

THE PEOPLE'S REPUBLIC OF BANGLADESH
BANGLADESH WATER DEVELOPMENT BOARD

**FEASIBILITY STUDY
ON
THE NORTH RAJSHAHI
IRRIGATION PROJECT**

**VOLUME 2
APPENDICES I-V**

AUGUST 1988

JAPAN INTERNATIONAL COOPERATION AGENCY

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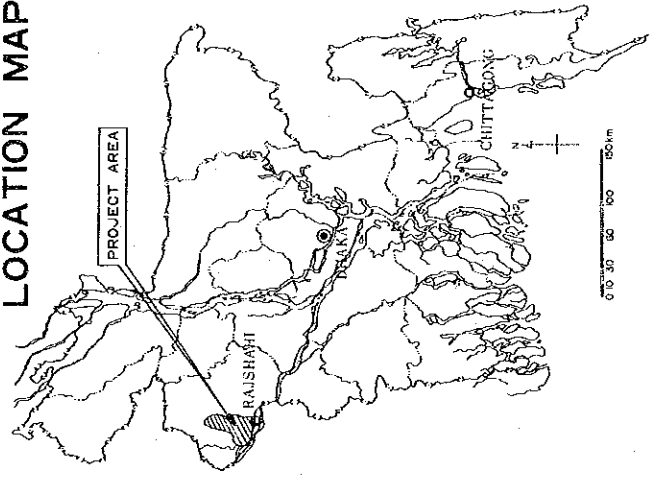
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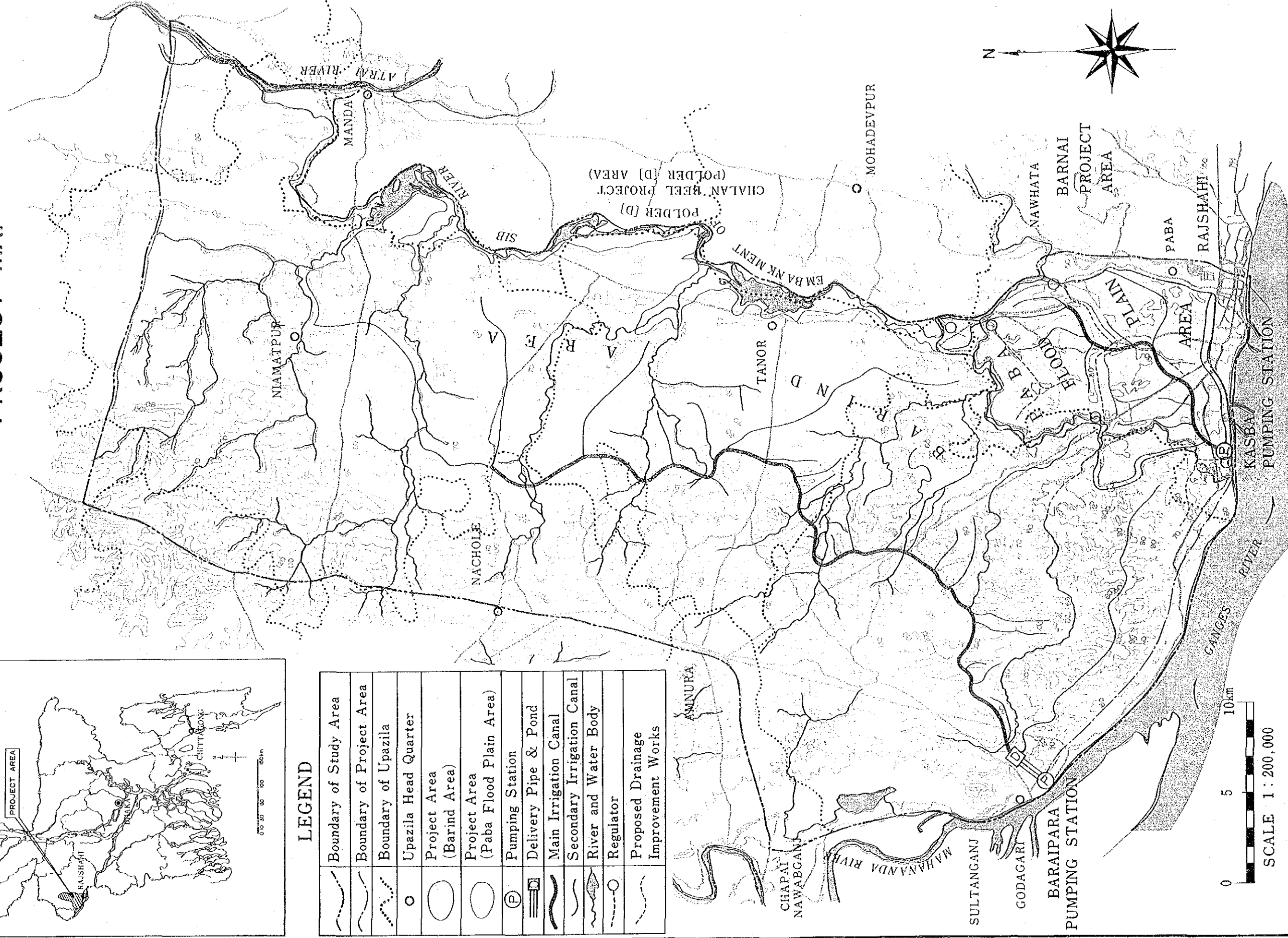
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LOCATION MAP

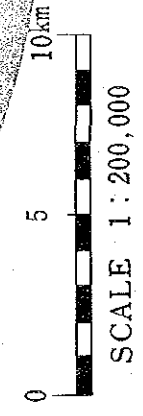
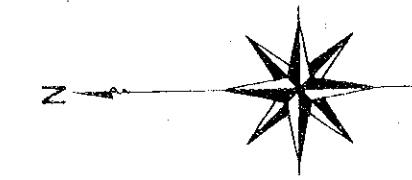


NORTH RAJSHAHI IRRIGATION PROJECT PROJECT MAP



LEGEND

	Boundary of Study Area
	Boundary of Project Area
	Boundary of Upazila
	Upazila Head Quarter
	Project Area (Barind Area)
	Project Area (Paba Flood Plain Area)
	Pumping Station
	Delivery Pipe & Pond
	Main Irrigation Canal
	Secondary Irrigation Canal
	River and Water Body
	Regulator
	Proposed Drainage Improvement Works



SCALE 1 : 200,000

APPENDIX I

SOIL AND LAND CLASSIFICATION

APPENDIX I

SOIL AND LAND CLASSIFICATION

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Glosary and References

Glosary

- Acid soil. A soil that gives an acid reaction (below pH 7.0)
Mod. acid-pH 5.6-6.5; Highly acid-pH less than 5.6;
- Alkaline soil. Any soil that is alkaline in reaction (above pH 7.0)
Mod. alkaline-7.4-8.4; Highly alkaline-pH more than 8.4
- Aman. Rice varieties grown in the monsoon season and harvested in November-December. T. aman or Transplated aman is sown in nursery beds and the seedlings transplanted in fields in June-August.
- Aus. Rice varieties grown in the pre and early monsoon season, usually sown in March-April and harvested in June-July. T. aus or transplanted aus is grown either by irrigation water or by early rainfall if sufficient rain occurs in March-April.
- Available moisture. Moisture availability for rabi crops.
High-Moisture available for more than 3 month.
Medium-Moisture available for 2-3 month.
Low-Moisture available for less than 2 months.
- Basin. The lowest part of a floodplain landscape, usually saucer shaped.
- Boro. Rice varieties growing in the dry season, usually with the help of irrigation. Boro varieties are sown in nursery beds and transplanted to flooded fields in December-January, to be harvested in April-May.
- Clod. An artificially formed soil maps.
- Compact; Difficult to penetrate with knife or spade.
- Drainage. The removal of water from the soil or land, either naturally or by artificial means (e.g. by ditches or pumps) . The term used to describe natural soil drainage in this report are described below.
Imperfectly drained. The soil remains wet for several weeks during the monsoon season and water may stand on the surface within field bunds for 1-2 weeks at a time following periods of heavy monsoon rainfall.

- Drainage. Poorly drained. The soil remains wet for several weeks during the monsoon season and is normally flooded for more than 2 weeks by not the whole year.
- Fallow. Cultivated land left without a crop during one or more growing seasons.
- Floodplain. Land made by deposition of river alluvium.
- Highland. Land lying above normal flood level.
- Kharif. Term applied to crops grown in the wet (monsoon) season.
- Landscape. The overall surface of a tract of land. For example, floodplain landscape normally includes both broad ridges and basins.
- Medium highland. Land that is flooded up to 1 m. deep during the monsoon season.
- Medium lowland. Land that is flooded up to 1-2 m. deep in the monsoon season.
- Mottled. Patches of different colours occurring side by side in the soil.
- MV. Modern variety of rice.
- Permeability. The rate of movement of water and air through the soil. The terms used to describe soil permeability in this report are defined below :
- Very slow permeability : rate of movement of water through the soil less than 3 cm per day.
- Slow permeability : rate of movement of water through the soil between 3-12 cm per day.
- Moderately slow permeability : rate of movement of water through the soil between 12-49 cm per day.
- Moderate permeability : rate of movement of water through the soil between 49-152 cm per day.
- Moderately rapid permeability : rate of movement of water through the soil between 152-305 cm per day.
- Rapid permeability : rate of movement of water through the soil between 305-610 cm per day.

