THE PEOPLE'S REPUBLIC OF BANGLADESH

BANGLADESH WATER DEVELOPMENT BOARD

FEASIBILITY STUDY
ON
THE KURIGRAM
IRRIGATION AND FLOOD CONTROL PROJECT
— NORTH UNIT —

VOLUME 2
APPENDICES

OCTOBER 1990

JAPAN INTERNATIONAL COOPERATION AGENCY

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SOIL AND LAND CLASSIFICATION

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1. Soil Survey Method

1-1. Previous Studies

A series of soil survey work was carried out by the Soil Survey Department (presently SRDI) as a part programme of the National Soil Survey Project for the systematic reconnaissance soil survey of the whole country. The survey work started in the early 1960 and was completed in 1975 under the technical assistance programme of the UNDP and the FAO. The reconnaissance soil survey of the Kurigram and the Gaibanda area was conducted in 1968/69.

As a result, the following maps have been published so far:

--- Reconnaissance soil map (scale:1/125,000),1970
--- Land capability map (scale:1/125,000),1970
--- Land use map (scale:1/250,000),1970

1-2. Objectives of the Present Study

The present study was carried out to explore and evaluate the land and soil resources of the project area aiming at the following points:

--- To review the existing data and to check the validity of the above mentioned soil map for use in agricultural development planning.

--- To make the supplementary soil survey to identify, classify and describeproperly the major kind of soils occurring in the project area.

--- To evaluate the soils in terms of land suitability under irrigation condition.

1-3. Method of Soil Survey

The survey in the project area was carried out in association with SRDI

officers. The procedures employed in surveying the project area are comprised of different steps which are stated below:

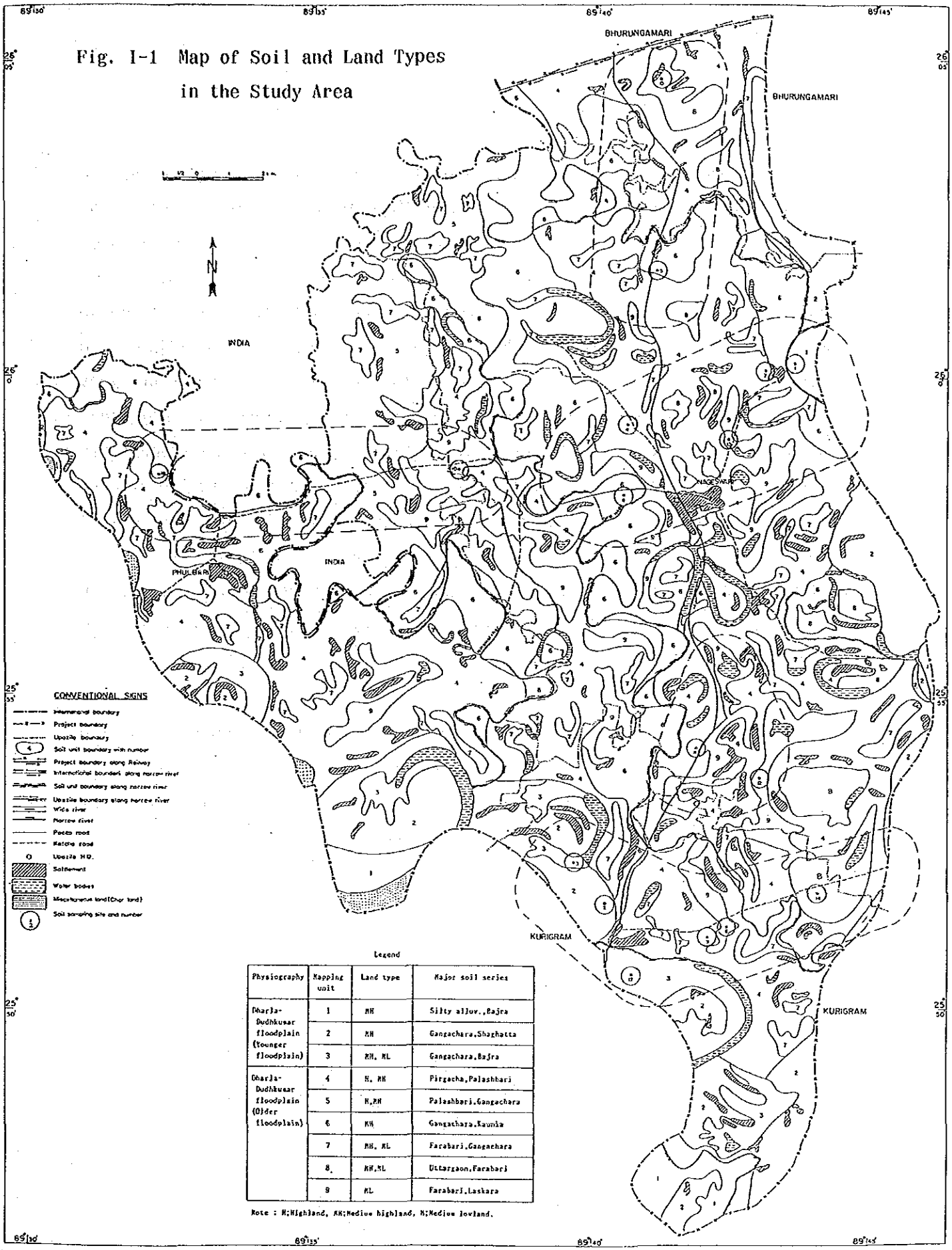
1) Review and evaluation of existing data
2) Preparation of photo-interpreted land type map (1/50,000)
3) Preparation of photo-interpreted soil map (1/50,000)
4) Field survey

The photo-interpreted land type map was superimposed over the enlarged reconnaissance soil map of the area. The probable soils which may occur in different land type units were then deduced from the reconnaissance soil map and the report. In this way, a photo-interpreted soil map of the project area was prepared.

Both the photo-interpreted soil map and interpreted aerial photo-graphs were used as base material during the field survey. The field survey was planned on a sample area basis. Five sample areas were selected in such a way that they covered all the landscapes and land types. Ground checking was as per the international standard. Soils were checked by opening small pits supplemented by auger holes. One or two standard pits for each soil series were opened, described properly as per the USDA Manual and samples were taken for a laboratory analysis. In all 49 soil samples from 17 soil profiles were collected for the laboratory analysis. Core samples from 7 major soil series were collected for the determination of the soil's physical properties.

The soil samples were properly analysed by the Department of Soil Science, University of Dhaka, in their department laboratory. The laboratory analysis includes the determination of texture, pH, CEC, organic carbon, nitrogen, phosphorus, calcium, magnesium, sulphur and zinc. The laboratory analysis also includes determination of bulk density, permeability and moisture retaining capacity.

Fig. I-1 Map of Soil and Land Types in the Study Area



Legend

Physiography	Mapping unit	Land type	Major soil series
Dharla-Dudhkumar floodplain (Younger floodplain)	1	MH	Silty alluv.,Bajra
	2	MH	Gangachara,Shaghatta
	3	MH, ML	Gangachara,Bajra
Dharla-Dudhkumar floodplain (Older floodplain)	4	H, MH	Pirgacha,Palashbari
	5	H,MH	Palashbari,Gangachara
	6	MH	Gangachara,Kaunia
	7	MH, ML	Farabari,Gangachara
	8	MH,ML	Uttargaon,Farabari
	9	ML	Farabari,Laskara

Note : H;Highland, MH;Medium highland, M;Medium lowland.

2. Soil Classification

2-1. Soils in the Project Area

In the project area three physiographic units were identified, i.e. active young floodplain, young floodplain and older floodplain. The soils of active or younger landscapes usually have sedimentational stratification or remnants of stratification while pedogenic soil formation is quite clear in the older landscape. The soils of active landscapes are still in their formation and no crops are grown there. The soils of younger landscapes are imperfectly to poorly drained. The soils occurring on the ridges or infilled channels are grey or pale-brown in colour, loamy in texture with weak to moderate structural development in the subsoil. The soils of the older landscapes are imperfectly to poorly drained, locally moderately well drained soils occur in the highest part of the landscape. The ridge part is composed of pale brown or mixed grey and brown or grey silt loam soils having weak to moderate structural development in the subsoils. The basin part is occupied by grey or dark greyish brown, loamy or clayey soils with moderate to strong structural development in the subsoils.

The soil series recognized in the project area have been correlated with the Soil Taxonomy, the USDA system of soil classification. According to the Soil Taxonomy, all the soils belong to the order of Entisols or Inceptisols. Detailed classifications are given in Table I-1.

Table I-1. Recognized Soil Series in the Project Area

Order	Suborder	Great group	Sub group	Soil series
Entisols	Aquent	Psamaquent	Typic Psamaquent	Sandy alluvium
		Fluvaquent	Typic Fluvaquent	Silty alluvium
		Haplaquent	Typic Haplaquent	Bajra
				Shaghatta
Inceptisols	Aquept	Haplaquept	Typic Haplaquept	Bonerpara
				Farabari
				Gangachara
				Kaunia
				Laskara
				Uttargaon
			Aeric Haplaquept	Jamun
	Ochrept	Dystrochrept	Aquic Dystrochrept	Palashbari
			Typic Dystrochrept	Pirgacha

2-2. Description of Soil Series

Description of the soil series contains an introductory statement indicating the major differentiating features of the soil, its parent material and drainage followed by a detailed description of a representative profile.

The nomenclature of the USDA Soil Survey Manual has been followed. In describing soil drainage, the terms "intermittently flooded" and "seasonally flooded" have been added, where relevant, to the appropriate drainage class designation. Intermittently flooded refers to soils which are periodically flooded by rain water for a few hours to less than two weeks at a time. Seasonally flooded soils are flooded cont uously for more than two weeks, but not for the whole year.

Colour notation is according to the Munsell Soil Colour Charts. In horizons where two colours each occupy about half of the soil mass, the colours have been described as "mixed" in the text and have been indicated by "and" in the detailed profile description.

Location of the profiles described are indicated by a stop number followed by the village and Upazila names.

The pH figures were recorded in the field using the Hellige Truog test kit.

Laboratory data are given in Table I-2.

The descriptions are given in alphabetical order of the series names.

Bajra series

The Bajra series is comprised of seasonally flooded, poorly drained soils developed in Dharla-Dudhkumar alluvium. They have gray, stratified silt loam in the subsoil. They occur on the younger floodplain ridges and unfilled channels and occupy about 720 ha in the project area.

Typical profile : Bajra, medium highland.
Location : Stop No.3 K/4; Char Baraibari, Bhogdanga, Kurigram.
Topography : Very gently sloping lower part of ridge.
Land use : Aus/jute-rabi crops.
Drainage : Poor. Flooded up to 30-60 cm for 2-3 months in the monsoon season.
Taxonomic classification : Typic Haplaquent.

Horizon	Depth(cm)	Description
Apg	0-10	Grey(5Y5/1) moist with few fine distinct yellowish brown mottles; silt loam; massive; firm moist; common fine tubular pores; many fine roots; abrupt smooth boundary; pH 6.5.
Bw1g	10-25	Grey(5Y5/1) moist with few fine distinct yellowish brown and olive grey mottles; silt loam; weak coarse angular blocky structure with remnants of stratification; firm moist; abrupt smooth boundary; pH 7.0.
Bw2g	25-40	Grey(5Y5/1) moist with few fine distinct yellowish brown mottles; silt loam; weak coarse angular blocky structure with remnant of stratification;firm moist; many fine tubular pores; clear smooth boundary; pH 7.0.

Cg	40-85	Grey(5Y5/1)moist with common fine distinct yellowish brown mottles; sillt loam; massive; friable moist; many fine tubular pores; pH 7.0.

Bonarpara series

The Bonarpara series is comprised of intermittently flooded imperfectly drained soils developed in the Dharla-Dudhkumar alluvium. They have dark greyish brown, silt loam subsoils with moderate structural development. This series occurs on the older floodplain ridges and occupys minor areasin the southern part of the project area.

Typical profile : Bonarpara, highland.
Location : Stop No.9K/9, Lakxmir Khamar, Bhogdanga, Kurigram.
Topography : Nearly level ridge.
Land use : Aus/jute-T.Aman-fallow.
Drainage : Imperfect.
Taxonomic classification : Typic Haplaquept.

Horizon	Depth(cm)	Description
Apg	0-15	Grey (5Y5/1) moist with common fine distinct yellowish brown and few fine distinct greyish brown mottles; silt loam; massive; friable moist; many fine roots; abrupt smooth boundary; pH 5.6.
Bw1g	15-30	Dark greyish brown (10YR4/2) moist with common fine distinct yellowish brown and few fine distinct dark brown mottles; silt loam; moderate angular blocky structure; patchy thin dark grey coating along ped faces; firm moist; many fine tubular pores; common fine roots; abrupt smooth boundary; pH 6.0.
Bw2g	30-45	Greyish brown (2.5Y4/2) moist with common fine distinct

yellowish brown mottles; silt loam; weak angular blocky structure; friable moist; many fine tubular pores; abrupt smooth boundary; pH 6.0.

C1g 45-65 Grey (5Y5/1) moist with few fine yellowish brown mottles; silt loam; massive; friable moist;many fine tubular pores; pH 6.0.

C2g 65-90 Light brownish grey (2.5Y6/2) moist with few fine dark brown mottles; very fine sandy loam; massive many tubular pores; pH 7.0.

Farabari series

The Farabari series is comprised of seasonally flooded, poorly drained, dark greyish brown, silty clay loam soils developed in the Dharla-Dudhkumar alluvium. They have moderate to strong angular blocky structures in the B-horizon and have a gray coating. They occur in the older floodplain basin area and occupy about 1,080 ha in the project area, mainly in the eastern part.

Typical profile : Farabari, medium highland.
Location : Stop No.14 K/21, Gopaler Khamar, Bhogdanga, Kurigram
Topography : Nearly level basin.
Land use : Boro-fallow (sometimes late T.Aman).
Drainage : Poor. Flooded upto 120-150 cm for 4-5 months.
Taxonomic classification : Typic Haplaquept.

Horizon Depth(cm) Description

Apg 0-15 Grey (5Y5/1) moist with few fine distinct yellowish brown mottles; silt loam; massive; friable moist; many very fine roots; abrupt smooth boundary; pH 6.5.

Bw1g 15-40 Dark greyish brown (10YR4/2) moist with common fine distinct

yellowish brown mottles; silty clay loam; strong coarse angular blocky structure; moderately grey coating along ped faces; firm moist; common very fine tubular pores; abrupt smooth boundary; pH 7.0.

Bw2g 40-55 Greyish brown (2.5Y4/2) moist with common fine distinct dark yellowish brown mottles; silty clay loam; moderate coarse angular blocky structure; patchy thin grey coating along ped faces; firm moist; abrupt smooth boundary; pH 7.0.

Cg 55-75 Olive grey (5Y5/2) moist with common fine distinct yellowish brown and few fine distinct olive brown mottles; silty clay loam; massive; abrupt smooth boundary; pH 7.0.

2A1b 75-120 Dark greyish brown (2.5Y4/2) moist with few fine distinct dark brown mottles; clay; massive; pH 7.0.

