4-3 Agricultural Development Plan

4-3-1 Framework of Agricultural Development

As this Project is for irrigation development, development plan is projected mainly on crop production in the irrigable area. Other relative sectors, viz., post-harvest, livestock and inland fishery will be dealt as follows:

(1) Post-Harvest Facilities

Existing capacity of post-harvest facilities are checked to be sufficient but not for the processing of proposed production of crops and if it is insufficient, establishment of additional processing capacity would be recommended in Section 4-4-3.

Crushing capacity of flour mills in the study area (only in Rajshahi town) is 5,600 tons, increased production of wheat after the project is 8,000 tons. New flour mills should also be established in 5 Upazila.

(2) Livestock

As for cattle related to land utilization, development of beef and milk production may not be practised in the project area for the following reasons:

- almost used as draft animal and fed by crop residue and by-products.
- no pasture and woodland in the project area for grazing.
- little possibility to introduce much fodder crops in the farm.

Moreover, improvement of health and nutrition of draft animal and encouragement of goat and poultry are progressing in the Northwest Rural Development Project. Therefore, livestock development plan will not be proposed in this study.

(3) Inland Fishery

After implementation of the Project, return water from the irrigated area may be supplied to the fishponds during the dry season when they suffer from water shortage.

Available water expected for fish culture in ponds especially in the dry season and prospect of increase in production of fish is described in Section 4-6-2.

4-3-2 Proposed Land Use

Land use may be used for agricultural purpose or it may be used for fishery, forestry, settlements or even recreation purpose. In this paragraph only, the agricultural land is taken into consideration. The present and proposed land uses are shown in TABLE 4-3.

The proposed land use which is shown by the cropping pattern is based on the land suitability of crops under irrigation. The land suitability is determined comparing with the land characteristics and the requirement of crops.

The project area is divided into three areas, e.g. (1) miscellaneous, (2) non-irrigable area, and (3) irrigable areas.

(1) Miscellaneous Area, 10,630 ha

Miscellaneous area includes settlements, water bodies, ponds and rivers.

(2) Non-irrigable Area, 11,560 ha

This area contains three areas, namely area below 45 feet elevation, Ganges river side and Sultanganj areas and highland area.

These two areas (miscellaneous and non-irrigable areas) are highly suitable for boro and they are mainly used for the cropping patterns of T.aman-boro, boro-fallow. The remainder is moderately suitable for T.aus and T.aman and the cropping pattern is mainly T.aman-fallow.

TABLE 4-3 PRESENT LAND USE AND PROPOSED LAND USE

IN THE PROJECT AREA

Total area; 77,000(ha)

Present land use	Acreage(ha)		Proposed land use
1. Micellaneous area	10,630		
2. None irrigable area	11,560		
(1) Area below 45 feet elevation	3,550	B.aman-khesari	B.aman-khesari
(2) Ganges river side & Sultanganj area	2,730	Boro - fallow, etc	Boro-fallow, etc
(3) Highland area	5,280	T.aman - fallow, etc	Soil unit; (11,15,16) T.aman-fallow, etc. Soil unit; (2,4)
3. Irrigable area	54,810		
(1) Barind area	45,340		
1) T.aman - fallow	28,260,(62.3%)		T.aman-wheat-SC(10%) Soil unit; (1,6)
2) Aus - T.aman	6,880, (15.1%)		Aus-T.aman-fallow (27%) Aus-T.aman-WC (3%) Soil unit; (1~6)
3) T.aman - boro	6,220, (13.7%)		T.aman-boro (60%) Soil unit; (1~6,11,14)
4) Aus - rabi crops	2,250,(5.0%)		
5) B.aman - khesari	550, (1.4%)		
6) Boro - fallow	1,140, (2.5%)		
(2) Paba area	9,470		
1) Sugarcane	2,240, (23.7%)		⊙Sugarcane (24%) Soil unit; 7,8,12
2) Aus/jute - rabi crops	2,180, (23.1%)		⊙T.aus-T.aman-(Sugarcane) (12%) Soil unit; 7,8,12 ⊙Jute-T.aman-WC (12%) Soil unit; 7,8,12
3) Aus - T.aman	1,600, (16.9%)		
4) T.aman - fallow	530, (5.6%)		⊙Fallow-T.aman-boro (24%) Soil unit; 9,10,12
5) Rabi and khesari vegetables	340, (3.6%)		⊙TDWR-boro (8%) Soil unit; 11
6) Mixed aus and B.aman	250, (2.6%)		⊙SC-T.aman-wheat (12%) Soil unit; 7,8,12
7) B.aman - fallow/rabi crops	60, (0.6%)		⊙Vegetables (4%) Soil unit; 8,12
8) B.aman - fallow/khesari	680, (7.2%)		⊙Fruit trees (4%) Soil unit; 7,8,12
9) Boro - fallow	1,260, (13.3%)		
10) T.aman - boro	180, (1.9%)		
11) T.aman - rabi	150, (1.5%)		

(3) Irrigable Area, 54,810 ha

This Area includes the Barind and the Paba area.

1) Barind Area, 45,340 ha

In the Barind area the cropping patterns are mainly T.aman-fallow with some aus-T.aman or T.aman-boro. The area is highly suitable for T.aus, T.aman and boro or moderately suitable for T.aus, T.aman, wheat and boro. Therefore, the proposed cropping patterns are decided as T.aman-boro, 60%, Aus-T.aman, 30% and T.aman-wheat, 10%.

2) Paba Area, 9,470 ha

The cropping patterns vary according to the flood conditions of areas. Highland is occupied by mainly aus/jute-rabi crops or sugarcane. Medium highland in low ridges and basins are usually occupied by T.aman-fallow or aus-T.aman-fallow. Medium low to lowland basins are usually occupied by B.aman-fallow/khesari or boro-fallow.

The highland areas, soil unit No.7, 8, 12 are highly suitable for aus, jute, wheat and mustard or fruit trees, vegetable, potato and mustard. Medium highland areas, soil unit No.9, 10, are highly suitable for boro or moderately suitable for boro. The areas of soil unit No.11 and 13, which mainly belong to medium lowland are similar to soil unit No.10 in the land suitability.

Major cropping patterns are sugarcane, 24%, fallow-T.aman-boro, 24%, T.aus-T.aman, 12%, jute-T.aman-WC, 12%, and SC-T.aman-wheat, 12%.

4-3-3 Proposed Farming Practice

(1) Cropping Calendar

Boro is usually grown in the rabi (winter & dry) season under irrigated condition. To avoid cold injury, seeding time should be started from mid-November and transplanting be practised from January to mid-February after 45-50 days of nursery period. Winter (rabi) crops such as wheat, oilseeds (mustard, linseed), potatoes, winter pulses and winter vegetables are grown in the same season. Winter crops may be seeded from mid-October to mid-December, but harvesting be completed by the end of March.

Aus is grown in the summer season (kharief-I). Direct seeded aus (B.aus) of LV is predominant under rainfed condition, but transplant aus (T.aus) of MV is proposed under irrigated condition. T.aus (MV) should be seeded from March to early April and transplanted through 30 days of nursery period, which may be harvested up to early August. Jute, summer pulses (mungbean), summer vegetables, etc. are grown in the same season. For increase of soil organic matter, introduction of green manure such as Sesbania is recommended during 60 days of growth duration between boro and T.aman (MV).

Grain yield of T.aman (MV) is dependent on the degree of low temperature at reproductive stage. Under irrigated condition T.aman (MV) should be transplanted up to 10th August with 30 days aged seedlings. After then, local improved varieties (LIV) such as Naizersail may be transplanted up to end of August. Vegetables may be grown in the same season (kharief-II).

The reasons for selected cropping calendar is explained in Appendix V-3-1.

(2) Management Practices

Under rainfed condition without project implementation, farmers will apply less quantity of fertilizer and pesticides than recommended dose because of fear of drought damage. Ensured irrigation with project may allow to increase application of these inputs and to intensify other management practices for high yield. As content of organic matters in soils is at low level, much more manure should be applied in the field, and introduction of green manure is recommended as described above for improvement of soil health. Moreover, deficiency of sulfur in soils are evident in Barind and that of zinc in Paba flood plain. Gypsum ($CaSO_4$) or zinc sulfate ($ZnSO_4$) should be applied in these deficient areas.

4-3-4 Proposed Cropping Pattern

Barind area and Paba flood plain are different in soil condition, existing cropping pattern and water resource of irrigation plan. Therefore, proposed cropping pattern should be projected separately.

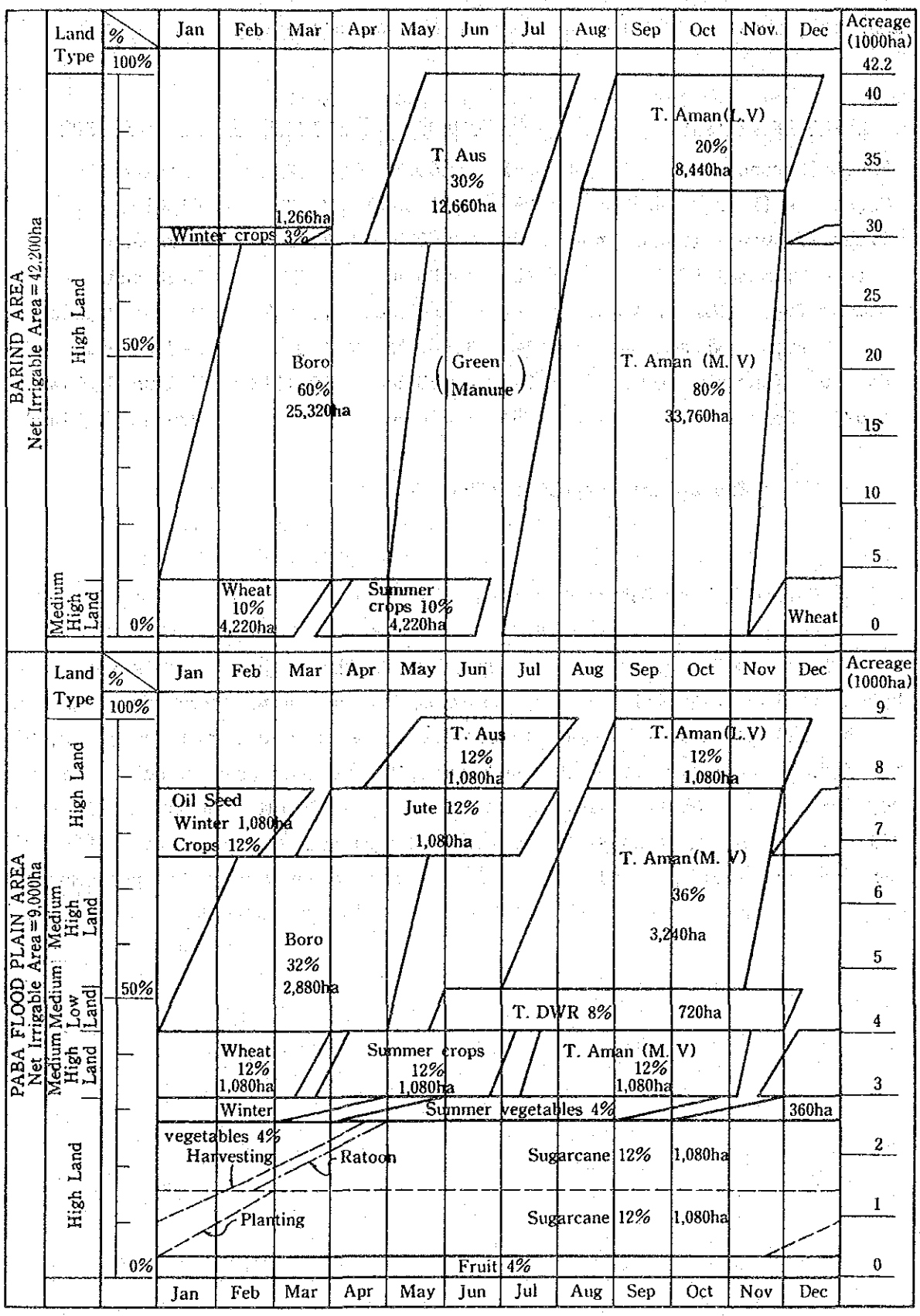
Depending on seasonal availability of water, the cropping season mentioned above, the proposed land use and crop suitability, cropping pattern in both the areas are proposed as shown in FIGURE 4-1.

As soils in Barind are not so suitable for dryland crops although suitable for paddy, the whole irrigable area should be covered with T.aman crop combined with boro, aus and some dryland crops in winter or summer season as follows:

Cropping Pattern	Coverage	Soil Mapping Unit	Land Type
T.Aus - T.aman - Fallow	27% 11,390 ha	1,2,3,4,5	Highland
T.Aus - T.aman - WC	3% 1,270 ha	2,6	Highland
SC - T.Aman - Wheat	10% 4,220 ha	1,6	Highland
GM - T.Aman - Boro	50% 21,100 ha	1,2,3,5,14	Highland
Fallow - T.aman - Boro	10% 4,220 ha	6,10,11	Medium Highland

WC = winter crop : pulses, oilseed, potato, vegetables
SC = summer crop : pulses, oilseed, vegetables

FIGURE4-1.PROPOSED CROPPING PATTERN



In Paba flood plain, sugarcane should have one ratoon crop and 3-year rotation with T.aus - T.aman. Others are T.aman combined with boro, aus/jute, wheat and winter or summer crops as follows:

Cropping Pattern	Coverage		Soil Mapping Unit	Land Type
Fruit (Perennial)	4%	360 ha	7,12	Highland
Sugarcane (Year-round)	24%	2,160 ha	7,12	Highland
T.aus -T.aman - (Sugarcane)	12%	1,080 ha	7,12	Highland
Jute - T.aman - WC	12%	1,080 ha	7,12	Highland
Summer Veg. - Winter Veg.	4%	360 ha	7,9,12	Medium Highland
SC - T.Aman - Wheat	12%	1,080 ha	10,13	Medium Highland
Fallow - T.aman - Boro	24%	2,160 ha	10,1113	Medium Highland
T.DWR - Boro	8%	720 ha	11	Medium Highland

T.DWR = Transplant deepwater rice.

4-3-5 Future Labour Balance

The total labour requirement by month in the project area is summed up based on the proposed cropping pattern, labour requirement by crop and month, and crop area. Peak labour requirement per month is 3,370,000 man-days in November and other peak is 3,100,000 man-days in July. Labour population of farm household including landless farmer in the study area (five Upazilas) is 196,332. When labour days are 25 per month, 4,900,000 man-days are available, therefore, labour requirement is met on peak month.

4-3-6 Target Yield and Production

(1) Target Yield

Target yield with project and yield without project are anticipated depending on present constraint in crop production, yield at farmers level, effect of irrigation, recommended cultural practices, situation of Agriculture Extension system, potential yield in research stations, etc.

In rainfed condition without project, rice yield may somewhat increase compared with present one due to gradual increase in coverage of MV with some improved cultural practices. Boro rice is usually grown under irrigation but LV will still remain.

In irrigated condition with project, however, constraint of drought in rice cultivation will be fully removed and yield of rice may increase remarkably due to both direct and indirect effects of ensured irrigation. Under irrigated condition improved cultural practices such as transplanting, fertilising, etc. can be easily conducted in time, application of inputs will be increased adequately and LV to be all replaced by MV or LV.

Irrigation can produce higher yield of sugarcane along with benefits of ratooning and increasing yield of late-planted cane. Wheat, potatoes, vegetables and other winter crops alos are significantly increased in yield under irrigated condition. The anticipated target yields of major crops in the project area are shown in the following table.

Target Yield and Total Production

Crops	Yield (ton/ha)	Production (ton)		
		Barind	Paba Flood Plain	Total
Rice (Total)		339,710	40,860	380,570
Aus	3.5	44,310	3,780	48,090
T.aman	4.0	168,800	21,600	190,400
T.DWR	1.5	-	1,080	1,080
Boro	5.0	126,600	14,400	141,000
Wheat	3.5	13,504	3,456	16,960
Pulses	1.2	4,812	1,080	1,710
Potatoes	12.0	2,520	3,240	5,760
Vegetables	9.0	7,560	4,050	11,610
Sugarcane	65.0	-	140,400	140,400
Jute	1.8	-	2,160	2,160
Fruit	9.0	720	3,240	3,960

(2) Target Production

Depending on the proposed cropping pattern, crop area and target yield, target production of each crop is computed as shown in the following tables. The total production of rice in the proposed irrigable area may increase to approximately 4.8 times of present production and wheat 2.0 times.

The present and anticipated yield and production of "without project" and "with project" in both the areas are shown in TABLES 4-4 and 4-5.

