As a result, the Study area for the North Rajshahi Irrigation Project has been selected in the western side of the Sib river of mainly Barind tract on the basis of availability of water in the Ganges river and topographic conditions for gravitational irrigation with pumping from the Ganges river.

The total Study area, therefore, covers 151,800 hectares.

3-1-2. Location

The Study area is located in the Rajshahi District about 270 km north-west of Dhaka, the capital. It lies between 24°20' and 24°55' North Latitude and between 88°15' and 88°45' East Longitude. It is bounded on the South by the Ganges river; on the west by the Mahananda river, railway road from Rajshahi to Amnura and the road from Amnura to Parbatipur; on the north by the road between Sultanpur and Sibpur; and in the east by the Atrai river in the northern portion and along the polder embankment line for Polder D Project from Manda to Naohata and by the road from Naohata to Rajshahi.

As stated above, the total Study area is 151,800 ha, in which the high land area called Barind tract is the most dominant area.

3-2. Physical Conditions

3-2-1. Meteorology

Bangladesh has a tropical monsoon climate with a hot and humid summer and a dry cool winter season.

In April or May, the south-west monsoon which origingates over the Indian Ocean, carries warm and moist air, causing local rainshowers accompanied by thunderstorms and cyclones. The south-west monsoon is preceded by the relatively moist and warm easterly "trades". This transition period from dry to wet season, sometimes lasting for several months (March to May), is often referred to as the "pre-monsoon" season.

The months of June to October are known as the "True Monsoon" season. At the beginning of November, the south-west monsoon has withdrawn from Bangladesh, giving way to the north-east monsoon. As it originates over the Siberian ice covered land mass, the north-east monsoon is cold and dry, causing relatively low temperatures during the winter season from November to February with little or no rainfall. The Project Area is located in the driest part of the country, where mean annual rainfall is about 1,400 mm in Rajshahi. About 85% of the annual rainfall occurs from June through October. The annual rainfall dispersion is high, in particular at Rajshahi where observed annual rainfall varied from 816 mm to 2,144 mm (period of record, 1920-1987).

The average monthly temperature is almost below 25°C from November to February and about 29°C to 30°C in March to October. The coldest month is January and the warmest is April or May. The daily lowest minimum temperature becomes about 6°C to 8°C in January and the highest maximum one becomes about 42°C to 44°C in April or May.

The annual average relative humidity is about 75% and the driest month is March or April for about 55% and the highest is about 85% to 87% in July or August.

The prevailing wind direction is southeasterly from April to September and northerly to northwesterly from October to March. The prevailing wind speed varies about 2.0 m/sec to 4.5 m/sec. The windspeeds in this area of the country are generally much lower than in the coastal belt.

Annual average evaporation is 1,563 mm at Rajshahi and monthly evaporation is highest in April for 188 mm when both temperature and duration of sunshine are relatively high and relative humidity still low. The sudden increase in cloudiness and relative humidity at the beginning of the monsoon season causes the evaporation to drop in the month of June.

Table 3-1. Climatological Data of Rajshahi (Mean Monthly Averages)

	Mean daily Temperatare (℃) (1)	Relative Humidity % (1)	Mean daily Windspeed (m/sec) (1)	Duration of Bright Sunshine (hrs/day) (2)	Pan evaporation (mm)
Jan.	18.4	70	0.9	7.2	53
Feb.	20.5	65	0.9	8.4	67
Mar.	25.8	54	1.0	8.3	118
Apr.	29.5	60	1.5	9.0	135
May	29.3	71	1.6	7.4	130
June	28.9	84	1.4	4.7	99
July	29.1	88	1.4	3.2	87
Aug.	29.5	86	1.3	6.0	90
Sep.	29.3	84	1.3	5.2	87
Oct.	27.4	80	1.0	5.0	81
Nov.	24.5	74	0.9	8.6	69
Dec.	19.9	73	0.9	8.1	56

Source (1) Climatological Data and Charts BMD 1985
(2) Statistical Year book of Bangladesh 1986
(3) Daily and Monthly Evaporation in Bangladesh

3-2-2. Hydrology and Water Resources

(1) Rainfall

The average annual rainfall at Rajshahi from 1920 to 1986 for 56 years is 1,397.5 mm. The latest ten years (1977/78 to 1986/87) average annual rainfall is 1,523.0 mm and the following ten years (1967/68 to 1976/77) one is 1,301.5 mm which is rather lower side than the long-term average. Among the latest 25 year record from 1962/63 to 1986/87, the minimum value is 959.0 mm in 1982/83 and the second minimum is 974.0 in 1974/75. Accordingly the drought year in 1982/83 can be included in the latest 10-year period. In addition, the Farakka barrage has been started the operation since 1975, therefore, the hydrological conditions before 1975 and after the year has been changed as described in the later paragraph. Hydrological study should not be mixed with the above two different conditions. Therefore, the recent 10-year from 1977 to 1986 has been selected for the hydrological studies for the Project.

In order to estimate the effective rainfall for crop water requirements, areal rainfall has been estimated among 5 stations adopting Thiesen Poligon Method. The command area ratios for Rajshahi, Tanore, Nachol, Godagari and Manda are 12%, 24%, 26%, 21% and 17%, respectively.

(2) Water Resources

As for the ground water, deep tube-well project is on-going in the Barind tract in the Project area. There is not enough ground water resources to irrigate about 20,000 to 40,000 ha of land; accordingly, no groundwater utilization for the Project has been considered.

As for the surface water resources, there are four major rivers in and near the Project area for irrigation use. The most reliable source of water is the Ganges river which flows into the southern boundary of the Project area. The Mahananda river flows into the western boundary of the Project area. The discharge capacity in the Mahananda river is about 7 to 8 m^3/sec in the driest months of April and May, which is only for supplemental water resources.

Along the eastern boundary of the Project area, the Sib river flows from north to south and confluenced to the Barnai river at Naohata. But the river water will be dried up during the dry season, except in the depression area (so-called Beel in Bangladesh) along the Sib river.

The Atrai river flows in the northern part of the Project area from north to south and confluenced at Manda to the Sib river. But the confluence point had been closed by embankment by the local people. The discharge of the Atrai river is very small during the dry season.

Accordingly, only the Ganges river has enough water for dry season irrigation. However, during pre-monsoon or post-monsoon, the river flow in the Mahananda, Sib and Atrai rivers can be utilized for supplemental irrigation water supply.

In the Mahananda river, supplemental irrigation water is also expected even during the dry season although the capacity will not be enough. Consequently, the main water resources during dry season for the irrigation water is the Ganges river and the supplemental irrigation water can be taken from the Mahananda river.

The daily minimum discharge at Hardinge Bridge in the Ganges river was recorded at 683 cu.m/sec on April 6, 1985.

3-2-3. Geology

The proposed Project area is composed of two distinct geological formations: one is the Barind Tract of old alluvium and the other is the Paba Flood Plain Area of new alluvium. Barind Tract is characterized by uneven and undulating topographic featurs with high ridges and moderately leveled low area in between the ridges. From log of boring and other relevant reference materials, it is found that Barind Tract is composed of alternate layers of clay and sand.

The top soil up to a depth of about 20 m is predominantly stiff clay with very low permeability. The clay soil is brownish in color and is very hard when dry. However, some top soils up to few meter depth by the side of the Ganges and Mahananda rivers are found to be relatively soft and seem to be of comparatively recent origin. The sand layer below the top clay varies in thickness which increases towards the Ganges and Mahananda rivers.

The Paba Flood Plain Area is more or less a plain land and is situated at much lower elevation than the Barind Tract. This area is very much influenced by Sib river. The top layer of soil is predominantly silty clay which is underlying with sand layers.

3-2-4. Soil and Land Classification

(1) Objectives

For proper planning and designing of an irrigation system the surveyor must take care on the different land types/topography, hydrological condition, drainage system and present land use pattern in corelation to the physical and chemical properties of soils. The present study is undertaken in general to explore and evaluate the soil resources of the Project area but in particular the study is undertaken from the following viewpoints:

1) To identify the different land types/topography.
2) To identify the different soil types/series/taxonomic classes.
3) To identify the different land use patterns.
4) Mapping of soils individually or in association.
5) Mapping of land use pattern.
6) To describe the different soil series along with its physical and chemical properties.
7) To evaluate the soils in terms of land suitability under irrigated condition.

The soil survey is carried out using the reconnaissance soil survey maps and data of Rajshahi district as base materials.

(2) Method of Soil Survey

The procedure employed in surveying the Project area comprises the different steps which are stated below:

1) Review and evaluation of existing data, reconnaissance soil survey of Rajshahi district, 1968.
2) Preparation of photo-interpreted land type map (Scale: 1:50,000)

3) Preparation of photo-interpreted soil map (Scale: 1:50,000)
The photo-interpreted land type map is super-imposed over the enlarged reconnaissance soil map of the area. The probable soils which may occur in different land type units are then deduced from the reconnaissance soil map and report. In this way, a photo-interpreted soil map of the area is prepared.

4) Field checking of reconnaissance survey:

Auger boring	175 sites (containing the sites in the Study area.)
Test pit digging	23 sites

5) Preparation of final soil map (scale: 1:50,000)

6) Preparation of land use map (-ditto-)

7) Preparation of land suitability map (-ditto-).

(3) Field Survey

The photo-interpreted soil map and interpreted aerial photographs both are used as a base material during the field survey. The field survey commenced on 27th November and ended on 20th December, 1987.

The field checking is planned on reconnaissance map basis so as to examine the different units at least in 2 replications. The number of checks were at the international standard. Soils are checked by opening small pits supplemented by auger holes. One or two standard pits for each soil series are dug, described properly and samples are taken for laboratory analysis. In all eighty-seven (87) soil samples from twenty-three (23) profiles are collected for laboratory analysis.

(4) Soil Classification

The soils of the Project area are classified into three main groups according to physiographic units, e.g., (1) Barind tract (b) Ganges floodplain, and (c) Tista floodplain. According to soil survey, twenty-one (21) soil series are identified in the Project area. Seven (7) soil series

are recognized in the Barind tract, eleven (11) soil series are identified in the Ganges floodplain and the remainder of three (3) soil series belongs to the Tista floodplain.

Detailed description of soils are given in the Appendix I.

(a) Barind Tract

The Barind tract is an elevated landscape, thought to be of a marine deposits of Mio-pliocene age. It comprises level mainly in the eastern part, to undulating and locally rolling topography. In the undulating and rolling areas the summits are usually almost level while the slopes are terraced. In the west, the tract is hilly and dissected by narrow, usually steamless, valley, there is relatively high and slopes downwards to the east.

The soils occurring on the level to rolling Barind tract, namely, Nijhuri, Ammura, Lauta soils, etc., are mainly imperfectly drained, mixed yellowish brown and grey, loamy with moderate to strong, medium and fine blocky structure in the subsoils. The clayey substratum, known as the Madhupur clay, occurs at a depth of about 1 meter. The reactions are usually acidic in nature. Minor area is occupied by brown soils which mainlyoccur on the highest part of the landscape. The valley soils, Nachol and Pauli series, comprise imperfectly to poorly drained, mixed grey and brown or grey soils with moderate structural development in the B-horizon. They are also acidic in reaction.

The major constraint of the crop production is the severe drought during the dry season in the Barind tract.

(b) Ganges Flood Plain

South-eastern part of the Project area is occupied by the Ganges floodplain. The landscape comprises level ridges, inter ridge depressions with shallow small and deep broad basins. Locally minor area is occupied by irregular landscape having man-made raised platform. The soils occurring on the higher part comprise imperfectly drained, pale brown, loamy, firable to slightly firm, with weak to moderate blocky structure in the B-horizon, Sara and Gopalpur series. The basins are usually occupied by poorly drained, dark grey to dark greyish brown, clayey soils, Mehendigonj, Ghior, Garuri series, etc. They are calcareous either from the top or below the subsoil. Some profiles are non-calcareous to a deeper depth.

The major constraints of the crop production are relatively deep seasonal flooding and wetness in the first part of the dry season.

(c) Tista Flood Plain

The Tista floodplain is an area of slightly irregular, low relief with a complex pattern of low, narrow ridges, small basins and infilled channels. The ridges are mainly covered by olive grey to grey, friable, loamy soils in the B-horizon, Dohali series. They are acidic in reaction. The basin margins and low ridges are occupied by grey to dark grey, clayey friable soils, namely Digli and Jaonia series. They are acidic in reaction.

The constraints of the crop production are relatively deep seasonal flooding and wetness in the first part of the dry season.

Based on the unique soil properties and the soil profile features, the soils in the Project area are classified into one order of Inceptisol, three sub-groups as Typic Haplaquepts, Aeric Haplaquepts and Aquic Entrochrepts in the higher categories of classification.