Gangachara series

The Gangachara series is comprised of intermittently to seasonally shallow flooded, imperfect to poorly drained soils developed in the Dharla-Dudhkumar alluvium. They have olive-grey or grey, silt loam subsoils with moderate structural development. They occur on the younger and older floodplain ridges and shallow basins and occupy about 18,210 ha.

Typical profile : Gangachara, highland.
Location : Stop No.5N/15, Raiganj, Raiganj, Nageswari.
Topography : Nearly level ridge.
Land use : Aus/jute-T. Aman-fallow.
Drainage : Imperfect.
Taxonomic classification : Typic Haplaquept.

Horizon	Depth(cm)	Description
Apg	0-12	Grey (5Y5/1) moist with few fine distinct yellowish brown mottles; silt loam; massive; friable moist; few fine tubular pores; many very fine roots; abrupt smooth boundary; pH 6.5.
Bwg	12-30	Grey (5Y5/1) moist with few fine distinct dark yellowish brown and few fine distinct yellowish brown mottles; silt loam; moderate coarse angular blocky structure; friable moist; many fine tubular pores; abrupt smooth boundary; pH 7.0.
C1g	30-55	Olive grey (5Y5/2) moist; silt loam; friable; many fine tubular pores; abrupt smooth boundary; pH 7.0.
C2g	55-80	Greyish brown (2.5Y4/2) moist; silt loam; friable moist; many fine tubular pores; pH 7.0.

Jamun series

The Jamun series is comprised intermittently flooded, imperfectly drained soils developed in the Dharla-Dudhkumar alluvium. They have an abundantly mottled silt loam B-horizon with grey and yellowish brown colours in nearly equal proportions. They occur on the older floodplain ridges and occupy about 3,740 ha.

Typical profile : Jamun, highland.
Location : Stop No.8n/1, Balatari, Newasi, Nageswari.
Topography : Nearly level ridge.
Land use : Aus/jute-T.Aman-fallow.
Drainage : Imperfect.
Taxonomic classification : Aeric Haplaquept.

Horizon	Depth(cm)	Description
Apg	0-10	Grey (5Y5/1) moist with common fine distinct yellowish brown mottles; silt loam; massive; friable moist; many fine tubular pores; many fine roots; abrupt smooth boundary; pH 7.0.
Bw1g	10-25	Grey (5Y5/1) and yellowish brown (10YR5/6) moist; silt loam; moderate angular blocky structure; friable moist; many very fine tubular pores;patchy thin grey coatings along ped faces; abrupt smooth boundary; pH 8.0.
Bw2g	25-45	Olive grey (5Y5/2) moist with common fine distinct dark yellowish brown and few fine distinct dark brown mottles; silt loam; friable moist; many fine tubular pore; clear smooth boundary; pH 8.0.
C1g	45-65	Grey (5Y5/1) moist with common fine distinct dark yellowish brown mottles; very fine sandy loam; friable moist; pH 8.0.

C2g	65-90	Grey (5Y5/1) moist with few fine distinct dark brown mottles; fine sandy loam; friable moist; pH 8.0.

Kaunia series

The Kaunia series is comprised of seasonally flooded, poorly drained soils developed in the Dharla-Dudhkumar alluvium. They have grey silty clay loams with moderate to strong angular blocky structures and grey to dark grey coatings in the B-horizon. They occur in the older floodplain basin area and occupy about 2,040 ha.

Typical profile : Kaunia, medium highland.
Location : Stop No.12N/29, Bhabanipur, Betorbandha, Nageswari.
Topography : Nearly level basin.
Land use : T.Aman-Boro.
Drainage : Poor. Flooded up to 60-90 cm for 3-4 months.
Taxonomic classification : Typic Haplaquept.

Horizon	Depth(cm)	Description
Apg	0-12	Grey (5Y5/1) moist with common fine distinct yellowish brown mottles; silty clay loam; massive; firm moist; many very fine roots; abrupt smooth boundary; pH 7.0.
Bw1g	12-25	Grey (5Y5/1) moist with common fine distinct yellowish brown and fine distinct dark yellowish brown mottles; silty clay loam; moderate to strong coarse angular blocky structure; continuous thick dark grey coatings along ped faces; firm moist;few fine tubular pores; common very fine roots; abrupt smooth boundary; pH 7.0.
Bw2g	25-40	Grey (5Y5/1) moist with common fine distinct yellowish brown and fine distinct dark brown mottles; silty clay loam; weak coarse angular blocky structure; firm moist; thin dark grey coatings along ped faces; common fine tubular pores; abrupt

smooth boundary; pH 7.0.

C1g	40-75	Grey (5Y5/1) moist with few fine distinct yellowish brown mottles; silty clay loam; massive; pH 7.0.
2A1b	75-120	Dark greyish brown (10YR4/2) moist with few fine dark brown and grey mottles; silty clay; massive; pH 7.0.

Lashkara series

The Lashkara series is comprised of seasonally flooded, poorly drained soils developed in the Dharla-Dudhkumar alluvium. They have dark grey silty clay to clay subsoils with strong angular blocky structures and thick dark grey coatings. They occur on the older floodplain basins and occupy about 520 ha.

Typical profile : Lashkara, medium highland.
Location : Stop No.13N/25, Telini, Bamandanga, Nageswari.
Topography : Very gently sloping basin.
Land use : T.Aman (late variety)-Boro.
Drainage : Poor. Flooded upto 90-100cm for 5-6months.
Taxonomic classification : Typic Haplaquept.

Horizon	Depth(cm)	Description
Apg	0-15	Dark grey (5Y4/1) moist with few fine strong brown mottles; silty clay loam; massive; firm moist; common fine tubular pores; many very fine roots; abrupt smooth boundary; pH 6.5.
Bw1g	15-35	Dark grey (5Y4/1) moist with few fine yellowish brown mottles; silty clay; continuous thick dark grey coatings along ped faces; firm moist; common fine tubular pores; common very fine roots; abrupt smooth boundary; pH 6.0.
Bw2g	35-65	Dark grey (5Y4/1) moist with few fine yellowish brown

mottles; silty clay; patchy thick dark grey coatings; firm moist; few fine tubular pores; clear smooth boundary; pH 7.0.

2A1b 65-90 Dark greyish brown (10YR4/2) moist with few fine dark brown mottles; clay; firm moist; pH 7.0.

Palashbari series

The Palashbari series is comprised of intermittently flooded, imperfectly drained soils developed in the Dharla-Dudhkumar alluvium. They have olive brown, silt loam subsoils with moderate structural development. They occur on the older floodplain ridges and occupy about 5,440 ha.

Typical profile : Palashbari, highland.
Location : Stop No.11N/8, Sripur, Hasnabad, Nageswari.
Topography : Nearly level ridge.
Land use : Aus/jute-T.Aman-fallow.
Drainage : Imperfect.
Taxonomic classification : Aquic Dystrochrept.

Horizon	Depth(cm)	Description
Apg	0-15	Grey (5Y5/1) moist with common fine distinct dark yellowish brown and few fine distinct dark brown mottles; silt loam; massive; friable mois many fine tubular pores; many fine roots; abrupt smooth b ndary; pH 6.5.
Bw1g	15-30	Olive brown (2.5Y4/4) moist with few fine distinct greyish brown mottles; silt loam ;weak to moderate coarse angular blocky structure; patchy thin grey coatings along ped faces; friable moist; many very fine tubular pores; clear smooth boundary; pH 7.0.

Bw2g	30-45	Olive brown (2.5Y4/4) moist with few fine distinct grey mottles; silt loam; friable moist; many fine tubular pores; abrupt smooth boundary; pH 7.0.
Cg	45-90	Light olive brown (2.5Y5/4) moist with fine distinct grey mottles; silt loam; massive; friable moist; many fine tubular pores; pH 7.0.

Pirgacha series

The Pirgacha series is comprised of moderately well drained soils developed in the Dharla-Dudhkumar alluvium. They have pale brown silt loam subsoils with weak structural development. They occur on the older floodplain ridges and occupy about 390 ha.

Typical profile : Pirgacha, highland.
Location : Stop No.16F/2, Kurosa Ferosa, Fulbari.
Topography : Nearly level ridge.
Land use : Aus/jute-rabi crops.
Drainage : Moderately well.
Taxonomic classification : Typic Dystrochrept.

Horizon	Depth(cm)	Description
Ap	0-15	Dark brown (10YR4/3) moist; silt loam; massive; friable moist; many very fine tubular pores; many fine roots; abrupt smooth boundary; pH 5.5.
Bw1	15-35	Dark brown (10YR4/3) moist with few fine distinct yellowish brown mottles; silt loam; weak coarse prism; friable moist; many fine tubular pores; clear smooth boundary; pH 6.0.
C	35-90	Dark brown (10YR4/3) moist with few fine distinct dark yellowish brown and grey mottles; silt loam; massive;

friable moist; pH 6.0.

Sandy alluvium

The Sandy alluvium is a miscellaneous land type occuring on the active and young floodplains. It is comprised of seasonally flooded poorly drained, grey, sandy alluvium soils. It occupies an area of about 350 ha.

Typical profile : Sandy alluvium.
Location : Stop No.10K/1, Kachhirchar, Pateswari, Kurigram.
Topography : Nearly level char.
Land use : Grasses.
Drainage : Poor. Flooded up to 90-180 cm for 4-5 months.
Taxonomic classification : Typic Psamaquent.

Horizon	Depth(cm)	Description
C1	0-15	Grey (5Y5/1) moist; sand; single grained; loose; common fine roots; abrupt smooth boundary; pH 7.0.
C2	15-60	Grey (5Y5/1) moist; loamy sand; massive; very friable moist; stratified; pH 7.0.
C3	60-90	Grey (5Y5/1) moist; loamy sand; massive; very friable moist; pH 7.0.

Shaghatta series

The Shaghatta series is comprised of intermittently or seasonally flooded, imperfectly to poorly drained soils developed in the Dharla-Dudhkumar alluvium. They have pale brown stratified, friable, silt loam subsoils. They occur on the younger floodplain ridges and occupy about 2,040 ha.

Typical profile : Shaghatta, medium highland.
Location : Stop No.2K/6, Nandadularvita, Kurigram.
Topography : Nearly level ridges.
Land use : Aus-T.Aman-fallow.
Drainage : Poor. Flooded up to 30-60 cm for 2-3 months.
Taxonomic classification : Typic Haplaquent.

Horizon	Depth(cm)	Description
Apg	0-15	Grey (5Y5/1) moist with few fine distinct yellowish brown mottles; silt loam; massive; slightly firm moist; many fine tubular pores; many fine roots; abrupt smooth boundary; p 6. 5.
Bw1g	15-25	Olive (5Y5/3) moist with few fine distinct olive grey and dark brown mottles; silt loam; weak coarse angular blocky structure with remnants of stratification; patchy thin grey coating along ped faces; friable moist; many fine tubular pores; common very fine roots; abrupt smooth boundary; pH 7.0.
Bw2g	25-35	Olive grey (5Y5/2) moist with few fine distinct dark yellowish brown mottles; silt loam;weak coarse angular blocky structure with remnants of stratification; patchy thin grey coating along with ped faces; friable moist; many fine tubular pores; clear smooth boundary; pH 7.0.
C1g	35-60	Grey (5Y5/1) moist with few fine distinct olive grey and

grey brown mottles; fine sandy loam; massive; friable moist; many fine tubular pores; pH 7.0.

C2g 60-85 Grey (5Y5/1) moist with few fine distinct olive brown mottles; fine sandy loam ; massive; pH 7.0.

Silty alluvium

The Silty alluvium is a miscellaneous land type occurring on the active floodplains. It is comprised of seasonally flooded, poorly drained, grey, stratified, medium or moderately fine textured, raw alluvium. It occupies about 530 ha.

Typical profile : Silty alluvium, medium highland.
Location : Stop No. 1N/23, Mollarhat, Char Damalgram, Nageswari.
Topography : Gently sloping charlands.
Land use : Grasses or Aus-rabi crops(locally).
Drainage : Poor. Flooded up to 100-180 cm for 5-6 months.
Taxonomic classification : Typic Fluvaquent.

Horizon	Depth(cm)	Description
Apg	0-15	Grey (5Y5/1) moist with few fine distinct dark brown mottles; silt loam; massive; friable; many fine tubular pores; common very fine roots; abrupt smooth boundary; pH 7.0.
C1g	15-30	Grey (5Y5/1) moist with few fine dark brown mottles; very fine sandy loam; friable moist; fine tubular pores; stratified; few very fine roots; clear smooth boundary; pH 7.0.
C2g	30-60	Grey (5Y5/1) moist; silt loam; friable moist; stratified; pH 7.0.

C3g	60-100	Grey (5Y5/1) moist with many fine distinct dark brown mottles; silt loam; friable moist; pH 7.0.

Uttargaon series

The Uttargaon series is comprised of seasonally flooded, poorly drained soils developed in the Dharla-Dudhkumar alluvium. They have dark greyish brown fine textured B-horizon with strong angular blocky structures and thick dark grey coatings along ped faces. They occur on the older floodplain basin areas and occupy about 400 ha.

Typical profile : Uttargaon, medium highland
Location : Stop No. 15B/12, Khamar Andhari, Andhari, Bhurungamari.
Topography : Nearly level basin.
Land use : T. Aman(late variety)-Boro.
Drainage : Poor. Flooded up to 60-90 cm for 2-3 months.
Taxonomic classification : Typic Haplaquept.

Horizon	Depth(cm)	Description
Apg	0-12	Grey (5Y5/1) moist with few fine distinct yellowish brown and few fine distinct dark greyish brown mottles; silty clay loam ; massive; firm moist; many fine roots; abrupt smooth boundary; pH 6.5.
Bw1g	12-25	Dark greyish brown (10YR4/2) moist with common fine distinct yellowish brown mottles; clay; strong coarse and medium angular blocky structure; continuous moderately thick dark grey coating along ped faces; firm moist; few fine tubular pores; abrupt smooth boundary; pH 7.0.
Bw2g	25-40	Greyish brown (2.5Y4/2) moist with common fine distinct yellowish brown mottles; silty clay; moderate coarse angular

blocky structure; few fine tubular pores; clear smooth boundary; pH 7.0.

Cg	40-75	Grey (5Y5/1) moist with common fine distinct yellowish brown and olive-grey mottles; silty clay loam; massive; few fine tubular pores; pH 7.0.