TABLE 4-4 TARGET YIELD AND PRODUCTION IN BARIND AREA

	Present			Without Project			With Project		
	Area (ha)	Yield (ton/ha)	Production (ton)	Area (ha)	Yield (ton/ha)	Production (ton)	Area (ha)	Yield (ton/ha)	Production (ton)
Rice (total)	50,470	1.35*	67,920	50,470	2.28*	114,843	80,180	4.24*	339,710
Aus	7,980	0.89	7,102	7,980	2.0	15,960	12,660	3.5	44,310
T.Aman	39,960	1.39	55,544	39,960	2.3	91,908	42,200	4.0	168,800
Deepwater Rice	590	1.08	637	590	1.3	767	-	-	-
Boro	1,940	2.39	4,637	1,940	3.2	6,208	25,320	5.0	126,600
Wheat	2,490	1.96	4,880	2,490	2.3	5,727	4,220	3.2	13,504
Pulses	170	0.71	121	170	0.8	136	4,010	1.2	4,812
Oilseeds	340	0.58	197	340	0.7	238	630	1.0	630
Patatoes	210	6.75	1,417	210	8.0	1,680	210	12.0	2,520
Vegetables & Others	1,940			1,940	-	-	720	-	-
Total Cropped Area	55,620			55,620			89,970		
Net Cropped Area	42,200			42,200			42,200		
Cropping Intensity	131.8%			131.8%			213.2%		

Note: * weighted average yield

TABLE 4-5 TARGET YIELD AND PRODUCTION IN PABA AREA

	Present			Without Project			With Project		
	Area (ha)	Yield (ton/ha)	Production (ton)	Area (ha)	Yield (ton/ha)	Production (ton)	Area (ha)	Yield (ton/ha)	Production (ton)
Rice (total)	7,790	1.18*	9,237	7,960	1.97*	15,655	10,080	4.05*	40,860
Aus	3,370	0.89	2,999	3,450	2.0	6,900	1,080	3.5	3,780
T.Aman	2,360	1.59	3,752	2,360	2.3	5,428	5,400	4.0	21,600
Deepwater Rice	1,780	1.06	1,887	1,870	1.3	2,431	720	1.5	1,080
Boro	280	2.14	599	280	3.2	896	2,880	5.0	14,400
Wheat	1,230	2.13	2,620	1,530	2.3	3,519	1,080	3.5	3,780
Pulses	500	0.75	375	500	0.8	400	1,620	1.2	1,944
Oilseeds	270	0.65	175	270	0.7	189	540	1.0	540
Patatoes	300	7.41	2,223	300	8.0	2,400	270	12.0	3,240
Vegetables	320	7.47	2,390	590	8.0	4,720	450	12.0	5,400
Sugarcane	1,820	45.82	83,392	1,950	50.0	97,500	2,160	65.0	140,400
Jute	750	1.45	1,088	1,670	1.5	2,505	1,080	2.0	2,160
Fruits	350	8.10	2,835	350	8.1	2,835	360	12.0	4,320
Others	900	-	-	900	-	-	-	-	-
Total Cropped Area	14,230			16,020			17,640		
Net Cropped Area	9,000			9,000			9,000		
Cropping Intensity	158%			178%			196%		

Note: * weighted average yield

4-4. Agricultural Supporting Services

4-4-1. Farmer's Organization

The farmers' organization of UCCA-KSS/BSS/MBSS system has been playing an important role to carry out economic activities such as crop production, marketing and distribution of agricultural outputs and inputs, establishment of irrigation equipment, and various types of off-farm activities including rice husking, fishering, bamboo and cane works, handloams, silk and jute craft, and supplying and distributing the funds for the above economic activities. Moreover, in the areas under BRDB Project or Program, the existing UCCA-KSS/BSS system would form an Irrigation Management Committee among themselves to control and distribute irrigated water rationally and would serve as collecting organization of water rates which may be specified in the notification regarding publicity.

The objectives of this Project are to improve the living standards of the rural people and to activate and stabilise the socio-economic viability in the rural communities, through increasing agricultural production, income of farmers and landless farmers and employment opportunities according to supply of irrigation water.

It is desirable for this Project to organize UCCA-KSS/BSS/MBSS system which can implement the economic activities in an integrated manner covering the whole of output, input and credit of agricultural production and socio-economic viability in the rural communities.

The Third Five-Year Development Plan also emphasized organization of farmers and landless farmers as one of important policies, following the Second Five-Year Development Plan.

Accordingly, it is recommended to promote more the organization of UCCA-KSS/BSS system in irrigated area of this Project under the full cooperation of BRDB.

4-4-2 Proposed Supporting Services

The agricultural development policy of the Government aims to decrease the population in household with income below the poverty line in rural area and establish food self-sufficiency of the country through increasing the agricultural production especially foodgrain and enlarging employment opportunities in the rural area.

Many of the agricultural development programs have not realized expected targets because agricultural development requires integrated components and simultaneously intensive, strong and continuous instruction and operation. For example, after construction of project facilities, production increase cannot be maintained without supply of fertilizer, agro-chemicals and so on. Along with the supply of agricultural and marketing of agricultural outputs, an agricultural extension service system is indispensable as distribution system of seeds and fertilizers, credit system, post-harvest facilities and advantageous marketing system for increase and stabilization of agricultural production and improvement in farmers' living standards.

(1) Agricultural Research Work

Although farmers in the Project area are accustomed to paddy cultivation, the projected shift from rainfed paddy cultivation to irrigated paddy cultivation and introduction of irrigated vegetable cultivation will entail some major adjustments for the farmers concerned in terms of working habits and management practices, especially in the Barind area which occupies most of the Project area. But the on-the-spot examination such as the test of adaptability of rice varieties in the farmer's field, is only conducted in this area. Though there are the regional station and sub-station of BRRI in the Rajshahi, the main research item of these stations is also breeding of cold tolerant and drought tolerant varieties. And, there is Sarail Farming System Research Site in the neighborhood of Chapal of Godagari Upazila, but this Site does not accumulate the data as to irrigation condition in dry season either because of unsatisfactory irrigation

facilities. In regard to upland crops, there are substations at Syampur at Chapai Nawabganj under a regional station. The main crops researched at Syampur are wheat and oilseed, etc. and at Chapai Nawabganj are mango, although both stations are located outside the Project. These stations lack research facilities and staff.

Therefore, it is important to provide immediately the research facilities and workers necessary for cultivation examination of paddy and upland crops under irrigatoin condition before the implementation of the Project in order to develop and accumulate adaptable farming practice and knowledge in the Barind area.

As mentioned above, BARC which is the apex organization for planning and coordinating research activities of all research institutes provides financial and material support as well as manpower training to strengthen research activities of all components of the national agricultural research system under the policy direction of a Governing Council of which the President is the Minister of Agriculture. It is necessary that the Government strengthens the research activities for NRIP through BARC, in order to accumulate the examination results as to farming technique under the irrigation condition.

It is also necessary that Government promotes the cooperation as to transfer of technology results, exchange of information and training of research staff through BARI and BRRI.

(2) Extension Services

Under DAE which plays the main role in the transfer of technology at regional, zila, upazila and union levels, the extension service organizations with working staff are established respectively. Especially those at upazila and union levels are the smallest unit, and at the same time, are staff of Upazila or Union Parishad which is

also headed by an elected upazila Chairman. At upazila level, each of Upazila Agricultural Officer (UAO) and Assistant and Junior Agricultural Extension Officers and two Subject Matter Officers (SMO) are working staffs. Most of UAO who are supervisors to Block Supervision of Agricultural Extension (BS) are graduates of Intermediate College of general course but are not agricultural technologists. Therefore SMO who are graduates of the Universities and are agricultural technologists play the role including instructor to BS with Subject Matter Specialist (SMS). But as the number of them is insufficient now, it is difficult to expect them to play the role as instructors to BS.

BS who has been trained during two years at Agricultural Extension Training Institute (AETI) situated in eight areas over the country visits Contact Farmers (CF) in order to initiate them new agricultural technique. CF spread the same information to general farmers (Non-CF). This system is called Training and Visit (T&V) system in which one BS covers 80 CF and one CF covers 10 Non-CF, namely, one BS covers 800 farmers that corresponds to an area covered by one BS of 800 ha to 960 ha. But this density per BS is low whereas the national target for rainfed agriculture is one BS per 400 ha. The responsibilities of BS mainly concern the establishment of demonstration plots (on average one in each Union), the provision of supplies via the KSS/BSS, the introduction of seeds of new varieties and assistance of cooperatives in obtaining credit, etc. It is said that not only the number of them is in sufficient but also the quality of their activities is low. The problems facing the present extension services which should be solved urgently are to attempt a complete instruction of new agricultural technique to farmers through progress of quality and increase of number of BS, to increase SMO as well as to strengthen study and training to UAO and SMO in Central Extension Resources Development Institute (CERDI). As mentioned above, although there is Train & Visit system covering Upazila, Union and farmers which has District Office as a center, it is evident that staffs and materials related to extension including vehicles are insufficient in

number and quality at present. In order to practice satisfactory activity aimed at extension services to the expansion of cropped area and introducton of new techniques for irrigated agriculture after implementation of the Project, it is indispensable to train and newly assign the staffs concerned, and to strengthen provision of materials and facilities.

Research results are delivered by regular meetings between researchers and staffs of offices at central level and country level respectively, and technical problems are brought forward from extension offices side to researchers' side in the process of discussion.

However, cooperation between research side and extension side on the spot by establishment of demonstration plots will be attained in the future because of insufficient staffs, and their lower quality.

Especially agricultural extension service and research activities on irrigation are little done in Barind area. Therefore, it is necessary to select crops which are suitable for soil, climate and geographical features in Barind area, and to strengthen instruction on farming practices. For this purpose, a pilto farm with about an area of 5 ha is to be constructed near Godagari in Barind area and agricultural extension service is to be concretely strengthened and promoted.

The functions of the pilot farm are as follows:

1) research on paddy and upland crops suitable for Barind area.
2) research on farming practices for each crop.
3) implementation of research, education and training staffs of extension services in order to diffuse research results of the above 1) and 2).
4) implementation on extension service activities as to farming practices and of feedback from the spot to the above 1) and 2).

(3) Local Government Work

As mentioned above, the representative local Government called the Upazila Parishad consists of an elected Union Chairman and officials of most of the Upazila level department of the development offices. They are under control of the development office, at the same time, they are now working under the control of the elected Upazila Chairman who is the chief executive of the Upazila Parishad. Therefore, officials of Upazila Parishads in the Project area who have the functions tied up with the will of the people and national policies for the development project (program) at the local level have to fulfill the functions to NRIP. The national Government takes measures to finance the local development program to be undertaken by the Upazila Parishad. Thus, the Upazila Parishads in the Project area have to become the local point of all activities of integrated development projects or programmes of their own with a reasonable scale and also have to become the implementing authority for execution of the divisible components of national level projects and programmes, which support the NRIP both at local and national levels.

(4) Agricultural Credit

The banks' operational strategy in Bangladesh, which is in accordance with the Government's priorities, places primary emphasis on agriculture, energy and human resource development. Especially, the heavy concentration of bank lending in agriculture (51% of total lending) reflects the dominance of this sector in the economy of Bangladesh. The Government would expand availability of agricultural credit and at the same time improve the recovery of maturing loans in order to aid farmers by means of effective utilization of funds. The rate of recovery of agricultural credit would be raised from about 55 percent in FY1986 to 60 percent in FY1987. Financial resources provided for institutional credit have been limited, which has been the major constraint to the wider use of agricultural institution credit by the small farmers. Though the total institutional credit given to agriculture by nationalized commercial banks, i.e.,

Bangladesh Krishi Bank (BKB), Sonali Bank, Bangladesh Samabaya Bank and others, has increased by about 300 percent between 1980/81 and 1984/85, 80 percent of the total credit requirement are still met from non-institutional sources for which the annual interest rate exceeds 50 percent. Therefore the Government and Banks would endeavour more and to expand availability of agricultural institution credit.

Agricultural institution credit is channelled to borrowers by two routes: one is directly, and other is through UCCA-KSS/BSS/MBSS system. The proportion of the former is about 60 percent and the latter is about 40 percent. Moreover, borrowers of the former will be able to rent at interest of only 16 percent, while borrowers of the latter have to rent at interest of 19 percent (short-term loan) to 16 percent (medium-term loan) although they can rent without any collateral. Besides, when penalty interest is included, the loan interest is 22 percent in all cases.

It is expected that the proportion of agricultural institution credit channel through UCCA-KSS/BSS/MBSS system increase more and the interest rates reduce more than current respective ones, and also that borrowers through UCCA-KSS/BSS/MBSS system under the Project of BWDB are able to rent at an appropriate interest rates, i.e., 14 percent for short-term loan and 12 percent for medium-term loan which are the same as in the case of Project under BRDB.

4-4-3 Post-Harvest Facilities

Total rice productions per year is 77,000 tons at present and 380,000 tons with project implementation in the project area. Then, new rice processing facilities for increased production of 303,000 tons will be necessary.

Increased production of wheat after project implementation will be about 8,000 tons for which new crushing facilities are necessary for the local consumption. Additional productions of oilseed after project implementation can be processed by existing capacities of oil mills in the study area. In case of sugarcane, maximum processing capacity of Rajshahi Sugar Mill is approximately 306,000 tons per year during 200 working days from November 1 to May 19. Increased production of cane may be 65,000 tons in the project area. If the receiving cane of the Mill from outside the project area within the command area of the Mill will not increase more than that in 1986-87 (226,900 tons), the existing capacity of the Mill could process the increased production of cane with project.

4-4-4 Proposed Marketing System

(1) Agricultural Input (Fertilizers)

According to the proposed cropping pattern and farming practice, it is anticipated that quantity of fertilizers used in the Project area will amount to about twice as much as that being applied for foodgrains production at present.

As mentioned above, the fertilizer distribution is the responsibility of the Bangladesh Agricultural Development Corporation (BADC). Domestically manufactured fertilizers are obtained from local factories and imported materials are received through the ports of Chittagong and Khulna and transported to intermediate godowns or Primary Distribution Points (PDP) or, occasionally, directly to upazila godowns. Retail sales to farmers are made by private dealers and Integrated Rural Development Program (IRDP) cooperatives at retail prices fixed by the Government.

Until the New Marketing System (NMS) for fertilizer has been introduced in 1978, the wholesale operation had previously been a monopoly of BADC, which operated the wholesale Thana Sales Centers (TSC). Since the NMS has been introduced to improve the efficiency of fertilizer distribution by maximizing the involvement of the private

(2) Agricultural Output (Foodgrains)

It is expected that quantity of foodgrains (rice and wheat) produced in the Project area will amount to about four times as much as that produced at present.

According to Farm Economic Survey, in the Project area it is said that about 60% of the total production are actually marketed. As mentioned above, in order to sustain farmers' incentives to produce, the Government, through the Ministry of Food (MOF), has implemented a price support programme for major crops including paddy and wheat. Over the years, the focus of MOF's procurement operation has been shifted from ensuring adequate public stocks to guaranteeing minimum prices for producers. Though the level of the foodgrain procurement price has largely brought the significant stabilization of prices in the open market, however, procurement prices are often lower than the open market prices in recent years.

Out of paddy actually marketed in the Project area, only about 15% passes MOF's procurement channel and the remaining 85% is marketed in the open market. The former is mostly composed of paddy produced by smaller farmers which is hulled with traditional dheki or small mills and the latter is composed of that by larger farmers which is exclusively hulled with large mills. This fact shows that the difference in income between those farmers has been extending.

Accordingly, it is necessary that the Government puts emphasis on MOF's procurement operation by arranging foodgrain procurement prices in order to dissolve differentials between procurement prices and open market prices as well as to guaranteeing the minimum prices for producers. Moreover, in the case of paddy, the Government should increase quantities procured under procurement programme, which have typically ranged from 2-6 percent of total production, in order to purchase much more paddy actually marketed by smaller farmers.

On the other hand, the smaller farmers must have foodgrain storages, large-scaled rice mills and dry yards with high capacity in order to raise the quality of paddy actually marketed, and to obtain a better position to sell it, especially in the rainy season. Moreover, they must be equipped with means of transportation such as ox-cart, boat and truck, and provide the network of information about the market to perform adequate and quick marketing activities. But the smaller farmers do not have their own funds, collaterals and power to equip those facilities. They would only do them by forming and organizing UCCA-KSS/BSS/MBSS system, which would improve the Government's marketing programme.