(5) Soil Mapping Units

In the Project area twenty-one (21) soil series are identified. According to the scale of the map in most cases it is not possible to map each of the soil series individually. However, they are mapped in association. The Project area is divided into sixteen (16) soil mapping units according to landscape and soil. The level, undulating and rolling lands are mapped separately, though the soils are similar. Also, highland or medium highland are mapped separately. Soil map of Project area is given in Fig. 3-1.

(6) Land Suitability Classification

Land suitability classification is a method of rating soils in terms of their relative suitability for production of crops. It may be done on the present state of land or with improvement such as provisions of irrigation, land leveling, etc. The present classification is done with provision of irrigation.

The land suitability classification of the Project area is done on the basis of land characteristics/qualities and crop requirements. In all, nine (9) land suitability mapping units are selected in the Project area. Land suitability map of Project area is shown in Fig. 3-2 (as per FAO/SRDI Bangladesh system).

1) Barind Tract

The areas of mapping unit No.1, 2 are highly suitable for T.aus, T.aman, boro and moderately suitable for wheat and sugarcane. The area of mapping unit No.5 is moderately suitable for T.aus, T.aman and boro. The unit No.9 is marginally suitable for T.aus and T.aman.

FIGURE 3-1. SOILS OF PROJECT AREA
NORTH RAJSHAHI IRRIGATION PROJECT

0 1 2 3 4 5km

LEGEND

Mapping unit	Physiography	Area ha.	Non. Agric. land	Agricultural land				Irrigation suitability
				Land type	%	Soils	%	
1	Barind Tract	12,940	Minor	Highland level	100	Nijhuri Amnura Lauta	70 20 10	Highly suitable
2	"	24,500	1,230	Highland Undulating	95	Nijhuri Amnura Atahar Nachal	60 20 10 5	Moderately suitable
3	"	1,540	Nil	Highland slopping	100	Amnura Nachal Nijhuri	60 30 10	Moderately suitable
4	"	2,780	140	Highland rolling	95	Nijhuri Atahar Nachal Amnura	50 20 15 10	Marginally
5	"	2,400	Nil	Highland valley	100	Nachal	100	Moderately suitable
6	"	4,770	Nil	Highland valley Medium high land valley	60 40	Nachal Pauli Nachal	60 30 10	Highly suitable
7	Ganges flood plain (Col.)	4,460	Minor	Highland Medium highland	90 10	Sara Gopalpur Ishurdi	60 30 10	Moderately suitable
8	"	480	20	Highland irregular Medium highland	85 10	Sara Gopalpur	75 10 10	Marginally suitable
9	"	300	Nil	Medium highland	100	Mohendigonj	100	Moderately suitable
10	"	1,970	Nil	Medium highland Medium lowland	80 20	Ghior Goruri Ghior Goruri	50 30 10 10	Highly suitable
11	"	5,730	Nil	Medium lowland Lowland	70 30	Santhia Ghior Ghior Santhia	60 10 20 10	Highly suitable
12	(Non Col)	1,070	30	Highland irregular Medium highland	85 10	Tahirpur Taghar	85 10	Marginally suitable
13	"	470	Nil	Medium highland	100	Taghar Marsa	80 20	Highly suitable
14	"	140	Nil	Medium highland	100	Gulai	100	Highly suitable
15	Tista flood plain.	480	Nil	Medium lowland Lowland	80 20	Digli Joania Joania	60 20 20	Highly suitable
16	"	2,340	Nil	Lowland Medium lowland	80 20	Joania Joania	80 20	Highly suitable
Miscella-neous	Settlements Water bodies Rivers Ponds	8,310 1,190 410 720						
Total project area		77,000						

Conventional signs

- Project boundary
- Upazila boundary
- Soil unit boundary
- Wide river
- Narrow river
- Railway with station
- Metalled road
- Katcha road
- Settlements
- Water bodies
- Rivers
- Ponds

N

TANOR

GARI

RANISHAI

FIGURE 3-2. LAND SUITABILITY OF PROJECT AREA
NORTH RAJSHAHI IRRIGATION PROJECT

0 1 2 3 4 5km

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LEGEND

Mapping unit	Highly suitable	Moderately suitable	Marginally suitable	Component soil unit	Area
1	T.aus, T. aman Boro	Wheat, sugarcane	Fruit trees, vegetables	1	12,940
2	T.aus, T. aman Boro	Wheat	—	6	4,770
3	Boro	T. aus, T. aman.	—	10,13,14	2,580
4	Boro	—	—	11,15	6,210
5	—	T. aus, T. aman, Boro	Wheat	2, 3, 5	28,440
6	—	Boro	—	9, 16	2,640
7	Aus, jute, wheat, potato, mustard	Fruit trees, vegetable, cotton.	T. aus, T. aman.	7	4,460
8	Fruit trees, vegetable, potato, mustard.	Aus, jute, wheat, sugarcane.	—	8, 12	1,550
9	—	—	T. aus, T. aman.	4	2,780
Total					66,370
Miscellaneous					10,630
Grand Total					77,000

Convention! signs

- Project boundary
- Upazila boundary
- Soil unit boundary
- Wide river
- Narrow river
- Railway with station
- Metalled road
- Katcha road
- Settlements
- Water bodies
- Rivers
- Ponds

TANORE

Kakan har R.S

BAGHA

BAGMARI

RAJSHAHI

2) Floodplain Area

The area of mapping unit No.3 belongs to medium highland and it is highly suitable for boro and moderately suitable for T.aus, T.aman. The area of mapping unit No.4, medium lowland, is highly suitable for boro. The mapping unit No.6 belongs to medium highland (poor drainage) and lowland. This unit is moderately suitable for boro. The mapping unit No.7 belongs to highland and it is highly suitable for aus, jute, wheat, potato, mustard and moderately suitable for fruit trees and vegetables. The mapping unit No.8 belongs mainly to highland and it is highly suitable for fruit trees, vegetables, potato, mustard and moderately suitable for aus, jute, wheat and sugarcane.

3-3. Socio-economic Conditions of the Study Area

3-3-1. Present Socio-economic Conditions

(1) General

The Study area, which consists of 39 unions and 1,412 villages, is administratively divided into five Upazilas, i.e., Niamatpur (in Naogaon Zila), Godagari, Paba and Tanore (in Rajshahi Sadar Zila), and Nachole (in Nawabaganj).

According to the population census in 1981, the total population in the Study area is 792,063 and the population density is 457 per sq.km. The population density of Paba Upazila shows exceptionally high, i.e., 1,068 per sq.km. because this Upazila is adjacent to the divisional headquarter of Rajshahi. Excluding Paba Upazila, the population density of Barind Tract area in highland is 348 per sq.km, which is near the average of rural areas.

The total number of households in the Study area is 122,480. Out of them, the non-municipal population in dwelling unit in the Study area is 565,189 and the number of households is 99,586, i.e., 5.7 persons per household (Paba area 5.3, Barind area 5.7 persons). This figure is slightly less than the regional average and almost the same as the country's average.

The net cultivated lands are 110,235 ha which occupy 64% of total land area and the ratio of farm households to total households is 66%, according to 1983-84 Agriculture Census. Both ratios show that the Study area is an agricultural area, however, the ratios are lower than those of the regional average. Except for Paba Upazila, the ratios of agricultural land area and farm household number to the total area and number of Barind area are 63% and 67%, respectively. These ratios are also lower than those of the regional average.

On the other hand, the available land area per capita is 0.22 ha (region, 0.17 ha) and the cultivable area per capita is 0.14 ha (region, 0.13 ha), which are higher than the regional averages.

The ratio of working population to the total population is 26% (male 47% and female 5%) which is higher than the regional average. Besides, about 73% of working population are engaged in agriculture.

In conclusion, the Study area is considered to have higher agricultural potentiality than the whole region.

(2) Population

The population of the Study area has increased rapidly. The annual average population growth rates were 3.7% between 1951-61, 3.9% between 1961-74, and 3.8% between 1974-81. Excluding Paba Upazila which was affected by population inflow to divisional headquarter Rajshahi, the rates of Barind area also were high, showing 3.9% between 1951-61, 3.5% between 1961-74, and 2.7% between 1974-81. Such a rapid population increase has

been a major restrictive factor, therefore, effective measures should be enforced.

Out of the total population of 792,063, male population is 421,829 and female population is 370,234. The sex ratio is 114 which is higher than the regional average of 105.

In regard to age distribution, population below 14 years of age is 40% and from 15 to 64 years of age is 51%. Population of older than 65 years is 9% and the dependency ratio is 95. This dependency ratio is lower than the whole region of 102 and shows that the load of workers in the Study area is higher than that of the whole region. Besides, the dependency ratio of Paba area is 86 compared with Barind area of 99.

(3) Employment

According to the population census of 1981, the working population of above 10 years of age is 135, 493 (male, 122,615 and female, 12,878). The ratio of working population to total population is mentioned in item (1) above, however, the ratio to working population of above 10 years old is 39% (male 69% and female 7%). On the other hand, persons of no working and unemployment which is 2.3% of the total working population according to the labor force survey in 1983-84 are 25% of the population excluding students and home workers (male, 13% and female 69%). Both ratios show lower figures than those of regional average.

The occupations of working population are agriculture (73%), service (5%), and others (21%), excluding manufacturing which occupies only 1%.

In agricultural sector, cropping occupies a major portion (98% of total agriculture). It is noted that 42% of working male population is engaged in agriculture, which is higher than both the regional average (37%) and the country's average (28%).

3-3-2. Social Infrastructure

As a whole, the social environment in the Study area is rather incongenial than that of the regional average. Both literacy ratio and enrolment ratio are low. The social infrastructure such as drinking water supply facilities, number of beds in hospital, electrification, communication and culture has not been developed.

3-4. Agriculture

3-4-1. Present Land Use

According to the land utilization statistics of 1986, land utilization of the Upazilas of the Study area is classified into four (4) categories, namely, net cropped area, current fallow, cultivable waste and not available for cultivation. The cultivable area in the Barind tract corresponds to about 82% of the gross area, and in the floodplain is about 70%. Land not available for cultivation which includes homesteads, water bodies and roads, is about 20% to 30% in the Study area (RSO).

Rice is the most important crop in the Project area, both in terms of acreage and crop yield. Aus and both transplanted and broadcast aman are grown, however, there is relatively little boro. Jute and sugarcane are the main cash crops. Sugarcane is mainly grown in the southern part of the Project area. Mustard, lentils, wheat, barley, potato, and khesari predominate among the rabi crops. Kharif and rabi vegetables are grown on a small scale along the homesteads.

The crops grown, cropping sequences and intensity of land use are mainly determined by elevation of the land in relation to flooding during the monsoon season and by the drainage and soil moisture content in the dry season.

In the Barind tract, the soils on the level highland belong to the land use unit No.4a, in which major cropping pattern is T.aman - fallow with some aus followed by T.aman or T.aman followed by boro, about 20% of the Project area. The soils on the undulating highland belong to the land use unit No.4b, in which main cropping pattern is T.aman - fallow with some aus followed by T.aman, aus followed by rabi crops and T.aman followed by boro. They occupy the most extensive acreage, with being about 40%. The sloping lands, usually terraced, on the highland valleys belong to the land use unit No.5a, which are predominantly used for T.aman-fallow, locally some T.aman followed by boro, about 10%. The rolling highlands and the valleys in between the uplands are used for predominantly T.aman-fallow, the land use unit, 4a.

In the floodplain area, the basin soils on the medium lowland and lowland belong to the land use unit No. 5C, which are predominantly used for a single crop of boro, 13% of the Project area. The level ridge soils on the highest part of the Ganges floodplain are used for sugarcane and aus/jute-rabi crops with some aus followed by T.aman and fallow/rabi crops, the land use unit No.3, about 7%. The man-made lands in the middle and northern part of Paba upazila are occupied by mainly aus/jute-rabi crops with rabi and kharif vegetables and sugarcane.

Five land use mapping units along with some sub-units have been recognized in the Project area. Land use map of Project area is given in Figure 3-3.