- Plough pan. A compact layer, usually about 5-7 cm thick, occurring immediately below the cultivated layer in some soils. It is formed by repeated pressure from the plough during ploughing of the moist or wet soil.
- Rabi crops. The crops grown and maturing in the dry season. Early rabi crops that sown in September-October. Late rabi crops that sown in November-February.
- Reaction. A term referring to the degree of soil acidity or alkalinity.
- Ridge. The term used for the relatively higher part of floodplain landscapes. Ridges or levees, developed by the deposition of sediments during high floods, from the natural banks of a river.
- Rolling. Landscape having 8-16 percent slopes.
- Soil series. A soil series represents a group of soils developed in similar parent material and resembling each other closely in their main properties such as colour, texture, structure, reaction, etc. in the subsoil.
- Soil structure. The arrangement of individual soil particles and their aggregates into certain defined patterns (or shapes).
- Subsoil. The layer below the topsoil. It has been changed from its original state (of rock or alluvium) by soil forming processes.
- Soil depth. Depth of A & B horizon together.
 Shallow-Depth of A & B ranges from 25-50 cm
 Mod. deep-Depth of A & B ranges from 50-90 cm
 Deep-Depth of A & B ranges from 90-150 cm
- Substratum - The layer of the soil that has not been altered by soil forming processes, usually occurring below the subsoil or sometimes below the top soil in very shallow soils.
- Texture (soil). The relative proportion of different particle sizes within the soil which determine whether it is sandy, clayey, etc.

Topsoil. The surface layer of the soil, usually the plough layer disturbed by cultivation, including the plough pan.

Undulating. Landscape having 3-8 percent slope.

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1 INTRODUCTION

1-1 Background

BWDB undertaken an irrigation project in greater Rajshahi District under the name of "The North Rajshahi Irrigation Project" to develop irrigation network for higher agricultural production, generation of employment facilities as well as to maintain the agricultural environment of the area.

Before implementation of the project, a feasibility study of the area was entrusted to JICA study team of Japan. JICA started the feasibility study in the later part of 1987.

To study the development of water resources of the area for irrigation purpose the study of soil resources is a pre-requisite and soil survey are carried out in more-detailed reconnaissance level for better understanding of soil - crop - water interaction.

1-2 General Nature of the Area

Location and Extent; The project area of the north Rajshahi Irrigation Project located in greater Rajshahi District, comprises part of Godagari, Tanore, Niamatpur, Paba and Manda upazilas. It lies between latitude 24°22' and 24°48' north and longitude 88°18' and 88°38' east. Rajshahi district town is located on the southern margin of project area. Tanore and Godagari upazila Head-quarter are located within the project area. The project area comprises area of 77,000 hectares.

Climate; The project area belongs to tropical monsoon climate. There are three main season such as winter (Nov. - Feb.) which is cold and receive minimum amount of rainfall (40 - 45 mm), premonsoon (March - May) is hot and receives moderate rainfall (160 - 204 mm) with periodic thunderstorm and monsoon (June - Oct.) is wet and receives higher amount of rainfall (1044 - 1193 mm).

These three seasons are also related to main cropping seasons such as rabi season (Nov. - Feb.), kharif-I (March - May) and kharif-II (June - Oct.). The highest temperature of about 30.5°C occurs in the month of May while lowest temperature of 18.3°C occurs in the month of January.

The annual average temperature is about 26°C, a bit higher in comparison with the district of eastern part of Bangladesh. Annual

rainfall of Rajshahi, Tanore, and Manda ranges from 1362 to 1438 mm. In Nawabgonj and Niamatpur it ranges from 1250 to 1325 mm. It reveals from the data that western part of the project area receives less rainfall than the eastern part. Also it reveals that the project area receives lowest amount of rainfall in comparison to the other parts of Bangladesh.

Geology and Physiography; The project area belongs to three broad physiographic units e.g. (a) Barind tract, (b) Ganges floodplain and (c) Tista floodplain.

(a) Barind tract; It is an elevated landscape, thought to be of a marine deposits of Mio-pliocene age, which was later on uplifted and broken into different fault lines, associated with denudation and human activities resulted in the present day topographic sequence. The landscape 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. The area is slightly tilted from north - west to south - east direction which is reflected and confirmed by the drainage pattern of the area. The sediments are usually loamy locally clayey, underlain by clayey sediments. The weathering of sediment usually reflected within a range of 1 - 2 meter, locally even less from the surface. In the valleys deluvial loamy sediments were observed over clayey substratum. All the sediments are acidic in reaction.

(b) Ganges floodplain; 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 platforms. On the ridge, inter ridge depressions and raised platform the sediments are loamy and calcareous locally non-calcareous while the sediments occurring in the basins are usually clayey and partially decalcified in the surface or subsurface layers.

(c) Tista floodplain; A minor part in north - east of the project area is occupied by the Tista floodplain. The landscape comprises deep broad basins. The sediments occurring on the basins are clayey in nature and are strongly acidic. Loamy soils occur on the basin margins.

1-3 Previous Studies

The Soil Survey Department (Presently SRDI) was created in 1962. Its primary objective was to carry out a Systematic Reconnaissance Soil Survey of the country (the then East Pakistan) under the Technical Assistance Programme of UNDP and FAO. The Survey works was completed by 1975 and the reports and maps were published in district wise in different times till 1977. The Reconnaissance Soil Survey of Rajshahi district was carried out as a part of the programme between 1966 and 1967. The Reports were published in 1968. The Reconnaissance Soil Survey was based on interpretation of aerial photographs and field observation. On the basis of Reconnaissance Soil Survey Reports and maps semi-detailed and detailed surveys are being carried out by SRDI and other different agencies like BWDB, local consultants in different proposed development projects/schemes. Detailed Soil Survey were carried out by SRDI for different Research Stations of BARI, BRRI between 1972 to 1982 in Bogra and Kushta districts bordering Rajshahi District.

The Detailed Soil Survey of Rural Development Academy Farm of Bogra was carried out by the District Office of the Soil Resources Department Institute (SRDI) and the Report was published in 1984. Similarly, the detailed soil survey of Meherpur Seed Multiplication Farm was carried out by SRDI and published the Report in 1976.

The survey techniques and procedures followed as USDA soil survey manual and FAO-guide lines. Taxonomic soil classification have been made in later stages, following the Soil Taxonomy USDA - 1975. The soil survey of the project area in more-detailed reconnaissance level is being carried out using the reconnaissance soil survey maps and data of Rajshahi district as base materials.

2 OBJECTIVES AND PROCEDURES OF THE STUDY

2-1 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 correlation to the physical and chemical properties of soils. The present study is 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 crop suitability under irrigated condition.

2-2 Method of Soil Survey

The procedure of soil survey in the project area comprises the different steps such as follows:

- 1) Review and evaluation of exiting data.
- 2) Preparation of photo-interpreted land type map
(Scales 1:50,000)
- 3) Preparation of photo-interpreted soil map
(Scales 1:50,000)

The photo interpreted land type map is superimposed 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 study area is prepared.

4) More-detailed reconnaissance survey:

Auger boring 175 sites. (containing the sites in the study area.)

Test pit digging 23 sites

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

6) Preparation of land use map (").

7) Preparation of land suitability map (").

2-3 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 randomly basis so as to examine the different units at least in 2 replications. The number of checks is decided by the international standard. Soils are checked by opening small pits supplemented by auger holes. One or two standard pits for each soil series are digged and described properly and soil samples are taken for laboratory analysis. In all 87 soil samples from 23 profiles are collected for laboratory analysis.

3 SOILS

3-1 Soil Classification

The soils of the project area are classified into three main groups according to physiographic units e.g. (a) 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 paragraph 3-2.

(a) Barind Tract

The Barind tract is an elevated landscape, thought to be 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 dissected by narrow, usually steamless, valley, there it is relatively high and slopes downwards to the east.

The soils occurring on the level to rolling Barind tract, namely Nijhuri, Amnura, Lauta soils, 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 mainly occurs 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 limitations of crop production are severe droughtiness in the dry season in the Barind tract.

(b) Ganges floodplain

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, friable 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 limitations of crop production are relatively deep seasonal flooding and wetness in the first part of the dry season.

(c) Tista Floodplain

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 Jamonia series. They are acidic in reaction.

The limitations of 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 subgroups as Typic Haplaquepts, Aeric Haplaquepts and Aquic Entrochrepts in the higher categories of classification as shown in the TABLE I-3-1.

TABLE I -3-1 CORRELATION OF SOIL SERIES IN SOIL CLASSIFICATION

Order	Subgroup	Floodplain		Barind Tract
		Ganges	Tista	
Inceptisols	Typic Haplaquepts	Garuru Ghior Gulai Maria Mehendiganj Santhia	Digli Janonia	
	Aeric Haplaquepts	Ishurdi Teghar	Dohali	Ammura, Atahara, Lauta, Nachol, Nijhuri, Noadda*, Pauli
	Aquic Entrochrepts	Gopalpur Sara Tahirpur		

Remarks : * Noadda; Aeric Haplaquepts or Dystochrepts.

3-2 Description of Soil Series

a) Barind Tract

i) Nijhuri Series

Nijhuri series includes imperfectly drained, mixed yellowish brown and grey, silt loam to silty clay loam subsoils with moderate blocky structure, overlying red mottled clay substratum.