After the Project implementation, most of cropped area, e.g., about 48,000 hectares are occupied by local and high yiled varieties of Aman. Therefore, it is anticipated that about 190,000 metric tons of Amans' products will be transported from farm-household to rice mills. Out of 190,000 metric tons, about 74,000 metric tons of milled rice will be actually marketed to local market. As the capacity of a chart with a pair of buffaloes or bullocks is 1.1-1.3 or 0.9-1.2 mt (average 1.1 mt), the required total number of carts with a pair of buffalos or bullocks passing the market road from storage or farm-household to local market is estiamted at about 134,000 on a return-trip. So the number corresponds to about 2.5 times as many as that of present carts. Accordingly, it is necessary that the network of marketing roads is newly constructed or improved and maintained by the central and local Government, and at the same time, it is necessary that the means of transportation such as ox-cart (a pair of buffaloes or bullocks), a boat, or truck are adequately introduced in order to meet with paddy and wheat and wheat increase in the Project area after the implementation of the Project.

4-5. Irrigation and Drainage Development Plan

4-5-1. Irrigation Water Requirements

(1) Water Requirement Factors

1) Consumptive Use

Observed daily pan evaporation records are available at Rajshahi from 1977 to 1986. In order to estimate a consumptive use of paddy, a pan evaporation method which is explained in the "Crop Water Requirements" published by FAO, has been adopted. The consumptive use of crop can be estimated by the following equation:

$$ET_{crop} = K_p \cdot K_c \cdot E\text{-pan}$$

where, K_p is pan coefficient and K_c is crop coefficient.

The values of K_p and K_c have been obtained for 0.8 and 1.29, respectively. As a result, the $K_p.K_c$ becomes almost 1.0. Therefore the direct reading of the daily evaporation data have been considered as a consumptive use of paddy.

Considering the irrigation command area for each type of canal, the capacities for the on-farm and tertiary canals were decided on the basis of maximum daily consumptive use while the secondary canal capacities were decided on the basis of the maximum 10-day average value and main canal capacities were based on the maximum monthly average consumptive use.

2) Percolation Rate

In accordance with the physical analysis of the soil types in the Project area as explained in Appendix I, the percolation rate in the top-soil (0 - 0.15 m) is slow to medium but the rate in the lower layer is almost zero due to the clay to silty clay types of soil.

For the safety side, the percolation rate has been decided at 1.0 mm/day in the overall Project area.

3) Pre-saturation requirements

The pre-saturation requirements were estimated according to the following parameters:

Pre-saturation period: 40 days

Pre-saturation requirement:

Land soaking	60.0 mm
Standing water	20.0 mm
Total	80.0 mm

4) Effective rainfall

Since the Project area is extended for about 60 sq.km in the size and the difference of the elevation is about 30 meters. The rainfall distribution is rather different in the daily basis. The areal rainfall analysis has been made adopting Thiesen Poligon method among 5 raingauge stations at Rajshahi (12%), Tanore (24%), Nachol (26%), Godagari (21%) and Manda (17%). The figures are the ratio of the command area.

The areal rainfall has been adopted to estimate the effective rainfall for the water requirements.

As for effective rainfall during crop growth, daily rainfall of 5.0 mm or less is considered ineffective while rainfall exceeding 5.0 mm is considered 80% effective. When effective rainfall exceeds the daily water requirement, the surplus is stored in the paddy field and used the following day. Effective rainfall, however, is limited to 80 mm/day due to over spill.

5) Growing stage requirements

Water requirement during crop growth has been computed as the sum of the daily consumptive use and the percolation rate.

(2) Irrigation Efficiency

Since the percolation rate in the Project area is very low, seepage loss from canal and on-farm level will also be expected to be very low.

The overall irrigation efficiencies during wet and dry seasons have been adopted at 57% and 61%, respectively, and the individual efficiencies are shown below:

Overall Irrigation Efficiencies

	Conveyance	Operation	Field	Total	Overall
Main	0.97	0.98	-	0.95	0.57 (0.61)
Secondary	0.96	0.97	-	0.93	0.60 (0.64)
Tertiary	0.97	0.95	-	0.92	0.64 (0.69)
Farm Ditch & On-Farm	-	-	0.70 (0.75)	0.70 (0.75)	0.70 (0.75)
Total	0.90	0.90	0.70 (0.75)	0.57 (0.61)	

Note: The figures in parentheses refer to the dry season.

(3) Simulation Analysis for Optimal Timing of Cropping Calendar

1) Concepts

Determining the optimal scheduling of a cropping calendar in an uncertain hydro-meteorological environment is an important aspect in operating and planning irrigation schemes. The specific problem dealt with this simulation analysis is the optimal allocation of a finite water resource without reservoir storage over an irrigation season for double cropping in a year with the combination of T-aman and Boro. This problem reduces to determining the irrigation start dates during each season and the optimum presaturation period. The problem is complicated by the stochastic and spatial variation of rainfalls, and the varying crop water requirements during crop growth.

Crop water requirements, which is closely related with evaporation, rainfall and river flow are stochastic variables, the stochasticities of which are known in general from past records. The problem is then to fit the cropping calendar, given a finite quantity of water over a growing season and with varying rainfall and evaporation, to maximize the irrigation acreage or to minimize the sizes of irrigation structures.

The approach used in this simulation analysis utilizes a dynamic stochastic programming model and available hydro-meteorological records at Rajshahi for rainfall and evaporation.

The irrigation water requirement is obtained by subtracting the effective rainfall from the computed crop water requirement. In determining the effective rainfall the water depth in the paddy field was allowed to fluctuate from a minimum of 20 mm after transplanting up to a maximum of 80 mm. The antecedent water level in the paddy field was also considered in the study.

Based upon the above-mentioned factors for the simulation analysis, several case studies have been conducted by shifting the cropping calendar by 10-day intervals.

2) Selection of a Suitable Cropping Calendar

In accordance with the results of the simulation analysis, two objectives have been considered to select the optimal cropping calendar from the hydrological point of view. One is the minimization of the peak specific diversion water requirement in one hectare. The peak diversion water requirements will affect the design capacities of pump and canal, and thus the construction cost. The other is the minimization of annual irrigation water requirements. The irrigation water requirements is the difference between the effective rainfall and the crop water requirements, and will be supplied by pumping from the Ganges river. So the minimizing of the irrigation water requirements throughout the irrigaton season will minimize the water resource utilization and also the pump operation costs.

(4) Design Water Requirement

According to the proposed cropping calendar and pattern, the cropping pattern has been categorized into two patterns. The main pattern is a combination of T-aman and Boro and the other is Aus and T-aman.

As explained above, simulation analysis has been made to minimize the water requirement and peak water requirement to utilize effective rainfall as much as possible.

In accordance with the proposed cropping calendar and above-mentioned two patterns of unit water requirements, diversion water requirement for Paba Flood Plain Area and Barind Area have been computed for 10 years from 1977 to 1986.

The maximum peak diversion water requirement during 10-year period appeared on September 3rd (10-day) in 1982 and the dry season peak appeared on April 2nd (10-day) in 1980.

Considering the estimated irrigation efficiencies for each irrigation canal, the design unit water requirements were decided, and the results are shown below:

Canal	Unit Design Water Requirement
Main and Pump	1.0484 l/sec/ha
Secondary	1.2345 l/sec/ha
Tertiary & SFD	1.5456 l/sec/ha

Accordingly, the maximum intake capacity for Barind and Paba areas are shown below. However, design capacity for proposed pumping station has been selected in the maximum value during dry season as also shown as follows:

	Barind Area	Paba Area	Total
Net Irrigation Area (ha)	42,200	9,000	51,200
Wet Season-Maximum Intake Capacity (m^3/s)	44.242	9.436	53.678
Dry Season-Maximum Intake Capacity (m^3/s)	42.588	8.247	50.835

4-5-2. Irrigation Plan

(1) Pumping Station

1) Type of Pumping Station

In selecting the type of pumping stations, the following three types of pumping station are being considered under this Project.

a) Floating Type Structure

All pump facilities are furnished on a floor of barge or pontoon in order to cope with the water stage fluctuation in the river and also river course shifting.

b) Inclined Type Structure

The pump facilities are installed along the side slope of the river embankment. This type is applicable when the river course is stable.

c) Fixed Type Structure

The pump facilities are installed inside the river land with connection canals constructed to conduct water.

2) Technical Problems of Floating Type of Pump

The Ganges river is a wild river changing always the river course elsewhere due to large amount of energy of the flow during wet season and numerous siltation in the water. In order to cope with such unpredictable changes of the river course, a floating type of pumping station can be recommendable.

The floating type of pumping station is called a barge or pontoon mounted pump equipment on it. A floating type of pumping station is basically excellent to cope with the river bank shifting. However, at present there are very few cases of large-sized floating pumps installed in the river in the world.

The capacity of small- and medium-sized floating type of pump station will be about less than 1.0 m^3/sec and 2 to 3 m^3/sec on one barge, respectively.

Large-sized floating type of pumping station could also be called the pump capacity with more than 10 m^3/sec on one barge.

For the large-sized type, however, the following problems on the installation, operation and maintenance should be solved:

a) Anchoring of a barge

The velocity of the Ganges river during flood season will be about 3 m^3/sec and the river carries a large amuont of energy of the river discharge. Under such water condition, using normal anchoring system of barge by anchors on the river bed would not be applicable. The river bed is always moving by tractive force of the river flow, especially on a sandy river bed.

In order to fix the barge in the river, a mooring pile will be driven in the river bed. Taking into consideration driving such a mooring pile into the river bed, which has an elevation of -20.0 meters PWD, and maximum flood water level of 22 meters, the required length of the pile will be 50 to 60 meters long with a special piling equipment in the river.

Another possibility is to fix the barge in the high velocity and turbulence of river flow. Self-elevating platform system with four spuds at the corners of platform, which is normally use for marine development can be applied for floating type of pumping station. However, the length of the spuds will be required about 40 to 45 meters to reach the river bed.

b) Intake Channel

In order to avoid such difficult anchoring in the river stream, it will be recommendable to provide an intake channel to float the barge to get anchoring from the river bank and to avoid direct influence of the current and waves to the barge. Therefore, the formation of the floating pump in an intake channel would become similar to the fixed type.

In addition, a dock yard is necessary near the site for painting, etc. for the maintenance of the barge in dry condition.

c) Desilting Problem

When the Ganges river water is lifted by pumps with the same amount of water lifted, the total siltation contained in the intake water will not be changed regardless of the type of pump station.

Normally, a desilting basin or intake channel is provided in front of a pump station for fixed pump station. The deposit of the sediment should be removed by dredgers to the original river. The pump impeller will not be much ground by sand because of the desilting basin.

As for the floating-type pump, the river water, which contains high suspended load, should be directly lifted by a pump. Accordingly, the impeller of the pump will be ground by sand and the suspended load will be deposited in the delivery pond or main canal. In the Baraipara site, the delivery pond is located at about 2.5 km inland from the river bank. The sediment disposal will become very difficult problem. Dredging will be required with high power to convey long distance of the sediment to dispose to the river. The sediment disposal near the delivery pond will be more costly than the dredging system because of land acquisition for disposal area.

d) Electric Power Cable

Large-sized pump and high head of lifting water will require high power supply. The size of power supply cable is about ø200 mm to ø300 mm in diameter. This size of the cable is not as flexible as the flexible pipe, and the high power voltage supply will be risky for the operator.

e) Variation of Total Head

The static head to lift water between wet and dry seasons is very much different. As for a fixed-type pump, the suction head is changed in accordance with the river water level change. On the other hand, for floating pump, the suction head is always constant but the delivery head is varied. In order to cope with such high difference, mixed flow type of pump can be introduced. It will be rather difficult to mount such large size of mixed flow type of pump on the barge. Due to the limitation of capacity of barge, volute type of pump will be more preferable to mount. However, the volute type pump has a limitation to cope with the lifting head change because of cavitation problem.

f) Operation and Maintenance

Due to limitation of barge size, large-sized pump equipment can not be accommodated. As a result, the capacity of one pump should be small (i.e., less than 1.5 m^3/sec to 2.0 m^3/sec). Then the number of pump unit or barge unit will be increased to satisfy the required total capacity to be lifted.

The total water requirement for the Baraipara site is 40 m^3/sec. So eight units for fixed type and 20 to 27 units for floating type will be required.

Accordingly, the cost of pump equipment for floating type can not expect a scale merit like fixed type.

In addition, for maintenance, it will require rather longer time or more engineers than the fixed one in order to maintain not only 20 to 27 units of pumps and motors but also the barge itself in dry conditions.

3) Alternative Study for Pumping Station for Barind Area

a) Alternative Plan

The proposed site for pumping stations have been selected at Baraipara on the basis of the river bank shifting records and cross-section survey results of the Ganges river.

A pumping station is also proposed at Sultanganj but should be limited to utilize during wet season only due to the sand dune at the confluence of the Mahananda river with the Ganges river during the dry season.

Accordingly, the following three alternatives have been compared to select the most suitable pump sites and pumping station type:

i) Alternative-1 (Ref. to Fig. 4-2)

The Baraipara site can be proposed as the pumping site for floating type for 34.0 m^3/sec instead of the Godagari site. A connecting canal to the existing natural depression for about 2.2 km will be necessary to be added to convey water from Baraipara to Sultanganj.

At Sultanganj, pump equipment to lift water from the Mahananda river for 6.0 m^3/sec together with the secondary lifting pumps of water from Baraipara for 34.0 m^3/sec will be facilitated in the pumping stations. This total capacity (40 m^3/sec) can also be utilized to lift water from the Mahananda river during wet season.

ii) Alternative-2 (Ref. to Fig. 4-3)

The Baraipara is the only site for pumping station where water can be lifted up throughout a year.

Instead of the floating pump, the standard fixed pumping station can be proposed at Baraipara instead of the floating pump.

iii) Alternative-3 (Ref. to Fig. 4-2)

Alternative Plan 3 proposes a direct lifting of the Ganges river water to the delivery pond at EL 30.5 m PWD by the floating pump with the capacity of 40 m^3/sec.

iv) Alternative-4 (Ref. to Fig.4-3)

The inclined mixed flow pump can be proposed at Baraipara instead of the floating pump.

b) Dimension of Pump Facilities on Alternative Plan

Necessary facilities for each plan are shown in Table 4-6.

c) Cost Estimation

Construction costs including the operation and maintenance cost for each alternative plan have been estimated.

Maintenance cost for floating type pumping station has been assumed to utilize the Towing Boat (5t), Anchor Boat (3t), and Crane Boat (10t) for the transfer of the barges in the river.

The results of the cost estimate is tabulated in Table 4-7.

It is indicated that Case II Proposed Plan (Fixed Type at Baraiparai) is the most recommendable for the construction of pump station for Barind Area.

4) Pumping Station at Kasba for Paba Flood Plain Area

The proposed pumping station for Paba flood plain area has been selected at Kasba as mentioned in Appendix II. A pump for irrigation and drainage purposes will be utilized at Kasba site. In order to utilize the pumping station for dual purposes, a fixed-type pumping station is preferable. Consequently, the fixed type pumping station has been recommended at Kasba site for the Paba flood plain area also taking into consideration the results of the case studies of pumping station type for Barind Area.