3-4-2. Farm Size and Land Tenure

(1) Farm Size

According to 1983-84 agricultural census there are 81,040 farm households of which 39,238 (48%) are small-size group, 31,791 (39%) are medium-size group and 10,011 (12%) are large-size group in the Study area. Whereas, there are 613,331 farm households of which 370,008 (60%) are small-size group 191,662 (31%) are medium-size group and 51,661 (8%) are

FIGURE 3-3. LAND USE OF PROJECT AREA
NORTH RAJSHAHI IRRIGATION PROJECT

0 1 2 3 4 5km

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LEGEND

Mapping unit	Land use mapping unit		Area	Component soil mapping unit
	1. Predominently double cropped land			
	1a. Broadcast aman – khessari / mustard and aus – T. aman with some T. aman – boro		1,970	10
	1b. Mixed aus and B. aman with some B. aman – khessari / fallow		300	9
2	2. Mainly double with some single cropped land			
	Aus/jute – rabi crops with some rabi and kharif vegetables and segercane		1,550	8,12
3	3. Double and single cropped land			
	Sugarcane and aus/jute – rabi crops with some aus – T. aman – fallow/ rabi crops.		4,460	7
	4. Mainly single with some double cropped land.			
4a	4a. Mainly T. aman – fallow with some aus – T. aman – fallow and T. aman – boro.		12,940	1
4b	4b. Mainly T. aman – fallow with some aus – T. aman – fallow and aus – rabi crops and T. aman – boro.		24,500	2
4c	4c. Mainly T. aman – fallow with some T. aman – rabi crops.		470	13
	5. Predominently single cropped land			
5a	5a. Predominently T. aman fallow, locally some T. aman – boro.		6,310	3, 6
5b	5b. Predominently T. aman – fallow		5,320	4, 5, 14
5c	5c. Predominently boro – fallow		8,550	11, 15, 16
	Miscellaneous landuse	Settlements	8,310	
		Water bodies	1,190	
		Big ponds	720	
		Rivers	410	
	Total		77,000	

Conventioni signs

- Project boundary
- Upazila boundary
- Soil unit boundary
- Wide river
- Narrow river
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- Katcha road
- Settlements
- Water bodies
- Rivers
- Ponds

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large-size group in the Rajshahi Region. According to the above, the proportion of small-size group is considerably lower and of large-size group is remarkably higher in the Study area as compared with those in the Rajshahi region. These farm households account 66%, 71%, and 73% of the total households in the Study area, Rajshahi region, and Bangladesh, respectively.

It is also noticed that the large-size group account to 12% of total farm households as compared with 8% in the Rajshahi region and 5% in Bangladesh.

(2) Land Tenure

According to the landownership pattern data in 1977, on the other hand, own-holdings are 52% and owner-cum-tenant holdings are 47% as same as that of the Rajshahi region. The result of the recent survey in Barnai shows that pure tenant-holding farmers are less, viz., own-holdings are 50%, owner-tenant holdings are 40%, and tenant-farmers are 10%.

Landlessness, which has important meaning on the analysis of land ownership, consists of three categories: Landless I, Landless II and Landless III.

Landless I means that households do not own land; Landless II owns homestead land but no "other" land; and Landless II owns homestead land and "other" land (up to 0.2 ha).

According to agricultural census of 1983-84, the status of landlessness in the Study area, the Rajshahi region and Bangladesh is as shown below:

Landlessness

Upazila	All Households	Landless I Number	%	Landless II Number	%	Landless III Number	%	Total Number	%
Niamatpur	29,140	1,614	5.5	6,225	21.4	3,265	11.2	11,104	49.2
Godagari	30,810	3,005	9.8	7,904	25.6	3,282	10.7	14,191	46.1
Paba	29,688	2,494	8.4	7,115	24.0	6,332	21.3	15,941	53.7
Tanore	21,004	932	4.4	5,667	27.0	2,307	11.0	8,906	42.4
Nachole	12,468	3,304	26.5	3,342	26.8	1,278	10.3	7,924	63.6
Total (Study Area)	123,110	11,349	9.2	30,253	24.6	16,464	13.4	58,066	47.2
Rajshahi (Region)	866,387	53,711	6.2	182,677	21.1	155,615	18.0	392,203	45.3
Bangladesh	13,817,646	1,198,056	8.7			3,668,315	26.5		
				1,965,002	14.2			6,831,373	49.4

Source: The Bangladesh Census of Agriculture and Livestock, 1983-84

Note: Households of Landless I and Landless II are non-farm households.
Households of Landless III include small farm households of 0.02-0.2 ha.

Landlessness has important meaning on basic human needs, employment problem, social uneasiness and progress in agricultural productivity, etc. that half or almost nearly half of all households (47% in the Study area, 45% in the Rajshahi region and 49% in the Bangladesh) are landless.

The proportion of Landless II households in the Study area is larger than that of the Rajshahi region and the Bangladesh.

3-4-3. Crop Production

The Study area includes five Upazilas, out of which four are situated in Barind area and one (Paba) in flood plain. Crop productions in these two areas are as follows:

(1) Crop Area

Each crop area and its percentage to total cropped area in Barind area and Paba flood plain are shown in TABLE 3-2. Within the total cropped area, rice occupies 91% and the other crops 9% in Barind area, while in Paba flood plain 50% and 50%, respectively. Cropping intensity of Barind area is lower (132%) than that of Paba flood plain (158%). Area of Transplanted aman (T.aman) is 72% in Barind and only 15% in Paba area where sugarcane and jute are predominant.

(2) Crop Yield

Average yields of each crop in both areas are shown in TABLE 3-3. As there are significant difference in yield between local variety (LV) and modern variety (MV), these are shown separately with percent area of each. Both in LV and MV of paddy, yield of boro is the highest and aus is the lowest. Yield of broadcast aman (B.aman, LV only) situates between T.aman (LV) and Aus (LV). Yield of rice is generally low due to damage and other reasons. There may be no substantial difference in rice yield between both areas. In most of non-rice field crops, however, yields are higher in Paba flood plain than in Barind area.

3-4-4. Cropping Pattern

In Barind area, most of cropped area is occupied by rice in which T.aman is the main crop. Therefore, cropping patterns in Barind area are simple and may be mainly mono-cropping of T.aman with some T.aman combined with boro, aus and upland crop (UC). Major cropping patterns in Barind area are shown as follows:

	Percentage of Area	Soil Series
Fallow - T.aman - Fallow	62	1, 2, 3, 4, 5, 6, 14
Fallow - T.aman - Boro	14	1, 2, 3, 6, 10
Aus - T.aman - Fallow	15	1, 2, 7, 10
B.aman - Fallow/UC	1	9, 11
Aus - Fallow - UC	5	2
Fallow - Boro	3	11, 15, 16

(UC includes wheat, pulses, oilseeds and vegetables)

In Paba flood plain, on the other hand, rice and upland crops occupy nearly equal area and T.aman is not the main crop, moreover, many kinds of upland crops are grown. There may be many cropping patterns in Paba area as follows:

	Percentage of Area	Soil Series
Sugarcane (year-round)	24	7, 8, 10, 12
Fallow - T.aman - UC	2	13
Aus - T.aman - Fallow	13	7, 10
Aus/Jute - Fallow - UC	23	7, 8, 12
Aus - T.aman - UC	4	7
Fallow - T.aman - Fallow	5	8, 12, 13
Fallow - T.aman - Boro	2	10
Fallow - Boro	13	11
B.aman - UC/Fallow	10	10, 11
Winter & Summer Vegetable	4	8, 12

3-4-5. Farming Practice

(1) Rice

As shown in TABLE 3-4-2, area covered by MV aus is the lowest and by boro is the highest, and lower in Barind than in Paba flood plain. These are attributed mainly to water supply. All aman varieties are usually photo-sensitive and aus/boro photo-insensitive.

Growing season of each type of rice is influenced by flood season and cropping pattern as well as temperature and rainfall. B.aus is restricted by rainfall in March to April and T.aman/boro by low temperature in reproductive growth stage as shown below:

	Seeding	Transplanting	Harvesting	Growth Duration Day
B.aus	Apr-May	-	Jul-Aug	95-110 (LV)
T.aus	Mar-Apr	Apr-May	Jul-Aug	110-130 (MV)
B.aman	Apr-May	-	Nov-Dec	220-260 (LV)
T.aman	Jun-Jul	Jul-Aug	Nov-Dec	130-150 (LV)
				150-160 (MV)
Boro	Oct-Nov	Jan-Feb	May-Jun	150-180 (MV)

(2) Wheat

Most of wheat cultivated is MV. Growth period of early variety is 100 days and medium variety 110 days, which is 20% higher yield than early one. Optimum seeding date and seeding rate (120 kg/ha) are important for good yield.

Cropped area of wheat is steadily increasing in the study area because of increase in demand and its tolerance to drought in the rabi season.

(3) Sugarcane

Sugarcane is usually planted in October to February and harvested in November to March. Growth period is 12-15 months and ratoon is not common under rainfed condition. Cropped area of sugarcane is gradually recovered after decline in 1984-85. Production of jute, however, fluctuated remarkably along with the change of price.

Jute is seeded in March to April and harvested in July to August. Growth period is 100-120 days.

(4) Other Crops

Pulses, oilseeds and vegetables are grown in both areas in winter and summer season. Main pulses are khesari (grass pea), lentil, black gram and chick pea. Cowpea and mungbean are not common but recommended for summer pulses. Most of oilseed is rape and mustard in winter season and some linseed and sesame. Major vegetable crops are brinjal (egg plant), radish, patal (small cucurbit, cabbage, cauliflower, tomato, pumpkin and spinach. Potatoes increased recently in the area and planted in November and harvested between February and March.

3-4-6. Farm Economy

Farm economic survey has been done in order to grasp socio-economic conditions of the farmers by size of operated area and landless farmers to a total of 500 households of farmers and landless farmers, viz., 50 households per village out of 2 villages in Paba area and 8 villages in Barind area.

(1) Family Size

Average family size is 6.3 persons, but the family size of large-size farmers (holding operated area of 3.0 ha and above) is 9.4 persons, which is twice as large as that of the landless farmers of 4.7 persons. The large-size farmers in Paba area have average family size of 12.6 persons and as the farmers become larger, they adopt a large family system including relatives and are trying to concentrate owned land and maintain labor power.

(2) Farm Household Income and Expense

Based on all surveyed farmers, average gross income of farm household per household is about 40,000 Tk of which 60% is agricultural gross returns and 40% is non-agricultural receipt. By operated area size, small-size farmers get twice gross income of that of landless farmers, and medium-size farmers get twice gross income of that of small-size farmers, whereas large-size farmers get about 133,000 Tk of gross income which correspond to 3.32 times of that of medium-size farmers. Class which agricultural gross returns occupy the most high proportion is medium-size farmers, i.e., about 70% out of household gross income, whereas large-size farmers occupy only about 60%. The results show that large-size farmers get non-agricultural receipt from managing mill factory or transport industry based on their holding fund and labour power, or renting concentrated owned land.

Based on the farm household's net income, the large-size farmers get remarkably high income, i.e., TK. 82,000, as compared with about TK. 13,000 of small and medium-size farmers. In net income per capita also, the same phenomenon is seen. This fact shows that the difference of income between large-size farmers and small- and medium-size farmers is extremely remarkable.

Each class gets more non-agricultural net income than agricultural net income, together, and then farm-household net income of medium-size farmers also makes a complete change and occupied with more non-agricultural income than agricultural income (i.e., about 60%).

The farm budget of farm household according to size are shown below:

Farm Household Economy Per Household (by Farm Size)

(Unit: TK.)

Item	Landless	Small Farms (0.6 ha)	Medium Farms (1.7 ha)	Large Farms (4.8 ha)	Total Average (1.8 ha)
Farm Household Gross Income	8,564	21,243	40,799	133,119	39,604
Farm Household Income	7,878	12,944	20,991	82,204	23,637
Disposable Income	7,837	12,595	20,092	78,620	22,702
Household Expenditures	8,301	11,887	19,224	33,775	16,424
Farm Household Economic Surplus	-464	708	868	44,845	6,278

Notes: 1) Farm Household Gross Income includes not only agricultural gross income but also non-agricultural income.
2) Agricultural gross income includes returns in kind and self-consumption.

Source: Farm Economic Survey

3-4-7. Farm Labour Balance

Total number of households which are engaged in agriculture are 122,645 in the study area. According to Labour Force Surveys (1983-1984), average number of working population per household in rural area is about 1.6 persons then, working population in agriculture is 196,232. When working days are 225 per year, the total number of available farm labour per year is 44,152,200 man-days in the study area.

In the present cropping pattern, labour requirement in agricultural operation per year is 25,882,900 man-days and 5,039,600 man-days are required in peak month of July due to overlapping of cropping term of both T.aman and Aus paddies.

Besides, assuming that the working days of 26 in July are taken, the available number of farm labour amounts to 5,102,032 man-day, thus farm labour balance would be possible.

3-4-8. Livestock and Poultry

Total number of bovine is approximately 326,000, sheep and goat 130,000 and pultry 556,000 in the three upazilas of Rajshahi District related to the study (1986-87). These indicate 2.6 times increase in bovine, 2% decrease in sheep and goat, and 25% increase in poultry in comparisoin with 1983-84. Eighty percent of bovine is cattle and 20% buffaloes. Bovine is mainly used for farm land preparation, threshing and transportation. Sheep and goat are both small size species and goat is much more raised than sheep. Within poultry, 70% are chicken and 30% duck.