Typical profile : Nijhuri, level highland.

Location : Stop No. T-14; Tanore, Uz - Tanore.

Topography : Level Barind.

Land use : T. aman - fallow.

Drainage : Imperfect. Remains wet/moist in the rainy season and unsaturated in the dry season.

Tax. sub-group : Aeric Haplaquepts.

Profile Description

<u>Horizon</u>	<u>Depth cm</u>	<u>Characteristics</u>
Ap1g	0-9	Grey (5Y 5/1) moist with few fine strong brown mottles; silt loam; massive; hard dry; many fine tubular pores; many fine roots; pH 6.0; abrupt smooth boundary.
Ap2g	9-14	Grey (5Y 5/1) moist with many fine distinct yellowish brown and strong brown mottles; silt loam; massive; hard dry; common fine tubular pores; common fine roots; pH 6.5; abrupt smooth boundary.
Bw1g	14-28	Yellowish brown (10YR 5/6) and grey (5Y 5/1) moist with common fine distinct dark yellowish brown mottles; silt loam; strong medium and fine subangular blocky; friable moist many fine tubular pores; few fine roots; few concretion; pH 7.0; abrupt smooth boundary.

Bw2g	28-43	Light olive brown (2.5Y 5/4) moist with common fine distinct grey and dark brown mottles; silty clay loam; strong medium and fine subangular blocky; friable moist; many fine tubular pores; few concretion; pH 7.0; abrupt smooth boundary.
Bw3g	43-65	Grey (5Y 5/1) moist with many prominent yellowish red and dark yellowish brown mottles; silty clay; moderate common and medium subangular blocky; firm moist; common fine tubular pores; few concretion; pH 7.0.
C1	65-100	Grey (5Y 5/1) with many present yellowish and dark brown mottles; clay; massive; pH 7.0.

Environmental Characteristics

Nijhuri soils occur on extensive, level areas of the Barind tract as well as on summits and slopes of broadly dissected areas of the tract. Locally, they occurs on closely dissected areas. During the monsoon season, these soils are usually intermittently flooded by rain water ponded within the fields. Three phases have been recognized: Nijhuri level, intermittently flooded phase; Nijhuri broadly dissected, terraced phase; and Nijhuri closely dissected, terraced phase.

ii) Amnura Series

Amnura series includes imperfectly drained, mixed yellowish brown and grey silt loam to silty clay loam subsoil with strong to moderate subangular blocky structure, overlying yellow mottled substratum.

Typical profile : Amnura, level

Location : Stop No. G-24, Saroil, Uz - Godagari.

Topography : Level.

Land use : T. aman - fallow.

Drainage : Imperfect. Remains moist/wet in the rainy season and unsaturated in the dry season.

Tax. sub-group : Aeric Haplaquepts.

Profile Description

<u>Horizon</u>	<u>Depth cm</u>	<u>Characteristics</u>
Ap1g	0-12	Grey (5Y 5/1) moist with common fine distinct strong brown mottles; silty clay loam; massive hard dry; many fine tubular pores; many fine roots; pH 7.0; abrupt smooth boundary.
Ap2g	12-17	Grey (5Y 5/1) moist with common fine distinct strong brown mottles; silty clay loam massive; hard dry, common fine tubular pores, many fine roots; pH 7.0; abrupt smooth boundary.
Bw1g	17-36	Yellowish brown (10YR 5/6) and grey (5Y 5/1) moist with few fine dark yellowish brown mottles; silty clay loam; moderate coarse and medium subangular blocky; firm moist; many fine tubular pores; common fine roots; pH 7.0; clean smooth boundary.
Bw2g	36-53	Yellowish brown (10YR 5/6) and grey (5Y 5/1) moist with many fine dark yellowish brown mottles; silty clay loam; moderate common and medium subangular blocky; many fine tubular pores; few concretion; pH 7.0; abrupt smooth boundary.
Bw3g	53-80	Grey (5Y 5/1) and yellowish brown (10YR 5/6) moist with few fine distinct dark yellowish brown mottles; silty clay; massive; firm moist; few iron-manganese concretion; pH 7.0.
C	80-100	Grey (5Y 5/1) moist with many yellowish brown and few dark yellowish brown mottles; clay; massive; few iron-manganese concretion; pH 7.0.

Environmental Characteristics

Amnura soils occur on extensive level areas of the Barind tract as well as on summits and slopes of dissected areas of the tract. During the monsoon season, these soils are usually intermittently flooded by rain water ponded within the fields. Five phases have been recognized: Amnura level, intermittently flooded phase; Amnura broadly dissected, terraced phase; Amnura closely dissected, terraced phase, Amnura steeply dissectly, terraced phase; and Amnura eroded phase.

iii) Lauta Series

Lauta series includes imperfectly drained, mixed yellowish brown and grey silty clay loam subsoil overlying grey clayey substratum at a shallow depth.

Typical profile : Lauta, highland.

Location : Stop No. T-27, Kamarga, Uz - Tanore.

Topography : Level.

Land use : T. aman - fallow.

Drainage : Imperfect. Remains moist/wet in the rainy season and unsaturated in the dry season.

Tax. sub-group : Aeric Haplaquepts.

Profile Description

<u>Horizon</u>	<u>Depth</u> <u>cm</u>	<u>Characteristics</u>
Ap1g	0-10	Grey (5Y 5/1) moist with common fine distinct strong brown mottles; silty clay loam; massive; hard dry; many fine tubular pores; many fine roots; pH 6.0; abrupt smooth boundary.
Ap2g	10-15	Grey (5Y 5/1) moist with few fine distinct strong brown mottles; silty clay loam; massive; hard dry common on fine tubular pores; many fine roots; pH 6.5; abrupt smooth boundary.

Bw1g	15-30	Yellowish brown (10YR 5/6) and grey (5Y 5/1) moist with few fine distinct dark yellowish brown mottles; silty clay loam; moderate coarse and medium angular blocky; firm moist, many fine tubular pores; pH 7.0; abrupt smooth boundary.
Bw2g	30-50	Grey (5Y 5/1) and yellowish brown (10YR 5/6) moist with many fine distinct dark yellowish brown mottles silty clay; moderate common and medium angular blocky; firm moist; few manganese concretion; pH 7.0; clear smooth boundary.
C	50-100	Grey (5Y 5/1) moist with few fine distinct dark yellowish brown mottles; clay; massive; fine moist; few non-manganese concretion; pH 7.0.

Environmental Characteristics

Lauta soils occur on extensive level areas of the Barind tract. During the monsoon season, slightly over half of these soils are intermittently flooded by rain water ponded within the fields. The remainder is flooded by river water. Four depths-of-flooding phases have been recognized: Lauta intermittently flooded phase; Lauta shallowly flooded phase; Lauta moderately deeply flooded phase; and Lauta deeply flooded phase.

iv) Atahar Series

Atahar soils includes imperfectly drained light olive brown to light yellowish brown, silty clay loam to silty clay soils grading into grey Madhupur clay.

Typical profile : Atahar, highland undulating.

Location : Stop No. G-3, Vill. Farsapara, Uz - Godagari.

Topography : Undulating.

Land use : T. aman - fallow.

Drainage : Imperfect. Remains moist/wet in rainy season and unsaturated in the dry season.

Tax. sub-group : Aeric Haplaquepts.

Profile Description

<u>Horizon</u>	<u>Depth cm</u>	<u>Characteristics</u>
Ap1g	0-8	Grey (5Y 5/1) moist with common fine strong brown mottles; silty clay; massive; dry hard; few fine tubular pores; many fine roots; pH 7.0; abrupt smooth boundary.
Ap2g	8-14	Grey (5Y 5/1) moist with few fine strong brown mottles; silt clay; massive; hard dry; few fine tubular pores; few fine roots; pH 7.0; abrupt smooth boundary.
Bw1g	14-35	Light yellowish brown (2.5Y 6/4) moist with few fine distinct grey mottles; silty clay; strong coarse and medium angular blocky; firm moist; common fine tubular pores; few manganese concretion; pH 7.0; clear smooth boundary.
Bw2g	35-60	Light yellowish brown (2.5Y 6/4) moist with common fine distinct grey mottles; silty clay; strong common and medium angular blocky; firm moist; few concretion; pH 7.0; clear smooth boundary.
C	60-100	Light grey (5Y 6/1) moist with common fine distinct dark brown mottles; clay; massive; firm moist; pH 7.0.

Environmental Characteristics

Atahar soils are developed in deeply weathered Madhupur clay and occupy summits and slopes of dissected areas of the Barind tract. During the monsoon season, they are usually intermittently flooded by rain water ponded within the fields.

Two phases have been recognized: Atahar broadly dissected, terraced phase; and Atahar closely dissected, terraced phase.

v) Nachol Series

Nachol series includes imperfectly to poorly drained mixed grey and yellowish brown clay loam, overlying grey, mottled yellow and brown, clayey substratum. They occur in the valley sites.

Typical profile : Nachol, highland.

Location : Stop No. G-25, Ghaighate, Uz - Godagari.

Topography : Slopping valley.

Land use : T. aman - fallow.

Drainage : Imperfect. Remain moist/wet in the rainy season and unsaturated in the dry season.

Tax. sub-group : Aeric Haplaquepts.

