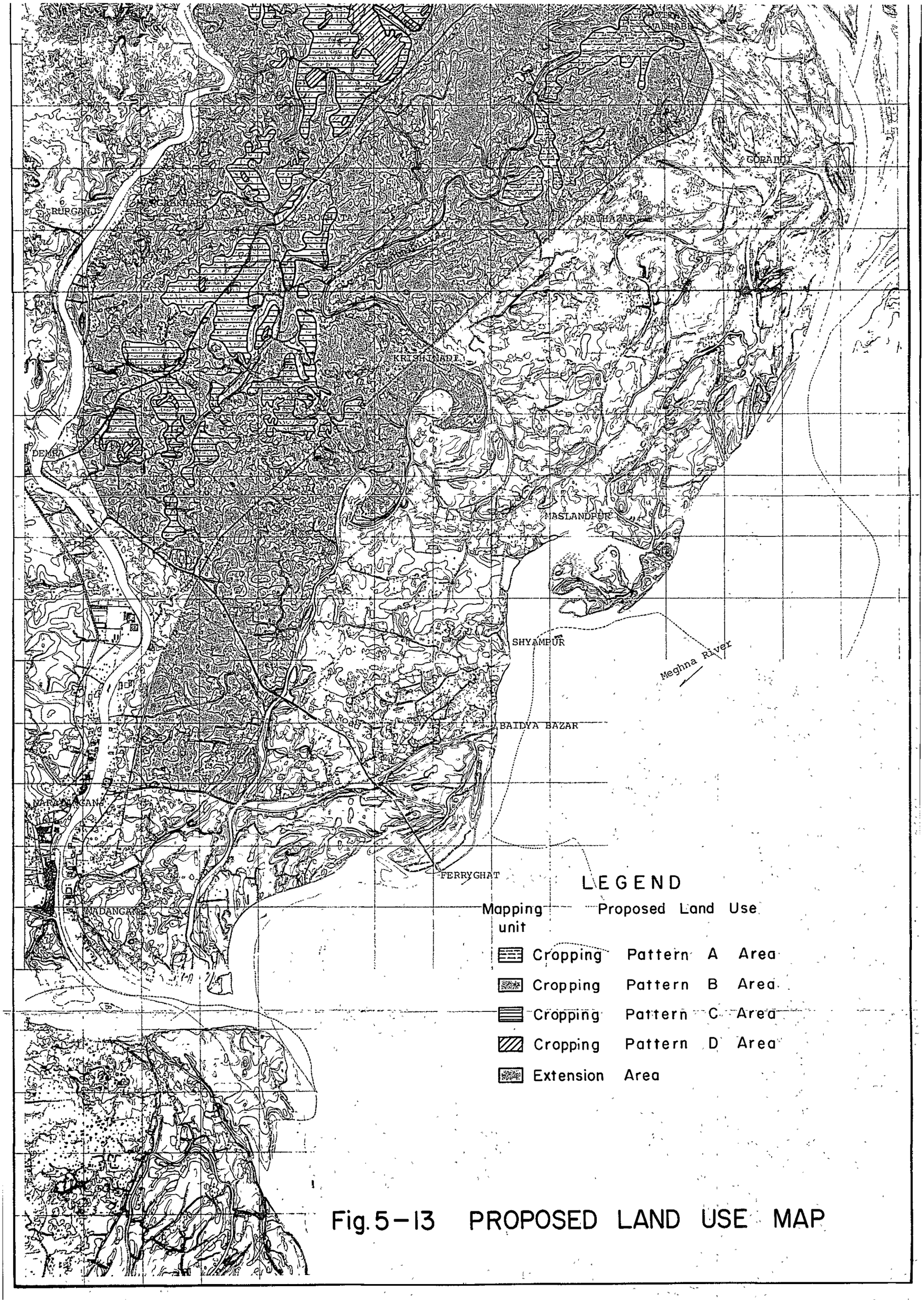


Fig. 5-13 PROPOSED LAND USE MAP

(iii) To attain the optimum yield with all the crops by arranging their combination into the cropping pattern most suitable to the given land level and by recommending rational use of fertilizers and agro-chemicals for each one of them; and

(iv) To make adherence to the intensive cropping calendars introduced under the project possible without resorting to mechanized farming but by productive combination of human and animal labour, the former through gainfull employment of the landless workers and marginal farmers and the latter through implementation of livestock improvement programme.

(3) Increases in Agricultural Production

Rice being the most important crop in the project area, its cropped area and production would be compared between the present and the future with project as follows:

Table 5-47 Comparison of Cropped Area and Production of Rice between the Present and the Future with Project

Season/Varieties	Present		Future with Project	
	Cropped Area (ac)	Production (tons)	Cropped Area (ac)	Production (tons)
T. Aus HYV	600	600	485	715
Local variety	17,000	4,930	-	-
LIV	-	-	1,790	1,325
B. Aman Local variety	34,700	11,450	550	280
T. Aman HYV	300	300	39,100	57,478
Local variety	2,200	1,210	-	-
LIV	-	-	9,872	9,082
Boro HYV	11,900	14,042	41,030	72,210
Local variety	1,300	767	-	-
Total	68,000	33,300	92,827	141,090
Percentage	(100.0)	(100.0)	(136.5)	(423.7)

Expansion of the cropped area and production-increases of various other crops would be as follows:

Table 5-48 Expansion of the Cropped Area and Production-Increases of Other Crops

	Present		Future with Project	
	Cropped Area (ac)	Production (tons)	Cropped Area (ac)	Production (tons)
Wheat	300	60	3,435	3,780
(%)	(100.0)	(100.0)	(1145.0)	(6300.0)
Upland Crops/1	1,380	5,645	13,768	17,685
(%)	(100.0)	(100.0)	(997.7)	(313.3)
Jute	1,600	880	3,936	3,188
(%)	(100.0)	(100.0)	(246.0)	(362.3)

/1 : Include pulses, oil seeds, vegetables, and sugar cane, etc.