Livestock Development Program is carried out by DSL (Directorate of Livestock Services). The program activities are artificial insemination, fodder production, prevention of diseases, fattening and goat distribution. The Artificial Insemination Centre located in Rajshahi town serves the development of cattle head in Rajshahi Region.

3-4-9. Inland Fisheries

Depending on the 1983-84 survey, catch from inland waterbody in Rajshahi Region is approximately 31,000 tons. Out of this catch, 34% is from rivers, 29% from beels, 26% from ponds and remaining 11% from flood area. The area of cultured ponds is 30% to total pond area (14,700 ha), but fish production is 65% of catch from the total ponds. Average fish yield in cultured pond is 1.17 ton/ha due to water shortage in dry season. Carp is the main species of fish from rivers and cultured ponds.

The Directorate of of Fisheries (DOF) administers inland fisheries. It controls government-owned ponds and natural or cultured fishery and supplies fingerling through Fish Seed Multiplication Farm (FSMF). There are five FSMFs in Rajshahi Region which produce fingerling and distribute to the growers.

3-5. Agricultural Supporting Services

3-5-1. Research Work

The Bangladesh Agricultural Research Council (BARC) has the responsibility to strengthen the agricultural research capability of the following institutes through planning and integration of resources and coordination of research effort.

The Bangladesh Agricultural Research Institute (BARI) is the largest and most diversified among the research agencies. The extent of research works are field crops (except for rice, jute and sugarcane) and horticultural crops including research fields of breeding, agronomic practices, soil management, agro-economy and post-harvest technology. It has 4 regional stations, 11 substations and 6 special crop research stations.

The Bangladesh Rice Research Institute (BRRI) has also many kinds of research field necessary for rice production. It has seven regional stations, one of which is Rajshahi station. Main item of the station is breeding of cold tolerant and drought tolerant varieties.

Other research agencies are as follows:

- Bangladesh Jute Research Institute (BJRI)
- Bangladesh Sugarcane Research and Training Institute (BSRTI)
- Bangladesh Tea Research Institute (BTRI)
- Institute of Nuclear Agriculture (INA)
- Bangladesh Institute of Development Studies (BIDS)
- National Livestock Research Institute (NLRI)
- Fisheries Research Institute
- Forest Research Institute

3-5-2. Extension Services

Department of Agriculture Extension (DAE) plays the main role for the transfer of technology. Under DAE, Regional Director supervises and coordinates with Deputy Director at District Office which has 2-4 subject matter specialists and one training officer.

At Upazila level, each Upazila has an Agricultural Officer (UAO), a Subject Matter Officer (SMO), and an Assistant or Junior Agricultural Extension Officer as working staff.

There is a Block Supervisor (BS) at Union level, who receives training from SMO on new technologies at the Upazila and visits Contact Farmers (CF) to disseminate the information. CF spread the same information to general farmers (Non-CF). This system is called as Training and Visit (T&V) system in which one BS covers 80 CF and one CF 10 Non-CF.

Livestock sector under DOLS and inland fisheries under DOF have extension staff at Upazila level.

3-5-3. Agricultural Input Supply

Main input materials for crop production are distributed by Bangladesh Agricultural Development Corporation (BADC) which has a department of seed production and distribution, fertilizer and irrigation equipment.

Improved seed (MV) is produced at seed farm under BADC along with the registered seed growers and distributed to the farmers through district and upazila offices of BADC. In case of sugarcane, however, improved and disease-free cane seed is produced at BSRTI farm and distributed through sugar mills to the growers.

BADC is the monopoly agent of chemical fertilizer, viz., urea, triple super phosphate, murate of potash and some others. Fertilizer is distributed to local dealers through district and upazila offices of BADC. As for pesticides, however, private companies import and sell them through their dealers located in the upazila and other important markets.

BADC and Agricultural Bank distribute irrigation equipment such as deep and shallow tubewells and lowlift pumps.

3-5-4. Post-Harvest Facilities

Small rice mills are widely scattered in towns and villages. They are usually equipped with one rice husking/cleaning machine and perboiled rice processing equipment consisting of boiling or steaming equipment and they have a yard for drying boiled paddy. Total number and husking capacity of the rice mills in the study area and Rajshahi town are 125 and 45,000 tons per year (1985), respectively. Twenty flour mills for wheat are located in Rajshahi town. Total crushing capacity of these mills was 5,600 tons in 1985.

Oil mills are usually situated in town and extract oil from local oilseed and imported one from Canada. There are 16 oil mills in Rajshahi town and Paba, which have a total of 1,400 tons production capacity.

Rajshahi Sugar Mill has a grinding capacity of 1,500 tons of sugarcane per day and more than 200,000 tons per year. It belongs to the Bangladesh sugar and Food Industries Corporation (BSFIC).

Rajshahi Jute Mill belongs to the Bangladesh Jute Mills Corporation (BJMC) and produce 2,800 tons of hessian and 2,200 tons of sack per year.

TABLE 3-2 CROP AREA AND ITS PERCENTAGE TO TOTAL CROPPED AREA (1985-86)

	Area(ha)			Percent area		
	Barind*	Paba**	Total	Barind	Paba	Total
Rice (Total)	137,760	15,534	153,294	90.6	49.7	83.6
Aus	21,729	6,686	28,415	14.3	21.4	15.5
T.Aman	109,094	4,657	113,751	71.8	14.9	62.0
B.Aman	1,624	3,645	5,267	1.0	11.7	2.9
Boro	5,313	546	5,859	3.5	1.7	3.2
Non-Rice (Total)	14,260	15,720	29,982	9.4	50.3	16.4
Wheat	6,796	2,981	9,777	4.5	9.5	5.3
Jute	367	3,252	3,621	0.2	10.4	2.0
Sugarcane	126	3,807	3,933	0.1	12.2	2.1
Pulses	414	975	1,389	0.3	3.1	0.8
Oilseeds	959	524	1,482	0.6	1.7	0.8
Potatoes	616	585	1,201	0.4	1.9	0.7
Vegetables	1,145	1,159	2,304	0.7	3.7	1.3
Condiments	234	195	429	0.2	0.6	0.2
Fruits	423	686	1,109	0.3	2.2	0.6
Others	3,206	1,556	4,764	2.1	5.0	2.6
Total Cropped Area	152,022	31,254	183,303	100	100	100
Net Cropped Area	115,150	17,506	132,656			
Cropping Intensity	133	178	138			

Source : Rajshahi Regional Statistical Office
Note : * Barind is the total of four Upazilas, Godagari, Tanore, Nachole and Niamatpur.
** Paba includes whole Upazila of Paba.

TABLE 3-3 AVERAGE YIELD OF CROPS (1983-84/85-86)

		Average Yield (ton/ha)			Percent Area (%)	
		Barind	Paba	Total	Barind	Paba
Aus	L	0.85	0.88	0.86	95	97
	M	1.68	1.54	1.66	5	3
	A	0.89	0.89	0.89		
T.Aman	L	1.30	1.28	1.30	87	38
	M	2.04	2.12	2.04	13	62
	A	1.39	1.59	1.43		
B.Aman		1.08	1.06	1.07		
Boro	L	1.62	1.54	1.61	36	6
	M	2.82	2.17	2.67	64	94
	A	2.39	2.14	2.34		
Wheat	L	1.14	1.23	1.16	10	6
	M	2.06	2.33	2.16	90	94
	A	1.96	2.12	2.01		
Jute		1.31	1.45	1.34	-	-
Sugarcane		42.2	45.8	44.0	-	-
Pulses		0.71	0.75	0.72	-	-
Oilseeds		0.58	0.65	0.60	-	-
Potatoes	L	6.54	7.21	6.81	75	48
	M	7.40	7.60	7.53	25	52
	A	6.75	7.41	7.07	-	-
Vegetables		6.02	7.47	6.31	-	-
Condiments		3.61	1.95	3.28	-	-
Fruits		7.81	5.96	7.44	-	-

Source: Rajshahi Regional Statistical Office

Remark: L : Local variety
M : Modern variety (High Yield Variety)
A : Average

3-5-5. Marketing

The main agricultural products traded in the Study area are paddy (rice), wheat, jute, sugarcane, etc.

The Government provides guaranteed support prices for paddy, wheat and sugarcane. Especially, the Government frames the institution of procurement program for paddy and wheat which determines procurement prices and quantities. This focus of MOF's (the Ministry of Food) procurement operation is to guarantee minimum prices for the farmers, sustain farmers' incentives to produce and assure a stable flow of reasonably priced foodgrain to the urban consumers. Recently, procurement prices are often lower than the open market prices and procurement procedures are troublesome.

In case of paddy, the quantities procured by MOF have typically ranged from 2 - 5% of total production which corresponds to roughly 10-30% of paddy actually marketed.

The most common marketing channels are divided broadly into the following two categories:

1) Producer (→ small millers) → Government procurement agents/1
→ Consumers/2 (government)
— Primary Market → Consumers (private)

2) Producers → Middlemen merchant (collector of cargo)
→ Big millers (wholesalers) → Retailers → Consumers (private)

/1 ... Officer in charge of the Local Supply Department, Government buyers, etc.

/2 ... Godowns of the Food Department for supply to the ultimate consumers.

Sugarcane is bought and milled by the three sugar mills. The mills operate purchasing centres where the farmers can deliver their cane. Depending on the sugarcane price large quantities are processed into "gur" at farmer level by rather primitive means, although sugar mills have an overcapacity.

Farmers sell their jute to itinerant merchants or directly at the local market where it is sold to representatives from the jute mills or to other traders.

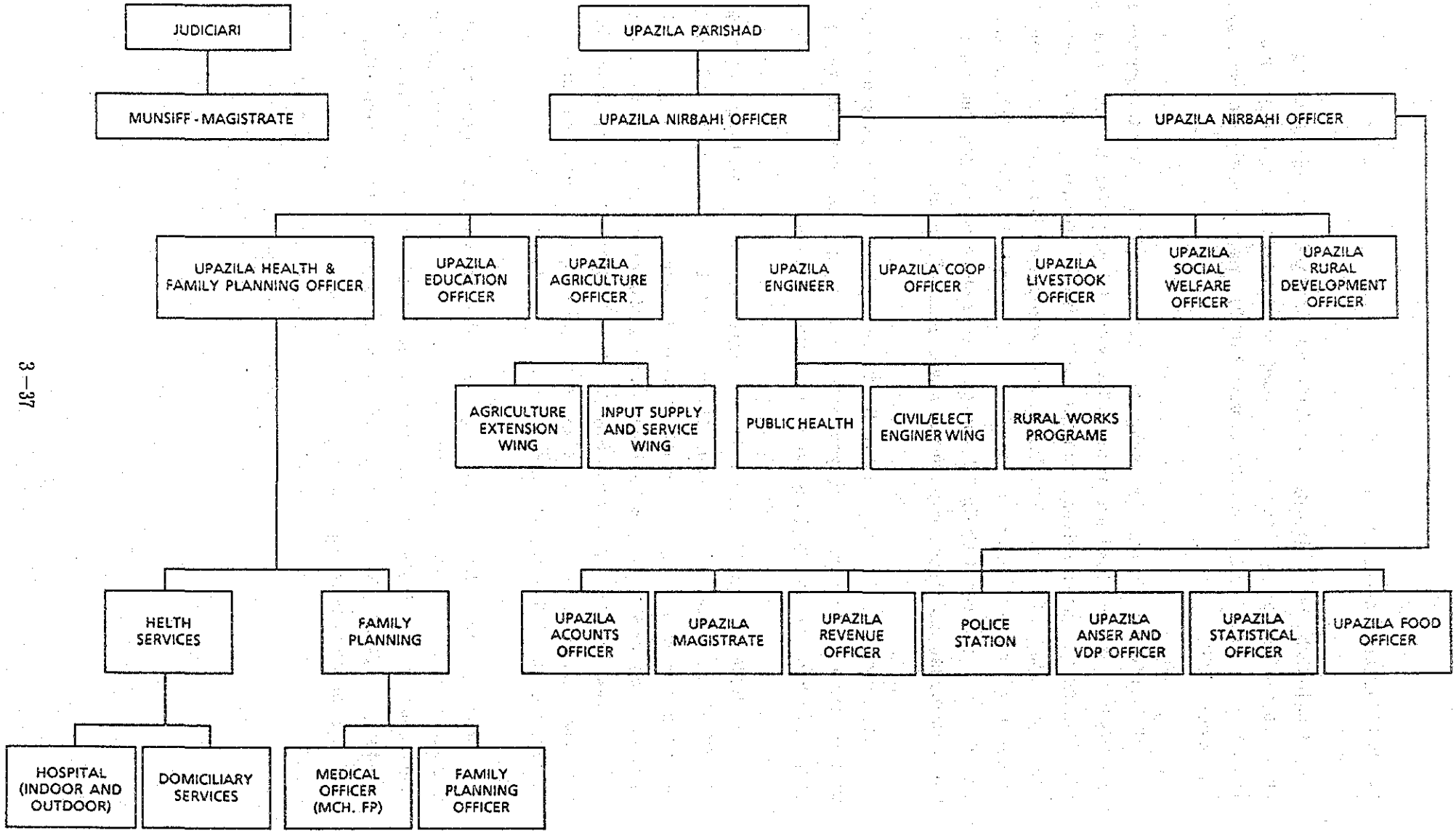
3-5-6. Local Government

The representative of the local government called the Upazila Parishad, which is headed by an elected Upazila Chairman consists of elected Union Chairmen and officials of Upazila level of the development officers. They are under the control of the development offices, 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. It is seemed that they have the functions tied up with the will of the people and national policies for the development projects (or programs) at the local level. There is an Upazila Nirbahi Officer who works as the principal staff officer to the Chairman of the Upazila Parishad but has no direct control/authority over other officers, i.e, Upazila Engineer, Upazila Agriculture Officer, Upazila Finance & Planning Officer and other officials in all major nation-building departments.