Profile Description

<u>Horizon</u>	<u>Depth cm</u>	<u>Characteristics</u>
Ap1g	0-12	Grey (5Y 5/1) moist with common fine distinct strong brown mottles; silty clay loam; massive; hard dry; many fine tubular pores; many fine roots; pH 7.0; abrupt smooth boundary.
Ap2g	12-16	Grey (5Y 5/1) moist with few fine distinct strong brown mottles; silty clay loam; massive; hard dry; common fine tubular pores; many fine roots; pH 7.0; abrupt smooth boundary.
Bw1g	16-30	Grey (5Y 5/1) and yellowish brown (10YR 5/6) moist with few fine distinct dark brown mottles; clay loam; moderate coarse and medium angular blocky; friable moist; many fine tubular pores few fine roots; pH 7.0; clear smooth boundary.

BW2g	30-45	Grey (5Y 5/1) and yellowish brown (10YR 5/6) moist with many fine distinct dark brown mottles; clay loam; moderate coarse and medium angular blocky; firm moist; many fine tubular pores; pH 7.0; clear smooth boundary.
C	45-85	Grey (5Y 5/1) moist with many fine distinct yellowish brown and dark brown mottles; silty clay; moderate coarse and medium angular blocky; pH 7.0.

Environmental Characteristics

Nachol soils are developed in local colluvium or alluvium from the Madhupur clay. They occur in nearly level to gently sloping valleys. During the monsoon season, most of these soils are intermittently flooded by rain water ponded within the fields.

Two phases have been recognized: Nachol intermittently flooded phase; and Nachol shallowly flooded phase.

vi) Pauli Series

Pauli series includes imperfectly to poorly drained, mixed grey and yellowish brown, occasionally grey, silty clay subsoil overlying strongly mottled grey clayey substratum.

Typical profile : Pauli, medium highland.

Location : Stop No. G-13, Dhalma, Uz - Godagari.

Topography : Very gently slopping valley.

Land use : T. aman - fallow.

Drainage : Poor. Shallowly flooded for about a month and remains unsaturated for about 6-7 months.

Tax. sub-group : Aeric Haplaquepts.

Profile Description

<u>Horizon</u>	<u>Depth cm</u>	<u>Characteristics</u>
Ap1g	0-11	Grey (5Y 5/1) moist with common fine distinct strong brown mottles; silty clay; massive; hard dry; many fine tubular pores; many fine roots; pH 6.5; abrupt smooth boundary.
Ap2g	11-16	Grey (5Y 5/1) moist with common fine distinct strong brown mottles; silty clay; massive; hard dry; common fine tubular pores; many fine roots; pH 6.5; abrupt smooth boundary.
Bw1g	16-30	Yellowish brown (10YR 5/6) and grey (5Y 5/1) moist with few fine strong brown and dark brown mottles; silty clay; moderate coarse and medium angular blocky; firm moist; common fine tubular pores; few iron-manganese concretion few fine roots; pH 7.0; clear smooth boundary.
Bw2g	30-45	Yellowish brown (10YR 5/6) moist with many fine distinct grey mottles; silty clay; moderate common and medium angular blocky; firm moist; common fine tubular pores; few iron-manganese concretion; pH 7.0; abrupt smooth boundary.
C1g	45-60	Grey (5Y 5/1) moist with many fine distinct strong brown and yellowish brown mottles; clay; moderate coarse and medium angular blocky; firm moist; few iron-manganese concretion; pH 7.0; clear smooth boundary.
C2g	60-100	Grey (5Y 5/1) moist with many prominent yellowish red mottles; clay; massive; pH 7.0.

Environmental Characteristics

Pauli soils are developed in local colluvium or alluvium from the madhupur clay. They occur in nearly level to gently slopping valleys. Most of these soils are intermittently flooded by rain water ponded within the fields.

Two phases have been recognized: Pauli intermittently flooded phase and Pauli shallowly flooded phase.

vii) Noadda Series

Noadda series including imperfectly drained light yellowish brown, loam/clay loam, with yellowish red or strong brown mottles and moderate sub-angular blocky structure in the B-horizon. Usually they occur on the higher part of Barind tract and in the project area only in Tanore Area it has been recognized as minor soils.

Typical profile : Noadda, highland.

Location : Stop No. T-4, Deotali, Uz - Tanore.

Topography : Level, in general undulating.

Land use : T. aman - fallow.

Drainage : Imperfect. Remains moist/wet in rainy season and unsaturated in dry season.

Tax. sub-group : Aeric Haplaquepts/Acquic Dystochrepts.

Profile Description

<u>Horizon</u>	<u>Depth cm</u>	<u>Characteristics</u>
Ap1g	0-8	Grey (2.5Y 5/1) moist with few fine strong brown mottles; loam; massive; hard dry; many tubular pores; many fine roots; pH 6.0; abrupt smooth boundary.
Ap2g	8-12	Grey (2.5Y 5/1) moist with many fine dark yellowish brown mottles; loam; massive; dary dry; many tubular pores; very fine roots; pH 6.5; abrupt smooth boundary.

Bw1g	12-26	Light yellowish brown (2.5Y 6/4) moist with common fine distinct grey and strong brown mottles; clay loam; moderate coarse and medium subangular blocky; friable moist; many fine tubular pores; few iron manganese concretion; pH 7.0; clear smooth boundary.
Bw2g	26-36	Light yellowish brown (2.5Y 6/4) moist with many strong brown and few grey mottles; clay loam; moderate coarse and medium sub-angular blocky; friable moist; many fine tubular pores; few iron-manganese concretion; pH 7.0; abrupt smooth boundary.
C1g	36-50	Grey (5Y 5/1) moist with many strong brown and dark yellowish brown mottles; clay; moderate coarse angular blocky; firm moist; many fine tubular pores; pH 7.0; abrupt smooth boundary.
C2g	50-85	Light brownish grey (2.5Y 6/2) moist with common fine distinct grey and dark yellowish brown mottles; clay; massive; pH 7.0.
C3g	85-100	Yellowish brown (10YR 5/6) moist with yellowish red and dark brown mottles; clay; massive; pH 7.0.

b) Ganges Floodplain

i) Sara Series

Sara series comprises intermittently flooded, imperfectly drained, pale brown, friable, calcareous silt loams with weak to moderate structural development in the B-horizon. Usually they occur on the highest part of the Ganges floodplain ridges and become droughty in the late rabi season.

Typical profile : Sara, level highland.

Location : Stop No. P-19, Vill. Rahi, Uz - Paba (North of Rajshahi - Dankura Road).

Topography : Level ridge.
 Drainage : Imperfect. Intermittent wetness in monsoon season.
 Remain unsaturated for about 6-7 months in the dry season.
 Tax. sub-group : Aquic Eutrochrepts.

Profile Description

<u>Horizon</u>	<u>Depth cm</u>	<u>Characteristics</u>
Ap	0-16	Olive-brown (2.5Y 4/4) moist; silt loam; massive breaking into coarse and medium clods; friable moist; many fine roots; calcareous; pH 7.5; abrupt smooth boundary.
Bw1g	16-30	Olive-brown (2.5Y 4/4) moist with few fine distinct grey mottles; silt loam; moderate coarse and medium angular blocky; friable moist; many fine tubular pores; common fine roots; calcareous; pH 7.5; clear smooth boundary.
Bw2g	30-42	Olive-brown (2.5Y 4/4) moist with few fine distinct grey mottles; silt loam; weak few fine tubular pores; calcareous; pH 7.5; clear smooth boundary.
C1g	42-55	Light olive-brown (2.5Y 5/4) moist with few fine grey mottles; slightly sticky, slightly plastic wet; calcareous; pH 8.0; abrupt smooth boundary.
C2g	55-75	Light olive-brown (2.5Y 5/4) moist; few fine grey mottles; very fine sandy loam; massive; calcareous; pH 8.0.
C3g	75-100	Light olive-brown (2.5Y 5/4) moist with few fine distinct dark yellowish brown mottles; silt loam; massive; calcareous; pH 8.0.

Environmental Characteristics

Sara soils are developed in young Ganges level deposits, now occupying the upper slopes of very gently undulating ridges. They are intermittently flooded by rain water in the monsoon season.

Four phases, one variant and one land-type have been recognized: Sara smooth relief phase; Sara, shallow, smooth relief phase; Sara irregular relief phase; Sara very young meander floodplain phase, Sara moderately well drained variant; and Sara madeland.

ii) Gopalpur Series

Gopalpur series comprises intermittently flooded, imperfectly drained, olive-brown, calcareous, silty clay loams with moderate angular blocky structure in the subsoil.

Typical profile : Gopalpur, highland.

Location : Stop No. P-2, Vill. Aligonj, Uz - Paba.

Topography : Nearly level Ganges floodplain ridge.

Land use : T. aman - rabi crop.

Drainage : Imperfect. Intermittent wetness in the monsoon season. Remains unsaturated for about 6-7 months in the dry season.

Tax. sub-group : Aquic Eutrochrepts.

Profile Description

<u>Horizon</u>	<u>Depth cm</u>	<u>Characteristics</u>
Ap1g	0-12	Olive-brown (2.5Y 4/4) moist with few fine strong brown mottles; silt loam; massive; firm moist; many fine tubular pores; slightly calcareous; pH 7.0; abrupt smooth boundary.
Bw1g	12-32	Olive-brown (2.5Y 4/4) moist with few fine distinct grey mottles; silty clay loam; moderate coarse to medium angular blocky; firm moist; many fine

tubular pores; calcareous; pH 8.0; abrupt smooth boundary.