FIGURE 4 – 2 ALTERNATIVE 1 AND 3

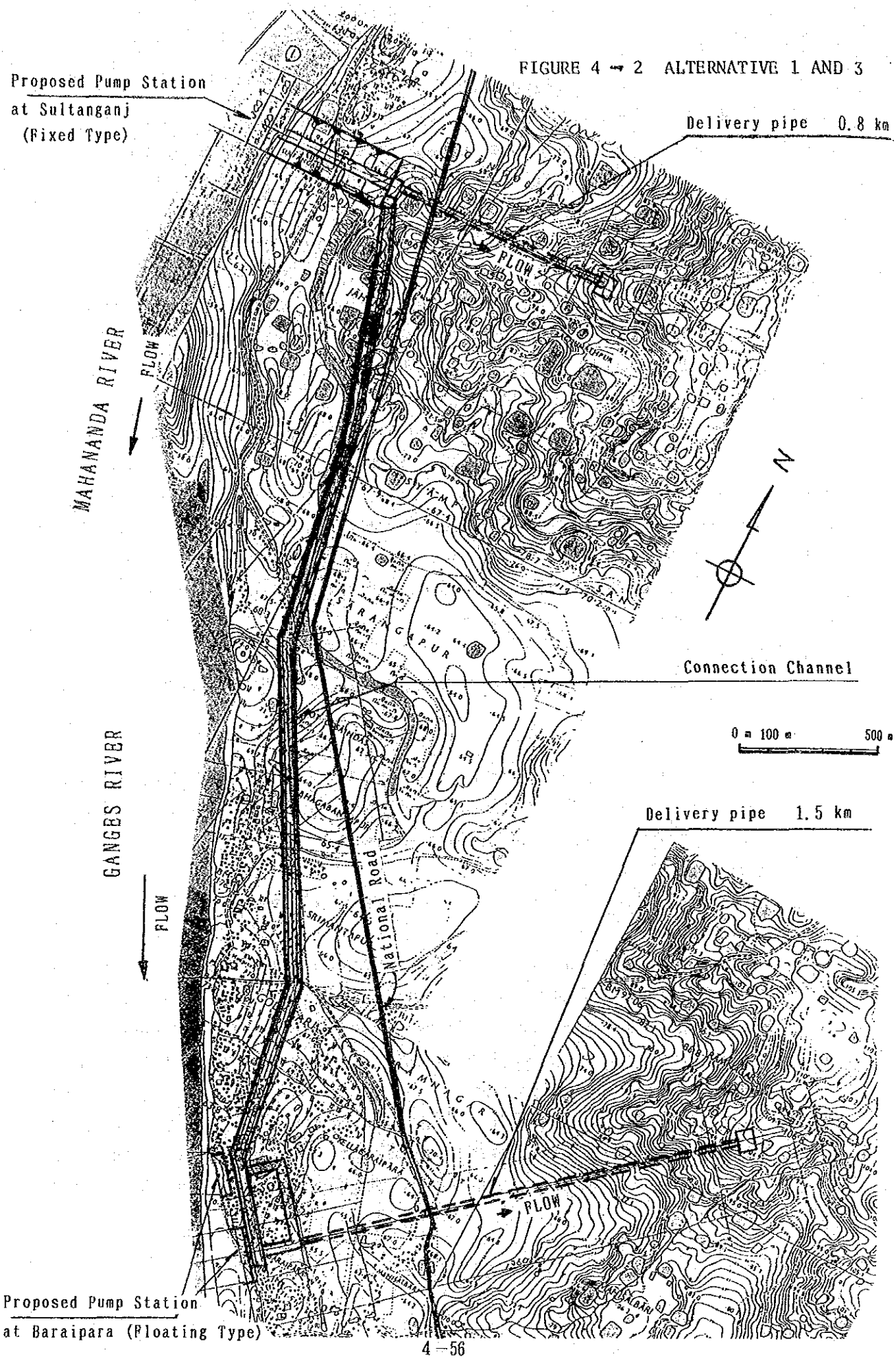


FIGURE 4 — 3 ALTERNATIVE 2 AND 4

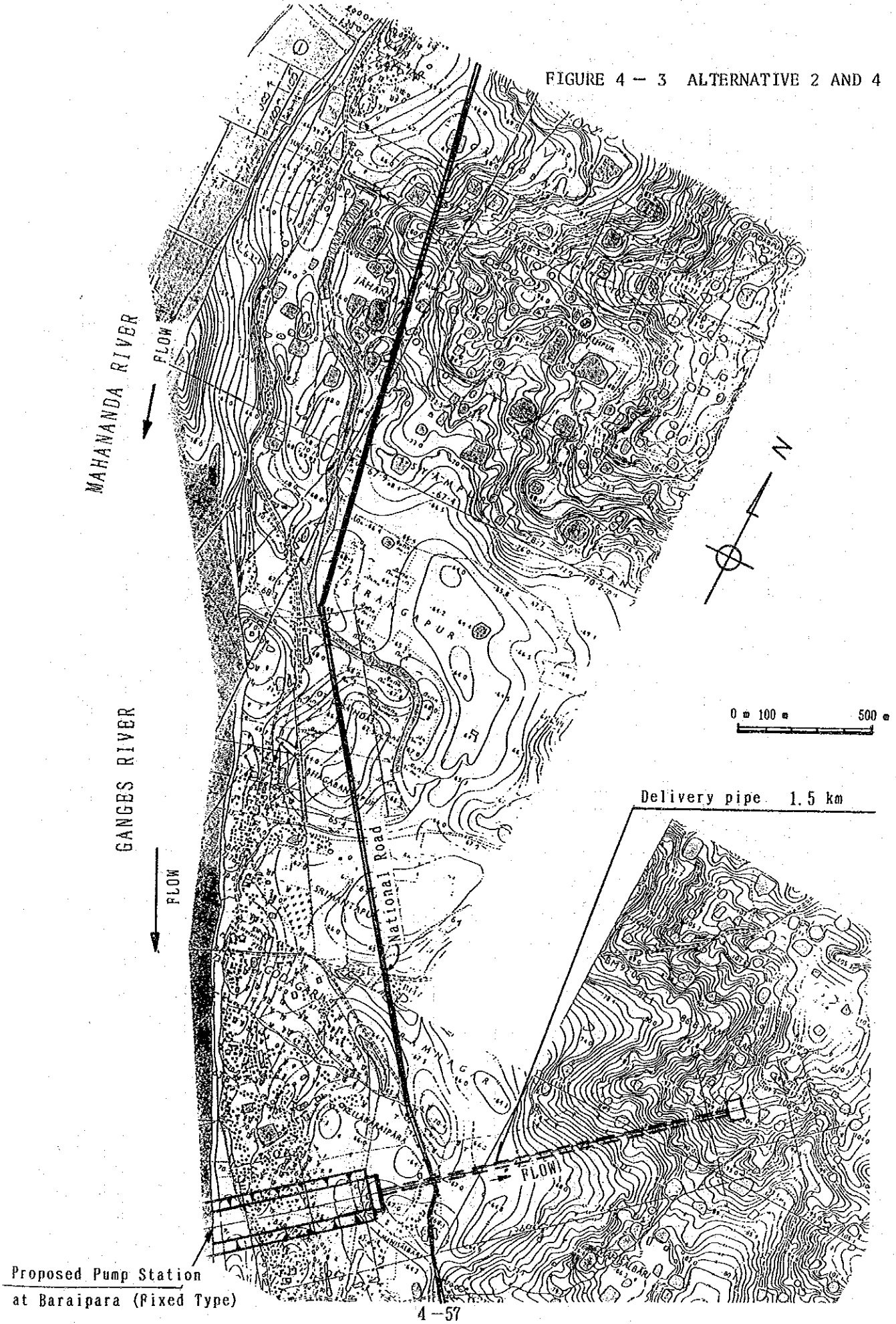


TABLE 4-6. DIMENSION OF PUMP FACILITIES

Item \ Pump Station	Alternative 1		Alternative 2	Alternative 3	Alternative 4
	Sultanganj P.S (Fixed)	Baraipara P.S (Float)	Baraipara P.S (Fixed)	Baraipara P.S (Float)	Baraipara P.S (Fixed)
Irrigation Requirement (㎥/s)	6.0	34.0	34.0	40.0	40.0	40.0
Water Level H.W.L (m)	20.4	20.4	20.4	20.4	20.4	20.4
L.W.L (m)	9.9	19.3	9.6	9.6	9.6	9.6
Discharge Water Level (m)	30.5	30.5	19.8	30.5	30.5	30.5
Actual Head (m)	20.6	11.2	10.2	20.9	20.9	20.9
Loss Head (m)	3.5	3.5	2.8	5.0	5.0	5.0
Total Head (m)	24.1	14.7	13.0	25.9	25.9	25.9
Pump Type	Vertical Mixed Flow Pump		Volute Pump OR Inclined M·F·P	Vertical Mixed Flow Pump	Double Volute Pump	Inclined Mixed Flow Pump
Bore (mm)	1650	1650 1350	1000	1650 1350	1000	1000
Capacity (㎥/s)	6.0	6.0 4.0	2.0	6.0 4.0	2.0	2.0
Motor Power (kw)	2000	1220 830	340	2100 1400	670	670
Pump Efficiency (%)	84.5	84.5 83.5	85	84.5 83.5	85	85
Pump Unit	1	3 4	17	4 4	20	20
Pipe Line						
Diameter (mm)	2000	2000	2000 1600	2000 1600	2000 1600	2000 1600
Length (km)	0.8	0.8	1.5	1.5	1.5	1.5
Unit	1	4 , 3	5 , 3	2 , 4	2 , 4	2 , 4

TABLE 4-7. COMPARISON OF COST FOR EACH CASE

(1000TK)

Item \ Case	Case I (floating, Fixed) Mixed Flow , Volute	Case I' (floating, Fixed)	Case II (Fixed)	Case III (floating)	Case IV (Fixed)
1. Construction Cost	2,223,600	1,909,800	1,327,800	1,774,000	1,463,100
2. Operation & Maintenance	231,200	206,300	112,800	137,700	112,800
Total Cost (Cost Ratio)	2,454,800 (170%)	2,116,100 (147%)	1,440,600 (100%)	1,911,700 (133%)	1,575,900 (109%)
3. Running Cost (Cost Ratio)	129,200 (108%)	122,300 (102%)	120,000 (100%)	123,800 (103%)	117,000 (98%)

5) Type of Pump

Generally, the type of the pump equipment is selected on the basis of the total head required at the proposed site.

The relation between the type of pump and total head is given as follows:

Type	Horizontal Axis (m)	Vertical Axis (m)
Volute Type	15.0m - more	15.0 m - more
Mixed Flow Type	2.0 - 9.0	9.0 - 20.0
Axial Flow Type	1.5 - 5.0	1.5 - 5.0

The design water levels at the proposed pumping stations at Kasba and Baraipara based on 100-year return-period are shown as follows:

	Kasba (m)	Baraipara (m)
High Water Level	20.325	21.826
Low Water Level	7.860	8.686
Difference (m)	12.465	13.140
Delivery Pond Elevation	19.800	30.500
Maximum Head (m)	11.940	21.814

The total head for both pumping stations are estimated on the basis of elevation of discharge pond and operation loss as shown below:

Kasba P.S. : 13.0 m (Approx.)
Baraipara P.S : 27.0 m (Approx.)

According to the total head required, horizontal volute type or vertical mixed flow type will be suitable for both pumping stations. Considering the water level fluctuation in the Ganges river, the volute type pump will have a cavitation problem during high water level in wet season due to discharge control by a valve. Accordingly, vertical mixed flow type has been recommended for both pumping stations.

(2) Canal Alignment

Irrigation canal routes have been selected taking into consideration of following points;

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

- to avoid canal alignment through village settlement as far as possible; and

- to avoid the proposed canal bed located on the embankment portion as much as possible.

Barind irrigation main canal route has been selected to maximize the command area and the total length is 48.8 km. It starts from Baraipara Pumping Station, running the highest area of Barind crossing the Abdulpur-Amunura branch railway, and it reaches the Hakimpur.

In order to increase the irrigable area as much as possible, the secondary and sub-secondary canals have been introduced in the undulating area. Therefore, the canal length density is higher than ordinary canal alignments.

Main canal route in the Flood Plain area has a total length of 13.9 km.

It starts from Kasba Pumping Station, running the center of this area, crossing the Abdulpur Amunura branch railway and it reaches the Chaubaria.

(3) Irrigation Networks

The layout of the proposed irrigation network systems are in FIG. 4-4.

Schematic diagram for each irrigation network is shown in FIG. 4-5 and FIG. 4-6 for Barind area and Paba flood plain area, respectively.

4-5-3. On-farm Development Plan

(1) Concepts of On-farm Development

The objectives of on-farm development are to provide terminal facilities to have the function for irrigation water distribution, for drainage of excess water and for increasing accessibility to farm plot through farm road.

Therefore, the terminal facilities for on-farm development should be planned under the consideration of following items.

- Topographical condition
- Soil condition
- Shape of farm-lot
- Acreage of farm-lot
- Present and future land-use
- Water management
- Construction cost

FIGURE 4 - 4. LAYOUT OF IRRIGATION CANAL NETWORK

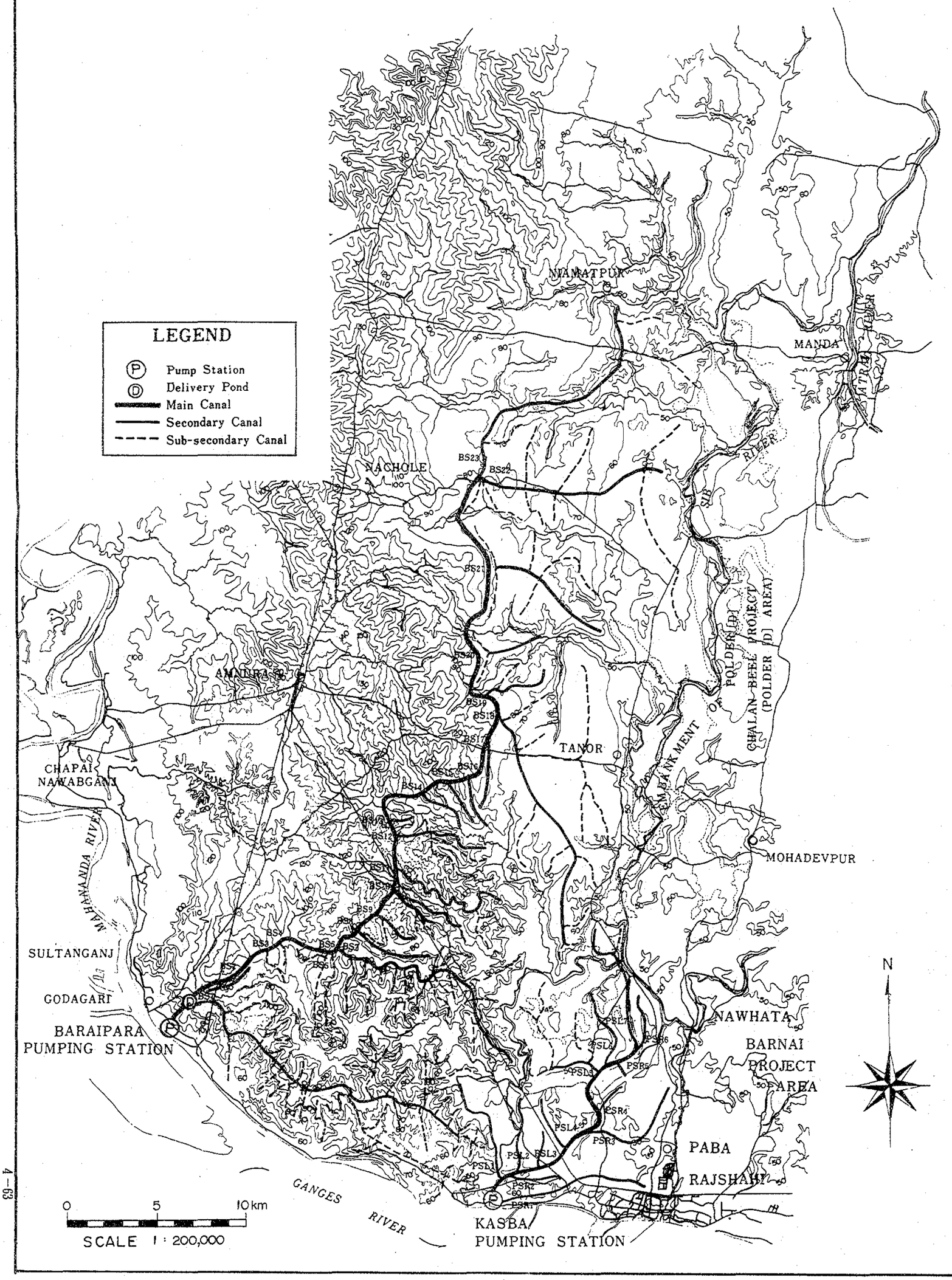
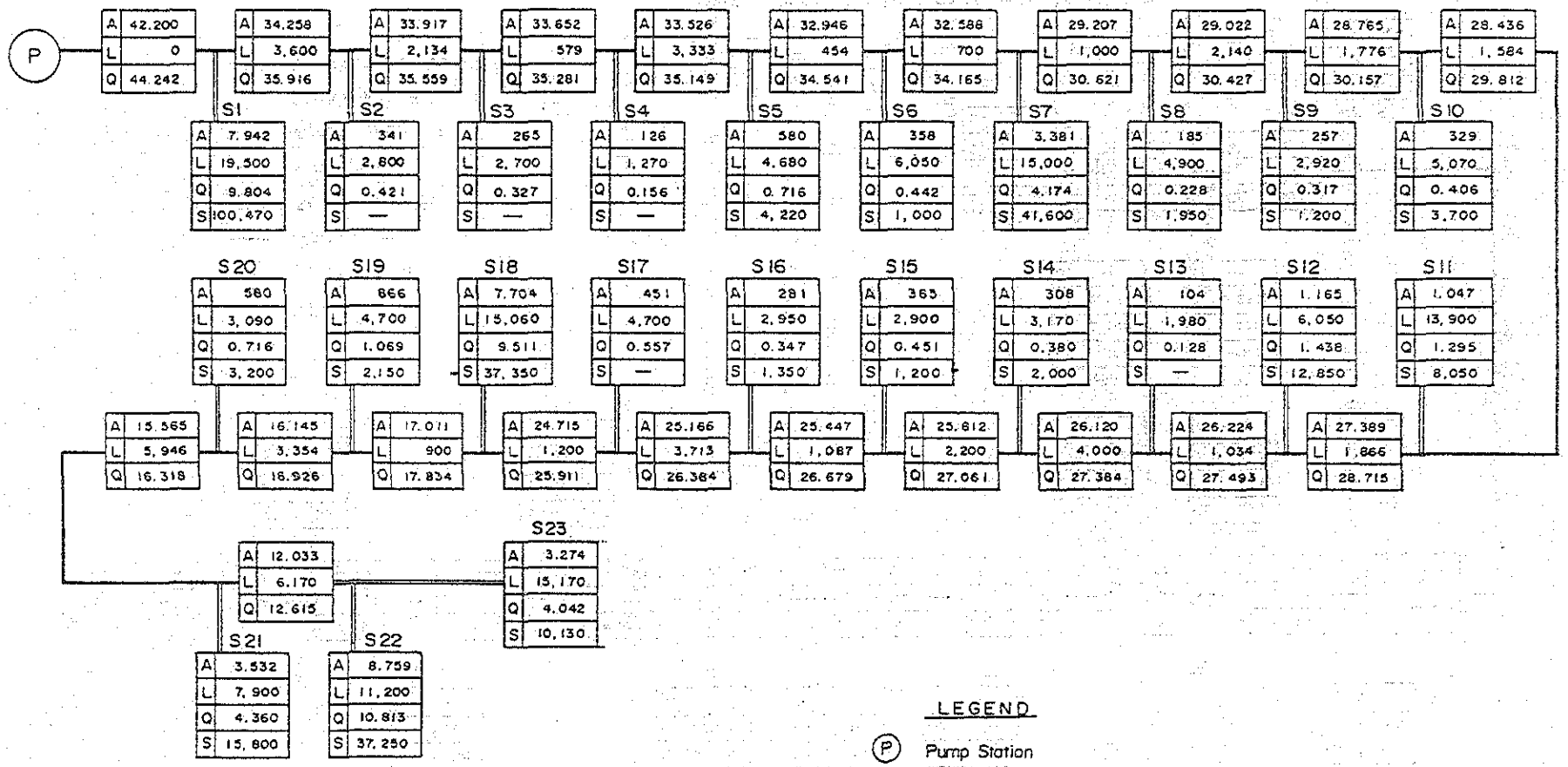