The national government takes measures to finance the local development programs to be undertaken by the Upazila Parishads.

Thus, the Upazila Parishad has become the focal point of all development activities at the local level. All the programs have to be undertaken on their own at reasonable scale. This Parishad has also the implementing authority for divisible components of national level projects and programs.

ORGANIZATION OF UPAZILA ADMINISTRATION (PARISHAD)



3-5-7. Farmers' Association

Bangladesh has already established traditional cooperatives. The traditional KSS in village, which had been already organized under the Integrated Rural Development Programme (IRDP), have rapidly reorganized to KSS under BRDB.

IRDP did not initially undertake the establishment of cooperatives (BSS/MBSS) for the landless poor. However, in response to criticism that KSS (farmers' cooperatives) served only richer farmers, IRDP tried to organize groups for the landless, and advocated the use of a two-tier cooperative system which operated at the level of the village through primary cooperatives (BSS/MBSS), which were federated at the Thana level in the TCCA under the Integrated Rural Development Program.

According to the Cooperative Societies Rules, a KSS/BSS must comprise with minimum 10 farmers of 18 years or more in age, and must be registered as per provisions in the Bangladesh Cooperative Laws.

The UCCA at Upazila level is the organization federating all KSS and BSS (MSS) in villages under equality of condition. This UCCA-KSS/BSS/MBSS system has been playing an important role to carry out economic activities such as crop production, marketing, establishment of irrigation equipment, and various types of off-farm activities including rice, husking, bamboo and cane works, handlooms, silk and jute craft, and to supply and distribute the funds for the above economic activities.

Besides, the UCCA-KSS/BSS systems are being encouraged to act as private wholesalers for fertilizer and are given credit by BADC against a bank guarantee. Moreover, in area under BRDB Project or Program, the existing UCCA-KSS/BSS system could form Irrigation Management Committee among themselves when necessary.

3-5-8. Agricultural Credit

Bank operations in Bangladesh started in 1973. As of 30 September 1985 the Bank provided 61 loans amounting to US$1.665 million for 55 projects.

The heavy concentration of bank lending in agriculture (51% of total lending) reflects the dominance of this sector in the economy of Bangladesh.

There are both institutional and non-institutional sources of agricultural credit in Bangladesh. The institutional sources of agricultural credit are Bangladesh Krishi Bank (BKB), Sonali Bank, Bangladesh Samabaya Bank, and other nationalized commercial banks. BKB supplies 60% (67% in actual) of institutional credit to agriculture.

These nationalized commercial banks have widespread network of branches all over the country. They have 280 branches in Rajshahi region and 28 branches (if including Boalia Upazila = Rajshahi city; 68 branches) in the Study area.

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. However, the total institutional credit given to agriculture has increased by about 300% between 1980/81 and 1984/85 (or from Tk. 3,734 million to Tk. 11,319 million). But 80% of the total credit requirement of agriculture are still met from non-institutional sources for which the annual interest rate exceeds 50%.

Agricultural institution credit is channelled to the borrowers by two routes: one is directly, the other is through UCCA-KSS/BSS/MBSS system. As to the proportion of both channels to total agricultural credit, the former is about 60% and the latter is about 40%.

As shown in Table V-8-4, borrowers of the former will be able to rent at an interest of only 16%, while borrowers of the latter have to rent at an interest of 19% (short-term loan) to 16% (medium-term loan) although they could rent without any collateral. In all cases, the loan interest including penalty interest is 22%.

Moreover, borrowers through UCCA-KSS/BSS/MBSS under Project of BRDB are able to rent at an interest which is relatively low, i.e., that of short-term and medium-term is 14% and 12%, respectively (penalty interest, 6%).

3-6. Irrigation, Drainage and Flood Control

3-6-1. Projects under BWDB

In and around the Study area, several development schemes are organized under the Rajshahi Circle of BWDB. The features of the major projects are explained below:

(1) Karnahar Barabilas Project

The Project area is located at about 8 km northwest of Rajshahi. The major objectives were to improve flood control by polder dike and drainage for 3,900 ha. The construction of this Project has been completed several years ago.

(2) Chalan Beel Project

The Project aims to control the flood effect from Atrai and Barnari rivers by construction of polder dike. The Project area was divided into Polder A, B, C and D areas in which construction for Polder A, B and C areas have been completed. The Polder D area is located along the left bank side of the Sib river and the implementation will be completed within a few years. The polder dike of the Polder D area forms the boundary of the North Rajshahi Irrigation Project.

(3) Barnai Project

The Project area is located between the Barnai river and Rajshahi-Natore road occupying about 56,600 ha and aims at flood control and drainage improvements. The feasibility study has been completed in 1984 and the implementation will commence from the end of 1987.

3-6-2. Other Related Projects

(1) Barind Integrated Area Development Project (BIADP)

The Barind Integrated Area Development Project implemented under BADC and BRDB covers Godagari, Tanore Upazilas of Rajshahi; Bholahat, Shibganj, Gomostapur, Nachole and Mawabganj of Nawabganj; Sapahar, Porsha, Manda, Niamatpur, Mohadevpur, Dhamoirhat and Patnitala of Naogaon Districts - all being to Rajshahi Barind. Out of total area of 12.5 lac acres, 10.25 lac acres is cultivable. The net cultivable area is 9.0 lac acres only. The present cropping intensity is about 117%. Of the total land area, 47% is high farm land and 38% medium farm land. Only 15% is lowland which means that as for 85% of the farm land of the Project area, multiple cropping (for HYV crops) will be possible especially during the winter months on conditions that the irrigation system is facilitated. About 46% of the land is cultivated under owner-cum-tenant land holding system. The percentage of pure tenant holders is negligible. According to BBS during 1982-83, a total of 9.0 lac acres was brought under cereal production of which only about 12% of land area was devoted to HYV varieties.

(2) North West Rural Development Project (NWRDP)

North West Rural Development Project financed by ADB has the Agriculture Development Program in its various components. The objective of the program is to improve the Government-owned derelict pond for landless people to enterprise fish culture. The ponds are leased to landless cooperatives (BSS) or women's cooperatives (WBBS) for a period of eight year. One BSS will operate in one village where 0.4 ha (one acre) of

pond will be available to a village group. Fish-polyculture (mixed culture of various species) will be adopted to increase the productivity per unit water area. To increase the income, agriculture is combined with duck and banana raising on the pond dikes.

The two Fish Seed Multiplication Farms (FSMF) are selected to be upgraded out of eight existing FSMFs in the Rajshahi Region. The selected FSMF will be provided with reliable water sources and distribution system, new ponds and a hatchery equipped to increase the production of hatching and fingerling of various cultivable species, and with a water testing kit and other necessary equipment.

3-6-3. Irrigation Conditions

Three types of irrigation methods, which are also common in other areas of Bangladesh are implemented in the Project area.

(1) Shallow Tube Well (STW)

A well, of which depth is within 30 meters and the capacity of about 0.5 cusec is called Shallow Tube Well. The irrigable area per well is about 4-5 ha.

According to 1985/86 Agro-statistics, there are about 500-600 shallow tube wells in the Project area. However, these wells are used only as a substitute irrigation method in the rainy season, and are not available in the dry season due to the decrease of groundwater level.

(2) Deep Tube Well (DTW)

A well, of which depth is about 30 meters or more, and the capacity of approximately 2.0/cusec is called Deep Tube Well. The irrigable area per well is about 20-4- ha.

At present, this method is implemented under Barind Tract Tube Well Project. This type of well has been installed in about 3,000 places, of which about 200 places are included in the NRIP Project area. However, in the high elevated portion of the Barind Tract, the ground water level is low in the dry season. The ground water recharge will not be enough in the Barind tract due to its clay texture.

(3) Low Lift Pump (LLP)

The water resources for LLP is surface water. Along the Ganges river (from Sultangonj to Rajshahi) in the Project area, few LLPs are existing. However, several LLPs are provided along the Mahananda river, although the areas are outside of the Project area. About 8 to 18 hectares of area can be irrigated by one LLP.

3-6-4. Flood and Drainage Conditions

Along the Ganges river, flood protection dikes have been constructed, which can be said that the flood of the Ganges river has been protected. However, an abnormal flooding in August to September 1987 caused severe damages to all over the country. In the Project area, the national road in the Godagari and Nawabgonj have been over-topped by the flood and the probability of the flood was 50 to 70-year return-period.

Rajshahi City protection project is under implementation to protect the city from erosion of the Ganges river. As of todate, five groins have been constructed.

The Sib river flows from north to south to catch the runoff from the Barind tract, which connects to the Barnai river at Naohata, and confluences to the Atrai river, and then flows into the Jamuna river. The elevation of the low flat area is lower than the water level in the Ganges river during rainy season making it rather difficult to drain the land water into the Ganges river. Therefore, the inland water should be drained from west to east even though the length of the river is very long.

The left side of the Sib river has been protected by the flood protection dike of the Polder D in the Chalan Beel Project. The right side of the Sib river which is the lower portion of the Barind tract will be affected by inundation.

3-7. Topographic Survey and Geological Investigation

3-7-1. Available Topographical Maps

(1) Topographical Maps

The following topographical maps of the Project area were available in Bangladesh.

1) Scale: 1:7,920
   One foot contour interval published in 1968. This map consists of 52 sheets to cover the Study area and has been used as a basic map for Project study.

2) Scale: 1:50,000
   50 feet contour interval, published in 1965.

3) Scale: 1:250,000

(2) Aerial Photographs

In addition to the above topographical maps, the following aerial photographs have been collected:

1) Scale: 1:30,000 taken in 1975.
2) Scale: 1:50,000 taken in 1983.
   Maps for the southern part of the Project area along the Ganges were not available.

3-7-2 Topographic Survey

The following survey works have been performed in the project area, the location of which is shown in Fig. 3-4.