Bw2g	32-50	Light olive-brown (2.5Y 5/4) moist with few fine distinct dark yellowish brown and grey mottles; silt loam; weak coarse to medium angular blocky; friable moist; common tubular pores; abrupt smooth boundary; pH 8.0; calcareous.
C1	50-60	Light olive-brown (2.5Y 5/4) moist with common fine distinct grey mottles; very fine sandy loam; massive; very friable moist; calcareous; pH 8.0; abrupt smooth boundary.
C2	60-100	Light olive-brown (2.5Y 5/4) moist with few line grey and dark yellowish brown mottles; silt loam; massive; friable moist; calcareous; pH 8.0.

Environmental Characteristics

Gopalpur soils are developed in young Ganges levee deposits, now occupying the upper slopes of very gently undulating ridges. They are either above normal floodlevel or flooded up to 0.3-0.6 meter deep for 1-3 month in the monsoon season, the highland soils are often intermittently flooded by rain water ponded within the fields, except the moderately well drained variant and Gopalpur made land soils.

Six phases, one variant and one land type have been recognized: Gopalpur highland, smooth relief phase; Gopalpur highland, irregular relief phase; Gopalpur highland, very young meander floodplain phase; Gopalpur medium highland, smooth relief phase; Gopalpur medium highland, irregular relief phase; Gopalpur medium highland, very young meander floodplain phase; Gopalpur moderately well drained variant; and Gopalpur made land.

iii) Ishurdi Series

Ishurdi series comprises seasonally flooded, poorly drained, olive-brown to dary greyish brown, finely mottled, calcareous silty clay. They

have moderate to strong angular blocky structure, with grey cutans on vertical ped faces in the subsoil.

Typical profile : Ishurdi, medium highland.

Location : Stop No. P-21, Vill. Damkura, Uz - Paba.

Topography : Level, lower part of the Ganges floodplain ridges.

Land use : Aus-T. aman - fallow.

Drainage : Poor. Flooded less than 1 meter deep for 2-3 months in the monsoon season. Remains unsaturated for about 5-6 months in the dry season.

Tax. sub-group : Aeric Haplaquepts.

Profile Description

<u>Horizon</u>	<u>Depth cm</u>	<u>Characteristics</u>
Ap ₁ g	0-12	Grey (5Y 5/1) moist with few fine distinct strong brown mottles; silty clay loams; massive; hard dry; many tubular pores; non-calcareous; pH 7.0; abrupt smooth boundary.
Ap ₂ g	12-18	Dark greyish brown (2.5Y 4/2) moist with few fine distinct yellowish brown mottles; silty clay; massive; hard dry; few fine tubular pores; non-calcareous; pH 7.0; abrupt smooth boundary.
Bw ₁ g	18-35	Olive-brown (2.5Y 4/4) moist with few fine distinct yellowish brown and grey mottles; silty clay; moderate in strong coarse and medium angular blocky; firm moist; patchy thin grey cutans along vertical ped faces; calcareous; pH 8.0; abrupt smooth boundary.
Bw ₂ g	35-49	Olive-brown (2.5Y 4/4) moist with few fine distinct grey mottles; silty clay loam; moderate coarse to medium angular blocky; firm moist; patchy thin grey cutans along ped faces; few fine tubular pores; calcareous; pH 8.0; abrupt smooth boundary.

C 49-100 Light olive-brown (2.5Y 5/4) moist with few fine distinct dark yellowish brown mottles; silt loam; massive; moist fine; calcareous; pH 8.0.

Environmental Characteristics

Ishurdi soils are developed in young and old Ganges levee deposits, now occupying nearly level to very gently undulating ridges. They are intermittently flooded by rain-water up to about 0.2 meter deep or flooded up to 0.3-1 meter deep for 2-4 months during the monsoon season. Five phases have been recognized: Ishurdi highland, smooth-relief phase, Ishurdi highland, irregular relief phase; Ishurdi medium highland, smooth relief phase; Ishurdi medium highland, irregular relief phase, and Ishurdi sedium highland, very young meander floodplain phase.

iv) Mehendigonj Series

Mehendigonj series includes seasonally flooded, poorly drained, olive to olive brown, calcareous silty clays to clays with moderate to strong prismatic and angular blocky structure with grey cutans in the subsoils.

Typical profile : Mehendigonj, medium highland.

Location : Stop No. P-4, Vill. Haripur, Uz - Paba.

Topography : Nearly level Ganges floodplain basin.

Land use : Sugarcane.

Drainage : Poor. Flooded less than 1 meter deep for 2-3 months in the monsoon season. Remains unsaturated for about 4-5 months in the dry season.

Tax. sub-group : Typic Haplaquepts.

Profile Description

<u>Horizon</u>	<u>Depth cm</u>	<u>Characteristics</u>
Ap1g	0-15	Grey (5Y 5/1) moist with few fine distinct yellowish brown mottles; silty clay loam; massive; firm many fine tubular pores; calcareous; pH 7.0; abrupt smooth boundary.

Bw1g	15-30	Olive-brown (2.5Y 4/4) moist with few fine distinct yellowish brown and grey mottles; silty clay; moderate coarse to medium angular blocky; firm moist continuous moderate thick grey cutans along vertical ped faces; many fine tubular pores; calcareous; pH 8.0; abrupt smooth boundary.
Bw2g	30-40	Olive-brown (2.5Y 4/4) moist with few fine distinct yellowish brown and dark yellowish brown mottles; silty clay loam; moderate coarse and medium angular blocky; friable moist; broken moderately thick grey cutans along the vertical and horizontal ped faces; common tubular pores; calcareous; pH 8.0; abrupt smooth boundary.
C1	40-60	Light olive-brown (2.5Y 5/4) moist with few fine distinct yellowish brown and grey mottles; silty clay loam; massive; calcareous; pH 8.0.
C2	60-100	Light olive-brown (2.5Y 5/4) moist with few fine dark yellowish brown and grey mottles; silt loam; massive; calcareous; pH 8.0.

Environmental Characteristics

Mehendigonj soils are developed in old Ganges alluvium and occupy nearly level basins mainly on the mixed young and older Ganges meander floodplain. These soils are seasonally flooded up to 1-2 meter deep for 4-6 months and dry out slowly in the dry season. Sometimes, they remain under shallow water for 1-2 months in the dry season. One variant has been recognized: Mehendigonj non-calcareous subsoil variant.

v) Ghior Series

Ghior series comprises seasonally flooded, poorly drained soils developed in Ganges alluvial heavy clay. The upper part of the subsoil comprises dark grey, non-calcareous clay with coarse breaking to fine angular blocky structure with prominent ped faces. The lower part of the

subsoil comprises brown to olive brown, calcareous silty clay to clays with dark grey cutans on vertical ped faces.

Typical profile : Ghior clay, medium highland.

Location : Stop No. P-24, Baya, Uz - Paba.

Topography : Nearly level ganges floodplain basin.

Land use : Broadcast aman - fallow.

Drainage : Poor. Flooded upto 1 meter deep for about 4-5 months in monsoon season. Remains unsaturated for about 3-4 months in the dry season.

Tax. sub-group : Typic Haplaquepts.

Profile Description

<u>Horizon</u>	<u>Depth cm</u>	<u>Characteristics</u>
Apg	0-16	Grey (5Y 5/1) moist with few fine distinct strong brown mottles; clay; massive breaking into coarse and medium clod; hard dry; common fine tubular pores; non-calcareous; pH 7.0; abrupt smooth boundary.
Bw1g	16-30	Dark greyish brown (2.5Y 4/2) moist with few fine distinct yellowish brown mottles; clay; strong medium and fine angular blocky (lenticular); continuous moderately dark grey cutan along vertical and horizontal ped faces and with pressure faces; firm moist; common very fine tubular pores; non-calcareous; pH 7.0; abrupt smooth boundary.
Bw2g	30-40	Dark greyish brown (2.5Y 4/2) moist with fine distinct yellowish brown and dark yellowish brown mottles; clay; strong medium breaking to fine angular blocky (lenticular); continuous moderately thick dark grey cutans along vertical and horizontal ped faces with dominant pressure faces; firm moist; few fine tubular pores; calcareous; pH 8.0; clear smooth boundary.

- C1 40-45 Olive-brown (2.5Y 4/4) moist with few fine distinct yellowish brown mottles; silty clay; moderate medium coarse and medium angular blocky; firm moist; patchy moderately thick dark grey cutans along vertical ped faces; common very fine tubular pores; calcareous; pH 8.0; abrupt smooth boundary.
- C2 45-100 Light olive brown (2.5Y 5/4) moist with few fine distinct dark yellowish brown mottles; silty clay; massive; calcareous; pH 8.0.

Environmental Characteristics

These soils are developed in old Gangetic alluvium and occupy basin margins and centres mainly on the older Ganges meander floodplain. They are flooded up to 1-2.7 meters deep for 3-5 months in the monsoon season. The basin-center soils remain saturated, sometimes under shallow water, for 1-2 months in the dry season.

Three depth-of-flooding phases and one variant have been recognized: Ghior medium highland phases; Ghior medium lowland phase; Ghior lowland phase; and Ghior medium highland, calcareous subsoil variant.

vi) Garuri Series

Garuri series comprises seasonally flooded poorly drained clays. The upper part of the subsoil comprises dark grey or dark greyish brown, non-calcareous clay with strong angular blocky structure with prominent dark grey cutans. The lower part of the subsoil comprises light olive brown, calcareous silty clay loam to clays with grey cutans along vertical ped faces.