Such large production-increases are the results obtainable from the expansion of the cropped area and the yield-increases per acre.

Table 4-49 Comparison of Crop Yields/ac

	Present (t/ac)	Future with Project (t/ac)
T. Aus HYV /1	1.00	1.47
LV /2	0.29	-
LIV /3	-	0.74
B. Aman LV	0.33	0.51
T. Aman HYV	1.00	1.47
LV	0.55	-
LIV	-	0.92
Boro HYV	1.18	1.78
LV	0.59	-
Wheat	0.20	1.10

/1 : HYV = High Yielding Variety
/2 : LV = Local Variedy
/3 : LIV = Local Improved Variety

	Present (t/ac)	Future with Project (t/ac)
Pulses	0.29	0.37
Oil Seeds	0.25	0.37
Vegetables	0.40	1.21
Jute	0.55	0.81
Sugar Cane	8.10	13.60

(4) Cropping Patterns

Cropping patterns A, B, C and D are all based on five-year rotation as detailed in Table 5-51 on the following page. The cropped area and cropping intensity under different cropping patterns would be as follows:

Table 5-50 Cropped Area and Cropping Intensity under Different Cropping Patterns

Cropping Pattern	Net Cropped Area (ac)	Total Cropped Area (ac)	Cropping Intensity (%)	Remarks
A	2,700	5,860	217	Area situated above inundation water level
B	49,400	98,305	199	Uninundable area plus area coming under inundation less than 1 ft in depth and 6 days in duration
C	4,350	8,700	200	1 - 3 ft inundation
D	550	1,100	200	3 - 6 ft inundation
(Sub-total)	57,000	113,965	200	
E	8,600	8,600	100	During dry season only
Total	65,600	122,565	187	

Table 5-51 Cropping Patterns Based on 5-Year Rotation

Cropping Pattern	First Year	Second Year	Third Year	Fourth Year	Fifth Year	Remarks
A	Winter Vegetables and Oil Seeds T. Aus (LIV) Wheat	Wheat Jute Wheat	Wheat Jute Wheat	Wheat Summer Vegetables T. Aman (LIV) Pulses	Pulses T. Aus (HYV) T. Aman (HYV) Winter Vegetables & Oil Seeds	Including Sugar Cane
B	Oil Seeds, Winter Vegetables and Pulses Jute Summer Vegetables T. Aman (HYV) Boro (HYV) Wheat	Wheat Boro (HYV) T. Aman (HYV) Boro (HYV)	Boro (HYV) T. Aman (HYV) Boro (HYV)	Boro (HYV) T. Aman (HYV) Boro (HYV)	Boro (HYV) T. Aman (LIV) Winter Vegetables, Pulses and Oil Seeds	Including Sugar Cane
C	Pulses T. Aus (LIV) T. Aman (HYV) Boro (HYV)	Boro (HYV) T. Aus (LIV) T. Aman (HYV) Boro (HYV) Oil Seeds	Boro (HYV) Oil Seeds T. Aman (HYV) Boro (HYV)	Boro (HYV) T. Aman (HYV) Boro (HYV)	Boro (HYV) T. Aman (HYV) Pulses	
D	Pulses B. Aman (LV) Boro (HYV)	Boro (HYV) B. Aman (LV) Boro (HYV)	Boro (HYV) B. Aman (LV) Boro (HYV)	Boro (HYV) B. Aman (LV) Boro (HYV)	Boro (HYV) B. Aman (LV) Pulses	
E	Boro (HYV) Pulses	Boro (HYV) Pulses	Boro (HYV) Pulses	Boro (HYV) Pulses	Boro (HYV) Pulses	

HYV = High Yield Variety LIV = Local Improved Variety LV = Local Variety

(5) Input Materials

Fertilizers recommended under the project include Urea (46% N), TSP (46% P_2O_5) and MP (60% K) and agricultural chemicals include Diazinon and Sumithion. Use of herbicides is not considered.

(6) Agricultural Production under Environmental Supports

Agricultural Production Plan proposed under the project which is incorporated with the livestock and fisheries improvement programmes would be operated around the axis of TCCA-KSS with well-arranged environmental supports in terms of construction of roads, rural markets, fish ponds, TTDC buildings, TCCA storages and BADC workshops. Detailed description would be made of all these supporting infrastructure and improved farmer services under corresponding sections of this Main Report as well as in the Notes.

Provision of these facilities and services for agricultural development are recommended to be made all over the Plan B area so that agricultural production potentials which would be generated in Phase I area through provision of the basic infrastructure should turn true in Phase II area also as soon as the similar basic infrastructure could be provided.

(7) Projected Agricultural Production in Phase I/Stage 1 Area and Plan B Area

In the same line of argument and in consideration of the stage-wise implementation of the project, it would not be meaningless to estimate the cropped areas and crop production in Phase I/Stage 1 area as well as in Plan B area on the basis of those projected towards Phase I area. There should, however, be one reservation to be made. That is, taking unit yield of different crops being equal, agricultural production in each project area depends on the size of farmland which would be brought under different cropping patterns which are basically prepared according to given topography and profile (in relation with inundation water levels during monsoon season) and soil conditions. Unit agricultural production either in amount or value (obtainable by dividing the total production by the total acreage) might not be equal among the three different project areas.