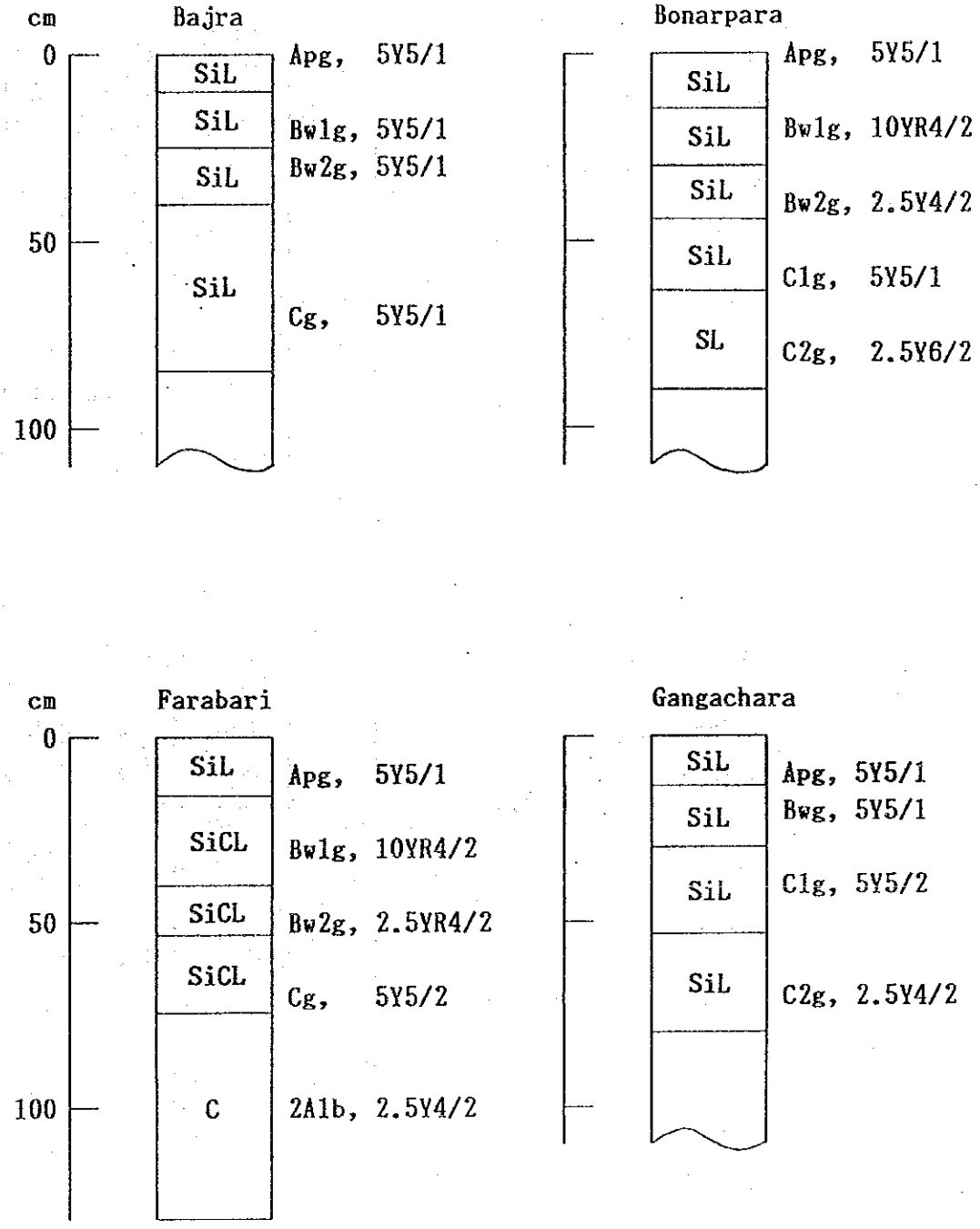


Fig. I-2 Soil Profile of Each Soil Series (1/4)

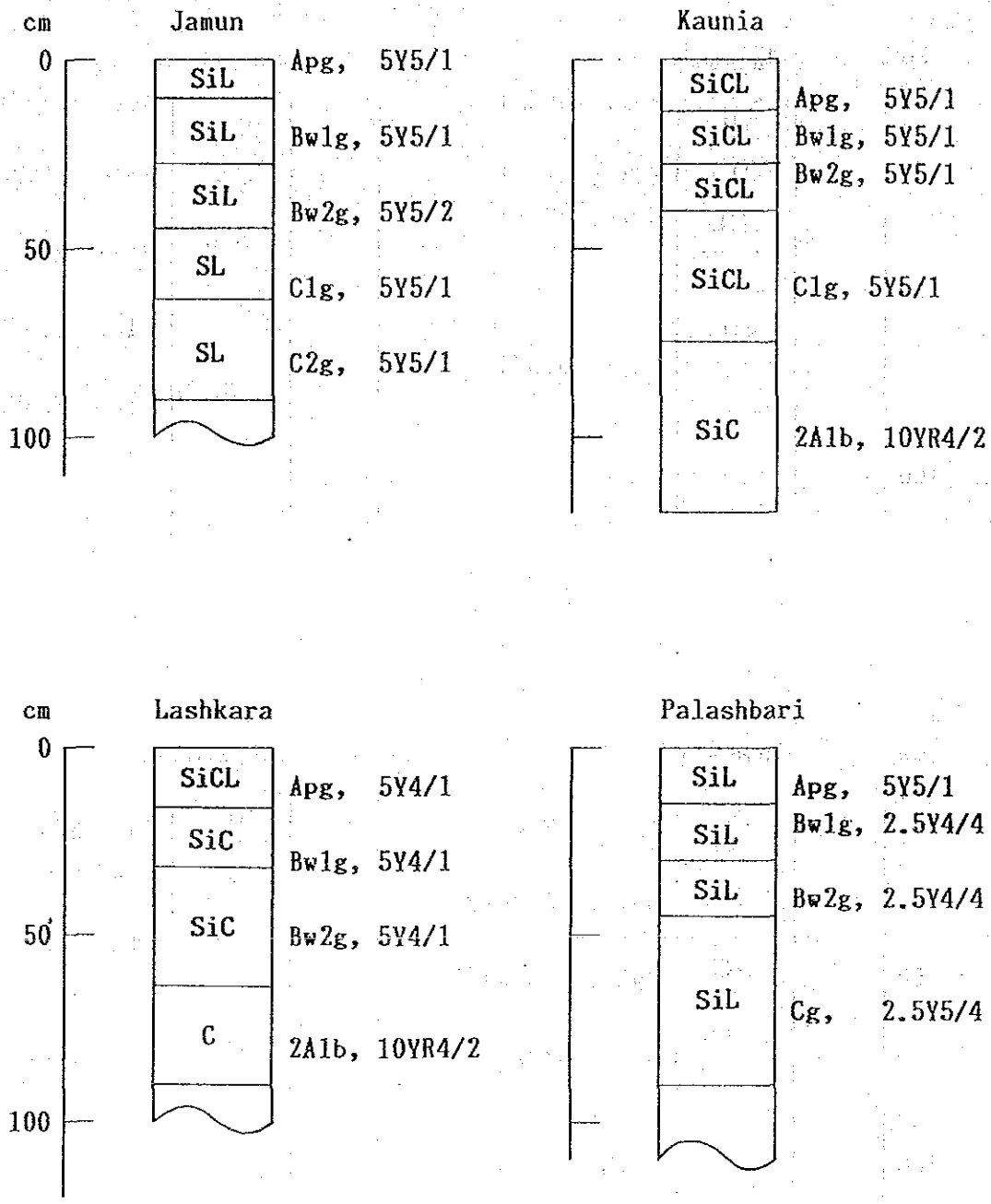


Fig. I-2 Soil Profile of Each Soil Series (2/4)

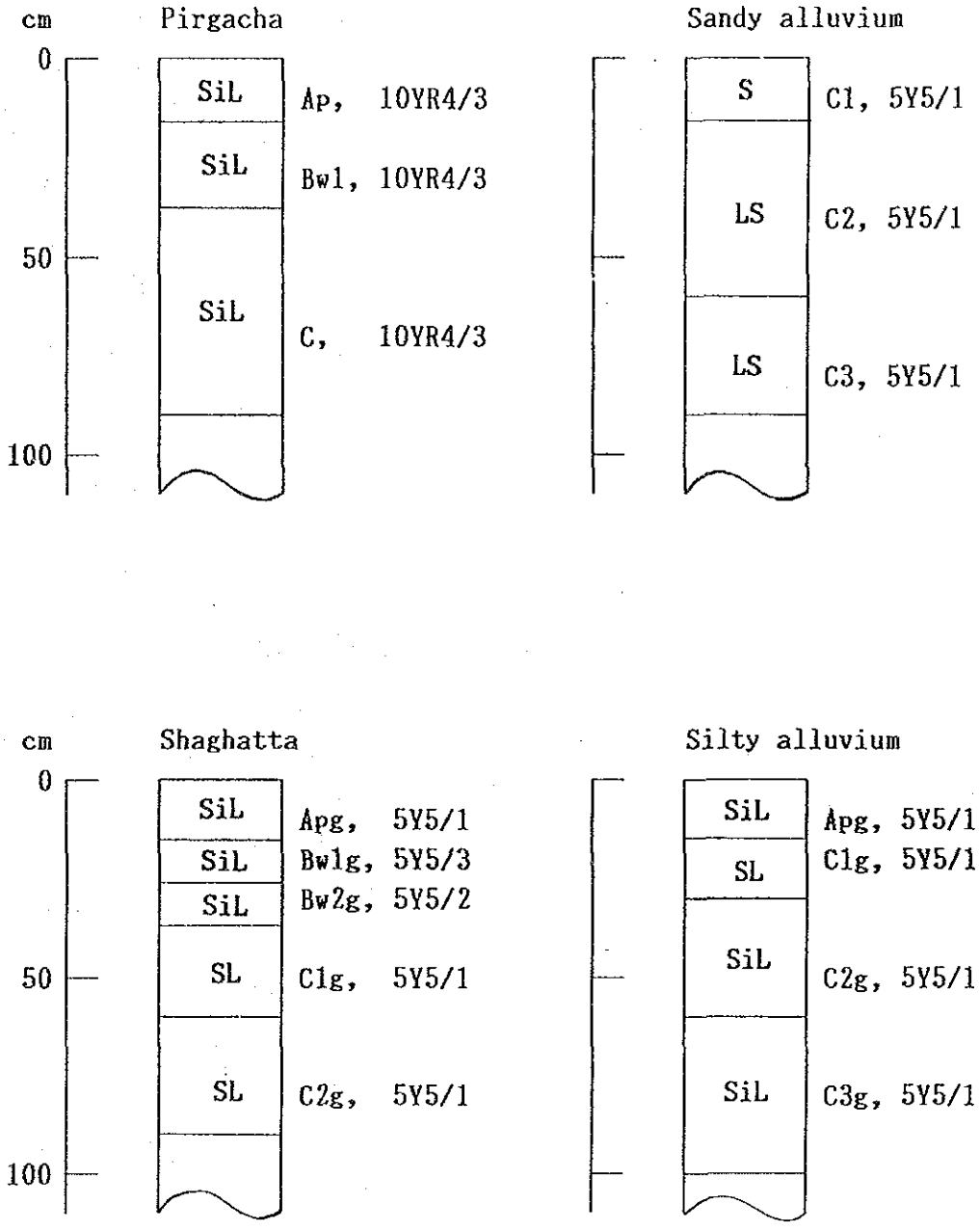


Fig. I-2 Soil Profile of Each Soil Series (3/4)

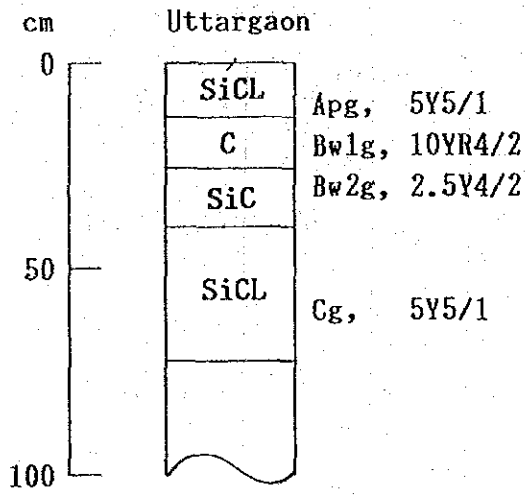


Fig. I-2 Soil Profile of Each Soil Series (4/4)

3. Description of Soil Mapping Units

The mapping units were arranged systematically starting from younger landscape to older landscape. Description of each mapping unit comprises location of occurrence, area, land type, soil character-istics, present land use, limitations and development possibilities.

(1) Mapping unit 1 (silty and sandy alluvium)

This unit mainly occurs in the southern part of the project area and a small part in the north east of Nageswari Upazila. The area occupied by the unit is about 900 ha.

Land type and soils

This unit mainly comprises young charlands. It is shallowly to moderately deeply flooded and 60 % of the unit belongs to medium highland and 40 % belongs to medium lowland.

Silty alluvium occupies about 60% and sandy alluvium occupies 40% of the unit. Silty alluvium comprises poorly drained, grey, stratified silt loam in the subsoil, overlying sandy or silty substratum. Sandy alluvium is more or less similar with silty alluvium except top and subsoil texture which is sandy in nature. Detail description of soils along with physical and chemical properties of the soils are given in the soil analysis section.

Present land use

This unit belongs to the land use mapping unit No.4, grass land and single with some double cropped land. Present land use is given in the following table.

Land type	Soils	Cropping pattern	%	Area(ha)
Medium highland	Silty alluvium	Aus/jute-R.C.	20	180
		R.C.-fallow	20	180
	Sandy alluvium	Grass land	20	180
Medium lowland	Silty alluvium	R.C.-fallow	20	180
	Sandy alluvium	Grass land	20	180

Limitations and development possibilities

Shallow to moderately deeply flooding, low moisture holding capacity, low organic matter, erosion and burial by fresh sediments are the main limitation for the development of agriculture in the unit.

After flood protection the soils may be used for leguminous crops for 2-3 years just to develop the soils.

With irrigation and proper management the silty alluvium could be used for maize, millet, groundnut, sweet potato. This soil is not suitable for irrigated wet-land crops.

(2) Mapping unit No.2 (Shaghatta-Gangachara association)

This unit occupies about 4,090 ha mainly in the southern and eastern parts of the project area. About 5 % of the unit is occupied by settlements.

Land type and soils

The area comprises young ridges and inter-ridge depressions. The higher part of the ridges are above flood level while the lower part of the ridges and inter-ridge depressions are shallowly flooded. About 20 % of the unit belongs to highland while 75 % belongs to medium highland.

The unit is occupied by Shagha a (45 %) and Gangachara soils (50 %). Shaghatta soil includes imperfectly to poorly drained, pale brown, friable, partly stratified silt loam subsoils. Gangachara soil comprises imperfectly to

poorly drained, grey, friable, silt loam subsoil with weak to moderate structural development. Detail description and physico-chemical properties of the soils are given in the soil analysis section.

Present land use

This unit is included in the land use mapping unit No.1, mainly double-cropped and partly triple cropped. Present land use is given in the following table.

Land type	Soils	Cropping pattern	%	Area(ha)
Highland	Shaghatta	Aus/jute-T.Aman-R.C.	10	410
		Aus/jute-R.C.	10	410
Medium highland	Gangachara	Aus/jute-T.Aman-fallow	45	1,840
	Shaghatta	Aus-T.Aman-R.C.	20	820
		T.Aman-Boro	10	410

Limitations and development possibilities

Shallow flooding, low organic matter and shortage of soil moisture in the dry season are the main limitations for agricultural development. With irrigation and application of organic and chemical fertilizers along with improved seeds and cultural practices, the soils can produce moderate to high yield of Aus/jute, wheat, maize, mustard or potato and moderate yield of T.Aman or Boro rice crops.The soils are moderately suitable for irrigation.

(3) Mapping unit No.3 (Bajra-Gangachara association)

This unit occurs in the southern part of the project area and occupies about 1,310 ha.