1) Benchmark Survey
2) Irrigation Canal Route Survey
3) Pumping Station Plain Survey
4) River Cross-section Survey
5) Sample Area Survey for Terminal Facility Layout
6) Others

(1) Benchmark Survey

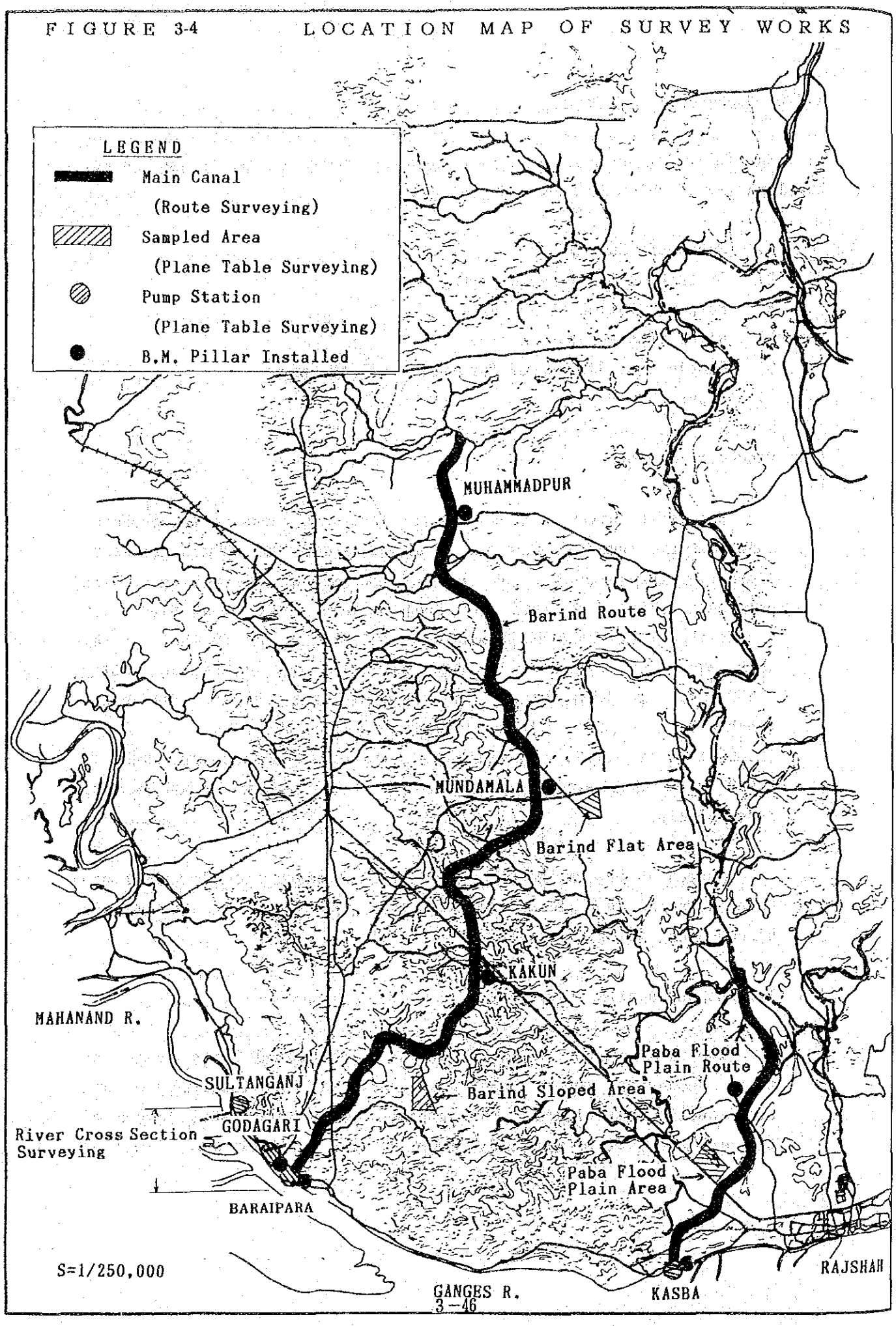
Benchmark survey is essential for levelling works of the proposed main canals, pumping stations, sampled areas and other necessary places in the project area. Bench mark values were set up at the permanent objects whithin the project area from available G.T.S benchmarks at Rajshahi and Nawabganj. All the heights in these survey works were given in P.W.D values, which can be obtained by adding 1.509 feet to G.T.S Detum, and converted into meter. The basic benchmark values at Rajshahi and Naogaon are 61.494 feet in G.T.S and 72.666 feet in G.T.S, respectively. As a result, benchmark values in P.W.D at Rajshahi and Naogaon are 19.203 meters and 22.609 meters, respectively.

Permanent benchmark pillars of BWDB standard specifications had been installed at 7 places including the proposed pumping stations and places along the main canals.

(2) Irrigation Canal Route Survey

Two main canals in the Barind and Paba Flood Plain Areas and three secondary canals have been surveyed for longitudinal and cross-sectional profiles. For longitudinal section, spot levels of the alignment were basically taken at 200 m intervals. Detailed

FIGURE 3-4 LOCATION MAP OF SURVEY WORKS



levels were taken where the alignment crosses the rivers, roads, railway and any depressions. Cross-sections of the alignment were taken at 200 m to 400 m intervals depending on the topographical conditions. Each cross-section was extended 50 m each side from the center line of the alignment. The total length of the survey works for the main canals for Barind and Paba Flood Plain Areas are about 54 km and 20 km, respectively.

(3) Pumping Station Plain Survey

Plane table survey has been carried out at the proposed pumping stations. Four sites were selectd to survey the pumping stations including intake and discharge pond at Sultanganj, Godagari, Baraipara and Kasba.

(4) River Cross-Section

Cross-sections of Mahananda River from Sultanganj to the confluence point with the Ganges River, and cross-sections of the Ganges River from Godagari to Baraipara and at Kasba have beeen surveyed in order to determine the present condition of the riverbed.

(5) Sample Area Survey for Terminal Facility Layout

Plane table survey has been performed in the sampled areas for layout of terminal facilities, and Mouza maps have also been collected for reference use. Three sites, approx. 200 ha each, were surveyed to make the contour maps for sampled areas such as Barind Sloped Area, Barind Flat Area and Paba Flood Plain Area.

(6) Others

The following additional survey works also have been done:

1) Cross-section levelling at the essential parts of Sib River and other rivers concerned.

2) Levelling of the datum line of the existing and newly installed hydrological staff gauges at Sultanganj, Godagari, Kasba, Rajshahi and Naohata.

3) Levelling of the old-railway from Godagari to Digram.

3-7-3. Geological Investigation

Geological investigation has been performed to obtain basic data of the sub-soil features for the proposed pumping stations.

The sub-soil investigation includes detailed field investigation, laboratory testing and technical works including analysis of soil engineering problems.

(1) Foundation of Pumping Stations

1) Sultanganj

In recent years the Ganges River is found to shift northward near the confluence of the Ganges with Mahananda river. As such there is much scouring and erosion near Godagari. The very stiff clay of the Barind Tract has been very effective against erosion, but the removal of the underlying sand layer by erosion has been causing considerable bank failures.

2) Godagari and Baraipara

The following points should be taken into consideration during planning and designing of hydraulic structures around Godagari and Baraipala.

a) Possible depth of scour should be taken into consideration while fixing location of structure and designing foundation near the Ganges River.

b) As sandy soil is easily erodable, large hydraulic structures by the side of the Ganges should have the foundation below the erodable sandy layers and plstic clay layers.

3) Kasba

Scouring and erosion of bank and bed of the Ganges river at Kasba site are also in progress. Possible depth of scour should be taken into consideration while fixing location of structure and designing foundation as well as at Godagari and Baraipara. Large hydraulic structures by the side of the river should have the foundation below erodable sandy layers.

In view of special characteristic of geological formation and scouring and erosion of the Ganges, it is recommended that any land-based pumping station should have the foundation supported by the bearing piles.

The results of the field investigation are shown in Table 3-4, which describe layer-thickness, lithology N-value and soil type respectively at each borehole.

(2) Foundation of Structures in the Project Area

The top-soil of the Barind Tract for about 20 m is stiff clay and as such most of the structures are expected to be supported on this layer.

In Bangladesh, embankment is generally constructed with soil obtained from the excavation of borrow pits/canals by the side of embankment. In the Barind Tract this soil will be mainly stiff clay. Compaction of this type of soil will need proper moisture content and suitable compaction equipment.

(3) Soil Mechanical Tests

Soil mechanical tests have been performed on soil samples collected from the boreholes at the proposed pumping stations and also from the proposed main canal sites.

1) Pumping Stations

Results of the laboratory test are summarized as shown in Table 3-5. These values will be useful for designing of hydraulic structures and analyzing the foundations at the proposed pumping stations.

2) Embankment Materials

In the design of main canal, laboratory tests were carried out at proposed main canal sites in order to determine the side slope of embankment and cutting works, and to presume settlement value of the foundation layer below embankment.

Results of the laboratory tests are summarized in Table 3-6.

TABLE 3-4. FIELD INVESTIGATION RESULTS AT PROPOSED PUMPING STATION

Bore Hole Site	Depth of Layer	N-Value	Soil Type (condition)
1. Sultanganj	0.0m~ 3.0m	2 ~ 4	Sandy Silt (very loose)
(B.H.-No.1A)	3.0 ~ 13.0	4 ~ 13	Clay (stiff)
	13.0 ~ 19.2	13 ~ 19	Sandy Clay (very stiff)
	19.2 ~ 21.0	8 ~ 20	Sand (loose)
	21.0 ~	20 ~ over 50	Sand (dense)
2. Sultanganj	0.0 ~ 1.2	3	Silt (soft)
(B.H.-No.1B)	1.2 ~ 10.1	3 ~ 12	Clay (med.stiff to stiff)
	10.1 ~ 16.0	12 ~ 26	Sandy Silt (med.dense to dense)
	16.0 ~ 20.1	17 ~ 22	Clay (very stiff)
	20.1 ~ 31.4	21 ~ 46	Sand (dense)
3. Jahanabad	0.0 ~ 5.5	3 ~ 18	Clay (soft to stiff)
(B.H.-No.2)	5.5 ~ 9.4	13 ~ 18	Sandy Silt (med.dense)
	9.4 ~ 17.4	18 ~ 19	Clay (very stiff)
	17.4 ~	19 ~ over 50	Sand (dense)
4. Godagari & Baraipala (B.H.-No.3)	0.0 ~ 2.0	2 ~ 3	Silt (soft)
	2.0 ~ 19.2	3 ~ 17	Clay (med.stiff to stiff)
	19.2 ~ 22.3	17 ~ 20	Sand (med.dense)
	22.3 ~	20 ~ 42	Sand (dense)
5. Kasba	0.0 ~ 1.7	2 ~ 5	Clay (soft)
(B.H.-No.3)	1.7 ~ 20.4	5 ~ 17	Clay (med.stiff to stiff)
	20.4 ~	17 ~ 39	Sand (med.dense to dense)

TABLE 3-5. SUMMARY OF LABORATORY TEST RESULTS (1)

Item \ Bore Hole Site	Sultanganj (B.H.-No.1A)		Jahanabad (B.H.-No.2)		Godagari & Baraipala (B.H.-No.3)		Kasba (B.H.-No.4)	
Depth of Sample (m)	4.04 to 4.50	8.54 to 9.00	2.0 to 2.46	4.04 to 4.50	2.04 to 2.50	4.04 to 4.50	2.04 to 2.50	4.04 to 4.50
Density : wet (t/m^3)	1.90	1.93	1.88	2.03	1.88	1.94	1.97	1.98
dry (t/m^3)	1.53	1.60	1.52	1.73	1.49	1.57	1.65	1.67
Unconfined Compression Strength								
: undisturbed (t/m^2)	10.87	15.04	13.20	25.85	5.78	14.95	17.34	19.24
: remould (t/m^2)	7.35	9.87	8.20	19.01	5.18	10.83	12.30	13.52
Shearing "Resistance Angle (degree)	4	5	3.5	4.5	5	6	4	4.5
Cohesion (t/m^2)	4.93	7.50	5.98	6.34	7.39	4.22	8.10	9.50

TABLE 3-6. SUMMARY OF LABORATORY TEST RESULTS (2)

Item \ Sampling Site	Dilshadpur - highland (A-1, A-2)	Sagona - lowland (B-1, B-2)
Depth of Sample (m)	0.30 to 0.76	0.30 to 0.76
Density : wet (t/m^3)	1.85 to 1.97	1.87 to 1.91
: dry (t/m^3)	1.55 to 1.63	1.55 to 1.57
Unconfined Compression Strength :undisturbed(t/m^2)	7.96 to 24.44	6.43 to 10.31
:remould (t/m^2)	4.71 to 16.25	3.87 to 6.65
Shearing Resistance Angle (degree)	4 to 8	5.5 to 12
Cohesion (t/m^2)	2.46 to 7.75	1.05 to 4.12

CHAPTER 4
THE PROJECT

CHAPTER 4. THE PROJECT

4-1. Development Plan

4-1-1. Development Constraints

(1) Topographical Features

The Barind tract forms high elevating and undulating area as a terrace landscape ranging from 15 to 45 meters in elevation.

There is no place to store the surface water, like a beel, in the Barind tract and the ground water surface is very low due to high elevated land. As a result, the availability of water resources in the Barind tract is quite limited. There would be limitation for ground water exploration due to clay type soil which can be hardly expected for ground water recharge, although scattered exploration for irrigation by DTW has been done by BADC.

The Ganges river water is the only available water resources for year-round irrigation in the Barind tract.

In order to irrigate the Barind tract, it is necessary to provide pumping stations along the Ganges river. It will require more energy or electric power capacity for irrigating the Barind tract than the flood plain area due to its high elevation. Moreover, more excavation and embankment for the canal layout will be required due to the undulating topographic conditions.

(2) Crop Production

Due to unstable rainfall pattern and insufficient irrigation water supply, unit yield in the Barind area is low and cropping intensity is lower than the flat area. The present low productivity and low yield are the results of insufficient irrigation water, inadequate irrigation and

related facilities, lack of cultivation funds, and incomplete agricultural support services. Among those, insufficient irrigation supply will be the deciding factor in future agricultural development area.

During the rainy season, very few accessible roads are provided in the Project area except metal road located along the Ganges river from Rajshahi to Chapai Nawbganj.