Typical profile : Garuri, medium highland.

Location : Stop No. 4-41, Baraipar, Uz - Paba.

Topography : Nearly level, Ganges floodplain basin.

Land use : Transplanted aman - Khesari.

Drainage : Poor. Flooded upto 1 meter. Deep for 3-4 months in the monsoon season. Remains saturated for about 5-6 months in the dry season.

Tax. sub-group : Typic Haplaquepts.

Profile Description

<u>Horizon</u>	<u>Depth cm</u>	<u>Characteristics</u>
Apg	0-12	Dark grey (5Y 4/1) moist with few fine faint yellowish brown mottles; clay; massive, breaking into coarse clod; hard dry; many tubular pores; non-calcareous; pH 7.0; abrupt smooth boundary.
Bw1g	12-25	Dark grey (5Y 4/1) moist with few fine distinct yellowish brown mottles; clay; strong medium to coarse angular blocky; firm moist; moderately thick dark grey cutans along vertical ped faces; many tabular pores; non-calcareous; pH 7.0; abrupt smooth boundary.
Bw2g	25-35	Dark grey (5Y 4/1) moist with common fine distinct yellowish brown mottles; silty clay; moderate coarse medium angular blocky; firm moist; moderately thick dark grey cutans along vertical ped faces; common tabular pores; calcareous; pH 8.0; abrupt smooth boundary.
C1g	35-60	Light olive-brown (2.5Y 5/4) moist with few line distinct dark yellowish brown and grey mottles; silty clay loam; massive; friable moist; calcareous; pH 8.0; abrupt smooth boundary.
C2g	60-100	Light olive-brown (2.5Y 5/4) moist with few line distinct dark yellowish brown mottles; silt loam; massive; calcareous; pH 8.0.

Environmental Characteristics

These soils are developed in older Gangetic alluvium and occupy relatively low floodplain ridges and basin margins mainly on the older Ganges meander floodplain. These soils are flooded up to 0.7-1.7 meter deep for 2-5 months in the monsoon season.

Two phases and one variant have been recognized: Garuri medium highland phase; Garuri medium lowland phase; and Garuri medium highland, calcareous subsoil variant.

vii) Santhia Series

Santhia Series includes seasonally flooded, poorly drained soils developed in heavy clay. The upper part of the subsoil comprises dark grey non-calcareous clay with strong coarse angular blocky structure with prominent ped cutans. The lower part of the subsoil comprises olive-grey to olive-brown calcareous silty clay to clays with dark grey cutans along vertical ped faces.

Typical profile : Santhia, medium lowland.

Location : Stop No. P-13, Vill. Hujuripara, Uz - Paba.

Topography : Nearly level Ganges floodplain basin.

Land use : Broadcast aman - fallow.

Drainage : Poor. Flooded upto 2 meter deep for 4-5 months in the monsoon season. Remains unsaturated for about 4-5 months in the dry season.

Tax. sub-group : Typic Haplaquepts.

Profile Description

<u>Horizon</u>	<u>Depth cm</u>	<u>Characteristics</u>
Apg	0-15	Dark grey (5Y 4/1) moist with few fine distinct strong brown mottles; clay; massive; breaking into medium clods; very hard dry; common fine tabular pores; non-calcareous; pH 7.0; abrupt smooth boundary.

Bw1g	15-35	Dark grey (5Y 4/1) moist with many fine distinct yellowish brown mottles; clay; strong coarse and medium angular blocky with continuous thick dark grey cutans along vertical and horizontal ped faces; firm moist; common fine tubular pores; non-calcareous; pH 7.0.
Bw2g	35-75	Light olive-brown (2.5Y 5/4) moist with few fine distinct grey mottles; clay; moderate coarse and medium angular blocky with broken thick dark grey cutans along angular blocky with brown thick dark grey cutans along vertical and horizontal ped faces; firm moist; common tubular pores; non-calcareous; pH 7.0; abrupt smooth boundary.
C	75-100	Light olive grey (5T 6/2) moist with few fine distinct yellowish brown mottles; silty clay massive; firm moist; fine tubular pores; calcareous; pH 3.0; abrupt smooth boundary.

Environmental Characteristics

Santhia soils are mainly developed in old Gangetic alluvium and occupy basin margins and centers on the oldest Ganges meander floodplain and mixed Ganges and Mahananda meander floodplains. These soils are flooded up to 0.7-3.3 meters deep for 2-5 months in the monsoon season. The basin center soils remain saturated, sometimes under shallow water, for about 2 months in the dry season. They become very hard and develop cracks when dry.

Eight phases and four variants have been recognized: Santhia medium highland phase; Santhia medium lowland phase; Santhia medium lowland, flood hazard phase; Santhia medium lowland, slow draining phase; Santhia medium lowland, irrigated phase; Santhia lowland phase; Santhia lowland, flood hazard phase; Santhia lowland, irrigated phase; Santhia medium highland, calcareous subsoil variant; Santhia medium lowland, calcareous subsoil variant; Santhia lowland, calcareous subsoil variant; Santhia lowland, calcic substratum variant.

viii) Tahirpur Series

Tahirpur series includes intermittently flooded; imperfectly drained, dark yellowish brown/olive brown. They have a moderate angular blocky structure in the subsoil. These soils are usually non-calcareous.

Typical profile : Tahirpur, highland.

Location : Stop No. P-15, Vill: Huguripara, Uz - Paba.

Topography : Old Gangetic floodplain ridge.

Land use : Aus-rabi crops (Potato, Wheat).

Drainage : Imperfect. Intermittently flooded by rain water up to less than 15-30 cm deep in the monsoon season. Remains unsaturated for about 7 months in the dry season.

Tax. sub-group : Aquic Euthrochrepts.

Profile Description

<u>Horizon</u>	<u>Depth cm</u>	<u>Characteristics</u>
Ap1g	0-16	Olive brown (2.5Y 4/4) with few fine distinct grey mottles; silty loam; massive; friable moist; many tubular pores; non-calcareous; pH 7.0; abrupt smooth boundary.
Bw1g	16-38	Dark yellowish brown (10YR 4/4) moist with few fine distinct grey mottles; loam; moderate coarse to medium angular blocky; many fine tubular pores; non-calcareous; pH 7.0; abrupt smooth boundary.
Bw2g	38-60	Light olive brown (2.5Y 5/4) moist with few fine distinct grey mottles; silt loam; weak coarse and medium angular blocky; friable moist; many tubular pores; non-calcareous; clear smooth boundary; pH 7.0.
C1	60-100	Light olive brown (2.5Y 5/4) moist with few fine distinct strong brown and grey mottles; very fine

sandy loam; massive; very friable moist; non-calcareous; pH 7.0; abrupt smooth boundary.

Environmental Characteristics

Tahirpur soils are developed in old Gangetic alluvium and occupy summits and slopes of nearly level to very gently undulating ridges on the oldest Ganges meander floodplain. These soils are intermittently flooded by rain-water up to less than 0.3 meter deep during the monsoon season, except small patches which are seasonally flooded up to 0.3-0.6 meter deep for 2-3 months.

Two depths-of-flooding phases have been recognized: Tahirpur highland and Tahirpur medium highland.

ix) Teghar Series

Teghar series comprise seasonally flooded, poorly drained, mixed olive-brown and yellowish brown non-calcareous; silty clay loam; with moderate angular blocky structure in the subsoil. They usually grade into a calcareous c-horizon.

Typical profile : Teghar, medium highland.

Location : Stop No. P-8, Kulpara, Uz - Paba.

Topography : Nearly level Ganges floodplain low ridge.

Land use : Aus-transplanted aman-fallow.

Drainage : Poor. Flooded upto 1 metre deep for 2-3 month. Remains unsaturated for about 6 months in the dry season.

Tax. sub-group : Aeric Haplaquepts.

Profile Description

<u>Horizon</u>	<u>Depth cm</u>	<u>Characteristics</u>
Ap _{1g}	0-12	Grey (5Y 6/1) moist with few fine distinct strong brown mottles; silt loam; massive; hard dry; many fine tubular pores; non-calcareous; pH 7.0; abrupt smooth boundary.

Ap2g	12-17	Grey (5Y 6/1) moist to light grey (5Y 7/1) dry with few fine distinct strong brown mottles; silty clay loam; massive; hard dry; common fine tubular pores; non-calcareous; pH 7.0; abrupt smooth boundary.
Bw1g	17-36	Olive-brown (2.5Y 4/4) and yellowish-brown (10YR 5/6) moist with few fine distinct grey mottles; silty clay loam; moderate coarse to medium angular blocky structure with moderate thick dark grey cutans along vertical ped faces; firm moist; many tubular pores; non-calcareous; pH 7.0; abrupt smooth boundary.
Bw2g	36-55	Olive-brown (2.5Y 4/4) and yellowish-brown (10YR 5/6) moist with common fine distinct grey mottles; silty clay loam; moderate coarse and medium angular blocky with brown thick dark grey cutans along vertical ped faces; friable moist; many tubular pores; non-calcareous; pH 7.0; abrupt smooth boundary.
C1	55-75	Olive-brown (2.5Y 4/4) moist with few fine yellowish brown mottles;; silty clay loam; massive friable moist; many tubular pores; irregular calcium carbonate nodules; pH 8.0.