Land type and soils

This unit mainly comprises depressions or infilled channels in the younger landscape. The area is shallowly to moderately deeply flooded. About 60 % of the unit belongs to medium highland while 40 % belongs to medium lowland. Bajra soil being the major soils occupies about 55 %. Gangachara and Shaghatta soils occupy about 30 % and 15 %, respectively. Bajra soil includes imperfectly to poorly drained, grey, stratified, siltloam subsoils, overlying stratified siltloam in the substratum. Gangachara and Shaghatta soils are described in the mapping unit No.2. Detail description of all the soils along with physico-chemical properties are given in the soil analysis section.

Present land use

This unit is included in the land use mapping unit No.3 double and single cropped land. Present land use is given in the following table.

Land type	Soils	Cropping pattern	%	Area(ha)
Medium highland	Gangachara Shaghatta Bajra	Aus/jute-R.C. Aus/jute-T.Aman-fallow	30 20	390 260
Medium lowland	Bajra	Boro-fallow	50	660

Limitations and development possibilities

Shallow to moderately deep flooding, low moisture holding capacity in the dry season are the main limitation for the agricul-tural development of the area. With flood control and irrigation, application of organic and chemical fertilizers, improved seeds and cultural practices, the soils could produce moderate yield of Boro and locally moderate yield of Aus and jute. The unit is moderately suitable for irrigated wet-land crops.

(4) Mapping unit No.4 (Gangachara-Palashbari association)

This unit occurs throughout the project area. It covers an area of about 15,640 ha. About 15% of the unit is occupied by settlements.

Land type and soils

This unit occupies the highest part of the older landscape. Mainly the area lies above flood level, however, locally minor area is shallowly flooded for 1-2 months by rain water during the rainy season. About 75 % of the unit belongs to highland while 10 % belongs to medium highland. The soils occur in this unit include Palashbari (20 %), Bonarpara (minor), Jamun (10 %) and Gangachara (55 %). Pala-shbari soil includes imperfectly drained, pale brown, friable silt loam subsoil with weak or moderate structural development. Bonarpara soildiffers from Palashbari soil in their dark greyish brown colour. Jamun soil comprises imperfectly to poorly drained, grey, friable or firm, silt loam subsoil with weak or moderate structural development. Bonarpara soil occupies minor area in the Kurigram Sadar Upazila. Detail description of soils along with physico-chemical properties are given in the soil analysis section.

Present land use

This unit is included in the land use mapping unit No.1, mainly double-cropped and partly triple-cropped. Present land use is givenin the following table.

Land type	Soils	Cropping pattern	%	Area(ha)
Highland	Palashbari	Aus/jute-T.Aman-fallow	45	7,040
	Bonarpara	Aus/jute-T.Aman-R.C.	25	3,910
	Jamun	T.Aman-Boro	5	780
	Gangachara			
Medium highland	Gangachara	Aus-T.Aman-fallow	5	780
		T.Aman-Boro	5	780

Limitations and development possibilities

Shortage of soil moisture in the dry season and low organic matter content reduce the yield of rabi crops. Intermittent wetness in the rainy season restricts the cultivation of Kharif vegetables. With irrigation and application of organic and chemical fertilizers along with improved seeds and cultural practices, Palashbari, Jamun, Bonarpara and part of Gangachara soils can produce moderate to high yield of wheat, maize, potato, tobacco, mustard, Aus, jute and sugarcane. With open field drain, Palashbari, Bonarpara and Jamun soils can be used for vegetables or horticultural crops. Gangachara soil can produce two transplanted rice crops or one rice crop followed by wheat, maize or mustard per year, the soils are moderately suitable for dry-land irrigated crops.

(5) Mapping unit No.5 (Gangachara consociation)

This unit occurs in the north western part of the project area, occupying about 2,450 ha. About 10% of the unit is occupied by settle-ments.

Land type and soils

The area is comprised of almost flat broad ridges. It is above the normal flood level but rain water is kept within the field ponds for T.Aman cultivation. Minor areas are shallow flooded in the monsoon season by rain water. About 80% of the land belongs to the highlands while 10% belongs to medium highlands. The area is predominantly occupied by Gangachara soil(80%). Jamun soil occupies only 10% of the area. Brief descriptions of the soils are given in mapping unit No.4. Detailed descriptions of the soils along with physico-chemical properties are given in the soil analysis section.

Present land use

This unit is included in land use mapping unit No.1, mainly double-cropped and partly triple cropped. The present land use is given in the following table.

Land type	Soils	Cropping pattern	%	Area(ha)
Highland	Jamun	Aus/jute-T.Aman-fallow	45	1,100
	Gangachara	Aus/jute-T.Aman-R.C.	25	610
		T.Aman-Boro	10	250
Medium highland	Gangachara	Aus/jute-T.Aman-fallow	5	120
		T.Aman-Boro	5	120

Limitations and development possibilities

Shortage of soil moisture and low organic matter reduces the yield of rabi crops. Intermittent wetness or shallow flooding restricts cultivation of Kharif vegetables in the monsoon season. With irrigation and application of organic and chemical fertilizers along with improved seeds and cultural practices, Gangacahara soil can produce moderate to high yields of Aus, jute, sugarcane, wheat, maize, mustard, potato and tobacco. T.Aman yield can be increased by adopting modern varieties. Part of the land may be successfully used for HYV Boro. This unit is highly suitable for irrigated dry-land crops and moderately suitable for irrigated wet-land crops.

(6) Mapping unit No.6 (Gangachara-Palashbari-Jamun association)

This unit mainly occurs along the Nilkumar and Girai rivers which passe through the middle of the project area from north to south. This unit occupies about 7,710 ha. About 10% of the area is occupied by settlements.

Land type and soils

This unit is comprised of an irregular landscape, mainly caused by linear ridges and infilled channels. A major part of the unit is above normal flood levels and belongs to the highlands. About 10% of the area is shallow flooded and belongs to the medium highlands. The soils in the unit include Gangachara (35%), Palashbari (30%), Jamun (20%) and Pirgacha(5%). Pirgacha soil includes moderately well drained, pale brown, friable silt loam subsoil with moderate structural development. Brief descriptions of Gangachara and Jamun soils are given in mapping unit No.2 and No.4, respectively. Detailed descriptions of all the soils along with physico-chemical properties are given in the soil analysis section.

Present land use

This unit is included in the land use mapping unit No.1, mainly double with some triple cropped land. The present land use is given in the following table.

Land type	Soils	Cropping pattern	%	Area(ha)
Highland	Pirgacha	Vegetables	Minor	
	Palashbari	Aus/jute-T.Aman-fallow	50	3,850
	Jamun	Aus/jute-T.Aman-R.C.	30	2,310
	Gangachara			
Medium highland	Gangachara	Aus/jute-T.Aman-fallow	5	390
		T.Aman-Boro	5	390

Limitations and development possibilities

Land irregularities, low moisture in the dry season, low organic matter, intermittent to shallow flooding in the rainy season are the major limitations of this unit. With irrigation and application of organic and chemical fertilizers along with improved seeds and cultural practices, Pirgacha, Palashbari, Jamun and Gangachara highland soils can produce moderate to high yields of Aus, jute, wheat, maize, mustard, potato and sugarcane. Jamun and Gangachara soils are both found in the highlands and medium highland can produce high yields of two transplanted rice crops per year. Pirgacha, Palashbari and Jamun soils are also suitable for fruit trees or vegetables. This unit is moderately suitable for dry-land irrigated crops and marginally suitable for wet-land irrigated crops.

(7) Mapping unit No.7 (Gangachara-Kaunia association)

This unit occurs throughout the project area and comprises about 2,920 ha.

Land type and soils

This unit contains small basins which are shallow-flooded (less than 1 m) by rain or river water in the monsoon season. The basins are gently sloped towards the center. They belong to medium highlands. The soils found in the basins are Gangachara (60%) and Kaunia (40%). Gangachara soil is comprised of poor drained, grey, friable to slightly firm, silt loam subsoils with moderate structural development in the subsoils. Kaunia soil includes poorly drained, grey, firm, silty clay loam subsoils with moderate to strong structural development. Detailed descriptions of the soils along with physico-chemical properties are given in the soil analysis section.

Present land use

This unit is included in the land use mapping unit No.3, double- and single cropped. The present land use is given in the following table.

Land type	Soils	Cropping pattern	%	Area(ha)
Medium highland	Gangachara	T.Aman-fallow	60	1,750
	Kaunia	T.Aman-Boro	40	1,170

Limitations and development possibilities

The shallow flooding in the monsoon season restricts the cultivation of HYV T.Aman. Early wetness and the shortage of moisture in the late Rabi season does not premit the growth of Rabi crops. With irrigation and application of organic and chemical fertilizers along with improved seeds and cultural practices, this soil could produce high yields of Boro (HYV). This unit is suitable for irrigated wetland crops.

(8) Mapping unit No.8 (Farabari association)

This unit occurs in the eastern part of the project area and occupies about 460 ha.

Land type and soils

This unit includes shallow-flooded basins of medium size. It is flooded by both rain and river water. It belongs to the medium highlands. The soils found in the unit are Farabari (90%) and Uttargaon (10%). Farabari soils include poorly drained, dark greyish brown, firm, silty clayloam subsoils with moderate to strong structural development. Uttargaon soil is comprised of poorly drained, dark greyish brown, silty clay to clay subsoils with strong structural development.

Present land use

This unit is included in the land use mapping unit No.2, mainly double-cropped and partly single cropped. The present land use is given in the following table.

Land type	Soils	Cropping pattern	%	Area(ha)
Medium highland	Farabari	T.Aman-Boro	70	320
	Uttargaon	T.Aman-fallow	30	140

Limitations and development possibilities

Shallow flooding restricts the cultivation of T.Aman modern varieties. Early wetness and late droughts do not allow the growth of any Rabi crops in the area. With irrigation and application of organic and chemical fertilizers along with improved seeds and cultural practices, this soil can produce high yield of Boro (HYV). This unit is suitable for irrigated wet-land crops.

(9) Mapping unit No.9 (Gangachara-Kaunia-Laskara association)

This unit occurs throughout the project area. It occupies an area of about 2, 600 ha. Minor areas are occupied by water bodies.

Land type and soils

It includes medium to broad basins which are shallow- to moderately deep (1-2 m) flooded by rain or river water. The basins are gently sloped towards the center. About 70% of the area belongs to medium highlands, while 30% of the area belongs to medium lowlands. The soils in the unit are comprised of Gangachara (40%), Kaunia (30%). Laskara (20%) and Uttargaon (10%). Brief descriptions of Gangachara, Kaunia and Uttargaon are given in the mapping unit No.7 and 8. Laskara soil includes poorly drained, grey to dark grey, firm, silty clay to clay subsoils with strong structural development. A detailed description of the soils along with physico-chemical properties are given in the soil analysis

section.

Present land use

This unit is included in the land use mapping unit No.3, double- and single-cropped land. Present land use is given in the following table.

Land type	Soils	Cropping pattern	%	Area(ha)
Medium highland	Gangachara	T.Aman-fallow	40	1,040
	Kaunia	T.Aman-Boro	30	780
Medium lowland	Laskara	T.Ama/Boro-fallow	10	260
	Uttargaon	T.Aman-Boro	20	520

Limitations and development possibilities

Shallow to moderately deep flooding, early wetness and late droughts are the main limitations for agricultural development. With irrigation and application of chemical fertilizers along with improved seeds and cultural practices, the soils in this unit can produce high yields of Boro (HYV). These soils are suitable for irrigated wet-land crops.

(10) Mapping unit No.10 (Farabari consociation)

This unit occurs in the eastern part of the area and occupies about 930ha.

Land type and soils

The area is comprised of broad basins which are mainly moderately deep (1-2m)-flooded by rain or river water. The basins are gently sloped towards the center. About 80% of the area belongs to medium lowlands and 20% belongs to medium highlands. The soils found in the area are comprised of Farabari (70%), Gangachara (10%), Kaunia (10%) and Uttargaon (10%). Brief descriptions of the

soils are given in the mapping unit No.7 and 8. Detailed descriptions along with physico-chemical properties are given in the soil analysis section.

Present land use

This unit is included in the land use mapping unit No.2, mainly double-cropped and partly single-cropped. The present land use is given in the following table.

Land type	Soils	Cropping pattern	%	Area(ha)
Medium highland	Gangachara	T.Aman-fallow	10	90
	Kaunia	T.Aman-Boro	10	90
Medium lowland	Farabari	T.Aman-Boro	60	560
	Uttargaon	T.Aman-fallow	20	190

Limitations and development possibilities

Shallow to moderately deep flooding, early wetness and late droughts are the main limitations for agricultural development. With irrigation and application of organic and chemical fertilzers along with improved seeds and cultural practices, the soils in this unit could produce high yield of HYV Boro. The soils are suitable for irrigated wet-land crops.

(11) Miscellaneous land types (settlements, charland, water bodies,etc)

The miscellaneous land types include settlements, charland, water bodies and rivers. It was not possible to separate all the settlements into mapping units. However, big settlements, water bodies and wide rivers were mapped as separate units as much as possible. Settlements occupy about 1,720 ha as an independent unit but in unit No.2,4,5 and 6 about 3,570 ha occupy an integral part of those units. Therefore, total settlements are about 5,290 ha. Minor parts of land

within the settlements are used for agricultural purposes such as homestead gardens, fuel wood or fruit trees. Permanent water bodies occupy about 1,180 ha. They are mainly the cut off rivers or the bottom of the basin areas. Rivers occupy about 760 ha.

Charland along the main rivers occupy about 120 ha. This land is not used for agricultural purposes. In the rainy season it goes under water and in the dry season remains barren.

The total miscellaneous lands including settlements, charland, water bodies and rivers together occupy about 7,350 ha of the project area.

4. Soil Analysis

4-1. Methods of Soil Analysis

The soil samples were analyzed by the Department of Soil Science, University of Dhaka.

(1) Chemical analysis

1) pH : pH meter with glass electrodes (soil:water=1:2.5).
2) EC : Electrical conductivity of saturated soil pastes.
3) Organic matter : Walkley and Black method (wet oxidation).
4) Total nitrogen : Kjeldahl method.
5) Cation exchange capacity (CEC) : Ammonium saturation method.
6) Exchangeable cations : Flame photometer (for Na and K) and atomic absorption spectrophotometer (for Ca and Mg).
7) Available phosphorus : Olsen method.
8) Available sulphur : BaSO4 precipitation.
9) Available zinc : Atomic absorption spectrophotometer.
10) Available potassium : Flame photometer.

(2) Physical analysis

1) Texture(particle size distribution) : Hydrometer.
2) Bulk density : Direct oven-drying of 100cc of soil core.
3) Moisture retention (pF) : Pressure plate method.
4) Permeability : Constant head method.

4-2. Chemical Properties of Soils

The analysis of chemical properties includes the determination of pH, EC, organic matter, total nitrogen, CEC, exchangeable sodium, potassium, calcium and magnesium, available phosphate, sulphur, potassium and zinc. The data of soil chemical properties is shown in Table I-2.