On the above assumptions, the cropped areas and production broadly categorized into (i) rice; (ii) wheat; (iii) upland crops; and (iv) jute would be compared between the present and the future with project in Phase I/Stage 1 area and Plan B as follows (their cost-benefit analysis would also be made in the corresponding Chapter of the Main Report as well as in the Notes):

Table 5-52 Projected Agricultural Production in Plan B Area

		Cropped Area (ac)	Production (tons)	Production Increase Ratio
Rice	P	98,250	49,350	4.4
	W	145,420	219,400	
Wheat	P	470	95	50.0
	W	4,270	4,700	
Upland Crops	P	5,110	9,000	3.0
	W	21,410	25,840	
Jute	P	10,000	5,500	1.6
	W	10,800	8,750	
Cropping Intensity	P	129	-	60%
	W	206	-	

Table 5-53 Projected Agricultural Production in Phase I/Stage 1 Area

		Cropped Area (ac)	Production (tons)	Production Increase Ratio
Rice	P	28,560	13,980	4.2
	W	38,700	58,760	
Wheat	P	126	25	64.4
	W	1,470	1,610	
Upland Crops	P	1,386	2,380	3.3
	W	5,780	7,850	
Jute	P	670	370	3.6
	W	1,660	1,340	
Cropping Intensity	P	129	-	55%
	W	200		

5.6.2 Livestock

The draft animals in the project area average about one head per 9 cropped ac, or one pair per 4.5 cropped ac, but due to the prevalence of such cattle diseases as rinder pest, hemorrhagic septicaemia, anthrax, black quarter, foot and mouth disease, liver fluke and tuberclosis, and almost universal infestation by intestinal parasites, their annual work loss is considerable and could hardly replenish additional animal power required to adhere to a very much more intensified farming calender proposed under the project, unless an effective livestock improvement programme is worked out and systematically implemented.

Although the five thanas have at present 5 thana Veterinary Dispensaries with more than 20 livestock officers /1 (TLO, VAS, VFA, TLA and inseminators), vaccination of the cattle (and poultry birds) is made very difficult mainly because of the shortage of supplies (vaccine, serum and drugs), the difficulty in moving them and in visiting villages by the officers.

Rice, straw, plus crop residues, sugarcane leaves, and grass along roadside and canal bands and on secondary growth in the paddyfield after harvest are main feeds of the draft animals. Such feeds which are not sufficient even during the rainy season become lower in the dry season and lowest toward its end (April). As fodder crops are grown on the minimum acreage, the animals are generally weakest when they are needed for preparing land for sowing Aus, broadcast Aman and jute. (A limited supply of fodder crops, rice bran, wheat bran, and oil cakes is reserved for small commercial dairy herds and farmers' milk cattle.)

Under these circumstances, the success of the project's agricultural production programme would need be guaranteed through implementation of carefully planned livestock improvement scheme based on the approved IRDP policy.

/1 : TLO = Thana Livestock Officer; VAS = Veterinarian Assistant Surgeon; VFA = Veterinarian Field Assistant; TLA = Thana Livestock Assistant.

Project Works

Livestock component of the IRDP is given major emphasis on lowering the mortality and parasite infestation of the draft animals and chickens as well as multiplication of healthy cattle population. The project would also popularize forage/fodder crops in the project area.

Having these objectives in view, the project would provide equipment to the thana veterinarian dispensaries for safekeeping vaccine, serum, and drugs in thanas. Two motorcycle cabs would be provided for moving supplies from the District stores to thana dispensaries. Motorcycles would be provided to thana officers and bicyles to vaccinators and inseminaters. Vaccine, serum and drugs including diagnostics would be supplied by the Livestock Department. Equipment and supplies are listed in 5.9.3.

Increase of Vaccinators: A total of 50 vaccinators (average ten per thana) could be recruited by the Livestock Department and deployed in the project area over a ten year period (year 4 to year 14) at the rate of 5 vaccinators a year. The new recruits plus the existing 12 VFAs and TLAS would make roughly one vaccinator per union. One additional TLA with a background in agronomy would be assigned to each of the five thanas for conducting field demonstration of forage and fodder crops. The VAS could manage the refurnished thana dispensaries and daily dispatching of vaccinators. The TLO would administer the thana programme and training of vaccinators, model farmers and KSS vaccinators.

Scheduled Visit to TCCA-KSS by Livestock Officers: The TLO, IRDP/TPO and TCCA Manager would joinly decide time schedules and routes for the vaccinators to visit each TCCA-KSS in the thana. On the scheduled day, the KSS manager and model farmer would ask all farmers to keep their draft animals in the village compound and chickens in coops, so that the vaccinator could finish his work quickly and move on to the next village.

TCCA-KSS Membership Livestock Registration: With assitance from IRDP thana officers, TCCA-KSS would compile a livestock register, which would record heads of adult and young draft animals owned by its members. The register would be kept up-to-date by members reporting changes in the weekly member meetings. Numbers vaccinated would also be recorded. Chickens would not be registered, but the number to be vaccinated would be discussed in the weekly member meeting prior to the "visit date" of the vaccinator. The vaccination request would be sent to the Thana Livestock Officer when the KSS officers go to TTDC for their weekly training sessions.

Training of KSS Vaccinators: As the number and membership of KSS expands, the VFAs would have to vaccinate increasing number of animals each year. A training programme for KSS vaccinators would be launched to train young KSS members to become vaccinators. The VFAs would bring sterilized field equipment and supplies to the village on the "visit day" and move on to other villages. The KSS vaccinator would vaccinate animals and poultry for KSS members. This would enable the LFAs recruited during the ten year project implementation period to cope with the increasing numbers of animals in years beyond that period.