FIGURE 4-5 DIAGRAM OF IRRIGATION SYSTEM NETWORKS
(BARIND AREA)



LEGEND

- (P) Pump Station
- Main Canal
- Secondary Canal
- A Area (ha)
- L Canal Length (m)
- Q Discharge (m^3/s)
- S Sub-Secondary Length (m)

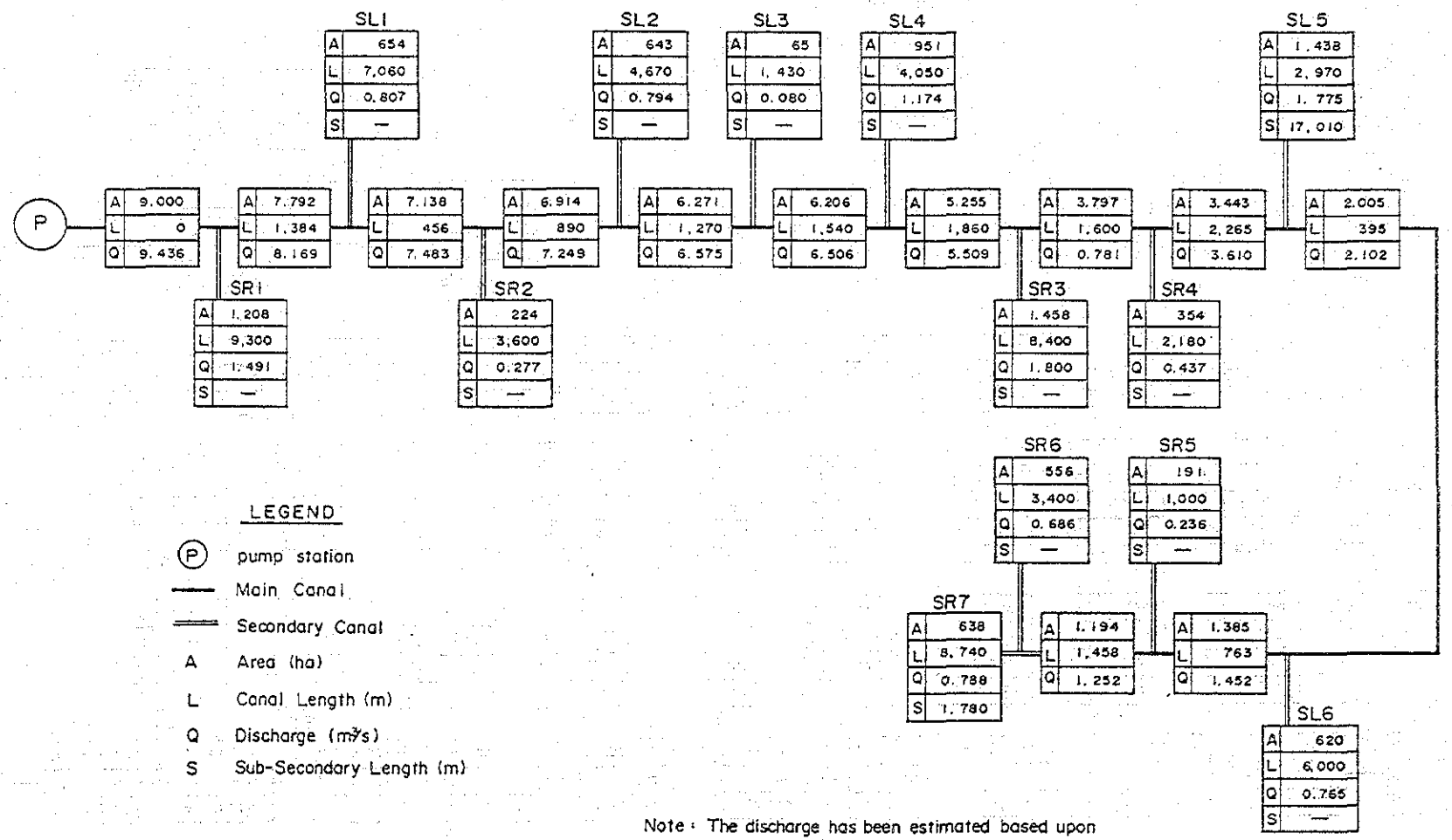
Note : The discharge has been estimated based upon the Unit Water Requirement for ;

Main Canal = 1.0484 L/sec/ha
Secondary Canal = 1.2345 L/sec/ha

FIGURE 4-6

DIAGRAM OF IRRIGATION SYSTEM NETWORKS

(FLOOD PLAIN AREA)



Note : The discharge has been estimated based upon the Unit Water Requirement for ;
Main Canal = 1.0484 L/sec/ha
Secondary Canal = 1.2345 L/sec/ha

For terminal facilities, layout of tertiary canal, farm ditch, farm draina and farm road are considered in accordance with the tropical conditions.

For the implementation, the required facilities for on-farm development should be carried out by farmer's groups except tertiary canal.

(2) Sample Area

Generally, the study or analysis for wider area shall be carried out on the sample area, after that, whole area of the project shall be estimated and evaluated based on the results of study or analysis.

As for sample area, the topographical condition is considered as the most important.

According to the characteristics of the topographic conditions in the Project area, the project area divided into four (4) categories depend on the land slope; namely, Barind Area classified into three types and Paba Flood Plain Area is independent as a flater field. Accordingly, four sample areas have been provided representing four categories.

The location of sample area is shown at attached FIG 3-4.

The characteristics of sample area are summarized in the following table:

Items / Sample Area		Acreage (ha)	Ground Elevation (m)	Land Slope (Appx.)
Barind Hilly Area	A	119	23 - 28	1/50 - 1/100
Barind Slope Area	B	181	22 - 27	1/100 - 1/200
Barind Flat Area	C	191	20 - 21.5	1/500
Flood Plain Area (PABA)	D	138	16 - 17	1/200 - 1/400

(3) Layout of the Terminal Facilities

1) Tertiary Canal

The tertiary canals are aligned across the contour line and located along tenant or lot boundaries so as to irrigate with minimum water surface in the tertiary canal.

The command area of one tertiary canal is planned covering about 50 hectares in average.

2) Farm-ditch

The farm-ditch is located along the contour line so that drop structures will not be necessary. One farm-ditch has been aligned covering approximately 10 hectares in average and the length will be about 500 meters.

In the slope area in the Barind area, a farm-ditch will have a function of farm drain as well as to catch excess water from the upper reaches.

3) Farm Drain

Farm drain will be provided to drain excess water from the paddy field.

The farm drain is located in the lowest area and the end of the farm drain should be connected with existing main drainage channels or rivers.

4) Turn-out and Check Structure

From the view point of irrigation water management, a turn-out will be located at an inlet of a check structure.

The results of lay-out for on-farm facilities are summarized in the following table:

Canal Items / Sample Area		Average Irrigable Area (ha)	Average Canal Length (m)	Canal Slope	Average Irrigable Area (ha)	Average Canal Length (m)	Canal Slope	Average Irrigable Area (ha)	Average Canal Length (m)	Canal Slope
Barind, T. Hilly	A	15	440	1/500	2.4	190	1/500 - 1/1,000	11	430	1/500
Barind, T. Sloped	B	60	750	1/500	7.9	465	1/500 - 1/1,000	21	600	1/500
Barind, T. Flat	C	64	1,130	1/1,000	7.6	434	1/500 - 1/1,000	28	1,000	1/1,300
Flood Plain PABA	D	23	750	1/1,000	11.5	385	1/500 - 1/1,000	17	770	1/1,000

4-5-4. Drainage Plan

(1) Drainage Analysis

1) Rainfall Analysis

The daily maximum, 2-day and 3-day maximum of successive rainfall have been obtained from the areal rainfall from 1977 to 1986 for 10 years.

Based upon the above data, the probability analysis has been made and the probable rainfall for 5-year return-period is selected as the design rainfall for drainage, because the drainage improvement plan in the Barnai Project has adopted the 5-year return-period.

Considering the coverage of a command area of drainage system, the value of the areal rainfall will be used for runoff analysis to decide the design capacity of the main drainage canal and regulator.

To select the observed hourly rainfall, for design purposes, the following criteria have been taken into consideration:

a) The total amount of rainfall should be as much as possible but should not be an abnormal value.

b) The hourly rainfall distribution should not be concentrated within a few hours but distributed for long period, but there should be distinct peak hourly rainfall.

Consequently, the observed hourly rainfall from 8th to 10th September 1986 has been selected as a representative rainfall pattern for design purpose.

The daily total rainfall was distributed in the respective days by the ratio between the observed daily rainfall and the corresponding return-period of rainfall.

2) Runoff Analysis for Drainage

Since there is no observed discharge records in the catchment area, it would not be possible to estimate the runoff based upon empirical method such as unit hydrograph or tank model. These approaches are reliable only when observed records are available for verifications.

In order to solve the problem, an approach utilizing hydraulic equations to compute unsteady flow in open channel which is called Kinematic Wave or Characteristic method was adopted to simulate the overland and channel flows. However, the runoff characteristics from paddy field is somewhat different from that of overland flow because of large retention capacities of paddy field. The retention characteristics of paddy field have to be integrated into the model. This method of runoff analysis is known as the "Compound Characteristics Method".

(2) Present Drainage Conditions

1) Water Level in the Ganges and Sib rivers

The water level fluctuation in the Ganges river at Rajshahi and in the Sib river at Nawhata shows that the water level at Nawhata from October to December becomes higher than the one in the Ganges river. During the post-monsoon period, the water in the Sib river can be drained to the Ganges river -- the inundation period in the flood plain area can be shortened.

According to the topographic map, the elevation of lower portion in the Paba area is approximately 13 meters (43 feet), therefore, it will be possible to shorten the inundation period for about one month.

2) Drainage Networks

The Sib river flows the eastern boundary of the Project area from north to south functioning as a catch of runoff from the Barind tract. The Sib river is confluenced to the Barnai river at Nawhata which flows from east to west. The Joakhali river is confluence to the Barnai river at Nawhata flowing from south to north along the embankment of Karnahar Barabila Polder. Near the Sitlai railway station, the Joakhali river crosses the railway and the Damkura Khal is confluenced to the Joakhali river near the railway crossing point.

The Damkura Khal was connected to the Ganges river at Kasba but at present the outlet of the Khal is silted and closed by deposit.

In the Paba flood plain area, the drainage networks can be divided into two areas. The northern portion in the Karnahar Barabila area drains to the north. It will be required to facilitate a regulator to drain to the Sib river.

In the southern portion of the Paba flood plain area, there are two natural drainage rivers. One is Joakhlai river flows from south to north and confluenced to the Sib river. Another is a natural drainage canal which flows the center of the area from south to north and confluenced at Nawhata to the Sib river or Barnai river.

(3) Drainage Improvement Plan

1) Barind Area

In the Barind area, the river course is rather steep and the river bank is too much eroded. It will be too costly to perofrm river training works such as re-excavation, bank protection and drop structures construction. This area has been neglected from the beneficial area.

The drainage improvement in the on-farm level has been planned. The main river course, however, in the Barind area will not be included. However, the river course improvement works along the Sib river, where the cross-section is not sufficient has been proposed.

2) Paba Flood Plain Area

a) Gravitational Drainage System

During the peak flood in the Ganges river, the water level becomes higher than the inland water level. So there is no possibility to drain to the Ganges river by gravity. However, during pre-monsoon and post-monsoon period, there will be a possibility to drain the Sib river through Joakhali river to the Ganges river through Damkura Khal.

Accordingly, the drainage plan is proposed to connect the Joakhali river at Kasba to the Ganges river site with a regulator.

The capacity of the drainage canal can be decided based on the recorded maximum discharge capacity at Nawhata which is about 160 to 170 cum/sec.

The design capacity of the proposed drainage canal has been decided at 150 cu.m/sec.

b) Drainage by Irrigation Pump at Kasba

The outlet of the drainage canal is located quite near to the proposed Kasba pumping station. During the peak flood time, the Ganges water level is higher than the water level in the Paba area. It will be possible to utilize the Kasba pumping station for drainage purpose.

The capacity of pump, however, is about 10 cum/sec which is rather small capacity for drainage purpose. In order to utilize the capacity of the pump effectively, it is necessary to limit the drainage area to cope with the pump capacity. Two regulators are proposed to limit the drainage area at Nawhata and at the railway crossing point of the Joakhali river near the Sitlai. When the Kasba pump is operated for drainage, these regulators should be closed to reduce the water level as low as possible.

4-6. Development Plan for Supplemental Components

4-6-1. Rural Road Network Development

At present, there is almost no accessible road for a car during the wet season in the Project area, except national road along the Ganges river, from Rajshahi to Chapai Nawabangj via Godagari.

After the implementation of the Project, not only the production of agriculture but also the agricultural inputs for farming practices will be increased for about 3 to 5 times compared with the present one.

Therefore, the existing road conditions in the Project area should be improved to convey the required total amount of farm input material and production.

According to the layout of the proposed irrigation canal, the total length of the main canal and secondary canals are 48.8 km and 157.7 km in the Barind area and 13.9 km and 62.8 km in the Paba area, respectively. These canals are provided with the operation and maintenance road.

In order to keep the accessibility of the road during the rainy season, the surface of the road should be paved by brick.

Based upon the layout of the operation and maintenance road and the existing road networks, link roads between the O & M and existing road have been proposed where the connecting distance is rather short.

At present, the average distance from farm field to the existing road is approximately 6 km in length. However, after the Project the distance will be shortened for about 2 km only.

4-6-2. Inland Fisheries Development

(1) Availability of Return-Flow

By irrigating the Barind area, a return-flow of irrigation water will flow into the Sib river. In the northern portion of the Sib river, several large-sized Beels are located which are dried up at present during the dry season. After the Project implementation, however, these Beels will have enough water even in the dry season due to the return-flow. It is expected that 20% to 40% of the irrigation water which is about 8 m^3/sec to 16 m^3/sec of return-flow will be available in the Sib river taking into consideration the capacity of the pumps at about 40.0 m^3/sec. This amount corresponds to 0.7 to 1.38 MCM per day capacity which will be used as supplemental water supply for fish ponds.