(1) pH : The pH of dry top soil on the ridges varies from 4.80 to 7.35, and in

the basin it ranges from 5.05 to 6.30. The pH Values of subsoil and substratum are usually higher than those of the topsoils. The pH test results in thefield with the Hellige truog test kit show a bit higher values than the laboratory test. It is found from the pH readings that most of soils belong to slightly acid to neutral groups.

(2) Electrical conductivity(EC) : The EC of the ridge topsoil varies from 0.16to 0.88 mS/cm, and in the basin it ranges from 0.26 to 0.42 mS/cm. EC for subsoils and substratums are usually lower than that of topsoils. There appears to be no salinity hazards in the project area.

(3) Organic matter : The Organic matter content is generally low to medium, ranging from 0.72% to 1.78% on ridge topsoils, and from 1.05 % to 2.43 % in basin topsoils. The contents usually fall regularly with depth.

(4) Total nitrogen : The Nitrogen content is generally low, ranging from 0.06 %to 0.22 % in ridge topsoils, and from 0.10 % to 0.22 % in basin topsoils. The contents usually fall gradually with depth.

(5) Cation exchange capacity (CEC) : The CEC of soils reflects difference inclay mineralogy as well as in both content and type of organic matter. The CECin the project area is, however, mainly determined by clay contents. The CECof topsoils varies from 4.26 to 21.09 me/100g on the ridges, and ranges from10.20 to 27.03 me/100g in the basin. The CEC of basin soils is higher than that of ridge soils, which reflects a higher clay content.

(6) Exchangeable bases : There is a good correlation between exchangeable calcium and the total exchangeable bases. The calcium accounts for about 60-70% of the total bases in most soils. The calcium content is low to medium varying from 2 to 6 me/100 g, and the magnesium content ranges from 0.5 to 3 me/100 g in most topsoils. Both exchangeable sodium and potassium contents is generally low, lying between 0.10 and 0.22 me/100 g in the topsoils.

(7) Available phosphorus : The available phosphorus content varies from 5.0 to 47.0 ppm and averages 20.7 ppm in topsoils. Most of the soils indicate

moderate to high contents of phosphorus. The contents usually fall with depth.

(8) Available sulphur : The available sulphur content of most soils in the project area is lower than 20 ppm, indicating a sulphur deficiency in most cases.

(9) Available zinc : The available zinc content ranges from 0.52 to 2.48 ppm and averages 1.50 ppm in the top soils. Less than 2 ppm of a zinc content is regarded as an in cator of the deficiency in soils. Most of soils in the project area show possible zinc deficiencies.

(10) Available potassium : The available potassium content ranges from 3.0 to 21.5 ppm. The Potassium level is low in most soils in the project area.

4-3. Physical Properties of Soils

The analysis of physical properties includes the determination of texture, bulk density, water availability and permeability. The physical properties are shown in Table I-3.

(1) Texture : Nearly all ridge soils are considered to be loam to silty clay loam in the USDA texture triangle, while basin soils are recognized as clay. The clay content ranges from 11 % to 56 % on the ridges and from 39 % to 73 % in the basins. The variation of sand, silt and clay content of profiles both in horizontal and vertical directions are mainly due to sediment variations rather than the result of a soil forming process.

(2) Bulk density : The bulk density of the soils ranges from 1.17 to 1.56 g/cc with an average of 1.38 g/cc. Basin soils have a higher bulk density on average and a narrow range in variation than ridge soils.

(3) Moisture retention (pF) : There is a clear difference in the available water between ridge soils and basin soils. The available water top soils ranges from 26.4 to 35.2 vol % in ridge soils, while that varies from 13.4

to 18.4 vol% in basin soils. The difference is mainly due to their textures.

(4) Permeability : The permeability of ridge soils is usually very small to moderately small, while that of basin soils is very small reflecting the difference in soil texture. The difference in permeability also affects the drainage, i.e., basin soils show poorer drainage than ridge soils.

Table I-2 Chemical Properties of Soils

Soil series	Sample No.	Depth (cm)	OM (%)	TN (%)	pH	EC (mS/cm)	CEC (me/100g)	Exchangeable cations (me/100g)				Available nutrients (ppm)			
								Na^+	K^+	Ca^{2+}	Mg^{2+}	P	S	Zn	K
(Ridge soils)															
Bajra	3K/4 -1	0-10	0.72	0.14	7.3	0.88	4.26	0.22	0.19	6.0	0.5	45.0	17.6	2.48	21.5
	3K/4 -2	10-25	0.72	0.11	7.5	0.29	12.42	0.24	0.26	8.0	3.5	16.0	14.9	1.10	15.5
	3K/4 -3	25-45	0.53	0.08	7.4	0.27	39.15	0.11	0.18	6.0	4.5	14.0	8.7	0.65	12.5
Bonerpara	9K/9 -1	0-15	0.98	0.22	4.8	0.16	10.99	0.26	0.19	5.5	0.5	28.0	25.2	1.25	6.0
	9K/9 -2	15-30	1.19	0.08	5.6	0.12	15.35	0.19	0.14	4.5	1.0	6.0	7.8	0.95	6.5
	9K/9 -3	30-45	0.98	0.10	5.5	0.15	15.15	0.11	0.13	4.0	1.0	4.0	26.1	1.25	8.5
Gangachara (highland)	4N/2 -1	0-10	1.52	0.13	5.5	0.22	8.58	0.16	0.10	4.0	1.5	10.0	15.81	1.25	3.0
	4N/2 -2	10-35	0.86	0.10	5.9	0.18	15.15	0.19	0.11	5.0	7.5	5.0	11.81	0.95	6.5
	4N/2 -3	35-45	0.66	0.07	6.1	0.15	27.52	0.19	0.10	2.0	0.5	6.0	8.81	1.30	19.0
Gangachara (highland)	5N/15-1	0-12	1.45	0.16	4.9	0.22	10.40	0.14	0.10	3.5	6.5	47.0	23.00	1.75	17.0
	5N/15-2	12-30	0.72	0.09	5.6	0.15	8.22	0.14	0.10	5.5	0.5	22.0	46.70	1.10	4.0
	5N/15-3	30-45	0.59	0.05	5.8	0.16	14.65	0.16	0.11	3.0	2.5	19.0	9.56	1.30	4.5
Gangachara (medium highland)	6N/13-1	0-15	1.78	0.17	5.2	0.21	21.09	0.16	0.11	3.5	3.0	7.0	22.44	1.35	6.5
	6N/13-2	15-30	0.86	0.15	6.1	0.15	25.54	0.22	0.13	2.5	8.0	5.0	12.25	1.35	7.5
	6N/13-3	30-45	0.79	0.09	6.3	0.18	40.10	0.16	0.13	5.0	0.5	8.0	10.06	1.98	10.0
Jamun	7N/22-1	0-10	1.40	0.15	5.2	0.29	7.92	0.16	0.11	3.5	0.5	31.0	17.63	1.15	4.0
	7N/22-2	10-30	0.86	0.11	6.1	0.18	12.38	0.16	0.10	4.0	1.0	5.0	10.94	0.80	11.0
	7N/22-3	30-50	0.72	0.10	6.0	0.24	30.49	0.19	0.11	3.5	3.0	4.0	10.50	1.08	7.0
Jamun	8N/1 -1	0-10	1.26	0.14	5.3	0.16	13.17	0.11	0.10	3.0	1.0	7.0	18.94	1.10	8.0
	8N/1 -2	10-25	0.47	0.07	5.4	0.15	4.95	0.11	0.10	4.0	0.5	8.0	5.69	0.82	2.5
	8N/1 -3	25-45	0.33	0.05	5.6	0.13	4.75	0.16	0.10	2.0	1.5	16.0	7.83	0.82	2.0
Parashbari	10N/27-1	0-12	0.72	0.10	5.1	0.23	8.12	0.11	0.11	5.5	2.5	33.0	17.19	1.85	4.0
	10N/27-2	12-22	0.59	0.08	5.9	0.18	9.70	0.12	0.11	3.5	3.0	14.0	15.38	1.80	8.0
	10N/27-3	22-35	1.45	0.07	6.0	0.17	10.69	0.19	0.16	4.0	1.0	21.0	7.38	1.88	8.5
Parashbari	11N/8 -1	0-15	0.72	0.06	5.3	0.26	11.19	0.17	0.13	2.0	0.5	13.0	20.31	1.15	7.0
	11N/8 -2	15-30	0.47	0.16	5.9	0.20	8.71	0.13	0.11	2.0	0.5	9.0	7.81	0.83	10.0
	11N/8 -3	30-45	2.03	0.08	5.7	0.25	8.71	0.18	0.11	2.0	0.5	10.0	17.75	0.83	4.5
Pirgacha	16F/P2-1	0-15	0.86	0.10	5.1	0.22	6.24	0.10	0.19	4.5	0.5	37.0	14.63	1.60	6.0
	16F/P2-2	15-35	1.91	0.05	5.7	0.19	5.25	0.22	0.14	1.0	0.5	30.0	9.81	1.00	11.5
Shaghatta	2K/6 -1	0-15	0.79	0.08	7.4	0.23	9.21	0.22	0.22	6.0	2.0	10.0	9.13	0.52	12.0
	2K/6 -2	15-25	1.05	0.13	7.4	0.32	9.21	0.16	0.21	4.9	2.6	6.0	11.94	1.62	15.5
	2K/6 -3	25-35	0.79	0.12	7.2	0.32	9.70	0.24	0.21	8.0	4.0	5.0	16.75	2.55	15.0
(Basin soils)															
Farabari	14N/21-1	0-15	1.45	0.12	6.3	0.42	10.99	0.17	0.14	4.5	3.0	13.0	13.69	2.35	8.0
	14N/21-2	15-40	0.98	0.14	6.2	0.40	26.53	0.24	0.16	7.5	3.0	11.0	15.81	2.35	13.0
	14N/21-3	40-55	2.38	0.09	6.4	0.31	32.97	0.16	0.16	3.0	0.5	3.0	7.81	1.90	21.5
Kaunia	12N/29-1	0-12	1.05	0.10	5.3	0.32	10.20	0.27	0.13	5.5	2.5	5.0	17.31	1.20	9.0
	12N/29-2	12-25	0.59	0.11	5.7	0.27	14.65	0.26	0.13	3.5	6.5	5.0	19.88	1.25	8.5
	12N/29-3	25-40	2.90	0.13	6.3	0.32	16.14	0.18	0.16	4.5	0.5	13.0	15.81	1.87	10.0
Laskara	13N/25-1	0-15	2.43	0.22	5.1	0.29	21.58	0.13	0.19	5.0	3.5	24.0	18.88	2.20	6.0
	13N/25-2	15-35	1.91	0.19	5.5	0.30	21.09	0.16	0.16	3.0	0.5	13.0	28.00	2.30	11.0
	13N/25-3	35-65	1.26	0.14	5.9	0.38	26.04	0.13	0.16	8.5	11.5	15.0	60.81	3.15	9.0
Uttargaon	15B/12-1	0-12	1.19	0.19	5.4	0.26	27.03	0.10	0.11	5.5	1.5	12.0	17.75	1.55	4.0
	15B/12-2	12-25	0.72	0.11	6.4	0.25	27.52	0.10	0.13	5.0	0.5	7.0	14.06	1.88	6.0
	15B/12-3	25-40	0.53	0.10	6.5	0.24	39.40	0.17	0.14	3.5	1.0	9.0	6.25	1.63	6.5
(Miscellaneous soils)															
Sandy alluvium	17K/S1-1	0-15	0.07	0.04	6.6	0.20	1.29	0.21	0.08	2.0	0.5	7.0	6.38	0.80	5.5
	17K/S1-2	15-60	0.07	0.03	7.4	0.27	2.28	0.18	0.08	2.0	0.5	12.0	5.94	1.22	7.5
Silty alluvium	1N/23-1	0-15	1.28	0.08	6.9	0.36	9.21	0.22	0.26	6.0	2.5	23.0	240.56	1.98	19.5
	1N/23-2	15-30	0.40	0.09	7.4	0.37	3.76	0.16	0.11	3.0	2.0	23.0	40.38	2.05	9.5
	1N/23-3	30-45	0.98	0.10	7.6	0.45	9.21	0.19	0.19	9.0	1.0	19.0	78.25	2.68	16.0

Table I-3 Physical Properties of Soils

Soil series	Sample No.	Depth (cm)	Sand (%)	Silt (%)	Clay (%)	Texture	Bulk density (g/cc)	Moisture content at pF2.0	pF2.5	pF4.2	Available water(vol%)	Permeability (mm/hr)	3-phase distribution Solid	Liquid	Gas
(Ridge soils)															
Gangachara (highland)	5N/15-1	0-12	22	52	26	SiL	1.23	38.9	37.8	6.2	32.7	0	46.6	46.6	6.8
	5N/15-2	12-30	22	47	31	CL	1.46	29.7	29.1	6.2	23.5	0.5	55.1	42.5	2.4
	5N/15-3	30-50	9	68	23	SiL	1.17	43.3	41.8	5.5	37.8	2.8	44.3	49.0	6.7
Gangachara (medium highland)	6K/13-1	0-15	7	45	48	SiC	1.21	39.6	38.7	10.6	29.0	0	45.7	46.7	7.6
	6K/13-2	15-30	2	45	53	SiC	1.56	27.7	26.8	12.1	15.6	0	56.8	41.7	1.5
	6K/13-3	30-45	2	42	56	SiC	1.49	29.3	28.7	12.1	17.2	9.5	55.8	42.6	1.6
Jamun	8N/1 -1	0-10	34	42	24	L	1.44	32.6	31.8	6.2	26.4	0	54.0	45.8	0.2
	8N/1 -2	10-25	47	29	24	SCL	1.26	39.3	37.4	4.0	35.3	2.0	48.1	47.0	4.9
	8N/1 -3	25-45	54	22	24	SCL	1.15	40.3	36.5	4.0	36.3	72.3	43.4	42.0	14.6
Palashbari	11N/8 -1	0-12	39	35	26	CL	1.36	33.1	31.9	6.2	26.9	0	51.3	43.4	5.3
	11N/8 -2	12-22	19	45	36	CL	1.55	26.6	25.6	7.8	18.8	0	58.5	39.7	1.8
	11N/8 -3	22-35	32	42	26	L	1.30	34.2	32.8	8.9	25.3	1.7	48.9	42.5	8.6
Shaghatta	2K/6 -1	0-15	2	60	38	SiCL	1.25	41.7	40.3	6.5	35.2	0	47.0	50.2	2.8
	2K/6 -2	15-25	7	65	28	SiCL	1.26	41.3	39.3	6.6	34.7	0.9	47.7	49.6	2.7
	2K/6 -3	25-35	9	53	38	SiCL	1.35	35.8	35.1	7.4	28.4	0.5	50.8	47.3	1.9
(Basin soils)															
Parabari	14K/21-1	0-15	34	27	39	CL	1.47	32.0	30.8	13.6	18.4	0	55.0	44.8	0.3
	14K/21-2	15-25	7	29	64	C	1.46	31.7	30.4	23.9	7.8	0	54.7	44.3	1.0
	14K/21-3	25-40	4	30	66	C	1.46	30.7	29.8	23.4	7.3	0	54.8	43.5	1.7
Kaunia	12N/29-1	0-15	19	33	48	C	1.47	31.7	30.7	13.4	18.3	0	54.5	44.9	0.6
	12N/29-2	15-25	32	12	56	C	1.49	31.1	30.0	14.6	16.5	0	55.2	44.3	0.5
	12N/29-3	25-35	2	13	66	C	1.39	35.0	34.0	17.1	17.9	0.4	52.0	47.1	0.9
Laskara	13N/25-1	0-15	17	12	61	C	1.42	33.6	32.4	19.8	13.8	0	53.4	46.1	0.5
	13N/25-2	15-35	9	20	71	C	1.52	29.8	28.6	28.5	1.3	0	56.3	43.3	0.4
	13N/25-3	35-65	2	25	73	C	1.49	29.7	28.6	26.6	3.1	5.0	55.4	42.5	2.0

5. Land Suitability Classification

5-1. Introduction

Land suitability classifications can be defined as the grouping of a specific area of land for a specific use. It reflects the degree of suitability such as highly suitable, moderately suitable, marginally suitable or not suitable.