Environmental Characteristics

Teghar soils are developed in old Gangetic alluvium and occupy nearly level to very gently undulating rides on the oldest Ganges meander floodplain. They are intermittently flooded by rain-water up to less than 0.3 meter deep or seasonally flooded up to 0.3-0.6 meter deep for 2-3 months.

Three phases, two variants and one land type have been recognized: Teghar highland phase; Teghar medium highland phase; Teghar medium lowland phase; Teghar highland, non-calcic substratum variant; Teghar medium highland, non-calcic substratum variant, and Teghar made-land.

x) Maria Series

Maria series includes seasonally flooded, poorly drained, dark grey to dark greyish brown, mottled yellowish brown, non-calcareous clay with angular blocky structure with dark grey cutans along vertical ped faces in the subsoil.

Typical profile : Maria, medium highland.

Location : Stop No. P-38, Teghar, Uz - Paba.

Topography : Nearly level, lower part of Gangetic floodplain ridge.

Land use : Transplanted aman - rabi crops.

Drainage : Poor. Flooded less than 1 meter deep for 2-3 months in the monsoon season. Remains unsaturated for about 6 months in the dry season.

Tax. sub-group : Typic Haplaquepts.

Profile Description

<u>Horizon</u>	<u>Depth cm</u>	<u>Characteristics</u>
Ap _{1g}	0-12	Grey (5Y 6/1) moist with few fine distinct strong brown mottles; clay; massive; hard dry; many tubular pores; non-calcareous; pH 7.0; abrupt smooth boundary.
Ap _{2g}	12-16	Dark grey (5Y 4/1) moist with few fine distinct strong brown mottles; clay; massive; hard dry; common fine tubular pores; non-calcareous; pH 7.0; abrupt smooth boundary.
Bw _{1g}	16-35	Dark greyish brown (2.5Y 4/2) moist with common fine distinct yellowish brown mottles; clay; strong coarse to medium angular blocky structure with patchy thin dark grey cutans along vertical ped faces; firm moist; tubular pores; non-calcareous; pH 7.0; abrupt smooth boundary.

Bw2g	35-50	Light olive-brown (2.5Y 5/4) moist with few fine distinct dark yellowish brown and grey mottles; silty clay loam; moderate coarse to medium angular blocky structure with patchy thin dark grey cutans along vertical ped faces; firm moist; common tubular pores; non-calcareous; pH 7.0; abrupt smooth boundary.
C1	50-80	Light olive-brown (2.5Y 5/4) moist with few fine distinct yellowish brown mottles; silty clay loam; massive; friable moist; non-calcareous; pH 7.0; abrupt smooth boundary.
C2	80-100	Olive (5Y 4/3) moist with few fine distinct yellowish brown mottles; silty clay loam; massive friable moist; calcareous pH 8.0

xi) Gulai Series

Gulai series comprises seasonally flooded, poorly drained, dark greyish brown, mottled yellowish brown, non-calcareous clays with strong angular blocky structure in the subsoil. They often overlie weathered Madhupur clay below about 75cm.

Typical profile : Gulai, medium highland.

Location : Stop No. P-27, Vill. Gulai bil, Uz - Godagari.

Topography : Nearly level Gangetic floodplain basin.

Land use : T. aman - fallow.

Drainage : Poor. Flooded up to 1 meter deep for about 2-3 month in monsoon season. Remains unsaturated for about 5-6 months in the dry season.

Tax. sub-group : Typic Haplaquepts.

Profile Description

<u>Horizon</u>	<u>Depth cm</u>	<u>Characteristics</u>
Ap ₁ g	0-15	Grey (5Y 5/1) moist with few fine distinct strong brown mottles; clay; massive; hard dry; many tubular pores; non-calcareous; pH 7.0; abrupt smooth boundary.
Ap ₂ g	15-22	Dark greyish brown (2.5Y 4/2) moist with few fine distinct yellowish brown mottles; clay; massive; hard dry; common tubular pores; non-calcareous; pH 7.0; abrupt smooth boundary.
Bw ₁ g	22-37	Dark greyish brown (2.5Y 4/2) moist with few fine distinct yellowish brown mottles; clay; strong coarse and medium angular blocky structure with continuous moderately thick dark grey cutans along vertical and horizontal ped faces; firm moist; few fine tubular pores; non-calcareous; pH 7.0; abrupt smooth boundary.
Bw ₂ g	37-52	Olive-brown (2.5Y 4/4) moist with few fine distinct yellowish brown mottles; clay; moderate coarse and medium angular blocky structure with continuous moderately thick dark grey cutans along vertical and horizontal ped faces; few fine tubular pores; non-calcareous; pH 7.0; clear smooth boundary.
C	52-70	Light olive-brown (2.5Y 5/4) moist with few fine yellowish brown mottles; clay; massive; firm moist; sticky; plastic wet; non-calcareous; pH 7.0.

c) Tista Floodplain

i) Dohali Series

Dohali series includes intermittently flooded, imperfectly drained, olive grey to grey, mottled dark yellowish brown, silt loam with weak angular blocky structure in the subsoil.

Typical profile : Dohali, highland.

Location : Stop No. N-2, Chack sita, Uz - Niamatpur.

Topography : Nearly level Tista floodplain ridge.

Land use : Aus-rabi crops/vegetables.

Drainage : Imperfect. Intermittently flooded by rain water up to 15 cm deep in the monsoon season. Remains unsaturated for about 7 months in the dry season.

Tax. sub-group : Aeric Haplaquepts.

Profile Description

<u>Horizon</u>	<u>Depth cm</u>	<u>Characteristics</u>
Ap1g	0-16	Grey (5Y 5/1) moist with common fine distinct dark yellowish brown mottles; silt loam; massive; friable moist; many tubular pores; pH 6.5; abrupt smooth boundary.
Bw1g	16-25	Grey (5Y 5/1) moist with many fine distinct dark yellowish brown mottles; very fine sandy loam; friable moist; weak coarse to medium angular blocky structure; many tubular pores; pH 7.0; abrupt smooth boundary.
Bw2g	25-55	Grey (5Y 5/1) moist with common fine distinct dark yellowish brown mottles; silt loam; weak coarse and medium angular blocky structure; friable moist; many fine tubular pores; pH 7.0; abrupt smooth boundary.

C₁ 55-100 Grey (5Y 5/1) moist with common fine distinct yellowish brown mottles; very fine sandy loam; massive; friable moist; common fine tubular pores; pH 7.0; abrupt smooth boundary.

Environmental Characteristics

These soils are developed in young Little Jamuna as well as in young Atrai alluvium levee deposits, now occupying summits and slopes of very gently undulating ridges mainly on the Little Jamuna and Atrai meander floodplains. They are intermittently flooded by rain-water up to 0.2 meter deep or flooded up to 0.3-1.3 meters deep for 1-4 months in the monsoon season. Dohali made-land soils are not flooded and excess of rain-water drains rather quickly.

These phases, one variant and one land type have been recognized: Dohali highland phase; Dohali medium highland phase; Dohali medium lowland phase; Dohali highland, yellowish brown subsoil variant; and Dohali made-land.

ii) Digli Series

Digli series comprises seasonally flooded, poorly drained, dark grey, mottled yellowish brown, clays with angular blocky structure in the subsoil. They often overlie weathered Madhupur clay below about 1 meter.

Typical profile : Digli, lowland.

Location : Stop No. T-26, Hatisal, Tanore.

Topography : Nearly level broad basin.

Land use : Irrigated boro - fallow.

Drainage : Poor. Flooded 2-3 meter deep for 3-4 months in the monsoon season. Remains unsaturated for about 5 months in the dry season.

Tax. sub-group : Typic Haplaquepts.

Profile Description

<u>Horizon</u>	<u>Depth cm</u>	<u>Characteristics</u>
A1g	0-15	Dark grey (5Y 4/1) moist with common fine distinct strong brown mottles; clay; massive; very hard dry; common fine tubular pores; pH 6.5; abrupt smooth boundary.
Bw1g	15-45	Dark grey (5Y 4/1) moist with many fine distinct yellowish brown mottles; clay; strong coarse and medium angular blocky structure; very firm moist; continuous thick dark grey cutans along vertical and horizontal ped faces; fine tubular pores; pH 6.0; abrupt smooth boundary.
Bw2g	45-65	Dark grey (5Y 4/1) moist with few prominent yellowish brown mottles; clay; strong coarse and medium angular blocky; firm moist; continuous moderately thick dark grey cutans along vertical ped faces; common fine tubular pores; pH 6.0 clear smooth boundary.
	65-80	Grey (5Y 5/1) and yellowish brown (10YR 5/6) moist; clay; weak coarse angular blocky firm moist; few fine tubular pores; pH 6.0.

Environmental Characteristics

Digli soils are developed in old Little Jamuna alluvium and occupy nearly level basins on the Little Jamuna meander floodplain. They are seasonally flooded up to 1.3-2.7 meters deep, locally up to about 3 meters, for 4-6 months and dry out slowly in the dry season.

One phase has been recognized: Digli irrigated phase.

iii) Jaonia Series

Jaonia series comprises seasonally flooded, poorly drained, dark grey, mottled dark yellowish brown, acidic, heavy clays in the subsoil.

Typical profile : Jaonia, lowland.

Location : Stop No. N-1, Chacksita, Uz - Niamatpur.