Projection of Vaccination Coverage: About 70,000 head of draft animals and 20,000 birds would be vaccinated in the first year of the project, increasing to about 100,000 and 150,000 respectively by the fifth year. If the KSS vaccinator training programme is successful, the project is expected to fully cover the draft animals and chickens belonging to KSS members in all villages by year 14.

Demonstration of Forage and Fodder Crops: To lessen the serious feed shortage particularly during the dry season, one demonstration field of forage and fodder crops would be set up in each of the five thanas covered under the project. Each field would consist of three to five plots: one or two for permanent fodder cropping (Napier and/or para grasses), two to three for short season forage crops (sorgham, maize, oats, Berseem clover, and sun flower). Each plot would be of 0.01 ac. The determination of the combination of crops to be grown in each demon-

stration field, the application of the demonstration results in the project area according to the land type and cropping pattern - either under rainfed or irrigated conditions -, etc., should be made in careful reference to the experimental results obtained at the Savar Farm by the German livestock team. The forage/fodder crop demonstration work which would be conducted by the Livestock Department should be closely linked to the research work being done at the Savar Farm and to the Department's own demonstration programme in other thanas. Joint planning between the Livestock Department, Department of Agriculture (Extension and Management) and IRDP would be necessary when successful demonstration leads into extension and seed multiplication.

Plan for Collection of Fees: The Livestock Department and IRDP would jointly launch a campaign among TCCA-KSS members for collecting fees for vaccination after this programme which lasts for ten year project implementation period with its operation/maintenance costs (of laboratory, field equipment and vehicles) being budgeted under the project cost and provided free to the farmers, has produced a clear impact in the KSS villages. The fees collected should be sufficient for covering the operation, maintenance and replacement of the laboratory and field equipment and vehicles provided by the project.

Implementation schedule is given under 5.8.2, and cost estimate is detailed in 5.9.3.

5.6.3 Fisheries

Background: Very important part of the protein diet of the Bengalis is supplied by fish, and nearly 90% of the fish catch is from inland fisheries. Once in the not-too-distant past, inland fish were considered adequate to furnish the dietary requirements of the common people in Bangladesh. In the recent past, however, a combination of events has changed the picture radically, and per-capita fish consumption declined from 11.54 kg per year in 1973-74 to 9.96 kg in 1976-77.

Inland fish production in the project area is deprived from the following sources: (a) capture fisheries in rivers (the Meghna and the Sitalakhya); (b) impondment fisheries in fresh water areas (khals and beels); and (c) culture fisheries in ponds, tanks and inundated paddyfields.

The basic strategy adopted by this project for agricultural development in the area is flood-control, drainage and irrigation; it calls for engineering works including construction of embankments along the banks of the two major rivers of the Meghna and the Sitalakhya. This would seriously handicap the impondment fisheries in the khals and beels connected with these rivers, as this kind of fishery is sustained by annual flooding. Young of several species of riverine fish enter these areas along with flood waters every year; after the floods subside these water bodies generally get isolated from the main streams, or otherwise, they are deliberately isolated from the main stream after the flood season by the construction of embankments and sluices; the young fish that are stranded there grow rapidly and provide rich harvests in the dry season before the onset of next monsoons. Construction of the permanent embankments along the river banks would cut once for ever this cycle of natural "stocking" and harvesting of fish along the rivers, mostly comprising carps, catfishes, murrels and feather backs. Development of pond fisheries is absolutely necessary to provide alternative employment to the people who have been supporting their livelihood on impondment fishery and, equally important, to supply more protein to the local population.

Introduction of Pond Fisheries in the Project Area

There are three types of ownership; public or Government ponds, private ponds and group-owned ponds. Some 3,000 Government and private ponds (Government ponds number about 80 only) and nearly 100 group-owned ponds (figures are available only for Araihazar thana as far as group-owned ponds are concerned) in the five thanas involved in the project. The group-owned ponds may have as many as 30 to 40 owners, as a result of inherited subdivisions, and are mostly unattended, dilapidated and non-productive. Even among the Government and privately owned ponds, nearly half as many are dilapidated and non-productive. The productive Government and privately owned ponds produce an average of about 12 maunds of fish per ac per year. Besides these ponds, there are large number of irrigation tanks which are, or could be, utilized profitably for raising fish.

The principal agency responsible for the development of inland fisheries is the Directorate of Fisheries, which operates under the administrative control of the Ministry of Fisheries and Livestock; and the responsibility of its development in the project area rests with Dacca District Fishery Officer.

Project Works

The project would concentrate on demonstrating the potential of improved pond fish culture for increasing the fish supply to local villages and rural markets, and for providing an alternative employment to the impondment fisheries along the embankment-sites and an additional source of income to landless people.

Survey, Demonstration Ponds, and Fish Seed Ponds: In view of the paucity of reliable information on hand, the TFO would start work by surveying the fish ponds in the project area and identifying on the mouja maps the public-owned and group-owned ponds. They will receive intensive training on the use of maps and the survey methods from Fishery Department experts of the Development Project of Fish Culture in Public Ponds

in the Northern Districts who have conducted similar surveys in Pabna and other Districts. The survey would record the location, ownership, dimension, time and depth of maximum and minimum water, bottom condition, water inlet and outlet, natural water vegetation and invertebrate animals, specific needs of rehabilitation, present fish production, disposal of the fish catch, and present uses of pond other than in fish culture.