The land suitability classification can be done on the present state of land as it is or on the state provided with improvements such as the provision of irrigation, application of fertilizers or land leveling. The present classification was done with provisions for irrigation and improved management. Therefore, land qualities like moisture availability and nutrient availability were not given due consideration.

Land suitability classification in the study area were conducted on the basis of land characteristics, land qualities and crop requirements.

5-2. Land Characteristics and Land Qualities

Land characteristics are the measurable inherent land properties such as soil texture, while land qualities are the functional properties such as availability of moisture. Eight items for land characteristics and qualities were considered for the project area as shown in Table I-4. The assessment was done only for the major soil units.

5-3. Crop Requirements

Crop requirements refer to a set of land characteristics and qualities that determine the production and management condition of a specific crop. For the project area, 10 crops were taken into consideration and the requirements were assessed which were presented in Table I-5.

Table I-4. Land Qualities/Characteristics of Different Mapping Units

Soil Unit No.	Land type	Slope	Drainage	Perme-ability	Texture	Eff. depth	Top soil cons.	Reaction
1	MH/ ML	Level	Poor	Moderate	Loams/ Sand	Deep	Friable	Neutral
2	MH	Level	Poor	Moderate	Loams	Deep	Friable	Neutral
3	MH/ ML	Level	Poor	Slow	Loams	Deep	Firm/ Friable	Neutral
4	H	Level	Imp.	Moderate	Loams	Deep	Friable	Neutral
5	H	Level	Imp.	Moderate	Loams	Deep	Friable	Neutral
6	H	Irre.	Imp.	Moderate	Loams	Deep	Friable	Neutral
7	MH	Level	Poor	Slow	Loam/ C. loam	Deep	Firm	Neutral
8	MH	Level	Poor	Slow	C. loam	Deep	Firm	Neutral
9	MH/ ML	Level	Poor	Slow	Loam/ Clay	Deep	Firm	Neutral
10	ML	Level	Poor	Slow	C. loam	Deep	Firm	Neutral

Notes (1) Eff. depth: Effective depth.

(2) Top soil cons.: Top soil consistency.

(3) H: Highland, MH: Medium highland, ML: Medium lowland.

(4) Irre.: Irregular.

(5) C. loam: Clayloam.

5-4. Land Suitability Classification

Land suitability classes were determined by comparing the landcharacteristics and qualities of different mapping units with those ofthe requirements of selected crops. The recognized classes in theproject area were S1;hbility such as S2; moderately suitable and S3; marginally suitable.

Land suitability classes

a) S1; Highly suitable : Land having no significant limitations to the sustained application of a given use or only minor limitations that will not significantly reduce the productivity or benefits and will not raise inputs above an acceptable level.

b) S2; Moderately suitable : Land having limitations which in aggregates are moderately severe for the sustained application of a given use; the limitations will reduce the productivity or benefits and increase the required inputs to the extent that the overall advantage to be gained from the uses, although still attractive, will be appreciably inferior to that expected on class S1 land.

c) S3; Marginally suitable : Land having limitations which in aggregate are severe for the sustained application of a given use and will so reduce the productivity or benefits, or increase the required inputs, this expenditure will be only marginally justified.

d) N; Non suitable : It contains two classes within the order of not suitable. One is N1, currently not suitable : Land having limitations which may be overcome in time but which can not be corrected with existing knowledge at currently acceptable costs; the limitations are so severe as to preclude successful sustained use of the land in any given manner. The other is N2, permanently not suitable : Land having limitations which appear so severe as to preclude any possibilities of successful sustained use of the land in any given manner.

Table I-5 Crop Requirements

Crop	Suit. class	Land type	Slope	Drainage	Perme-ability	Texture	Eff. depth	Top soil cons.	Reaction
Fruit tree	S1	H	Level	Well-mod. well	Mod.	Loam/ C. loam	Deep	Friable	Neutral
	S2	-	Irr.	Imp.	Rapid	Clay	Mod. deep	-	Mod. acid/ alkaline
	S3	-	Roll.	Poor	Slow	S. loam	Shallow	-	Highly acid
	N	MH-L	Hilly	V. poor	-	Sand	V. shallow	Firm	Highly alkaline
Sugar -cane	S1	H	Level	Well-Imp.	Mod.	Loam/ C. loam	Deep	Friable	Neutral
	S2	MH	Irr.	Poor	Rapid	Clay	Mod. deep	-	Mod. acid/ alkaline
	S3	-	Roll.	-	Slow	S. loam	Shallow	Firm	Highly acid
	N	ML/L	Hilly	V. poor	-	Sand	V. shalow	-	Highly alkaline
Potato	S1	H	Level	Well-Imp.	Mod.	Loam	Deep	Friable	Neutral
	S2	MH	Irr.	Poor	Rapid	S. loam/ C. loam	Mod. deep	-	Mod. acid/ alkaline
	S3	ML	Roll.	-	Slow	Clay	Shallow	-	Highly acid
	N	L	Hilly	V. poor	-	Sand	V. shallow	Firm	Highly alkaline
Wheat/ Maize	S1	H/MH	Level	Well-poor	Mod.	Loam	Deep	Friable	Neutral
	S2	ML	Irr.	-	Rapid	C. loam	Mod. deep	-	Mod. acid/ alkaline
	S3	L	Roll.	-	Slow	Clay/ S. loam	Shallow	Firm	Highly acid
	N	-	Hilly	V. poor	-	Sand	V. shallow	-	Highly alkaline
Mus-tard	S1	H/MH	Level	Well-poor	Mod.	Loam	Deep	Friable	Neutral
	S2	ML	Irr.	-	Rapid	C. loam	Mod. deep	-	Mod. acid/ alkaline
	S3	-	Roll.	-	Slow	Clay/ S. loam	Shallow	Firm	Highlyacid
	N	L	Hilly	V. poor	-	Sand	V. shallow	-	Highly alkaline

Ground -nut	S1	H/MH	Level	Well- poor	Mod.	Loam/ C. loam	Deep	Friable	Neutral
	S2	ML	Irr.	-	Rapid	S. loam	Mod. deep	-	Mod. acid/ alkaline
	S3	-	Roll.	-	Slow	Sand	Shallow	-	Highly acid
	N	L	Hilly	V. poor	-	Clay	V. shallow	Firm	Highly alkaline
Jute (HYV)	S1	H	Level	Well- poor	Mod.	Loam/ C. loam	Deep	Friable	Neutral
	S2	MH	Irr.	Poor	Rapid	S. loam	Mod. deep	-	Mod. acid/ alkaline
	S3	-	Roll.	-	Slow	Clay	Shallow	Firm	Highly acid
	N	ML/L	Hilly	V. poor	-	Sand	V. shallow	-	Highky alkaline
T. Aus (HYV)	S1	H	Level	Imp.	Slow	C. loam/ Clay	Deep	Firm	Neutral
	S2	MH	Irr.	Poor	Mod.	Loam	Mod. deep	Friable	Mod. acid/ alkaline
	S3	-	Roll.	V. poor	-	S. loam	Shallow	-	Highly acid
	N	ML/L	Hilly	Well- mod. well	Rapid	Sand	V. shallow	-	Highly alkaline
T. Aman (HYV)	S1	H	Level	Imp.	Slow	C. loam/ Clay	Deep	Firm	Neutral
	S2	MH	Irr.	Poor	Mod.	Loam	Mod. deep	Friable	Mod. acid/ alkaline
	S3	-	Roll.	V. poor	-	S. loam	Shallow	-	Highly acid
	N	ML/L	Hilly	Well/ mod. well	Rapid	Sand	V. shallow	-	Highly alkaline
Boro (HYV)	S1	H/MH	Level	Imp./ poor	Slow	Clay/ C. loam	Deep	Firm	Neutral
	S2	ML	Irr.	-	-	Loam	Mod.	-	Mod. acid alkaline
	S3	L	Roll.	V. poor	Mod.	S. loam	Shallow	Friable	Highly acid
	N	-	Hilly	Well/ mod. well	Rapid	Sand	V. shallow	-	Highly alkaine

Notes (1) S1:highly suitable, S2:moderately suitable, S3:marginally suitable, N:non suitable.
(2) Irr.:irregular/undulating, Roll.:rolling.
(3) Imp.:Imperfect, Mod.:moderately, V.poor:very poor.
(4) C.loam:clayloam, S.loam:sandyloam.

Table I-6. Land Suitability Mapping Unit

Mapping unit	Land suitability			Component soil unit
	Highly suitable	Moderately suitable	Marginally suitable	
1	Boro(HYV)	T. Aus, T. Aman	mustard, wheat sugarcane, jute	7,8
2	Boro(HYV)	-	T. Aus, T. Aman mustard, wheat	9
3	-	Boro(HYV)	wheat, mustard	3,10
4	sugarcane potato, wheat maize, mustard groundnut, jute	fruit trees T. Aus, T. Aman	Boro	4,5
5	wheat, maize mustard groundnut	sugarcane, jute potato T. Aus, T. Aman	Boro	2
6	-	fruit trees sugarcane, jute potato, wheat maize, mustard groundnut T. Aus, T. Aman	Boro	6
7	-	groundnut	sugarcane mustard, potato wheat, maize	1

5-5. Description of Land Suitability Mapping Units

(1) Mapping unit No.1

- Soil unit No.7 : Gangachara-Kaunia, Medium highland, 2,920 ha.
- Soil unit No.8 : Farabari, Medium highland, 460 ha.

This unit is comprised of shallow flooded basins and belongs to the medium highlands. The area is flooded less than 1 m by rain or river water in the rainy season. This unit belongs to land use mapping unit 2 and 3b. Shallow flooding restricts the cultivation of T. Aman modern varieties. Early wetness and late droughts do not allow the growth of any Rabi crops in the area. The soils in the area are suitable for Boro, and moderately suitable for T.Aus and T. Aman with irrigation and the application of organic and chemical fertilizers along with improved seeds and cultural practices.

(2) Mapping unit No.2

- Soil unit No.9 : Gangachara-Kaunia-Laskara, Medium highland / Medium lowland, 2,600 ha.

This unit is comprised of medium to broad basins which are shallow to moderately deep (1-2 m) flooded by rain or river water. About 70% of the area belongs to medium highland and the rest belongs to medium lowland. This unit is included in land use mapping unit 3b. Shallow to moderate deep flooding, early wetness and late droughts are the main limitation for agricultural development. The soils are suitable for irrigated wet land crops, and could produce high yields of Boro with irrigation and the application of chemical fertilizers along with improved seeds and cultural practices.

(3) Mapping unit No.3

- Soil unit No.3 : Bajra-Gangachara, Medium highland / Medium lowland, 1,310 ha.
- Soil unit No.10 : Farabari, Medium highland / Medium lowland, 930 ha.

This unit is mainly comprised of depressions, infilled channels or broad basins, which is shallow to moderately deep flooded by rain or river water. This unit belongs to land use mapping unit 2 and 3a. Shallow to moderately deep flooding, a low moisture holding capacity in the dry season are the main limitations for the agricultural development in the area. The soils are suitable or moderately suitable for irrigated wet land crops. They could produce moderate to high yields of Boro with irrigation and improved management.

(4) Mapping unit No.4

- Soil unit No.4 : Gangachara-Palashbari, Highland / Medium highland, 15,640 ha.
- Soil unit No.5 : Gangachara, Highland/Medium highland, 2,450 ha.

This unit is comprised of the highest part of the older landscape. About 80% of the unit belongs to highland while 10% belongs to medium highlands. Most of the area is above normal flood levels. This unit is included in land use mapping unit 1. Shortages in soil moisture in the dry season and the low organic matter content reduce the yield of Rabi crops. Intermittent wetness in the rainy season restricts the cultivation of Kharif vegetables. The soils are highly suitable for irrigated dry land crops, and moderarely suitable for irrigated wet land crops.

(5) Mapping unit No.5

- Soil unit No.2 : Shaghatta-Gangachara, Highland / Medium highland, 4,090 ha.

The area is comprised of young ridge and inter-ridge depressions. The highest part of the ridges are above flood levels while the lower part of the ridges and interridge depressions are shallow flooded. About 20% of the unit belongs to highlands while 75% belongs to medium highland. This unit is included in a land use mapping unit 1. Shallow flooding, low organic matter and a shortage in soil moisture in the dry season are the main limitations for agricultural development. The soils are moderately suitable for irrigation, and

they could produce moderate to high yield of Aus, jute, wheat, maize, mustard or potato and moderate yield of T.Aman or Boro with irrigation and improved management.

(6) Mapping unit No.6

- Soil unit No.6 : Gangachara-Palashbari-Jamun, Highland, 7,710 ha.

This unit is comprised of an irregular landscape, mainly caused by linear ridges and unfilled channels. The major part of the unit is above normal flood levels and belongs to the highlands. This unit is included in land use mapping unit 1. Land irregularity, low moisture in the dry season, low organic matter, intermittent to shallow flooding in the rainy season are the major limitations of this unit. The soils are moderately suitable for irrigated dry land crops. They could produce moderate to high yield of Aus, jute, wheat, maize, mustard, potato and sugarcane with irrigation and modern management.

(7) Mapping unit No.7

- Soil unit No.1 : Silty and sandy alluvium, Medium highland / Medium lowland, 900 ha.

This unit is mainly comprised of young charlands, which is shallow to moderately deep flooded. This unit belongs to land use mapping unit 4. Shallow to moderately deep flooding, low moisture holding capacity, low organic matter, erosion and burial by fresh sediments are the main limitation for agricultural development. The soils are not suitable for irrigated wet land crops. The silty alluvium could be used for maize, millet, groundnut and sweet potato.