Fish ponds will be developed at the right bank of the Sib river where water depth is about 1 to 1.5 meters. There are a few thousands of ponds or tanks in the Project area. These ponds or tanks are mainly used for fish culture, village water supply and irrigation water supply. During the dry season, the water in the ponds will be dried up due to evaporation and seepage loss.

Fresh water will be able to supply to these ponds and tanks throughout the year from the proposed irrigation canals. The production of fish in these ponds can be easily increased.

Accordingly, there will be two ways of fish culture in the Project area. One is in the Sib river and beels and another is in ponds and tanks in the Project area.

(2) Catch Fish in the Beels

Along the Sib river, water can be available throughout the year. The natural sporing area of fish will be generated and the production of catch fish will automatically be increased in the Sib river and existing beels located along the river.

(3) Fish Pond Culture

Fish ponds located in the Project area, whether the ponds belong to private or government, can intake the irrigation water for fish culture. Fingerling and feeding supply in the pond will be required to increase the productivity.

4-6-3. Rural Water Supply

It is rather difficult to obtain the village water during the dry season due to highland of Barind area. There are many small ponds in the Project area which can be used as village water. The water quality and amount of the existing ponds are not sufficient for the rural people.

The irrigation water can be utilized for village water supply leading by small canal from the proposed irrigation canal to the existing ponds in the residential area. The required capacity of the village water supply will be about 0.5 m^3/sec which was estimated based on the 50 l/day per capita for the consumption and population of 800,000.

The capacity of 0.5 m^3/sec is only 1.2% of the irrigation requirement and can be supplied within the loss of irrigation water.

CHAPTER 5
FACILITY PLANNING

CHAPTER 5. FACILITY PLANNING

5-1. Design of Pumping Station

5-1-1. Main Features of Pumping Stations

(1) Basic Dimensions for Design

Design capacity of the pumps has been decided considering the water requirement and the water level of the Ganges river at the proposed pump sites, as shown below:

Pumping Station	Baraipara, P.S	Kasba P.S
Maximum Water Requirement	44.242 m^3/s	9.436 m^3/s
Design Pump Capacity	42.588 "	8.247 "
Design Water Level		
Low Water Level	8.686 m	7.860 m (Ganges R.)
High Water Level	21.826 m	20.325 m (Ganges R.)
Delivery Water Level	30.500 m	19.800 m

The design capacity of the pumps has been decided based on the maximum water demand during the dry season, because the capacity can cover the maximum demand during the wet season due to the high water level in the river.

(2) Type of Pumping Station

As previously mentioned, the fixed with vertical mixed flow type of pump equipment has been selected for both Kasba and Baraipara sites.

(3) Diameter and Number of Pumps

In order to maximize the efficiency of pump operation and to minimize the operation and maintenance cost, the size and number of units of pump equipment have been carefully selected. Combinations of

the size and the required units of pump equipment have been carefully examined taking into consideration the seasonal fluctuation of irrigation water demand.

The following combinations of pump equipment have been considered:

Case I	1/3 of maximum demand
Case II	1/4 of maximum demand
Case III	1/5 of maximum demand

Based on the said combinations, the cost for pump facilities and operation and maintenance costs have been estimated. The following size and number of the units of pump equipment are selected:

Baraipara P.S	ø1,650 mm x 4 unit
	ø1,350 mm x 4 unit
Kasba P.S	ø1,350 mm x 1 unit
	ø1,000 mm x 2 unit

A stand-by pump will not be provided because maintenance of the pumps can be done during non-irrigation period from October to December.

(4) Specific Dimension of Pumps

The proposed specific dimensions for both sites are shown in the following table:

Station / Items	Baraipara, P.S		Kasba, P.S	
Pump Facilities	Vertical Mixed Flow		Vertical Mixed Flow	
Capacity (m^3/s)	399	240	247	124
Diameter (mm)	1,650	1,350	1,350	1,000
Max. Actual Head (m)	22.0	22.0	12.0	12.0
Max. Total Head (m)	27.0	27.0	13.0	13.0
Power Source	Electric Motor		Electric Motor	
Output (kw)	2,390	1,460	720	370
Number of Pump	4	4	1	2
Max. Discharge	415	250	283	142
W.L of Suction Pipe (m)	8.5		7.70	
W.L of Delivery Pipe (m)	30.50		19.80	

Note: The variation of actual head is 9.0 m in average year.
The characteristic curve of pump equipment are attached in Appendix VIII.

5-1-2. Design of Pumping Station

(1) Design of Intake Canal

On the basis of the grain size analysis of suspended materials in the Ganges river, the velocity and length of the intake canal have been decided for a function of desilting basin located in front of the pumping station.

Items	Baraipara	Kasba	Remarks
- Pump Capacity	42.588 m^3/s	8.247 m^3/s	The water depth is decided based on water level in dry season.
- Depth of Water in the Canal	2.10 m	1.50 m	
- Velocity of Discharge	0.20 m	0.20 m	
- Length of Basin	300 m	200 m	
- Width of Basin	100 m	30 m	

(2) Height of Sill at Inlet Structure and Height of Bottom at Suction Tank

The height of the sill is decided on the basis of the velocity at inlet and it is found to be 0.5 m per second. On the other hand, the height of the bottom of the suction tank is decided considering the screen loss and the submerged depth of the pumps.

The details are shown in the following table:

	Baraipara, P.S	Kasba, P.S
Design Discharge	42.588 m^3/s	8.247 m^3/s
Lowest Water level	8.686 m	7.860 m
Width of Inlet (B)	40.20 m	11.20 m
Water Depth (H)	2.10 m	1.50 m
Height of Sill	6.50 m	6.30 m
Screen Loss	0.10 m	0.10 m
Water level of Suction Side	8.50 m	7.70 m
Submerged Depth of Pumps	4.40 m	3.70 m
Elevation of Bottom at Suction Pump	4.10 m	4.00 m

(3) Scale of Pump House

Taking into consideration the following factors, the sizes of the pump houses are decided as shown below.

- Diameter of the pumps
- Size of power equipment
- Distribution of the valves and pipes
- Scale of overhead travelling crane

	Width (m)	Length (m)	Height (m)
Baraipara, P.S	16.50	54.00	13.0
Kasba, P.S	14.70	23.60	12.0

(4) Foundation Treatment and River Bank Protection

1) Foundation Structures

According to the test boring data of the proposed pumps site, the shallow layer is covered with very hard clay, and deep layer consists of sand with high degree of consolidation.

From the result of the standard penetration test, the N-value at an elevation of -3.0 m or -4.0 m could be expected more than 30, so that this layer should be the bearing zone to support the foundation of the pumping station. The concrete piles for foundation treatment have been applied for the proposed pumping station sites.

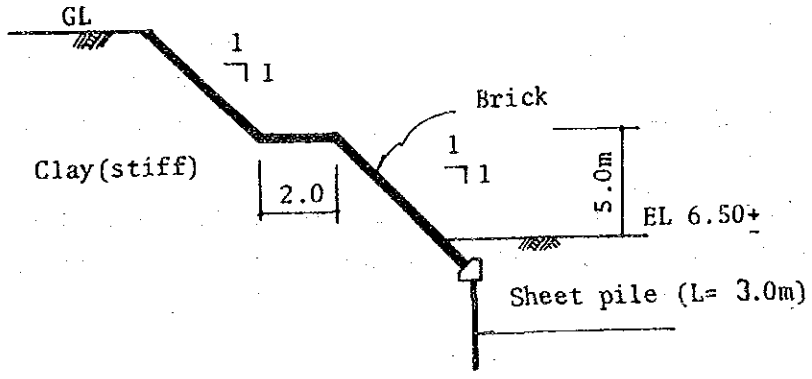
The bearing capacity of the pile shall be estimated by the following formula.

$$Ra = 1/3 \{30\ NAP + \left(\frac{NsLs}{5} + \frac{NcLc}{2}\right) \phi \}$$

2) Protection of River Bank Erosion

The flood protection structure is required to install for the protection of the erosion of river bank at the conjunction of the Ganges River and intake canal.

A typical section of the structure is shown as follows:



(5) Design of Discharge Pond

Discharge Pond should be connected with the main canal directly, therefore, the lay-out will be carried out based on the following:

- Flow velocity in the pond should be kept within 0.5 m/sec.
- Outlet of the pipeline should be located as it can protect the wave.
- Sedimentation in the pond is also considered.

Under these considerations, the dimensions of the structure are decided as follows:

	Baraipara, P.S (m)	Kasba, P.S (m)
Width of Discharge Pond	45.0	15.0
Length of Discharge Pond	8.0	50.0
Depth of Discharge Pond	3.3	2.8

(6) Dual Purpose Pumps for Irrigation and Drainage at Kasba Pumping Station

It has been proposed to review the possibility of dual-purpose pumps for irrigation and drainage at Kasba Pumping Station. Considerable terms for drainage plan at Kasba Pumping Station are shown below.

- Inside water level 13.70 m
- Outside water level 20.325 m
- Actual Head 6.700 m
- Total Head 7.700 m

Considering the above conditions, the capability of the pump has been evaluated based on the characteristic curve of the proposed pump equipment.

As a result of the evaluation, it is found that the control of the discharge valves is necessary to avoid cavitation. The total capacity of the pumps is about 10.0 m^3/sec, as computed below:

ø1,000 mm Q = 320 m^3/m = 5.4 m^3/s
ø1,350 mm Q = 300 m^3/s = 5.0 m^3/s

As for application of the dual-purpose pumps, regulators will be required at the proposed sites.

5-2. Irrigation and Drainage

5-2-1. Irrigation Canals

(1) Canal Lining and Design

Canal would be of excavation-without timbering type and unlined.

The proposed cross sections would be obtained from cutting or embanking.

The slope of the canal would be 1 in 7,000 to 1 in 5,000 due to the topographic condition of the project area.

The maximum allowable velocity in the canal would be about 0.7 m/s.

Standard cross section has been designed as a trapezoid.

(2) Hydraulic Depth

Standard hydraulic depth of irrigation canal usually ranges from 1.5 m - 2.0 m.

The water depth of the main and secondary canals have been proposed as following:

Discharge m^3/s	H : B
Q - 1.0	1:2
1.0 - 5.0	1:3
5.0 - 10.0	1:4
10.0 - 50.0	1:5

(3) Freeboard

The freeboard may be taken as one quarter of the water depth plus 0.3 meter with a maximum limit of 1.0.

(4) Inside Slope

Based on the results of soil mechanical tests of the samples collected along the canal routes, inside slopes have been tentatively determined as follows:

Main Canal	1 : 1.5
Secondary Canal	1 : 1.5

(5) Bank Width

Width of the main canal banks would be 4.5 m for O & M road side and 1.5 m on the other side.

The bank width of secondary canals would be 3.5 m on O & M side and 1.5 m on the other side.

(6) Flow Formula

The following Manning's formula is used in the Bangladesh design standard:

$$Q = A \cdot V$$

$$V = 1/n \cdot R^{2/3} \cdot S^{1/2}$$

where, Q: design discharge (m^3/s)
V: mean velocity of flow (m/sec)
R: hydraulic mean radius (m)
S: canal slope
n: coefficient of roughness 0.030

(7) Standard Cross-Section

As for the standard cross-section eight types are proposed for the main canals and 13 types for the secondary canals, as follows:

Barind Main Canal	4 types
Flood Plain Main Canal	4 types
Secondary Canal and Sub-secondary Canal ...	13 types

5-2-2. Appurtenant Structures

(1) Bifurcation Structures

The bifurcation structures are designed in accordance with diversion water capacities of the supply canals.

(2) Measurement Structures

Almost all of the bifurcation structures have gate (head gate) and water level gauge, therefore, diversion of water could be measured. However, at the leading points of secondary canals (diversion of water below 1.0 m^3/s) double orifice gates are installed.

(3) Check Structures

Check structures are required to control and raise the water level in the main canal so that the required flow can be diverted to the branch canal through one or more head gates or turnouts.

Two check structures have been proposed for Barind main canal and one for Flood Plain main canal.

(4) Drop Structure

A drop structure will be constructed to maintain the design slope of the canal. The vertical drop is a simple structure for small discharge, but not for a large discharge and drop. Therefore, for main canals, the chute type structure will be adopted.

(5) Wasteway and Spillway

In principle, when a cross-section of a canal is changed a wasteway should be planned. The wasteway incorporates a spillway to drain overflow water automatically.

(6) Crossing Facilities of Rivers

An inverted siphon is planned for drainage canals in consideration of the relationship between water level in the canal and probable water level in crossing the drainage canal, and in comparison of the flow amount in the irrigation canal and estimated flood in the drainage canal.

When flood drainage is larger than the flow amount in the irrigation canal, irrigation siphons shall be installed for economical reason. When a small drainage canal crosses an irrigation canal, a drainage culvert or drainage culvert pipes are proposed.

(7) Road Crossing Facilities

A bridge is planned where the irrigation canal crosses the existing road. As shown in DRAWINGS the general structural design of the bridges to be constructed is of a concrete slab type.

(8) Over Chute

When drainage flow is relatively small, an overchute to convey drainage water over the irrigation canal is planned rather than a drainage culvert from economic viewpoint.

5-2-3. Regulators

Five regulators have been proposed for drainage improvement in the Flood Plain area.

The size and location of each regulator is presented below:

Regulator	Location	Vent Size and No. of Vents	Type
No.1	Junction of D2 canal and Sib river	3.0m x 5.0m x 10	A1
No.2	Junction of D3 canal and Ganges river	3.0m x 3.0m x 10	A2
No.3	Toakhari river	3.0m x 5.0m x 10	A1
No.4	D1 canal	1.5m x 2.0m x 2	B
No.5	D4 canal	1.5m x 2.0m x 1	B

5-2-4. Drainage Canals

(1) Canal Lining and Design

Re-excavation of existing river courses are proposed to improve the drainage condition. Typical cross-section of a drainage canal is composed of a low water discharge area and a high water discharge area, therefore, cross section is planned as complex sections.

The gradient of canal would be 1 in 10,000 and the maximum and minimum flow velocities at design discharge would be taken as 0.7 m/s and 0.3 m/s, respectively.

(2) Inside Slope

On the basis of the results of soil tests of the samples collected along the canal routes, inside slopes have been determined as 1 in 1.5.

5-2-5. Terminal Facilities

According to the study of sample area, tertiary canals farm ditch and farm drain for the on-farm development are summarized in the following table.

Items		Tertiary C.		Farm-Ditch		Farm-Drain	
Type / Area		Canal Densities (m/h)	Total Length (km)	Canal Densities (m/h)	Total Length (km)	Canal Densities (m/h)	Total Length (km)
Barind Tract Hilly Area	A	30	262.1	78	681.3	40	349.4
Barind Tract Slope Area	B	13	230.4	59	1,045.7	31	549.4
Barind Tract Flat Area	C	18	283.3	57	897.2	36	566.7
Flood Plain (PABA)	D	32	288.0	33	297.0	44	396.0
Total			1,063.8		2,921.2		1,861.5

In this case, canal capacity is decided on the basis of the following criteria:

-	Tertiary Canal	1.55 lit/sec/ha
-	Farm Ditch	1.55 lit/sec/ha
-	Farm Drain	8 lit/sec/ha

Each type is a representative of the following acreages:

A Type	20.7%	8,735 ha
B Type	42.0%	17,724 "
C Type	37.3%	15,741 "
Sub-total	100%	42,220 "
D Type	100%	9,000 "

5-3. Road Networks

Development plan of rural road networks in the project area, which composed of O & M roads along the main canal and secondary canal have been connected with the existing roads.

The length of O & M roads and link roads are as follows:

(unit: km)

	Length of O/M road	Length of Link of road	Total
Main Canal	62.7	-	62.7
Secondary Canal	220.5	4.4	244.9
Total	283.2	4.4	287.6

5-4. Agricultural Supporting Facilities

5-4-1. General

In the Barind area agricultural extension or research activities are not properly made. So it is necessary to strengthen the farming practises or selection of crops, water management and so forth.

For this purpose a pilot farm is proposed to be constructed near Godagari to promote agricultural extension services.

5-4-2. Agricultural Supporting Facilities

(1) Pilot Farm

A pilot farm covering about 5 ha will be constructed for the following purposes:

1) Research on suitable rice or field crops for the Barind area.
2) Research on the farming system for each crop.
3) Training of agricultural extension staffs.
4) Practice of agricultural extension.