In order to develop pond management methods commensurate to local farmers' capabilities, three trial-cum-demonstration ponds of about one ac would be established in each of the five thanas belonging to the project area, using three levels (high, medium and low) of inputs respectively. Initially, the low input level would be recommended for adoption by project-selected ponds. The medium and high level ponds would demonstrate potentials. Inputs would include locally produced dry cow-dung, mustard oil cake and locally available chemical fertilizers and lime. Carp fries would be stocked at an appropriate rate. Public ponds would be used for this trial/demonstration. The ponds would be rehabilitated under the RWP before the trial/demonstration work began. Cost of pond operation, fish harvest and price of the catch would be recorded. Because the Thana Fishery Officers would be busy with the pond survey, and since they are not adequately trained for conducting trials, the supervision and record keeping of the trial/demonstration ponds would be handled by the District Fishery Officer (DFO). Pond keepers (Field men) would be hired to attend to day-to-day management chores under the supervision of the DFO. The DFO would be trained and assisted by the Fishery Department experts.

It is expected that both the survey and trial/demonstrations would be completed in each area by the second year of the project implementation there. A total of 250 ac public ponds would have been selected in the project area, and located on the mouja maps by the TFOs. Practical training and extension material would have been prepared by the Fishery Department based on the two year trial/demonstration results. Beginning the second year, each thana would also establish fish seed ponds of appropriate size (to be decided during the second year) for multiplying fish fingerlings for distribution to TCCA-KSS Fish Cooperatives in the third year and thereafter. The seed ponds would be managed by the same

field man who attends to the trial/demonstration ponds. The thana fish seed ponds are not intended for supplying the entire fish fries need of the thanas. Farmers would be assited by TCCA to obtain fingerlings from local commercial ponds.

Organization of TCCA-KSS Fishery Cooperatives: Based on TFO's survey result and mouja maps, IRDP thana officers would assist TCCA to organize the people who have been sustaining their livelihood on the impondment fishery along the embankment-sites as well as the landless people living in surrounding villages into Fishery Cooperatives. The Cooperatives would become primary societies of TCCA. The Government grant the TCCA Fishery Cooperatives the right to use the ponds and harvest the fish. Such ponds would be reclaimed and rehabilitated by RWP over a three to four year period. The cost of rehabilitation would be absorbed by the RWP budget. Each Fishery Cooperatives would elect a pond keeper from among their family members. The TFOs would be trained by the District Fishery Officer on pond management. They would, in turn, train the KSS pond keepers, make scheduled visits to each project pond, arrange for supply of fish fries when needed, and assist the Fishery Cooperatives in preparing pond management plans. Based on the managed plan, IRDP/TCCA officers would assist the Cooperatives in the preparation of short-and-medium-term credit application from the Janata Bank, procurement of inputs, and marketing surplus fish in rural markets which the project RWP would build.

Supply of Equipment: The project would provide necessary equipment supplies, and vehicles to the fishery officers. District Fishery Officer would be provided with a four-wheel drive vehicle, each TFO, a motorcycle, and each Field Man, a bicycle. Equipment and vehicles to be provided by the project and the project operation costs are listed in 5.9.3. Implementation shedule of the pond fishery component is shown in 5.8.2.

Additional Staff: One additional TFO would be assigned to each thana; 10 Field men would be recruited to assist the DFOs and TFOs, two in each thana.

5.7 Supporting Infrastructure and Farm Services

5.7.1 Rural Development Mechanism

General

Rural development programmes proposed under the project are established on a set of policies and meant to be implemented according to the methodology based on a certain principles. One of such policies is to pay good attention for increasing gainful employment opportunities on behalf of the landless workers and marginal farmers, while augmenting agricultural production (including livestock and fisheries production) by taking full advantage of the infrastructural improvements designed under the project. The second is that, as the project area shares the problems common to other rural areas in Bangladesh - both constraints as well as potentialities -, the rural development plans to be effected in the project area should be those which could answer the country-wide problems, either directly or indirectly.

The project adheres to the principle of combining, dove-tailing and harmoniously merging the four important elements for agricultural development into one organic mechanism, though not necessarily one entity provided that a proper linkage can be maintained among them. These elements comprise (i) rural credit; (ii) input supply; (iii) planned production under proper extension services; and (iv) marketing. They are not linked in a linear manner only as, for instance, while marketing badly needs credit, its success promises good recovery and makes it revolving. Only when these four elements would be organically combined and allowed to cooperate in a link-up system, we could hope for capital accumulation in the rural society and its ploughing-back for further agricultural development.

Methodologically or technologically speaking, Bangladesh does least suffer from the paucity of schemes, plans, programmes and projects meant for rural development. No serious attention, however, has ever been paid to the post-harvest technology or strategy such as threshing, drying,

storage and marketing. While pre-harvest technology which is based on proper combination of such as water, seeds, fertilizers, pesticides, etc. plus farming techniques and, therefore, inseparably connected with rural credit, input supply and extension, the post-harvest technology, because it involves threshing, drying and storage, would naturally be concluded by marketing. Proper attention to the post-harvest technology would thus accompany better care for transport, warehousing and marketing to fill the vacuum inherent to hethertofore plans, programmes and projects.

IRDP which has been an established policy for agricultural development since the start of the First Five Year Plan in this country means to be a package programme. Even with IRDP, marketing is almost completely forgotten or at least less cared for compared to rural credit, input supply, extension and minor irrigation. The project, therefore, decided to adopt IRDP guideline as its rural development strategy but better care for marketing would be added both technologically and methodologically and a near-perfect "package programme" would be introduced under the Project.