APPENDIX II

METEOROLOGY AND HYDROLOGY

APPENDIX II

METEOROLOGY AND HYDROLOGY

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Table Ⅱ- 1 List and Duration of Collected Data

Data type	Station	River name	Data period
Rainfall	Bhurungamari		
	Kurigram		
	Lalmonirhat		
	Ulipur		
	Chilmari		
	Kaunia		
	Rangpur		
Discharge	Talukshimulbari	Dharla	
	Kurigram	〃	
	Pateswari	Dudhkumar	
	Bahadurabad	Brahmaputra	
W. level	Talukshimulbari	Dharla	
	Kurigram	〃	
	Pateswari	Dudhkumar	
	Noonkhawa	Brahmaputra	
	Chilmari	〃	
	Bahadurabad	〃	
Sedimentation	Talukshimulbari	Dharla	
	Pateswari	Dudhkumar	
	Bahadurabad	Brahmaputra	
R. cross section	Barrage side	Dharla	
	Pateswari	Dudhkumar	
Temparature	Rangpur		
Humidity	〃		
Sunshine	〃		
Wind speed	〃		
Evaporation	〃		

Table II - 2 Annual rainfall data

Unit: mm

Year	Bhurun-gamari	Kurigram	Lamonirhat	Ulipur	Chilmari	Kuania	Rangpur
1961	NA	NA	NA	NA	NA	NA	1502
62	NA	NA	NA	1687	NA	2372	1527
63	NA	NA	2194	2716	NA	NA	NA
64	NA	2260	3194	3006	NA	2216	1999
65	3205	2143	2181	2423	1720	1434	1658
66	3123	1937	NA	2178	1751	1817	1496
67	4405	1891	NA	1828	1695	2126	1823
68	3829	2273	2960	2680	2341	2374	2080
69	4158	2194	2676	2390	2207	2459	2892
70	3897	2219	NA	2359	2570	2327	2017
71	NA	NA	NA	NA	NA	NA	NA
72	NA	1864	1591	NA	1125	NA	1256
73	3336	3249	3244	2670	3358	3575	3028
74	3823	3355	4070	2978	3838	4901	3009
75	NA	1690	2061	1499	1771	2130	1813
76	2952	2228	1676	1765	1943	1654	2399
77	4029	2135	2769	2221	2275	2295	2441
78	1971	1707	2126	1592	1784	1735	2047
79	2216	2446	2480	2053	1812	2392	1902
80	2786	1835	1994	2002	1730	1841	2114
81	1892	1609	2009	1877	1421	2252	2223
82	2652	2365	2453	1965	NA	NA	2115
83	3181	2378	2107	2052	2290	2267	2224
84	3915	2861	3354	2666	2778	3002	3278
85	2603	2450	2926	2111	1810	2736	2556
86	3015	2487	2364	2572	2559	2434	2360
87	3930	2980	3991	2857	3231	3820	3326
88	2647	3081	2099	2922	2815	2549	2111

Table Ⅱ - 3 Consecutive Rainfall Data

Station: Bhurungamari Unit: mm

year	1 day	3 days	5 days	10 days	15 days	30 days
1965	129	281	379	474	504	670
66	191	297	377	477	614	698
67	206	305	404	566	643	898
68	196	304	515	589	918	1328
69	184	303	348	571	880	1409
70	171	331	430	583	660	1283
73	179	334	455	501	762	1264
74	229	372	521	554	637	1019
76	152	361	417	742	853	1247
77	173	394	516	569	1001	1100
78	132	211	282	325	475	800
79	132	208	264	408	537	856
80	136	373	555	743	836	1075
81	109	182	279	377	420	623
82	147	319	424	539	652	852
83	183	406	475	584	623	1104
84	236	380	535	696	752	1143
85	125	263	320	474	548	915
86	182	288	355	447	559	1019
87	180	410	614	824	886	1340
88	158	287	356	445	639	801

Table Ⅱ - 4 Consecutive rainfall data

Station: Kurigram

Unit: mm

year	1 day	3 days	5 days	10 days	15 days	30 days
1961	99	179	219	270	378	460
62	137	250	316	334	436	497
63	-	-	-	-	-	-
64	127	241	289	425	440	566
65	116	175	258	355	405	635
66	153	280	314	459	554	677
67	108	171	223	256	329	504
68	147	219	311	476	509	862
69	176	276	309	387	434	706
70	158	233	312	497	504	834
71	-	-	-	-	-	-
72	130	226	286	387	466	675
73	235	459	584	711	963	1434
74	203	385	461	489	661	1083
75	89	208	217	222	312	482
76	279	533	605	690	1050	1098
77	119	191	226	301	451	619
78	116	154	249	311	346	555
79	285	375	412	559	630	941
80	132	178	210	272	339	438
81	135	196	246	254	314	506
82	274	370	391	549	582	899
83	216	313	313	457	581	768
84	156	295	328	442	649	820
85	138	268	307	418	507	732
86	140	197	279	335	495	765
87	180	442	457	695	751	1246
88	203	342	448	571	637	902

Table Ⅱ - 5 Annual effective rainfall and drought days

Bhurungamari station

Year	Effective rainfall (mm)	Consecutive drought days	Annual total drought days
1965	2126	81	287
66	2338	111	273
67	3277	87	244
68	2577	157	260
69	3009	70	257
70	-	-	-
71	-	-	-
72	-	-	-
73	2132	72	285
74	2463	201	290
75	-	-	-
76	2185	95	290
77	2868	91	270
78	1546	191	307
79	1697	79	306
80	1946	113	295
81	1443	97	298
82	2014	125	292
83	2188	89	279
84	2766	108	265
85	1978	102	291
86	2176	49	283
87	2756	113	261
88	1908	176	295

Table Ⅱ - 6 Annual effective rainfall and drought days

Kurigram station

Year	Effective rainfall (mm)	Consecutive drought days	Annual total drought days
1964	1689	121	294
65	1610	110	304
66	1440	96	286
67	1437	160	301
68	1707	97	296
69	1616	69	293
70	-	-	-
71	-	-	-
72	1384	101	305
73	1962	68	287
74	2287	163	288
75	1332	183	306
76	1414	150	319
77	1637	162	288
78	1254	214	317
79	1563	128	309
80	1370	78	309
81	1185	98	317
82	1598	121	309
83	1548	111	303
84	2040	116	280
85	1861	104	303
86	1828	82	293
87	1946	125	297
88	2165	45	284

Table II - 7 Monthly average

Month	Temp. (°C)	Humidity (%)	Sunshine (hrs)	Windspeed (km/day)	Evaporation (mm/day)
Jan	17.33	81.9	7.8	123.0	2.3
Feb	19.69	76.2	8.0	131.5	4.0
Mar	23.56	67.5	7.7	154.6	5.4
Apr	27.03	71.3	7.3	180.9	6.4
May	27.70	79.6	6.5	157.4	5.2
Jun	28.58	84.9	6.0	180.9	4.8
Jul	27.89	87.0	4.0	148.8	4.8
Aug	29.21	85.8	4.9	149.3	4.7
Sep	28.52	86.8	5.0	133.4	3.6
Oct	26.66	84.9	7.4	116.9	3.5
Nov	22.75	79.5	8.7	131.5	3.1
Dec	19.05	83.7	7.8	118.6	2.4

N.B. Recorded at Rangpur observation station

Table II - 8 Monthly average temperature

Station: Rangpur Unit: °C

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1960	17.2	21.5	23.2	29.3	30.2	28.5	28.7	29.5	28.3	27.3	22.4	19.9
61	18.8	18.2	24.6	28.2	28.1	28.3	29.4	29.4	28.8	26.7	21.8	16.9
62	16.3	20.3	24.1	29.0	26.5	28.4	29.3	28.7	29.5	26.4	22.3	18.7
63	17.5	21.2	23.5	26.7	26.7	28.8	28.7	29.1	29.7	26.9	21.9	19.6
64	16.4	20.2	25.4	26.7	27.5	28.3	28.2	29.2	28.9	27.4	23.2	18.0
65	17.9	19.3	23.6	26.0	27.8	28.4	28.6	28.3	28.4	26.6	21.6	18.4
66	18.0	21.9	25.4	29.9	29.3	28.1	28.8	29.0	28.5	25.5	22.0	18.7
67	17.4	20.1	22.4	24.9	27.7	29.5	28.9	31.0	29.3	26.6	23.2	21.0
68	-	-	-	-	-	-	-	-	-	-	-	-
69	16.4	19.3	22.2	26.6	27.5	27.4	29.6	29.6	29.2	26.3	22.6	18.8
70	17.0	19.5	24.1	28.6	29.6	27.9	28.3	29.1	29.0	26.7	23.7	18.0
71	17.6	18.3	-	-	-	-	29.7	29.3	28.5	27.0	24.0	22.4
72	17.9	18.2	21.6	24.0	26.3	26.3	27.8	-	27.8	27.3	25.6	20.6
73	-	-	-	-	-	-	-	-	-	-	-	-
74	-	-	-	-	-	-	-	-	-	-	-	-
75	-	-	-	-	-	-	-	-	-	-	-	-
76	-	-	-	-	-	-	-	-	-	-	-	-
77	-	-	-	-	-	-	-	-	-	-	-	-
78	18.7	20.6	21.7	27.2	27.2	28.4	28.6	30.0	28.1	27.4	22.7	18.5
79	15.6	16.9	21.7	27.1	31.1	31.4	30.3	29.1	28.2	26.0	23.3	18.6
80	17.1	20.3	24.2	28.9	26.2	28.8	29.0	28.7	29.0	26.5	22.9	20.1
81	17.1	19.8	23.6	25.1	26.5	29.4	-	-	-	27.6	22.6	18.4
82	18.3	19.4	23.0	26.0	28.6	28.3	29.0	29.2	28.9	26.7	22.1	18.3
83	16.5	18.1	23.5	25.6	26.3	28.6	30.5	29.0	27.9	26.7	22.9	17.8
84	16.4	18.9	24.1	27.9	26.5	28.5	28.3	29.4	27.5	26.9	21.9	18.3
85	17.0	19.0	24.7	27.7	27.2	28.8	27.9	29.4	28.0	26.4	22.1	19.1
86	17.4	19.2	24.1	25.4	27.0	28.8	28.5	29.1	27.0	25.0	22.5	18.8
87	17.7	21.7	23.6	26.8	28.1	29.2	28.3	28.4	28.3	26.7	23.0	19.8
88	18.3	21.0	24.1	27.1	27.5	28.7	29.2	28.9	28.7	27.1	23.0	20.4

Table II - 9 Monthly average humidity

Station: Rangpur Unit: %

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1960	77	73	68	50	70	87	88	87	90	83	83	88
61	84	76	63	63	80	86	86	88	86	87	83	85
62	82	75	61	60	83	88	86	89	87	83	82	83
63	78	66	67	72	81	86	89	88	85	85	81	80
64	74	72	65	75	82	87	89	85	86	85	80	78
65	77	72	67	70	79	87	86	87	86	81	82	79
66	81	74	61	67	73	87	88	89	87	85	86	83
67	81	77	76	73	77	79	84	79	84	86	85	85
68	-	-	-	-	-	-	-	-	-	-	-	-
69	82	78	75	77	78	79	86	84	84	84	84	84
70	86	84	78	75	79	86	87	85	87	89	84	84
71	87	84	-	-	-	89	87	88	87	88	88	88
72	86	88	81	79	80	83	86	-	86	87	88	89
73	89	85	85	83	85	85	84	83	87	85	86	88
74	-	-	-	-	-	-	-	-	-	-	-	-
75	88	88	88	84	86	85	88	89	91	92	92	92
76	91	91	88	88	87	89	91	90	87	89	92	92
77	91	-	-	82	80	84	85	87	87	90	-	91
78	89	88	40	62	82	87	88	81	85	76	76	70
79	69	62	46	57	66	78	86	81	82	81	80	79
80	73	68	62	67	79	84	84	86	86	83	73	73
81	77	69	61	73	81	81	-	-	-	75	71	75
82	74	64	63	70	74	84	85	83	85	80	77	78
83	76	66	57	64	81	82	85	84	87	86	80	86
84	84	74	65	67	86	86	89	85	89	87	79	84
85	82	77	67	70	81	85	89	85	88	86	82	83
86	84	71	56	75	78	85	87	85	90	87	85	83
87	85	82	76	76	80	88	92	89	91	88	86	87
88	85	78	72	75	84	86	88	90	88	85	80	83

Table II - 10 Monthly average windspeed

Station: Rangpur Unit: Knot

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1960	2.0	2.0	3.0	4.0	3.0	3.0	3.0	3.0	2.0	2.0	2.0	2.0
61	2.0	2.0	3.0	3.0	4.0	3.0	3.0	3.0	3.0	2.0	2.0	2.0
62	2.0	2.0	3.0	4.0	3.0	3.0	3.0	3.0	2.0	2.0	2.0	2.0
63	2.0	2.0	4.0	3.0	3.0	3.0	3.0	3.0	2.0	2.0	2.0	2.0
64	3.0	3.0	3.0	3.0	4.0	3.0	3.0	3.0	3.0	3.0	3.0	2.0
65	2.0	2.0	3.0	4.0	3.0	4.0	3.0	3.0	2.0	2.0	2.0	3.0
66	3.0	2.0	3.0	3.0	3.0	4.0	3.0	3.0	2.0	2.0	2.0	2.0
67	2.0	3.0	3.0	4.0	4.0	3.0	4.0	2.0	2.0	2.0	2.0	2.0
68	-	-	-	-	-	-	-	-	-	-	-	-
69	2.0	3.0	3.0	3.0	21.0	3.0	3.0	3.0	3.0	2.0	3.0	2.0
70	3.0	3.0	4.0	4.0	3.0	3.0	3.0	2.0	3.0	2.0	3.0	2.0
71	2.0	3.0	-	-	-	3.0	3.0	3.0	3.0	2.0	3.0	3.0
72	2.0	2.0	3.0	3.0	4.0	3.0	3.0	-	2.0	2.0	2.0	2.0
73	2.0	2.0	3.0	3.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
74	-	-	-	-	-	-	-	-	-	-	-	-
75	2.0	2.0	2.0	3.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
76	2.0	2.0	3.0	3.0	3.0	3.0	2.0	2.0	2.0	2.0	2.0	2.0
77	2.0	-	-	3.0	3.0	2.0	2.0	2.0	2.0	2.0	-	2.0
78	2.0	2.0	4.0	4.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
79	4.0	4.0	6.0	5.0	4.0	5.0	4.0	5.0	5.0	3.0	3.0	3.0
80	3.0	3.0	4.0	4.0	4.0	4.0	4.0	4.0	3.0	3.0	3.0	2.0
81	3.0	3.0	3.0	4.0	3.0	3.0	-	-	-	3.0	4.0	3.0
82	4.0	5.0	5.0	5.0	4.0	4.0	4.0	5.0	3.0	3.0	4.0	3.0
83	4.0	4.0	5.0	5.0	4.0	4.0	3.0	4.0	4.0	4.0	4.0	3.0
84	4.0	4.0	5.0	5.0	5.0	5.0	5.0	6.0	5.0	4.0	5.0	4.0
85	4.0	4.0	6.0	6.0	6.0	5.0	5.0	5.0	5.0	4.0	4.0	4.0
86	4.0	5.0	6.0	7.0	4.0	5.0	5.0	5.0	5.0	4.0	4.0	4.0
87	4.0	4.0	5.0	6.0	4.0	4.0	5.0	5.0	4.0	3.0	4.0	4.0
88	4.0	4.0	5.0	5.0	5.0	6.0	4.0	4.0	4.0	4.0	5.0	4.0