4-1-2. Basic Development Concept

(1) Objectives

The proposed Project aims to expand agricultural production and thereby increase income of residents in the area through the introduction of modern agricultural technology and stable year-round irrigation water supply by surface water. Furthermore, the Project is intended to improve the living standards of local residents by introducing rural development such as road network, fisheries and village water supply. Employment opportunities in the area will also be increased not only during the implementation period of the Project but also by stimulating private sectors of post-harvest system and marketing activities.

In order to achieve the above objectives, the main component of the development plan is to provide irrigation facilities in agricultural land for mainly rice. The water resources development to supply irrigation water will be necessary to lift up water from the Ganges or Mahananda rivers by pumps. In addition, supplementary components functionary related to the irrigation development, such as road network development and fish pond culture development are incorporated into the Project.

A development plan and appropriate size of the Project to be developed are determined in accordance with the alternative studies.

(2) Development Concepts

The Project area can be categorized into two distinct areas from the viewpoint of topography, soil condition, cropping pattern and flood effect.

The lower flat area is located in the Paba Upazila and belongs to the flood plain area of about 13,000 hectares. This area will be called "Paba Flood Plain Area" or "Flood Plain Area" in the report. Another area is located in high and undulated area, called Barind Tract which is flood-free area. This area will be called "Barind Area" in the report.

Since characteristics for both areas are so different that the Paba Flood Plain Area and Barind Area will be better to consider the development plan separately.

The following development concepts for the Project have been determined taking into consideration the natural and physical features, and availability of the water resources.

1) Stable and timely irrigation water supply through the year.

2) The size and capacity of pumps and irrigation facilities should be decided on the basis of supplemental irrigation during wet season. In order to utilize the facilities effectively throughout the year, the dry season irrigable area should be reduced to have the same capacity in the wet season requirements.

3) The irrigation water should be pumped from the Ganges river to attain year-round irrigation on the basis of surface water resources development.

4) Considering the topography, soil and agricultural farming system in the Project area, the irrigation system for Barind area and Paba flood plain area should be separated.

5) The Project aims to increase the unit yield of crops and crop intensity and overall production through the introduction of irrigated farming technology.

6) Introduction of irrigated farming technology and strengthening of supporting and extension services.

7) Introduction of vegetable and other diversified crops and increasing the cropping intensity.

8) Strengthening and expansion of existing agricultural support system, especially in the Barind area.

9) Introduction of post-harvest technology and improvement of existing facilities.

10) Establishment and improvement of systematic drainage networks in the Paba flood plain area.

11) Establishment of a road network system to ensure effective functioning of irrigation facilities, water management, farm production, marketing activities and accessibility during the wet season.

12) Establishment and reinforcement of farmers' organization for supply farm inputs, credit, appropriate water management and irrigation facility maintenance.

13) Economic and technical optimization of the Project size development on the basis of alternative studies, and,

14) Study on the stage-development of the Project implementation.

(3) Development Approaches

An overall development plan for the whole proposed area will be initially formulated. Based on this plan, a stage-development plan will also be studied as practical method of implementation.

1) Overall Development Plan

Taking into account the present natural, social and economic conditions, the proposed land use and farming types for the Project area will be studied.

The proposed Project aims to promote rural development by increasing productivity, farm income and employment opportunities through irrigation development.

As for the irrigation development, several alternative studies will be performed to optimize the development size (especially irrigation acreage) and capacity of major irrigation facilities. The optimization of the irrigation facilities will be considered together with the capacities of pump stations on the Ganges and Mahananda rivers.

2) Study for Alternative Plan

The Barind tract forms undulating area as a terrace landscape ranging from 15 to 45 meters (50 to 150 feet) in elevation with an average slope of 1 to 500 to 1,000. In the southern and western areas, the tract is hilly and dissected by narrow (usually streamless) valleys.

In the northern and eastern parts, the tract becomes rather flat with an average slope of 1 to 1,000. In the south-west area along the Ganges river, the elevation of the land near the river is 15 to 20 meters (60 to 70 feet). With about 3 to 4 kilometers from the river to the inland, the elevation rises up to about 30 to 33 meters (100 to 110 feet). The hill ranges over 20 kilometers. The lowest elevation of the ridge is about 24 meters (80 feet), and this makes it difficult to irrigate the Barind tract.

In order to irrigate the Barind tract, it is necessary to provide pumping stations along the Ganges river.

According to records of river bank shifting of the Ganges River, Baraipara is the most stable bank in the past several decades. Along the Mahananda river, Sultangonj is also a stable site for pumping station but only for wet season use. Accordingly, Baraipara and Sultangonj are proposed for the pumping station sites.

Taking into consideration the high ridge along the Ganges River near the Baraipara and Sultangonj, it will be required to lift the river water to rather high elevation to go over to the ridge to irrigate the Barind tract.

To irrigate the Barind tract from the Baraipara and Sultangonj, the high lifting of Ganges river water by pumping stations can irrigate more areas. In order to irrigate more areas, high cost of pump equipment as well as electric charges will be required or vice-versa.

Compromise should be made to find the optimal point of elevation to be irrigated. Then alternative studies are required.

Due to the high ridge along the Ganges river, it will be rather difficult to irrigate the lower portion of Barind tract from the proposed pumping station at Baraipara, because there will be very; few irrigable areas along the Ganges river from Baraipara to western side of Rajshahi. The proposed pumping station should be located near the Rajshahi for low flat area. Therefore, the irrigation areas will be divided into two areas of low flat area and elevated high area.

In order to utilize the return-flow and effective use of the pumped irrigation water, the route and layout of the irrigation canal will be carefully selected.

There are many farm ponds and small-scale impoundings in the Project area for the agricultural and village water uses. Supplemental water supply to these existing impoundings can be considered by connecting them with the proposed irrigation canal.

3) Stage Development Plan

To attain the increase of the productivity and expected benefit from the overall development plan, new technology of farming practice, and social infrastructures such as supply system for the necessary farm input, providing of post-harvest facilities and marketing facilities are inevitable.

Therefore, in order to develop the whole Project area, it is necessary to provide not only the irrigation facilities but also all the relevant social infrastructures at the same time.

However, taking into consideration the economic and social conditions of the country, a step-by-step development method (so-called stage-development) will be more practicable and realizable method of implementation. The stage-development plan will be studied within the framework of the overall development plan.

4-1-3. Project Components

Under the present Project, the following three components were selected as tangible and studied for economic feasibility:

a) Establishment of an agricultural development plan based upon providing irrigation and drainage facilities.

b) Improvement of a road network, rural communication and transportation conditions in the area by utilizing operation and maintenance road for irrigation facilities; and,

c) Inland fisheries development in existing ponds and tanks in the area utilizing irrigation water and the return-flow.

4-2. Water Resources Development Plan

4-2-1. Availability of Water Resources

As for the ground water, deep tube-well project is on-going in the Barind tract in the Project area. There is not enough ground water resource to irrigate about 20,000 to 40,000 ha of land; accordingly, no groundwater utilization for the Project has been considered.

As for the surface water resources, there are four major rivers in and near the Project area for irrigation use. The most reliable source of water is the Ganges river which flows in the southern boundary of the Project area. The minimum discharge at Hardinge Bridge was observed at 683 m^3/sec on 6th April 1985. The Mahananda river flows into the boundary of the Project area. The available discharge in the Mahananda river is about 7 to 8 m^3/sec in the driest months of April and May, which may be used only for supplemental water resources.

Along the eastern boundary of the Project area, the Sib river flows from north to south and confluenced to the Barnai river at Naohata. But the river water will be dried up during dry season, except in the depressions (so-called Beel in Bangladesh) along the Sib river.

The Atrai river flows in the northern part of the Project area from north to south and confluenced at Manda to the Sib river. But the confluence point had been closed by an embankment by the local people. The discharge of the Atrai river is very small during the dry season.

Accordingly, only the Ganges river has enough water for dry season irrigation. However, irrigation water is expected during pre-monsoon or post-monsoon in the Mahananda, Sib and Atrai rivers.

In the Mahananda river, supplemental irrigation water is also expected even during the dry season although the capacity will not be enough.

Consequently, the main water resources during the dry season is the Ganges river and for supplemental irrigation water during the wet season is the Mahananda river.

4-2-2. Selection of Sites for Proposed Pumping Stations

(1) Available Records of River Bank Shifting

Available records of the Ganges river bank shifting in the Project area, from Sultangonj to Rajshahi, are quite limited. The records of river bank shifting surveyed by Joint River Commission (JRC) for the Ganges river has mainly covered from Sardah (15 km downstream from the Rajshahi) to the downstream of the Hardinge Bridge. There is only one report for the river bank shifting record covering from the Farakka Barrage to the Hardinge Bridge. The report was published in July 1981 by Bangladesh Water Development Board, Water Investigation Directorate and titled "Bank Line Movement of the Ganges (from 11 mile below Farakka Barrage to Gorai off-take) 1973-1980".

In addition, old maps such as Upazila maps showing the Ganges river banks, topographic maps have been collected.

In order to obtain the most accurate river bank line movement, aerial photographs taken in 1975 (scale: 1:30,000) and 1983 (scale: 1:50,000) have also been collected. The photographs in 1983, however, do not cover in the southern part of the Project area along the Ganges river.

Furthermore, in order to determine the latest river conditions, river cross-section survey has been performed during the Study period in December 1987 from the Sultangonj to Baraipara and in the Kasba area.

(2) Pumping Station Site for Barind Area

The left bank of the Mahananda and Ganges rivers from Sultangonj to Godagari has changed very much. The Ganges river near Godagari and at the confluence with Mahananda has shifted about 1.3 km during 1975 to 1983. According to the latest survey results (1987) the bank line again moved back to river side from 1983 for about 600 m.

Accordingly, the Ganges River is oscillating near Godagari and the mouth of the Mahananda river.

The river of the Mahananda river at Sultangonj and 1.6 km downstream of Godagari at Baraipara of the Ganges River are quite stable for long period. As for the Sultangonj, however, the right bank is not so stable as the left bank. Accordingly, the Sultangonj is not preferable for the proposed pumping station for a year-round irrigation purpose from the viewpoint of the river bank stability and the availability of the river water for irrigation during the dry season. Since the river bank is stable enough at Sultangonj, the site can be proposed for a pumping station which will be operated during the wet season only.

10 cross-section surveys have been performed from Mahananda confluence to Baraipara across the Ganges river. The results of the observations were as follows:

a) From Mahananda river mouth to Godagari, the river bed is too shallow for pump stations.

b) The bank line near Godagari is concave and is subjected to serious erosion and deposition possibility in future.

c) At Baraipara near the Railway Bazar, the Ganges bank line is very stable for the last 50 years and channel is very deep near the left bank where a pumping station is proposed.

d) The deeper portion is located near the left bank in 1987 and also in 1974 as shown in the cross-section survey conducted by the JICA Study Team and JRC, respectively.

e) Pumping station site at Baraipara is considered most suitable.

Accordingly, the Baraipara is selected as the most suitable site for a proposed pumping station for Barind Area for a year-round irrigation purpose for the both points of river bank stability and quantity of the available river water during dry season.

(3) Pumping Station Site for Paba Flood Plain Area

The aerial photograph taken in 1983 is not available along the Ganges river in the southern portion near the Rajshahi City.

The river bank line movement has been studied by the available Paba Upazila map surveyed in 1940, topographic map scale of 1:50,000 surveyed in 1968. The most accurate record of the river bank condition is the aerial photographs taken in 1975.

The river bank was eroded in around 1940. However, since 1975, the river bank near the Kasba has not changed for about 12 years. The downstream of Kasba near the Rajshahi has been eroded for about 1.3 km during 1975 to 1980.

The cross-section of the river in Kasba shows that the river course is located near the left bank and the depth of water is sufficient for proposed intake site.

Accordingly, the Kasba site has been selected as a proposed pumping station for Paba flood plain area.

4-2-3. Alternative Plans for Irrigation System

The Project area consists of two areas; namely, the Paba flood plain area and the high elevated Barind area. From economic, and operation and maintenance points of view, it would be better to separate the irrigation systems for the two areas.

At first, the boundary of the Paba area should be delimited on the basis of the irrigation networks. The alternative plans will be studied within the Barind area.

There is a highly elevated area near the Sultanganj at an elevation of 36.6 meters for about 1.6 km from the Mahananda river to the point, where delivery pond can be proposed. It has not enough water to irrigate the whole area from the proposed Sultanganj pump station in the Mahananda river due to the limitation of available river flow during the dry season.

River flow in the Ganges river at Baraipara is sufficient. However, the distance from the Baraipara to the highest point (proposed delivery pond site), is rather far by about 6 km.