As has been argued in 5.6.1: Agricultural Production, the agricultural production programme proposed in the preceding section would bring fruitful results only when it could be guaranteed by the provision of commensurating supporting facilities and services - the basic programme package based on the Integrated Rural Development Programme. It has been strongly recommended that Araihazar and Narayanganj thanas might be brought under the IRDP as early as practicable so that when the supporting facilities and services programme should start reinforcing the present IRDP framework and function in Phase I area (comprising the major parts of three thanas of Narsingdi, Rupganj and Baidya Bazar), the similar enlivening measures could be taken in Araihazar and Narayanganj, thus offering the overall project benefits to the entire Plan B area as and when the similar construction and agricultural production programmes would come to be adopted toward Phase II area.

The programme for strengthening supporting facilities and services proposed in the following paragraphs are, therefore, meant for the Plan B area in general and not limited within the boundary of Phase

I area alone. The economic evaluation of the project pertaining specifically to Phase I area, however, would require the capital and annual costs required for this programme separately from those towards the entire Plan B area; they could be calculated on area basis, that is: the entire Plan B area = 111,600 ac (100.0%) comprising 71,600 ac (64%) of Phase I area and 40,000 ac (36%) of Phase II area.

5.7.2 Rural Works

Rural Works Programme under the project would comprise (a) Rehabilitation, Construction, and Improvement of Roads; (b) Construction of the Paved Rural Markets; and (c) Rehabilitation of Abandoned Fish Ponds. In working out and executing its programme, it is very important to bear two things in mind: the first is that it should be well dove-tailed with the project's Construction Programme (mainly concerned with major works related to flood-protection, drainage and irrigation as well as road network) particularly in division of work boundary, construction responsibilities, supervision and appropriation of fund, and adjustment of time tables; the second is that the current RWP practices need to be adhered to the official procedures and not allowed to deviate therefrom resulting in such as the mis-selection of work sites based on local political pressures rather than actual needs, delays in processing union proposals which causes late approval and fund appropriation, and biased recruitment of labourers.

Project Approach

The project approach is to make the selection of work sites and the preparation of detailed time tables for preparing designs and estimates, floating tenders, selecting bids, appropriating funds, recruiting landless labourers, beginning and completing construction, and inspections, in consultation with the project authorities in charge of the construction programme and agricultural production program, and then to enforce strictly the Government's own procedures for RWP. Local consulting firms may be employed to assist the Ministry of Local Government, Rural Development and Cooperatives in overseeing project implementation.

Project Works

Pucca (paved) Roads: Within Plan B area there are portions of District council roads which need to be improved and upgraded through rehabilitation of the brick surfaces, covering them with bituminous carpet, provision of shoulders with adequate width and slope, inlcuding replacement and improvement of bridges. These works will have to be done, however, in the closest engineering consultation with the flood-control, drainage,

irrigation and road network works in dimension, schedule and resources allocation. Therefore, the Pucca (paved) Road component under the project would better be non-specified as to the total length and kinds of work to be done but tentatively suggested with the probable length and the nature of the work as follows:

Length : About 10 miles in total

Kind of Works: About 5 miles - earthwork plus bituminous carpeting
About 5 miles - earthwork plus brick herringbone
About 10 bridges - improvement or replacement.

Katcha (Dirt) Roads: The project would improve 300 mi. of union roads, covering about half of all existing roads in the five thanas involved in the project area. The selection of the roads for improvement will have to be made in consultation with the project authorities in-charge the construction programme. In general, the criteria for selection of the road to be improved favours roads connecting the larger and most populated villages and roads that provide access to the paved District roads and roads providing travel between thanas.

Improvements will provide for a standard 16 ft road surface of compacted earth. The road rehabilitation programme will bring the chosen existing roads to desirable standards.

Rural Markets: Bi-weekly rural markets congregate in the open air in or near towns. Frequent rains during the monsoon disrupt the markets and damage the quality of the produce. This forces farmers to sell at low prices. Some thirty covered rural markets will be built in five thanas. The exact location of the markets will be decided by the Project Implementation Committee.

The 30 markets will each have 5,000 sq ft of paved ground and a corrugated galvanized sheet iron roof. The pavement will consist of a bricksoling surfaced with 1.5 inches of cement mortar screed. Surrounding the paved area will be 10,000 sq ft of graded area and 2,000 linear ft of drains. A 1.5 cusec tubewell (with pucca surrounding pad)

will be provided adjacent to the paved shelter areas to furnish drinking water and washdown water for the vegetable and fish sections of the market.

Fish Ponds: The present status and plan for fish production in the ponds are discussed in the Notes. The RWP concerns only the physical rehabilitation work of about 250 ac of fish ponds in the project area, to make fish culture possible. Tentatively, 60 ac each will be rehabilitated in the project area belonging to Araihazar and Baidya Bazar thanas, 50 ac each in that in Narsingdi and Rupganj, and 30 ac in that of Narayanganj thana. The work will consist of dewatering, dredging and deepening, bottom improvement, repairing the embankment, proper sloping and removal of hyacinth and other water plants. The rehabilitation will be started after the thana fishery officers have surveyed and selected the ponds, and IRDP has organized the fishermen who were engaged in impondment fisheries along the proposed embankment sites and the landless people in surrounding villages into TCCA fishery cooperatives to manage the reclaimed ponds.

5.7.3 Thana Facilities

Thana facilities include office buildings and living quarters for thana level officers, godowns, workshops and veterinarian dispensaries, belonging to various Government agencies or TCCAs. Fortunately, the project area has three Thana Training and Development Centers (TTDC) each for Rupganj, Araihazar and Baidya Bazar and the project area belonging to Narsingdi and Narayanganj can expect to get full benefits from their TTDCs because only short distance separates TTDC and the project area in each case.