Table II - 11 Monthly average sunshine

Station: Rangpur Unit: hrs

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1979	-	-	-	-	-	-	-	4.8	6.4	7.3	-	6.8
80	8.2	6.6	7.0	7.5	6.3	6.1	5.4	5.1	5.4	8.2	9.7	8.9
81	8.7	8.8	7.9	7.7	8.1	8.5	-	-	-	10.8	10.2	8.3
82	-	-	-	-	-	-	4.4	6.1	5.9	8.4	7.6	6.8
83	-	8.6	9.1	6.7	6.6	6.8	5.0	6.2	5.8	6.3	9.1	7.2
84	6.8	-	8.4	8.7	3.9	5.5	3.1	5.7	4.6	6.0	9.2	7.7
85	-	-	6.1	7.1	5.1	5.2	3.3	-	5.5	8.0	8.7	7.1
86	7.6	8.4	7.7	6.0	-	-	-	4.1	3.5	4.9	-	6.9
87	7.9	8.5	7.5	7.7	9.1	4.8	2.7	4.5	3.8	6.9	7.4	8.3
88	7.6	7.6	8.2	-	6.4	5.3	4.1	3.0	4.9	7.8	8.1	8.0

Table II - 12 Monthly average evaporation

Station: Rangpur Unit: mm/day

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
83	-	7.4	5.5	5.8	3.7	3.5	3.8	3.4	-	3.7	3.3	2.3
84	2.3	3.3	5.1	7.8	4.3	5.3	5.9	5.3	4.1	3.9	3.4	2.1
85	2.3	3.1	5.7	6.9	6.0	5/0	6.0	5.7	3.9	3.4	2.9	2.4
86	2.3	3.8	6.4	5.8	5.5	5.4	4.6	5.0	3.6	3.2	2.7	2.4
87	2.4	3.3	4.8	6.1	6.2	5.1	4.3	4.5	3.1	3.3	2.9	2.6
88	2.4	3.3	4.8	6.0	5.4	4.4	4.0	3.2	3.7	3.8	3.5	2.4

Table II - 13 Annual discharge records

River : Dharla
Station: Talukshimulbari

Unit: cu.m/s

Year	Maximum	Minimum	Average
1968	6450.0	55.8	543.0
69	3370.0	28.3	398.0
70	NA	NA	NA
71	NA	NA	NA
72	877.0	39.6	211.0
73	756.0	29.7	181.0
74	1660.0	64.8	349.0
75	891.0	57.7	228.0
76	1520.0	44.4	294.0
77	1150.0	81.2	361.0
78	1340.0	68.4	309.0
79	1130.0	58.1	265.0
80	715.0	150.0	393.0
81	NA	NA	NA
82	NA	NA	NA
83	NA	NA	NA
84	NA	NA	NA
85	NA	NA	NA
86	1890.0	62.4	286.0
87	5810.0	55.8	505.0

Table Ⅱ - 14 Annual water level records

River : Dharla

Station: Talukshimulbari

Unit: m/PWD

Year	Maximum	Minimum
1962	30.43	26.85
63	NA	NA
64	NA	NA
65	30.58	27.02
66	32.76	26.78
67	30.65	26.76
68	30.89	26.90
69	29.96	26.77
70	29.97	26.74
71	NA	NA
72	30.12	27.44
73	30.41	26.93
74	30.54	27.01
75	31.14	27.08
76	30.97	26.87
77	30.94	26.88
78	30.99	27.28
79	30.62	27.26
80	31.20	27.23
81	30.79	26.64
82	30.85	25.64
83	31.44	27.19
84	31.74	27.82
85	31.13	27.84
86	31.73	27.53
87	32.05	27.52

Table Ⅱ - 15 Annual discharge records

River : Dharla
Station: Kurigram

Unit: cu.m/s

Year	Maximum	Minimum	Average
1973	4750.0	56.6	808.0
74	6170.0	79.8	931.0
75	2830.0	88.0	538.0
76	2580.0	70.8	476.0
77	2050.0	92.0	610.0
78	1900.0	76.5	415.0
79	1250.0	83.3	298.0
80	1700.0	52.9	415.0
81	651.0	56.9	149.0
82	1270.0	60.9	241.0
83	1960.0	54.0	355.0
84	NA	NA	NA
85	4670.0	51.5	530.0
86	2140.0	66.7	393.0
87	7810.0	61.7	538.0

Table Ⅱ-16 Annual water level records

River : Dharla

Station: Kurigram

Unit: m/PWD

Year	Maximum	Minimum
1960	26.49	21.78
61	NA	NA
62	27.02	22.04
63	NA	NA
64	26.70	22.33
65	26.61	22.05
66	26.35	21.96
67	26.32	22.30
68	26.53	22.24
69	25.87	22.82
70	26.28	22.37
71	23.26	22.31
72	27.04	22.31
73	26.20	22.42
74	26.72	22.62
75	26.52	22.57
76	26.31	22.24
77	26.18	22.33
78	25.83	22.31
79	26.37	22.54
80	26.58	22.19
81	26.58	22.13
82	26.48	22.57
83	26.62	22.39
84	27.38	22.36
85	26.75	22.47
86	25.91	22.12
87	27.50	22.19
88	27.41	22.12

Table II - 17 Annual discharge records

River : Dudhkumar
Station: Pateswari

Unit: cu.m/s

Year	Maximum	Minimum	Average
1968	*23100.0	88.0	871.0
69	2360.0	72.2	442.0
70	4670.0	78.7	779.0
71	NA	NA	NA
72	4240.0	62.3	798.0
73	993.0	79.0	246.0
74	1640.0	84.9	404.0
75	1160.0	71.3	305.0
76	7190.0	62.5	808.0
77	809.0	90.6	322.0
78	*1020.0	80.1	201.0
79	1120.0	76.9	280.0
80	*659.0	56.0	185.0
81	*283.0	60.2	109.0
82	*979.0	90.6	267.0
83	*867.0	86.3	246.0
84	NA	NA	NA
85	NA	NA	NA
86	892.0	69.9	203.0
87	5670.0	65.4	563.0

* Has been excluded from the analysis due to irregularities in data.

Table Ⅱ - 18 Annual water level records

River : Dudhkumar
Station: Pateswari

Unit: m/PWD

Year	Maximum	Minimum
1962	26.21	25.21
63	29.93	25.86
64	30.26	25.92
65	29.87	25.59
66	29.42	25.47
67	29.64	25.50
68	30.08	25.71
69	29.17	25.85
70	29.48	25.83
71	NA	NA
72	29.10	25.88
73	29.52	25.94
74	30.24	26.38
75	29.52	26.40
76	29.38	25.88
77	30.15	26.05
78	29.69	26.17
79	29.95	26.08
80	29.93	26.12
81	29.64	26.17
82	30.29	26.00
83	30.67	26.03
84	30.86	26.08
85	30.00	26.43
86	29.72	26.40
87	30.46	26.24
88	30.69	26.22

Table II -19 Annual discharge records

River : Brahmaputra

Station: Bahadurabad

Unit: cu.m/s

Year	Maximum	Minimum	Average
1960	64800.0	3790.0	19000.0
61	53800.0	3990.0	18800.0
62	69400.0	3540.0	18900.0
63	56400.0	3770.0	28300.0
64	63100.0	3170.0	19200.0
65	64200.0	3500.0	18900.0
66	68900.0	3950.0	23100.0
67	69600.0	3620.0	18600.0
68	62300.0	3880.0	18600.0
69	56000.0	4020.0	17500.0
70	75000.0	2860.0	21700.0
71	NA	NA	NA
72	66600.0	3140.0	17600.0
73	67300.0	3280.0	18100.0
74	91100.0	3200.0	21900.0
75	52200.0	4050.0	18500.0
76	65600.0	3990.0	17700.0
77	66600.0	4530.0	23400.0
78	56600.0	4050.0	18400.0
79	66100.0	4330.0	20900.0
80	61200.0	4020.0	19400.0
81	66500.0	3500.0	17200.0
82	55900.0	3980.0	17800.0
83	56500.0	3530.0	18800.0
84	77000.0	3840.0	21000.0
85	63800.0	3660.0	19600.0
86	43100.0	3360.0	16300.0
87	74000.0	3990.0	21700.0
88	98600.0	5240.0	24300.0

Table II -20 Annual water level records

River : Brahmaputra
Station: Bahadurabad

Unit: m/PWD

Year	Maximum	Minimum
1960	19.48	12.22
61	18.91	11.95
62	19.99	12.41
63	NA	NA
64	19.84	12.97
65	19.69	13.17
66	19.62	13.24
67	19.50	13.30
68	19.80	13.41
69	19.84	13.14
70	19.20	13.03
71	20.75	13.00
72	18.98	13.05
73	19.88	13.37
74	20.26	13.35
75	19.60	13.01
76	19.87	12.89
77	19.99	13.02
78	19.63	13.02
79	19.78	13.26
80	20.10	13.24
81	19.48	13.04
82	19.42	13.12
83	19.93	13.05
84	20.11	13.48
85	19.62	13.24
86	19.15	13.15
87	19.71	13.38
88	20.62	13.68

Table Ⅱ - 21 Annual water level records

River : Brahmaputra
Station: Noonkhawa

Unit: m/PWD

Year	Maximum	Minimum
1962	28.07	21.64
63	27.71	21.90
64	NA	NA
65	27.59	21.72
66	27.45	21.73
67	27.39	21.40
68	27.53	21.58
69	27.58	21.35
70	27.88	21.28
71	27.11	21.29
72	27.96	21.32
73	27.79	21.97
74	27.99	21.78
75	27.55	21.70
76	27.63	21.87
77	27.77	21.61
78	27.41	20.97
79	27.32	21.29
80	27.96	21.71
81	27.30	21.23
82	NA	NA
83	26.71	20.70
84	26.45	20.92
85	26.51	20.35
86	26.12	20.26
87	26.70	19.99
88	28.10	20.17

Table Ⅱ - 22 Annual water level records

River : Brahmaputra
Station: Chilmari

Unit: m/PWD

Year	Maximum	Minimum
1962	25.07	16.43
63	NA	NA
64	NA	NA
65	23.26	16.39
66	23.81	16.60
67	23.97	16.63
68	24.04	16.80
69	23.79	16.51
70	24.19	16.58
71	24.08	16.49
72	24.09	16.92
73	23.88	17.07
74	24.46	16.92
75	23.78	17.00
76	23.90	16.72
77	24.11	16.31
78	23.68	16.02
79	NA	NA
80	24.25	17.18
81	NA	NA
82	NA	NA
83	24.12	16.63
84	24.26	17.35
85	23.93	17.63
86	23.44	17.27
87	24.56	17.36
88	25.06	17.65

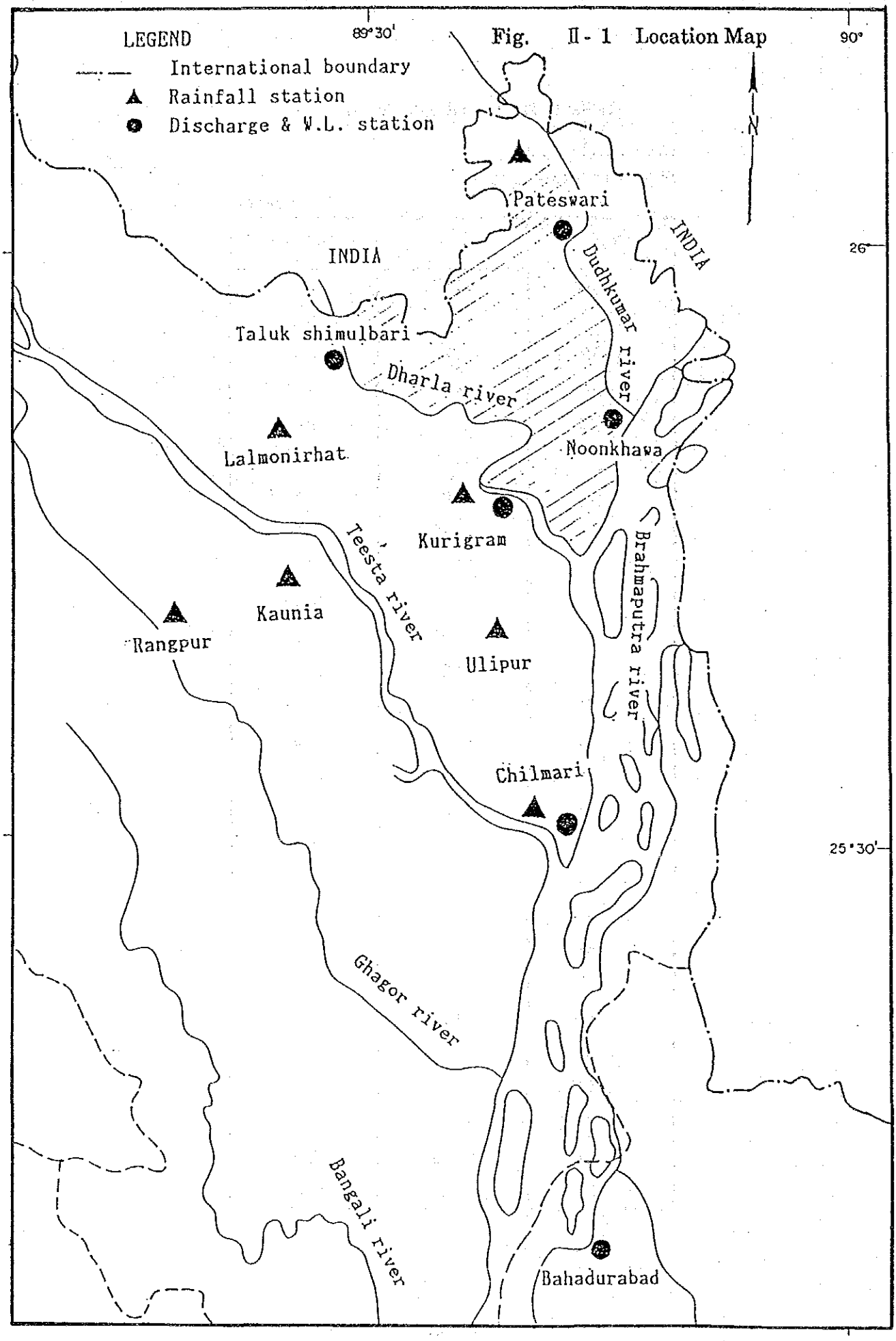

Fig. II - 1 Location Map

Flow measurement

In order to know the minimum flow during the dry season at the main and reversible pumping stations a survey was conducted. Velocity was measured by a current meter at 50m interval at two flow depth i.e. 0.2D and 0.8D. The flow depths were measured at 25m interval. Then from the average velocity and measured flow depths the discharge was obtained. The results of the flow measurements are presented in the table below.

Data	River	V (m/s)	W.L. (m/PWD)	D (m)	L (m)	A (m2)	Q (cms)
13/2/90	Dudhkumar	0.25	26.72	2.62	285	444	111
4/3/90	Dudhkumar	0.20	26.75	2.32	300	421	93
12/2/90	Brahmaputra	0.83	-	8.00	365	1063	886

Where, V = average velocity
W.L. = water level
D = max. flow depth
L = total length of the cross section
A = cross section area
Q = discharge

It was confirmed that the stage-discharge curve at Pateswari used by the BWDB precisely correspond to the measurement results.

Fig. Ⅱ- 2 Stage-discharge Curve and Mesured Discharge