(2) Required Facilities

1) Research Institute
   (office, training room, extension office)
2) Research Equipment
3) Accommodation
4) Pilot Farm
5) Vehicle for Extension
6) Motorcycle for Extension
7) Communication System

CHAPTER 6
ORGANIZATION AND MANAGEMENT

CHAPTER 6. ORGANIZATION AND MANAGEMENT

6-1. Project Implementation

6-1-1. Executing Agency of the Project

The principal implementation agency for the project execution will be the Bangladesh Water Development Board (BWDB). Under the Ministry of Irrigation Water Development and Flood Control, the BWDB will be responsible for planning and implementing new water development projects as well as for operation and maintenance of the completed projects.

BWDB has five members each in the Departments of Planning, Administration, Finance, Implementation and O and M, under the supervision of the chairman. At present 62 projects are being implemented under the four project offices, while 339 projects are operated and maintained under the nine O/M offices in the country.

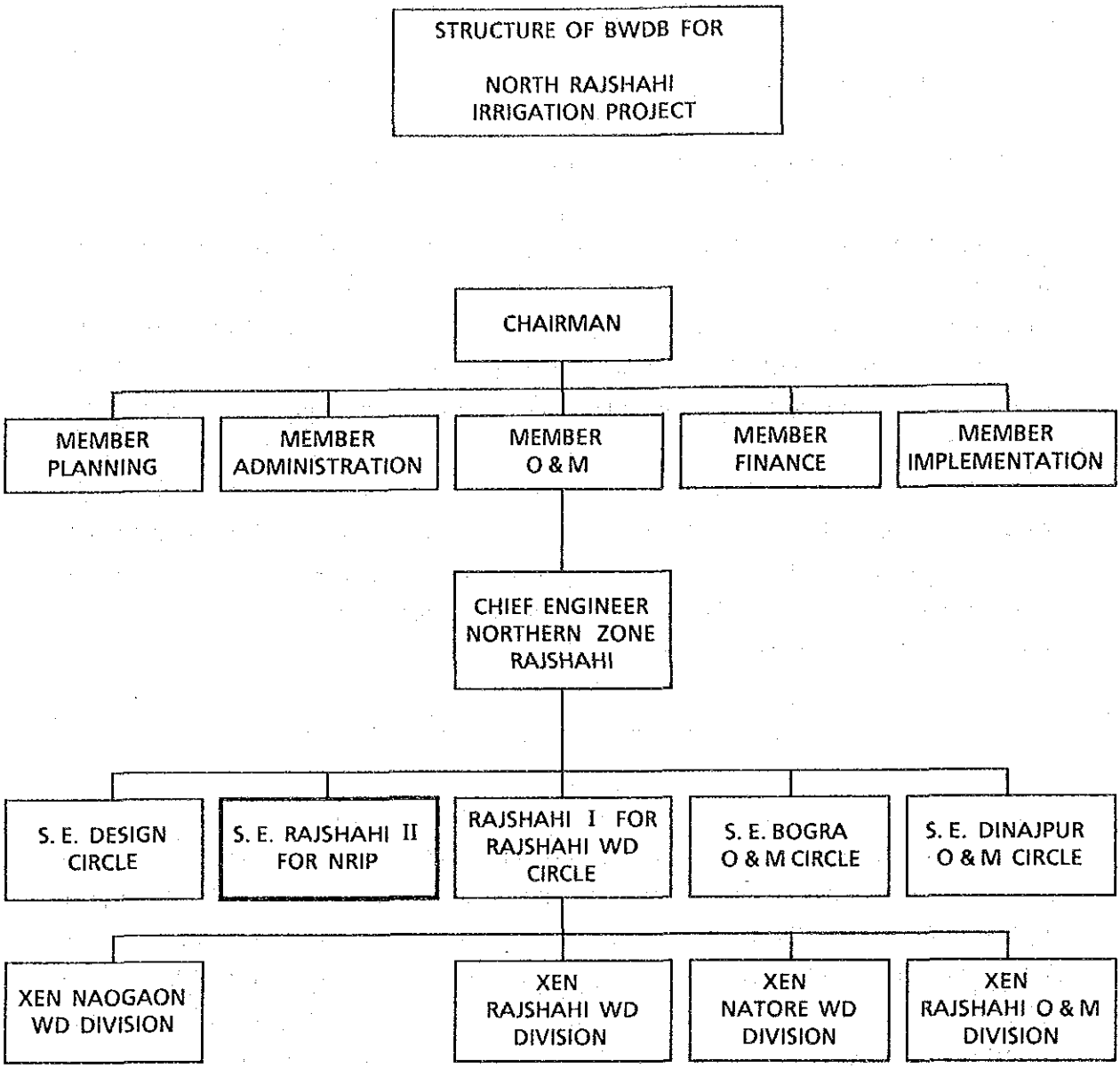
The present organization of BWDB is shown in Figure IX-1-1 and IX-1-2 of Appendix IX.

The North Rajshahi Irrigation Project (NRIP) will be implemented by Rajshahi Water Development Circle under the supervision of the Chief Engineer Northern Zone, Rajshahi. As shown in Figure 6-1 and Figure 6-2, the superintending engineer's office for NRIP will be newly established under the Chief Engineer Northern Zone, Rajshahi and three executive engineers (two for civil, one for mechanical) will be recruited under the superintending engineer.

6-1-2. Financing

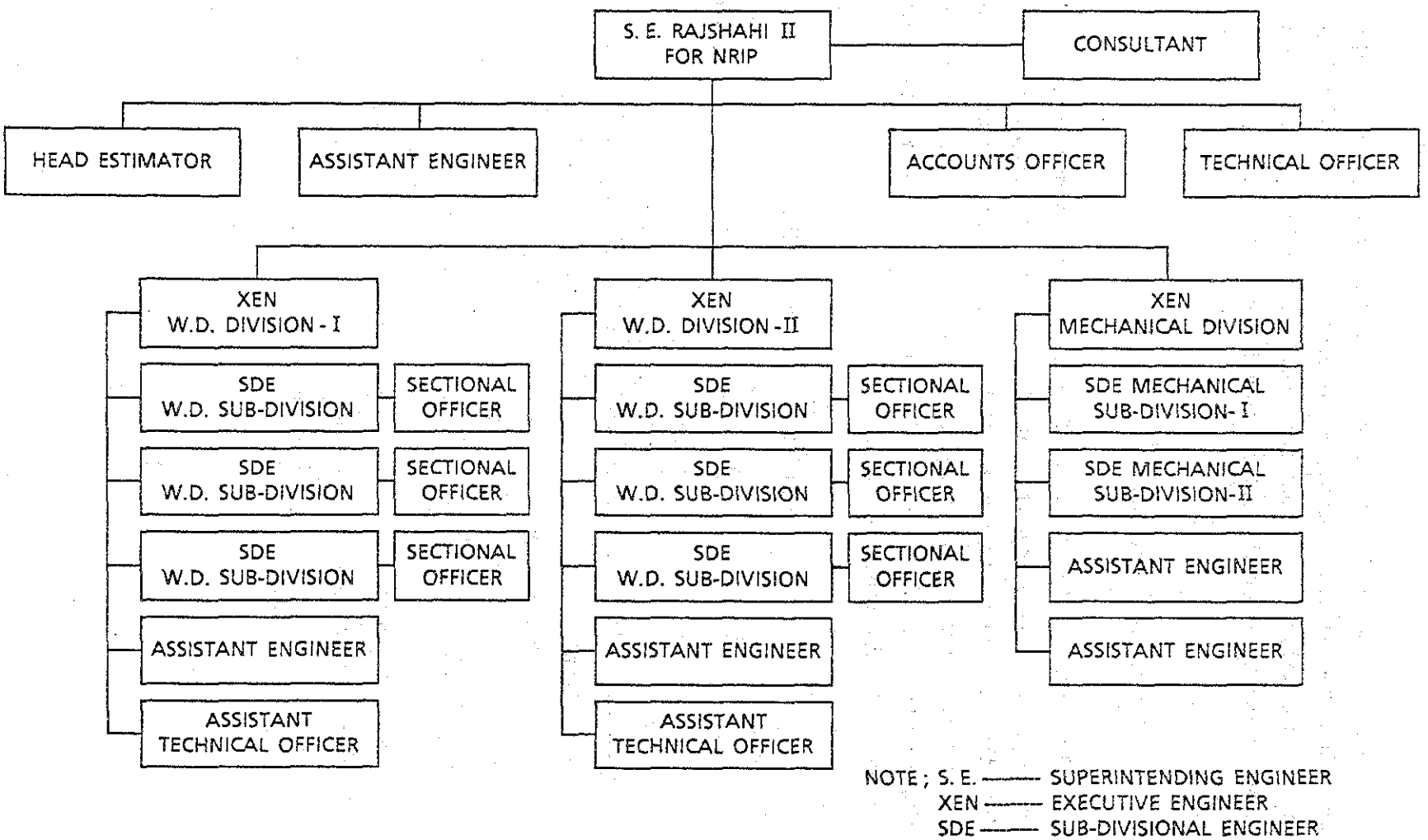
A certain portion of the total project cost will be financed by international financing agencies and the Bangladesh Government.

FIGURE 6-1



NOTE ; S. E. --------- SUPERINTENDING ENGINEER
XEN -------- EXECUTIVE ENGINEER
SDE --------- SUB-DIVISIONAL ENGINEER

FIGURE 6-2 PROPOSED ORGANIZATION CHART OF IMPLEMENTATION FOR THE NORTH RAJSHAHI IRRIGATION PROJECT



6-1-3. Construction Mode

A qualified contractor for the civil works of the project will be selected under local competitive bidding. On the other hand, a qualified contractor will be selected for the supply of construction machines and pump equipment under the international competitive bidding.

6-1-4. Consulting Services

The Engineering staff of the project agency should have the capability to carry out the detailed design and construction supervision for the ordinary structure of the project facilities. However, the consulting services are required for the specific items to assist the engineering staff. The total man-month of consulting services is estimated in the table below.

Man-month of Consultants

(Unit: Man-month)

Item	Detailed Design	Construction Supervision	Total
Consultant			
- Foreign Expert	84	245	329
- Local Expert	118	-	118
Total	202	245	447

The breakdown of consulting service is summarized in Table X-5-15 of Appendix X.

6-1-5. Land Acquisition

Land acquisition for the pumping stations and along the canal alignment will be undertaken by the project executing agency before the start of construction works. The details of land acquisition is shown in Table X-4-16 of Appendix X.

6-1-6. Coordinating Committee

The Ministry of Agriculture, the Ministry of Forest, Livestock and Fisheries, the Ministry of Land Administration, Local Government, Rural Development and Cooperatives will be responsible for agricultural extension and research, fisheries development, marketing and credit. The Power Development Board will be in charge of supplying electricity to the pumping station, while the Bangladesh Telephone and Telecommunication Board will provide communication system.

Since various ministries or organizations will be involved in this project, it is recommended that a Coordinating Committee be organized for proper implementation of the project in both central and local levels.

The Central Committee will mainly coordinate the activities of the organization concerned to formulate appropriate schemes and advise on the program activities. The local committee, will coordinate the activities of various local organizations such as local agencies, local government's research units and farmers' associations in order to promote on-farm development and water management.

The proposed Central and Local Coordinating Committees are shown in Figure IX-1-5 and Figure IX-1-6, respectively.

6-2. Implementation Schedule

6-2-1. Detailed Design and Pre-Construction Stage

Detailed design of the project will take at least one year including topographical survey and geological survey. The loan procedure and tendering will also take one year.

6-2-2. Construction Stage

(1) The climatological condition in the project area limits earthworks to be carried out during the wet season from June to October. It is necessary to dewater the construction site after the rainy season from July to September.

The construction works will start with drainage facilities in the Flood Plain area, and proceed to irrigation canal, pumping station. The construction works in the Barind area will commence one year after the Flood Plain area starts.

(2) Earthworks for pumping stations and major structures such as regulator, main bridge and culverts will be carried out by construction machines so as to shorten the construction period.

(3) Earthworks for irrigation canal, drainage and minor structures will be carried out by man-power so as to promote employment opportunity in the project area.

(4) Land acquisition will be performed at earlier stage before the construction works start.

6-2-3. Implementation Schedule

According to the Project Implementation Schedule, the Project implementation will start within two and a half years after the completion of the Feasibility study taking into consideration the loan procedures, detailed design and tendering.

The construction of major works will take about six years. On-farm works will also be carried out in parallel with the major works to supply irrigation water as early stage as possible. The implementation program is shown in Figure 6-3.

FIGURE 6-3 The Project Implementation Schedule

	1st Year			2nd Year			3rd Year			4th Year			5th Year			6th Year			7th Year		
	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III
I. Detailed Design																					
II. Tendering																					
III. Loan Procedure																					
IV. Construction																					
1. Land Acquisition																					
2. Procurement of Equipment																					
3. Preparation Works																					
4. Flood Plain Area																					
a. Pumping Station																					
b. Irrigation Canal																					
c. Irrigation Facilities																					
d. Drainage Facilities																					
e. Road and Bridge																					
f. On-farm																					
g. Transmission Line																					
h. Telephone Line																					
5. Barind Area																					
a. Pumping Station																					
b. Irrigation Canal																					
c. Irrigation Facilities																					
d. Road and Bridge																					
e. On-farm																					
f. Transmission Line																					
g. Telephone Line																					
6. Agricultural Extension																					
V. Consulting Service																					

6-3. Organization for Operation and Maintenance

6-3-1. Operation and Maintenance Works

Operation and maintenance works are comprised of the following items:

(1) Pumping Station
- Civil works
- Mechanical and Electrical Works
- Operation of Pumps
- Dredging

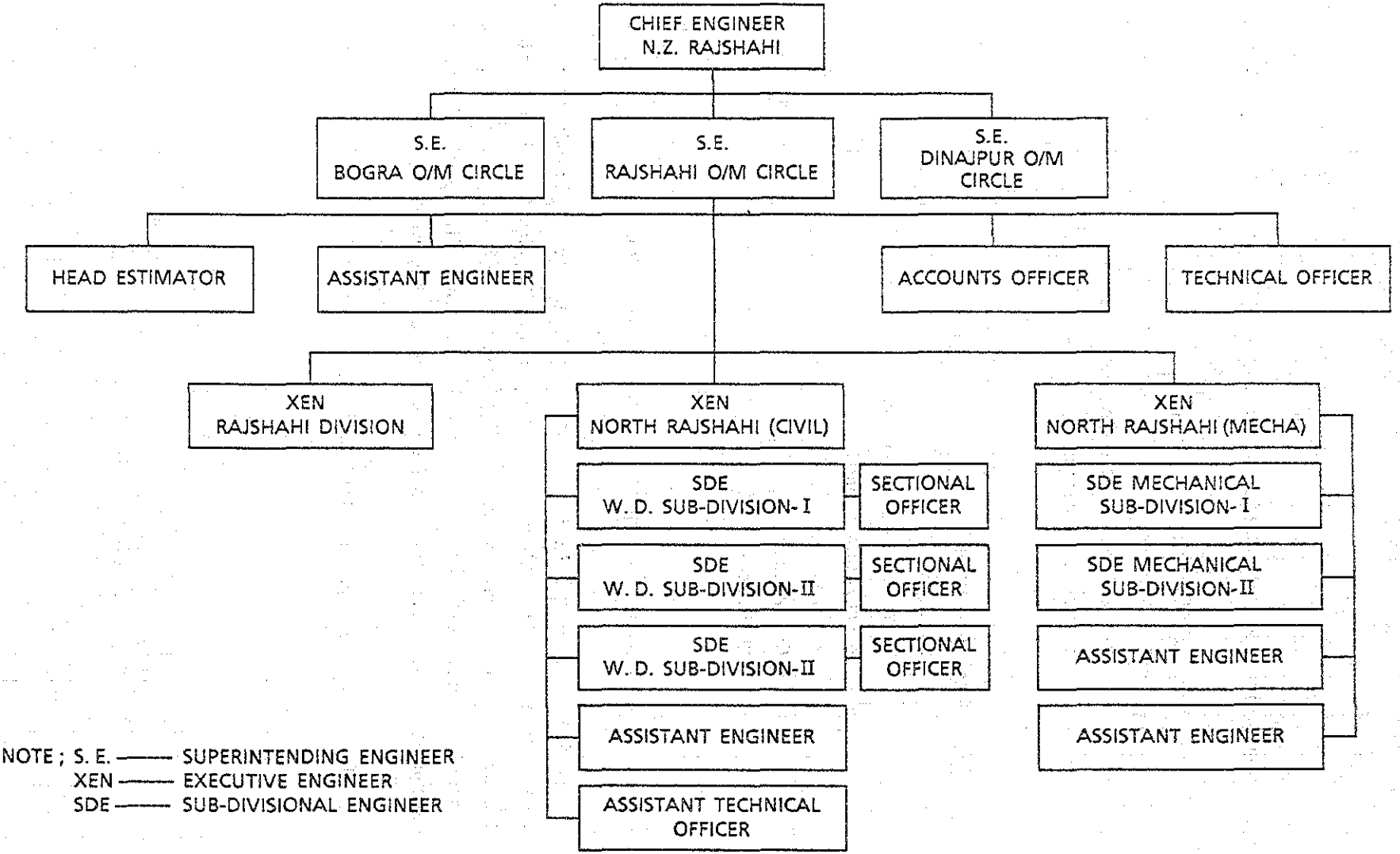
(2) Canal and Road
- On-farm
- Main and Secondary Canal
- Embankment (Road)
- Bifurcation
- Check Gate
- Regulator

6-3-2. Organization for Operation and Maintenance

After the completion of the project, the jurisdiction will be transferred to the Chief Engineer N.Z. Rajshahi. Under the Chief Engineer, the Superintending Engineer's office consisting of two executive engineers (one for civil, another for mechanical) will be responsible for operation and maintenance of the project.