Nearby the TTDC, twinplex two-story buildings are built and provide living quarters for the line department officers. The office and dormitory buildings of TTDC in the five thanas are in use (excepting those of Narayanganj) but the lack of family living quarters has been a hardship to line department officers who have been recently appointed. As most of the supporting staff such as Village Extension Officers, vaccinators, and TCCA inspectors and village accountants are recruited locally, they usually live with their families.

The Union Agricultural Assistant (UAA) is the front line extension officer being the only civil servant at the union level and yet he is not provided with an office or living quarters. Several of them get free room and board in larger farmers' homes. This often subjects them to undue influence.

The BADC owns two fertilizer godowns of 400-ton capacity, one at Narsingdi and the other at Baidya Bazar, and one 500-ton capacity general godown at Narsingdi. The TCCAs have no storage facilities. This has restircted TCCAs from providing marketing services to its members.

The BADC has a workshop and fuel and oil storages in each of the five thanas for servicing low-lift pumps and tubewells. The workshops are generally short of working tools.

Project Works

TTDC Buildings: The project will bring the construction of seven Twin Quarters (two each in Araihazar and Baidya Bazar thanas and one each for the project area of each of Narsingdi, Rupganj and Narayanganj thanas).

TCCA Storages: The project will construct two fertilizer godowns, for TCCAs, one each at Rupganj and Araihazar and four general godowns one each for the five thanas involved in the project area, excepting Narsingdi where the BADC already has one general godown with the capacity of 500 tons. The fertilizer godown can be used for storing BADC fertilizers for the thana. The TCCA will serve as store-keeper for BADC and manage all the fertilizer stores in the five thanas. It will directly distribute fertilizers to KSS members, but serve as BADC's agent for fertilizers intended for farmers who are not KSS members. The BADC will pay TCCA a commission according to standard rates on a per maund basis. The general godown will be used by TCCA as transit storage and distribution depot for various items such as seeds, pesticides, spares and farm produce.

The fetfilizer godown will have a 400 ton capacity, and a 3,200 sq ft floor space. The general godown will have a 200 ton capacity and 1,600 sq ft floor space. They both include storage areas and separate small living quarters for a store keeper and darwan (watchman). The buildings will all have 11 inch brick walls and a plastered and reinforced concrete floor and roof. The units would be standard and familiar to local construction contractors.

BADC Thana Workshops: The BADC's workshops and fuel and oil storages existing in the project area are for servicing low-lift pumps and tubewells which has been provided under the Minor Irrigation Scheme. Under the project, almost all the low-lift pumps which have been used in lowland area for dry season irrigation will become superfluous because of the irrigation facilities to be provided through the project construction programme. Most of the tubewells which have been installed in the area lying below the proposed main irrigation canal will likewise become useless; they will have to be re-installed in the area situated above the

proposed main irrigation canal. Probably installation of some additional tubewells (both deep and shallow) may become preferable to the provision of booster pumps operable from the main irrigation canal for irrigating the area lying above it. At any rate, the pumps and tubewells which have so far been productively used will need to be re-allocated within and outside of the project area. As the existing BADC workshops are generally short of working tools, they have to be supplied with additional tools and facilities.

Implementation Procedures

The Circle Officer (Development), assisted by Thana Overseers/Supervisors, will use the existing standard design and specification of the existing BADC godowns for TCCA godowns with adequate adjustment to dimensions. He will prepare bids and float tenders for the constuction of Thana buildings. For preparing bids and float tenders for TCCA godowns, he will consult the project authorities.

The Thana Project Executive Committee will select the successful bid. The Circle Officer (Development) will award the contracts and he and Thana Overseers/Supervisors will supervise the construction.

The Circle Officer (Development) will make payments to contractors and inspect the completed construction for official acceptance. The detailed steps and time table would be the same as those for RWP. The local consulting firms to be hired for the RWP component might also assist in executing this component.

Implementation schedules of the RWP and Thana Facilities are given in 5.8.3, and the cost estimates are made in 5.9.4.

5.7.4 Rural Credit, Input Supply, and Marketing

As has been discussed under the "Rural Development Mechanism" in the above, the project visualizes consolidation in one mechanism of the four important elements for agricultural production-increase, viz: (i) rural credit, (ii) input supply, (iii) planned production under proper extension services, and (iv) marketing. In this respect, the project calls upon all the officials concerned and the farmers coming under it to concentrate their efforts at strengthening TCCA-KSS system so that it could be the proper mechanism for providing all the four above-mentioned services in a combined manner. Needless to say, TCCA-KSS system is still rather weak but it is built on a sound basis proven by BARD and it can be reasonably expected to function as the rural institution meant for an overall agricultural development through capital accumulation in the rural society and its ploughing-back for an increased reproduction

The strategy of the project is therefore on one hand to make TCCA-KSS very attractive to small farmers and on the other hand to tighten up discipline in distribution of inputs and credit among the TCCA-KSS members and in marketing their surpluses. The project also solicit both TCCA-KSS and the Government extension officers to try to work in higher degree of cooperation between each other so that the TCCA-KSS members will be provided with the most welcome services which would help making their input the most rewarding investment and repayment of their loans very easy (coupled by effective marketing of their produce through TCCA-KSS without intermediary exploitation.)

To help strengthen TCCA-KSS as a basic farmers' organization, a system for allocation of rural credit and inputs (seeds and fertilizers, in particular) to TCCA-KSS members and marketing their produce will be adopted in the project area.

A. Project Approach

The Integrated Rural Development Program headquarters will start a two-way functioning of purchasing and marketing on behalf of TCCA-KSS in the project area; it will enter into marketing contract of paddy with

the Food Ministry on one hand, and purchasing contract (of seeds, fertilizers and pesticides) with the BADC on the other. IRDP needs to enter into banking arrangements with the Janata Bank for smooth transactions accompanying both marketing and purchasing contracts on behalf of the area TCCA-KSS's.