There is a long depressed area like a river along the Ganges river from Godagari to Sultangonj which can be utilized for a leading canal to convey the pumped water at Baraipara pump station to the Sultangonj. A secondary pump equipment will be necessary to lift the water from the Baraipara to the proposed delivery pond site (EL. 36.6 meters) together with the water from the Mahananda river at Sultangonj.

(1) Alternative Plans for the Barind Tract

In order to find the most optimal elevation of the pumping point for the irrigation system for the Barind Area, the following three alternative plans have been proposed:

Alternative Plan 1 : Pumping point EL 36.6 m (120 feet)
Alternative Plan 2 : " EL 30.5 m (100 feet)
Alternative Plan 3 : " EL 24.4 m (80 feet)

(2) Sib River Reservoir Plan (Alternative Plan 4)

In Barind area, the northern part from the road between Tanore and Mandamara is less undulated than the southern part. It is possible to irrigate more area in the northern area than the southern area at the same elevation of the pumping point. In order to irrigate more area in the same energy for pumping, the irrigation system for Alternative Plan 4 has been considered to propose a pumping station in the northern portion near Niamatpur. The elevation of delivery point of the pump station is proposed at EL. 27.4 m (90') considering the topography. The route of the main canal has been selected to irrigate from north to south.

In order to convey the irrigation water pumped from the Ganges river, the Sib river can be utilized as a main canal during dry the season and also the water from the Ganges as well as its own river flow can be stored in the river course and beels along the river.

The Sib river flows from north to south and the Joakhali river surrounding the Karnahar Barabila Polder flows to the south near the Ganges river. Therefore, a pump station is proposed at Kasba village in the Ganges river to lift the Ganges water and to connect to the Joakhali river, in order that the water be supplied to the Sib river. To limit the water supply area in the Sib river, a regulator will be provided at Naohata. The top of the regulator can be used as road, which will be wider than the existing bridge at Naohata.

The optimal water surface elevation in the Sib river should be determined in storing the water volume as a reservoir. When the storage capacity in the Sib river is increased, the pump capacity from the Ganges river can be reduced but the submerged area is increased. On the contrary, when the storage capacity in the Sib river is decreased, more water should be supplemented from the Ganges river and the capacity or size of pump should be increased but the submerged area can be minimized.

Four types of water surface elevations; namely, 12.2 m (40 feet), 13.7 m (45 feet), 14.3 (47 feet) and 14.9 m (49 feet) have been studied to estimate the storage capacity, required pump capacity and net irrigation acreage.

On the basis of the construction cost and the benefit from the area for each use, the financial basis of economic justification has been made.

As a result, the water surface elevation at 13.7 m (45 feet) for irrigation area of 21,630 ha has been selected as the most economical scheme among them.

Consequently, the water surface elevation of 13.7 m has been selected in the Alternative Plan 4.

(3) Comparative Study between Beneficial Area and Facilities for each Plan

The results obtained from the layout of irrigation facilities for each plan on 1/50,000 topographic map, are shown below:

Beneficial Areas for Each Plan

Area	The Barind Tract				Paba Area
	Alternative Plan				
	Plan-1	Plan-2	Plan-3	Plan-4	
Study Araa	138,500	138,500	138,500	138,500	13,300
Excluded Area	37,700	70,400	119,000	98,000	0
Project Area	100,800	68,100	19,500	40,500	13,300
Unirrigable Area	12,700	13,800	8,800	11,200	0
Gross Beneficial Area	88,100	54,300	10,700	29,300	13,300
Homestead and Others	15,800	9,800	1,900	5,270	3,300
Cultivated Area	72,300	44,500	8,800	24,030	10,000
Net Beneficial Area	65,050	40,060	7,920	21,630	9,000

In accordance with the projected area in each alternative, required facilities and cpacities have been estimated. The main features of the facilities and capacities for each alternative plan are listed in Table 4-1.

(4) Comparison of Economic Justification

The consruction cost, operation and maintenance cost, and benefits for each plan have been estimated. In order to justify the economic viability of the alternative plans, the financial basis of internal rate of return (FIRR) has been estimated, as shown in Table 4-2.

TABLE 4-1 MAIN FEATURES OF ALTERNATIVE PLANS

	Barind Area			
	Plan 1 EL. 36.50 m	Plan 2 EL. 30.50 m	Plan 3 EL. 24.40 m	Plan 4 EL. 27.40 m
Net Irrigation Area (ha)	65,050	40,060	7,920	21,630
(%)	162.4	100	19.8	54.0
1. Pumping Station				
1) Ganges Pump				
Capacity (Max) (m^3/s)	68.2	42.0	8.3	15.0
Capacity (Design) (m^3/s)	64.5	40.0	7.8	14.0
Intake W.L (EL, m)	8.50	8.50	8.50	8.30
Delivery W.L (EL, m)	36.60	30.50	24.40	18.30
Actual Pump Head (m)	28.10	22.00	15.90	10.00
Motor Power (kw)	32,110	15,400	2,850	2,170
Operation Hour (Hr)	4,000	4,000	4,000	4,000
2) Booster Pump				
Capacity (Max) (m^3/s)	-	-	-	22.5
Capacity (Design) (m^3/s)	-	-	-	20.0
Intake WL. (EL, m)	-	-	-	12.20
Delivery WL. (EL, m)	-	-	-	27.40
Actual Pump Head (m)	-	-	-	15.2
Motor Power (kw)	-	-	-	4,840
Operation hour (hr)	-	-	-	4,000
3) Delivery Pipe (m)	1,800	1,400	1,700	1,000
2. Irrigation Facility				
1) Main Canal Length (m)	50,400	48,800	24,000	45,000
2) Secondary Canal Length	257,400	157,700	61,000	50,000
3. On-farm Facility				
Slope Area (ha)	40,790	25,120	4,790	-
Flat Area (ha)	24,260	14,940	2,950	21,630
4. Drainage				
1) Canal (m)	-	-	-	-
2) Regulators	-	-	-	-
5. Canal Related Structure				
1) Rail Road Crossing	11	7	2	4
2) Bridge	18	11	3	6
3) Gate Nawhata (w×h)	-	-	-	$70^m \times 5^m$
4) Gate Atrai (w×h)	-			$20^m \times 3^m$

TABLE 4-2 ECONOMIC JUSTIFICATION OF ALTERNATIVE PLANS

×1,000TK

	Barind Area			
	Plan 1 EL. 36.50 m	Plan 2 EL. 30.50 m	Plan 3 EL. 24.40 m	Plan 4 EL. 27.40 m
1. Basic data				
Net irrigable area (ha)	65,050	40,060	7,920	21,630
Delivery WL. (m)	36.60	30.50	24.40	27.40
Q max (m^3/sec)	68.2	42.0	8.3	22.5
Sediment Volume (m^3)	68,154	44,227	8,315	22,688
2. Construction Cost				
1) Pumping Station	3,417,000	1,747,000	34,000	1,430,500
2) Irrigation Canal	351,700	236,000	97,100	108,500
3) Facilities	123,700	83,000	34,100	38,100
4) Road and Bridge	280,100	173,000	34,200	93,400
5) On Farm	90,900	56,000	11,000	30,200
6) Transmission Line	113,400	58,000	11,300	37,200
7) Telephone Line	400	400	400	900
8) Constraction Equipment	222,700	131,000	25,900	70,700
Sub-total	4,599,900	2,484,400	554,000	1,809,500
9) Land Aquisition	289,100	194,000	79,800	89,200
Sub-total	4,889,000	2,678,400	633,800	1,898,700
10) Contingency (15%)	733,300	401,700	95,000	284,800
Total construction Cost	5,622,300	3,080,100	728,800	2,183,500
Construction Cost /ha	86,430	76,887	92,020	100,947
3. O & M Cost				
Electric Charge	165,900	88,300	11,800	42,900
Dredging	3,800	2,400	500	1,300
Pump & Canal	36,800	22,700	4,500	12,200
Sub-total	206,500	113,400	16,800	56,400
Miscellaneous	20,600	11,300	1,600	5,600
Sub-total	227,100	124,700	18,400	62,000
Administration	4,300	4,300	4,300	4,300
Total	231,400	129,000	22,700	66,300
O & M cost per ha	3.557	3.220	2.866	3.065
4. Benefit				
With Project NPV	1,731,637	1,066,407	210,839	575,836
Without Project NPV	425,098	261,780	51,719	141,379
Net Benefit	1,306,539	804,627	159,120	434,457
5. Financial IRR	13.0%	14.7%	12.7%	11.0%

4-2-4. Selection of the Optimal Size of the Project

(1) Selection of Optimal Alternative Plan

As shown in Table 4-2, the economic justification should be made on the basis of total construction cost which also includes land acquisition cost. The financial basis of internal rate of return, therefore, has been estimated. It was observed that the FIRR in the Alternative Plan 2 shows the highest and the construction cost per hectare shows the minimum.

As for the operation and maintenance cost per hectare, the cost is proportionately increased in accordance with the increase in acreage. This tendency is due to the fact that the electricity charge for the required pump is increased not only for the increase in acreage but also for the pumping head increse.

Consequently, the Alternative Plan 2 (pumping up elevation 30.5 m) has been selected to be recommended for the Project development.

(2) Net Irrigable Area of the Project

Further detailed study on the base map 1 to 7,920, and topographic survey has been made along the main canal route, sample areas for on-farm development, etc. on the basis of the selected Alternative Plan 2.

According to the land use map, the total area is estimated at 77,000 ha, in which the Rajshahi urban and residential area located in the both sides of the national road from Rajshahi to Godagari along the Ganges river have been included. The area should be excluded from the Project area.

In the alternative studies, the area near the Sultanganj has been included in the Project area, but due to the change of the proposed pumping station at Baraipara, the area can not be irrigated by gravity because of the high elevation. The area has also been excluded from the final project area.

As a result, the total project area has been fixed at 72,270 ha in which Barind area and Paba area are 60,610 ha and 11,600 ha, respectively.

As for the Barind area, there is a few beels along the Sib river. When the irrigation water is supplied to the Barind area, there will be perennial flow from the return-flow of the irrigation water in the Sib river.

Therefore, the existing beels and river course will not be dried up even in the dry season and can be utilized for inland fisheries development area.

On the other hand, the low land area along the Sib river is normally submerged by flooding of the river during wet season. During dry season at present, however, a part of the submerged area is planted for Boro by LLP. It will not be recommendable to provide irrigation facilities in this area because of the submergence during wet season. Therefore, this area has not been considered as the beneficial area of the Project though the conditions of the area will remain as they are. This area can be expected to increase the production of Boro due to the return-flow of irrigation water, but for safety side of project benefit estimation, this area has been neglected from the beneficial area.

However, the existing water body area in the beels and the Sib river course has been proposed for fisheries development area.

As for the submerged area during wet season, water level records at Nawhata in the Sib river have been selected to decide the flood water level. As shown in TABLE II-1-15, Maximum Water Level at Nawhata from 1961

to 1987, the monthly average maximum water level shows at 13.710 meters (44.980 feet) in September. Also, the average of the annual daily maximum water level at Nawhata from 1961 to 1986 for 25 years as shown in TABLE II-1-11 is at 13.854 meters (45.454 feet).

Based upon the above average maximum water level at Nawhata, the submerged area has been defined below 13.716 meters (45 feet) which is 4,800 hectares.

Consequently, the area below 13.716 meters (45 feet), which is 4,800 hectares, has been neglected from the beneficial area.

Based on the gross area of the Project, the elevation of area, layout of canals and area for irrigation facilities upto on-farm level has been estimated and the total net irrigation area has been fixed at 51,200 ha in which the Barind and Paba areas are 42,200 ha and 9,000 ha, respectively. The results are shown in the following table.

Net Irrigable Area

	Flood Plain Area				Barind Area				Total Irrgable Area	
	Gross Area	High Land	Irrigable Area		Gross Area	High Land	Irrigable Area			
	ha	ha	ha	%	ha	ha	ha	%	ha	%
Gross Area	11,660	110	11,550	100.00	55,810	5,730	50,080	100.00	61,630	100.00
Residential etc.	1,720	11	1,709	14.80	4,260	437	3,823	7.63	5,532	8.98
Rivers	-	-	-	-	392	39	353	0.70	353	0.57
Ponds	118	3	115	1.00	578	59	519	1.04	634	1.03
Water Body	252	-	252	2.18	53	8	45	0.09	297	0.48
Sub-total	2,090	14	2,076	17.98	5,283	543	4,740	9.46	6,816	11.06
Farm Land	9,570	96	9,474	82.02	50,527	5,187	45,340	90.54	54,814	88.94
Right of Way	(Approx. 5%)		474	4.10	(Approx. 7%)		3,140	6.27	3,614	5.86
Net Irrigable Area			9,000	77.92			42,200	84.27	51,200	83.08
Deep Water Rice			(720)				-		(720)	