The proposed organization chart is shown in Figure 6-4.

FIGURE 6-4 PROPOSED ORGANIZATION CHART OF OPERATION AND MAINTENANCE FOR THE PROJECT



NOTE ; S. E. —— SUPERINTENDING ENGINEER
XEN —— EXECUTIVE ENGINEER
SDE —— SUB-DIVISIONAL ENGINEER

6-4. Irrigators' Association

Farmers who would benefit from this Project shall construct farm ditches which divert irrigation water from tertiary canals into on-farm.

Efficient and economic distribution of irrigation water by this Project would not be obtained until construction of farm ditches are appropriately implemented. Moreover, inadequate operation and maintenance of water system of this irrigation equipment (main facilities to farm ditches with on-farm) after completion of the construction phase will greatly undermine the effectiveness of this Project and may even lead to the occurrence of calamities.

Though an irrigators' association requires organizational capability and potential funds which can construct farm ditches appropriately, control irrigation water efficiently and use them economically, there are no more excellent farmers' association than UCCA-KSS/BSS/MBSS system which has been carrying out various economic activities and supplying the funds for these activities as mentioned in 4-1 of Chapter 4. UCCA-KSS/BSS/MBSS systems are able to perform the function of an irrigators' association in combination with BWDB through farming Irrigation Management Committee among themselves as well as collecting irrigation water fees which the Government would intensify recovery of operation and maintenance costs from beneficiaries of publicly-funded gravity irrigation systems who are supplied with irrigation water at low service rates.

According to irrigation development plan, a water users' group at lowest level will consist of one group which is supplied with irrigation water by one farm ditch with an area of approximately 10 ha which has tertiary outlet, covering about 10 farmers. Five water users' groups at farm ditch level will form that of one tertiary level with an area of approximately 50 ha with turn-out of lateral canal, which corresponds to about 50 farmers. Ten water users' groups at tertiary level form that of one lateral canal level with an area of approximately 500 ha, covering 500 farmers. An irrigators' association units will be composed of these ten

water users' groups at one lateral canal level and/or a small command area under the main canal with an area of approximately 500 ha, which corresponds to about 500 farmers.

These irrigators' association units combine would be combined forming an allied association under main canal system and/or an administrative area of Upazila. This allied association would form a federated irrigations' association under NRIP, which is a federate system at function level.

In order to achieve the target of the Project, the Irrigation Management Committee of UCCA-KSS/BSS/MBSS system, which is originally a federate organization at administrative level, can fulfill a function as an irrigation organization, and federate system at function level by using irrigation water systematically, efficiently and economically.

The UCCA-KSS/BSS/MBSS system which has been playing an important role to promote farmers' agricultural and non-agricultural economic activities on the whole and has funding, organizing, planning and implementing abilities to be able to support farmers, must conduct water management and recover water charge rate of NRIP in collaboration with BWDB, while BWDB must provide training programs in order to make them fully understand water management.

CHAPTER 7
PROJECT COST

CHAPTER 7. PROJECT COST

7-1. General

7-1-1. Condition of Cost Estimation

The project cost is estimated under the following conditions.

1) The project cost is estimated on the basis of the market price as of December, 1987.

2) The construction works would be done on contract basis. Civil works are done on the local contract basis, mechanical and electrical works in the pumping station are done on the foreign contract basis.

3) All the construction machineries are procured by BWDB and lent to the contractor. So only maintenance and operation cost of the machinery are included in the estimated construction cost.

4) The project cost consists of construction cost, associated cost, physical and price contingency.

5) The exchange rate between Bangladeshi Taka and US dollar has been adopted at US$1.00 = Taka 33.0 for economic analysis and the official rate of US$1.00 = Taka 31.5 for financial basis.

6) The physical contingency related to the construction and associated costs is set at 15 percent.

7) The price escalation rate is predicted at 2.3% for foreign currency and 8.0% for local currency.

7-1-2. Construction Cost

(1) Unit Price of Material and Labour

The unit price of material, and labour is mainly based on "the Schedule of Rate for Rajshahi Circle 1986", "the Schedule of Rate for Pabna Project 1987" and current market price. Detailed unit price is shown in Table X-1-1 and Table X-1-2 of Appendix X.

(2) Unit Price of Civil Works

The unit price of civil works is mainly based on "the Schedule of Rate for Rajshahi Circle 1986". Those that are not available in the schedule are calculated by adding up all the necessary materials, labours, operation and maintenance cost for machines and overhead. Detailed unit price is shown in Table X-1-3 of Appendix X.

(3) Construction Cost Component

Construction cost consists of the following construction works.

1) Pumping Station
2) Irrigation Canal
3) Irrigation Facilities
4) Drainage Facilities
5) Road and Bridge
6) On-farm
7) Transmission Line
8) Telephone Line

The breakdown of each construction work is shown in Table X-4-1 to Table X-4-10 of Appendix X.

7-1-3. Associated Cost

Associated cost is composed of construction machinery, Agricultural supporting facilities, Land acquisition, consulting service and project administration cost.

The breakdown of each item is shown in Table X-4-11 to Table X-4-17.

7-2. Project Cost

7-2-1. Cost Estimation

The project cost is estimated at about 4,983 million Taka, including foreign currency component of 2,358 Taka, local currency of 1,818 Taka, and import tax of 807 million Taka, as shown in Table 7-1.

The summary of the project cost is shown from Tables X-3-1 to X-3-14 of Appendix X.

TABLE 7-1. PROJECT COST

(Unit: '000 Taka)

Item	F/C	L/C	Tax	Total
1. Construction Cost				
a. Pumping Station	1,402,887	183,039	572,036	2,157,962
b. Irrigation Canal	36,082	235,875	-	271,957
c. Irrigation Facilities	54,898	57,328	-	112,226
d. Drainage Facilities	89,810	114,165	-	203,975
e. Road and Bridge	14,118	222,723	-	236,841
f. On-farm	-	70,663	-	70,663
g. Transmission Line	46,705	6,765	23,352	76,822
h. Telephone Line	240	960	-	1,200
Sub-total	1,644,740	891,518	595,388	3,131,646
	(53%)	(28%)	(19%)	
2. Associated Cost				
a. Construction Machinery	102,363	5,473	51,402	159,238
b. Agricultural Supporting Facilities	11,900	12,190	5,400	29,490
c. Land Acquisition	-	222,875	-	222,875
d. Consulting Service	190,938	38,016	-	228,954
e. Project Administration	4,332	74,642	2,166	81,140
Sub-total	309,533	353,196	58,968	721,697
Total (1 + 2)	1,954,273	1,244,714	654,356	3,853,343
3. Physical Contingency	256,623	170,500	98,153	525,276
4. Price Escalation	140,312	407,903	56,307	604,522
Grand Total	2,351,208	1,823,117	808,816	4,983,141

7-2-2. Annual Disbursement Schedule

The annual disbursement schedule of the project is based on the project implementation schedule, and the summary is presented as follows.

Annual Disbursement Schedule

(Unit: million Taka)

Year	Foreign Currency	Local Currency	Tax	Total
1st	63.9	10.1	-	74.0
2nd	91.3	62.9	33.9	188.1
3rd	559.5	300.5	241.5	1,101.5
4th	929.2	455.2	389.8	1,774.2
5th	357.2	386.7	107.6	851.5
6th	230.2	379.4	36.8	646.4
7th	119.1	228.2	-	347.3
Total	2,351.0	1,823.0	809.0	4,983.0

Details of Annual Disbursement Schedule is given in Table X-6-1 of Appendix X.

7-3. Operation and Maintenance Cost

After the completion of construction work, the following costs will be incurred in the operation and maintenance of the Project.

- Electricity charge for pumping operation
- Maintenance cost for pump facilities
- Dredging cost for intake canal and drainage canal
- Operation and maintenance cost for hydraulic structures
- Administration cost.

CHAPTER 8
PROJECT JUSTIFICATION

CHAPTER 8. PROJECT JUSTIFICATION

8-1. General

The Project aims to reduce poverty and meet the basic needs of the rural people. To achieve these these objectives, the Project, placing main emphasis on agricultural production depending on irrigation, consists of three plans: irrigation equipment, fish culture in fresh water and road network combined with irrigation. The project is one of the important regional development plans closely related to the following major governmental development policies:

- To increase agricultural productivity.
- To provide employment opportunities for the landless farmers, agricultural labourers and the unemployed.
- To balance economic growth disparities among rural areas.

In this chapter, financial and economic analysis from the standpoints of private and national economy is carried out for project cost, operation and maintenance cost and benefits. Project cost and benefits are estimated by constant prices as of 1987.

8-2. Project Cost

Total project construction cost for 51,200 ha of the proposed irrigation area has been estimated at Tk.4,983 million in financial value, which is equivalent to Tk.97,000/ha and Tk.3,164 million in economic value, which is equivalent to Tk.61,800/ha. The tax for transfer expenditure has been deducted from the local portion of the financial project cost. Land acquisition also has been deducted from the local portion of the financial project cost, because economic value of farmland to be compensated is estimated as the net production value without

project. This deducted financial project cost has been converted to the border price by multiplying with the standard conversion factor of 0.8. This conversion factor is also applied to the conversion for economic value of operation and maintenance cost. The proposed operation and maintenance cost per year reaches Tk.144 million (Tk. 2,810/ha) on financial base and Tk.115 million (Tk.2,240/ha) on an economic base. On the assumption that the project will be started in 1989, the variation of project cost is tabulated as in the following TABLE 8-1.

TABLE 8-1. PROJECT COST

(Unit: ' 000 TK.)

Year	Construction Cost		O & M Cost		Total	
	Financial	Economic	Financial	Economic	Financial	Economic
1989	74,068	69,682	-	-	74,068	69,682
1990	188,085	123,069	-	-	188,085	123,068
1991	1,101,484	656,992	-	-	1,101,486	656,992
1992	1,774,228	1,098 898	-	-	1,774,228	1,098,898
1993	851,448	551,196	6,826	5,440	858,274	556,636
1974	646,447	436,736	40,667	32,482	687,114	469,218
1995	347,381	227,427	69,343	55,421	416,724	282,848
1996	-	-	107,536	85,973	107,536	85,973
1997	-	-	143,699	114,900	143,699	114,900
1998	-	-	"	"	"	"
1999	-	-	"	"	"	"
.	.	.	.	.	.	.
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.	.	.	.	.	.	.
2014	78,201	51,000	"	"	221,900	165,900
2015	377,201	254,000	"	"	520,900	368,900
2016	519,501	353,200	"	"	663,200	468,100
2017	283,801	194,700	"	"	427,500	309,600
.	.	.	.	.	143,699	114,900
.	.	.	.	.	.	.
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.	.	.	.	.	.	.
.	.	.	.	.	.	.
2034	78,201	51,000	"	"	221,900	165,900
2035	377,201	254,000	"	"	520,900	368,900
2036	519,501	353,200	"	"	663,200	468,100
2037	283,801	194,700	"	"	427,500	309,600
2038	-	-	"	"	143,699	114,900
Total	7,500,500	5,681,400	6,259,700	4,193,500	13,760,200	9,874,900

8-3. Project Benefits

Project benefits from increased crop production fishery production and service road network have been estimated.

8-3-1. Crop Benefits

Cropping intensity and yield increase are appropriate for crop benefits, details of which are provided in TABLE 8-2 and TABLE 8-3. Cropping ratio will be increased by implementation of the irrigation projects; yield increase will be realised by stable irrigation water supply and agricultural extension services.

TABLE 8-2. BENEFITS OF CROP (FINANCIAL)

	Without						With						Incremental Benefit (1,000TK)
	Per Mecte					Total	Per Mecte					Total	
	Yield (t)	G.P.V. (TK)	P.C. (TK)	N.P.V. (TK)	Area (ha)	N.P.V. (1,000 TK)	Yield (t)	G.P.V. (TK)	P.C. (TK)	N.P.V. (TK)	Area (ha)	N.P.V. (1,000TK)	
AUS	2.0	10,000	8,233	1,767	11,414	20,169	3.5	17,500	8,570	8,930	13,740	122,698	
T. Aman	2.3	12,420	9,066	3,354	43,321	141,945	4.0	21,500	10,224	11,376	47,600	541,498	
B. Aman	1.3	7,150	5,427	1,723	2,463	4,244	1.5	8,250	5,470	2,780	720	2,002	
Boro	3.2	16,320	7,962	8,358	2,200	18,555	5.0	25,500	8,169	17,331	28,200	488,734	
Sub-Total					58,418	184,913					90,260	1,154,932	970,019
Wheat	2.3	11,730	5,273	5,457	4,020	25,957	3.5	17,850	6,914	10,936	5,300	57,961	
Sugarcane	50.0	32,000	7,057	24,943	1,995	49,761	65.0	41,600	10,124	31,476	2,160	67,988	
Jute	1.5	7,950	3,510	4,440	1,801	7,995	2.0	10,500	4,343	6,257	1,080	6,758	
Pulses	0.8	2,560	2,486	75	673	50	1.2	3,840	2,588	1,252	5,629	7,048	
Oilseeds	0.7	7,490	3,860	3,630	608	2,207	1.0	10,700	4,080	6,620	1,173	7,765	
Potato	8.0	32,000	16,138	16,862	4,126	66,431	12.0	48,000	18,918	29,082	2,008	58,397	
Sub-Total					13,221	151,402					17,350	205,917	54,515
Ground Total					71,640	336,315					107,610	1,360,849	1,024,034

Note: See Appendix XI-2 Benefits

TABLE 8-3. BENEFITS OF CROP (ECONOMIC)

	Without						With						Incremental Benefit (1,000TK)
	Per Mecte					Total	Per Mecte					Total	
	Yield (t)	G.P.V. (TK)	P.C. (TK)	N.P.V. (TK)	Area (ha)	N.P.V. (1,000 TK)	Yield (t)	G.P.V. (TK)	P.C. (TK)	N.P.V. (TK)	Area (ha)	N.P.V. (1,000TK)	
AUS	2.0	10,166	6,945	3,221	11,414	36,764	3.5	17,791	7,844	9,947	13,740	136,672	
T. Aman	2.3	11,691	7,063	4,628	42,321	195,862	4.0	20,332	8,362	11,970	47,600	569,772	
B. Aman	1.3	6,608	4,641	1,967	2,463	4,845	1.5	7,625	4,959	2,666	720	1,920	
Boro	3.2	16,266	7,706	8,560	2,200	19,003	5.0	25,415	9,436	15,979	28,200	450,608	
Sub-Total					58,418	256,474					90,260	1,158,972	902,498
Wheat	2.3	13,844	4,642	9,202	4,020	36,992	3.5	21,067	6,606	14,461	5,300	76,643	
Sugarcane	50.0	33,100	8,334	24,766	1,995	49,408	65.0	43,030	12,483	30,547	2,160	65,982	
Jute	1.5	11,489	2,789	8,700	1,801	15,669	2.0	15,318	2,776	11,292	1,080	-12,195	
Pulses	0.8	2,812	2,424	388	673	261	1.2	4,218	4,578	1,442	5,629	8,117	
Oilseeds	0.7	5,981	3,860	2,121	608	1,290	1.0	8,544	4,578	3,966	1,173	4,652	
Potato	8.0	25,632	14,787	10,845	4,125	44,736	12.0	38,448	18,609	19,839	2,008	39,837	
Sub-Total					13,221	148,366					17,350	207,426	59,070
Ground Total					71,640	404,830					107,610	1,366,398	961,568

Note: See Appendix XI-2 Benefits