On purchasing side, IRDP will act in a way as a procurement agent of the TCCA-KSS's in the project area for the entire amount of seeds (HYV), fertilizers and pesticides which will be required season after season by the member-farmers of KSS which transforwards its indent for such input requirements to its TCCA, and TCCA further transforwards thana totals of KSS's indents to IRDP headquaters. Now, IRDP will be in a position to enter into purchase agreement with the BADC for the entire amount of input requirements for implementation of the farm plans prepared by all the TCCA-KSS's in the area. The BADC will be paid for the amount by the corresponding increase of its credit account which it holds with the Janata Bank while the same amount will be entered into debit account held by the IRDP with the Janata Bank. The Janata Bank will, then, instruct its branch-offices in the project area to issue rural credit to the KSS in the amount required for purchase of input materials when they arrive at thana godown (BADC or TCCA). When fertilizers and other input supplies arrive at the thana godown (BADC or TCCA), each TCCA-KSS will take bulk delivery from the godown for all members and distribute to members according to the original farm plan. Such credit will be issued by a check in favour of BADC, and this check will be transmitted by Janata Bank to Thana Inspector, BADC, upon receipt of the fertilizers, HYV seeds, etc. by the KSS.

On marketing side, IRDP will likewise act as a sales agent of TCCA-KSS's for the entire marketable surplus of paddy (later on, plus polished rice) which TCCA-KSS collect from amongst the area member-farmers. When the IRDP enters into paddy sales agreement with the Food Ministry, the latter will pay or promise to pay the amount into the IRDP's account held with the Janata Bank. The Janata Bank will, then, instruct its branch-offices in the project area to provide loan to each KSS for the amount equivalent to the amount of the paddy to be purchased by the same KSS from its member-farmers. The KSS will, in turn, recover the loan from each member-farmer (for inputs supplied on credit before the season) when

he delivers his marketable surplus of paddy after each season. Such paddy will be collected by TCCA and delivered at the central or local storage depots as designated by the Food Ministry. The manager of the central or local storage depot will issue receipt to the KSS manager who transforward it to TCCA and TCCA to the IRDP, for final settlement of the IRDP-Food Ministry agreement on paddy marketing. (In this case, the Warehousing Corporation may function as an agent of the Food Ministry in foodgrain collection through TCCA-KSS.) When KSS will have recovered the credit provided with its member-farmers for the input supplies which have been productively used during the preceding season, it will pay back the amount to the local branch-office of the Janata Bank. This will settle the rural credit account which the Bank has had with TCCA-KSS for input supplies in the preceding season.

All the above depends upon the farm plan to be prepared by each TCCA-KSS for a whole year and its breakdown into each season, based on the improved KSS membership land register and KSS land maps to be introduced by IRDP. Both the whole year and the seasonal farm plans will list area of rice (separately for HYV, LIV and local varieties) and other crops to be grown by each member, and the KSS total. In their preparation, TCCA-KSS will get pertinent advices and suggestions from the Government extension officers. The whole year farm plan is meant for TCCA-KSS grasping the rural credit and input requirements for a coming one year and to make necessary arrangements for their smooth allocation, and the seasonal farm plan will be prepared during the weekly member meetings of KSS well in advance of the planting time of each season. In the same member meetings, KSS members will be told of the allocations of urea, TSP and MP per ac of HYV rice and LIV (local improved variety) rice, and other crops, and the official prices per maund (or seer) of different varieties of seed and fertilizer. Members will be informed about the quantity of fertilizers each is entitled to receive. Rural credit application will be processed during the same meetings; a subtotal will be made in the plan for credit covering the cost of fertilizers, etc. Based on the farm plan, three sets of totals will be obtained each season by every KSS: (i) total areas of HYV rice, LIV rice, local variety rice and other crops to be grown by KSS members during that season; (ii) total quantity of fertilizers, etc.

requested by the KSS, and (iii) total rural credit requirement of the KSS for that season, with a sub-total for fertilizer credit (sub-totals for other input supplies to be made on credit may also be made.)

When the seasonal farm plan will be prepared under the guidance of the Government extension officers, each KSS must make sure how much paddy or any other crops will be brought back by its member-farmers, after their domestic consumption at the end of the season. In this connection, it would be necessary for each KSS to prepare reliable membership register covering the age of all the dependents (with annual income for those enjoying gainful employment) and other data necessary to calculate the amount of paddy consumable during each season of a year.

The KSS chairman will submit the farm plan(s) with the above totals and the amount of paddy his KSS would collect after that season to TCCA for transmittal to the IRDP headquarters, to enable the IRDP serve as purchase agent of input supplies and sales agent of paddy with the BADC and the Food Minsitry, respectively, and to prearrange rural credit with the Janata Bank.

The project credit, not only short- but medium-term, will be supplied through the Janata Bank. The procedures for loan application, approval, book-keeping and supervision will be tightened with a primary objective to break the habitual willful defaulting by the farmer borrowers. The reasons why the Janata Bank has been selected as the project rural credit lending institution and the limitation of recipients of the project credit to TCCA-KSS members are explained in the corresponding section in the Notes.

The implementation of the rural credit component of the project would involve such problems as the settlement of outstanding debits of cooperative members, the definition of the purposes and requirements of short- and medium-term credit, the terms and conditions of credit, the lending procedures, the guarantee provisions, the provisions for natural calamities, and the improvement of loan records and documents. They are also specified in the corresponding section in the Notes.