Topography : Nearly level Tista floodplain basin.

Land use : Irrigated boro - fallow.

Drainage : Poor. Flooded 2-3 meter deep for about 5-6 months in the monsoon season. Remains unsaturated for 3-4 months in the dry season.

Tax. sub-group : Typic Haplaquepts.

Profile Description

<u>Horizon</u>	<u>Depth cm</u>	<u>Characteristics</u>
Ap1g	0-10	Grey (5Y 5/1) moist with few fine distinct yellowish brown mottles; silty clay; massive; hard dry; firm moist; common tubular pores; pH 6.0; abrupt smooth boundary.
Ap2g	10-16	Grey (5Y 5/1) moist with few fine distinct dark yellowish brown mottles; clay; massive; few fine tubular pores; pH 6.0; abrupt smooth boundary.
Bw1g	16-35	Dark grey (5Y 4/1) moist with common fine dark yellowish brown mottles; clay; strong coarse and medium angular blocky; firm moist; common tubular pores; pH 6.0; abrupt smooth boundary.
Bw2g	36-50	Dark grey (5Y 4/1) moist with common fine dark yellowish brown mottles; heavy clay; strong coarse and medium angular blocky; firm moist; common tubular pores; pH 7.0; clear smooth boundary.

50-100 Greyish grey (5Y BG 5/1) with common fine distinct dark yellowish brown mottles; clay; strong coarse and medium angular blocky; firm moist; tubular pores; pH 7.0.

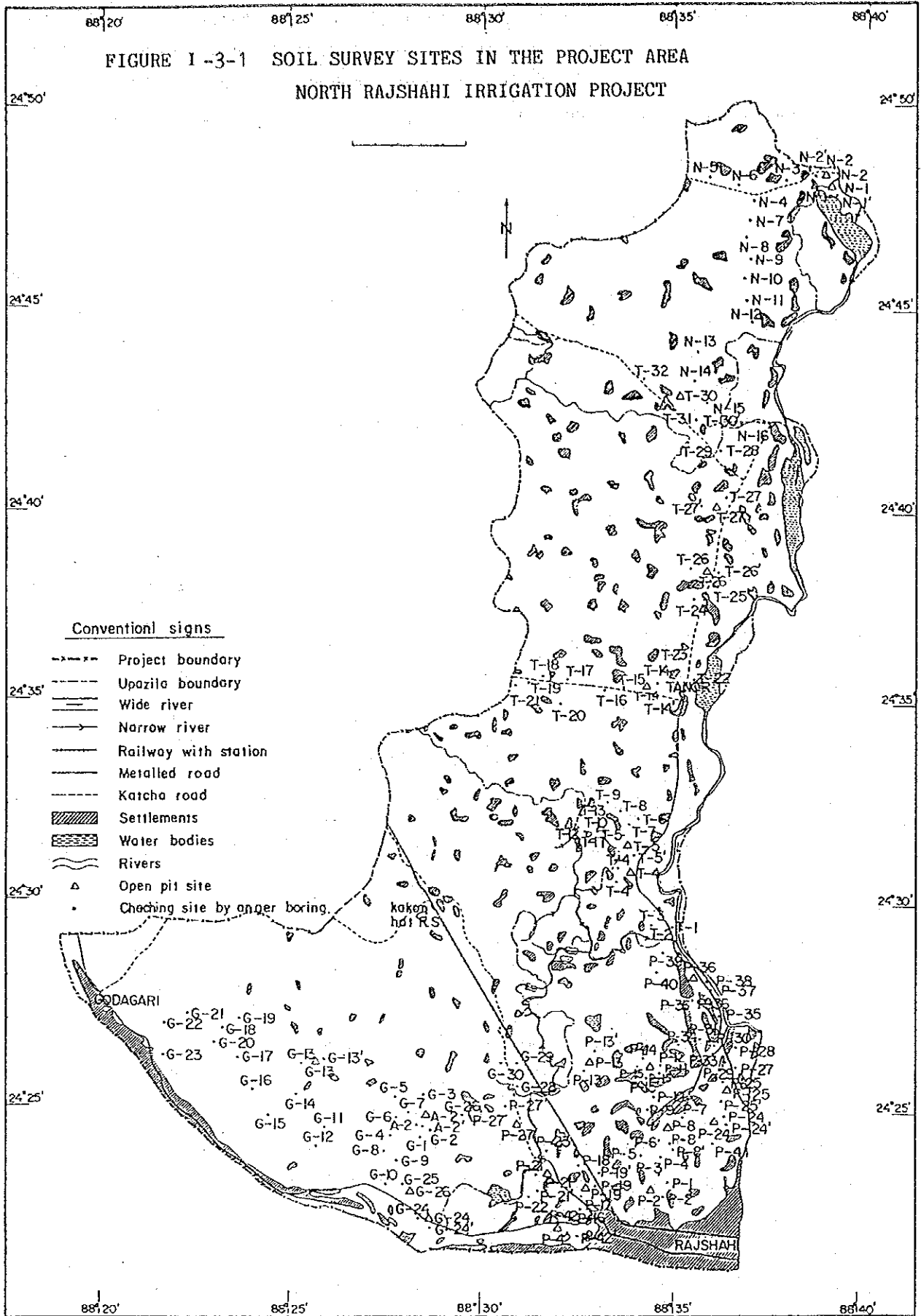


TABLE I -3-2 CHARACTERISTICS OF SOIL SERIES(1/4)

Physiography	Soil Series	Land Type	Layers/ Horizons	Colour	Texture	Structure	Consistence	pH	Drain
Barind Tract	Noadda	Highland Undurating	Topsoil	G	Loam	Massive	Hard Dry	6.0	Imperfect
			Subsoil	Lyb	Clay Loam	Mod. Coarse and Subangular Blocky	Friable Moist	7.0	
			Subst	G	Clay	Mod. Coarse Angular bk.	Firm Moist	7.0	
	Atahar	Highland Undurating	Topsoil	G	Silty Clay	Massive	Hard Dry	7.0	Imperfect
			Subsoil	Lyb	Silty Clay	Strong Coarse and Med. Angular bk.	Firm Moist	7.0	
			Subst.	Lg	Clay	Massive	Firm Moist	7.0	
	Ammura	Highland Level	Topsoil	G	Silty Clay Loam	Massive	Hard Dry	7.0	Imperfect
			Subsoil	Ybtg	Silty Clay Loam	Mod. Coarse and Med. Subangular bk.	Firm Moist	7.0	
			Subst	G	Clay	Massive	Firm Moist	7.0	
	Mijhuri	Highland Level	Topsoil	G	Silt Loam	Massive	Hard Dry	6.0	Imperfect
			Subsoil	Ybg	Silt Loam	Strong Med. and Fine Subangular bk.	Friable Moist	7.0	
			Subst	G	Clay	Massive	Firm Moist	7.0	
	Lauta	Highland Level	Topsoil	G	Silt Loam	Massive	Hard Dry	6.0	Imperfect
			Subsoil	Ybg	Silt Loam	Mod. Coarse and Med. Angular bk.	Firm Moist	7.0	
			Subsoil	G	Clay	Massive	Firm Moist	7.0	
	Nachol	Highland Valley	Topsoil	G	Loam	Massive	Hard Dry	7.0	Imperfect
			Subsoil	Gtyb	Loam	Massive	Hard Dry	7.0	
			Subst.	G	Slay Silty Clay	Mod. Coarse and Med. Angular bk.	Firm Moist	7.0	
	Pauli	Med. Highland Valley	Topsoil	G	Loam	Massive	Hard Dry	6.5	Poor
			Subsoil	Ybtg	Loam	Mod. Coarse and Med. Angular bk.	Firm Moist	7.0	
			Subst.	G	Clay	Mod. Coarse and Med. Angular bk.	Firm Moist	7.0	

TABLE I -3-2 CHARACTERISTICS OF SOIL SERIES(2/4)

Physiography	Soil Series	Land Type	Layers/ Horizons	Colour	Texture	Structure	Consistence	pH	Drain
Ganges Flood Plain Calcareous	Sara	Highland Level Ridge	Topsoil	Olive b	Silty Loam	Massive	Friable Moist	7.5	Imperfect
			Subsoil	Olive b	Silty Loam	Mod. Coarse and Med. Angular bk.	Friable Moist	7.5	
			Subst.	Light olive b	Very Fine Sandy Loam	Weak Coarse Angular bk.	Slightly Sticky Slightly Plastic, Wet	8.0	
	Gopalpur	Highland Level Ridge	Topsoil	Olive b	Silt Loam	Massive	Firm Moist	7.0	Imperfect
			Subsoil	Olive b	Silty Clay Loam	Mod. Coarse and Med. Angular bk.	Firm Moist Very Friable	8.0	
			Subst.	Olive b	Very Fine Sand Loam	Massive	Moist	8.0	
	Ishurdi	Med. Highland Bevel Ridge	Topsoil	G	Silty Clay Loam	Massive	Hard Dry	7.0	Poor
			Subsoil	Olive b	Silty Clay	Mod. and Strong Coarse Angular bk.	Firm Dry	8.0	
			Subst.	Light olive	Silt Loam	Massive	Friable Moist	8.0	
	Mehendigonj	Med. Highland Level Basin	Topsoil	G	Silt Clay Loam	Massive	Firm Dry	7.0	Poor
			Subsoil	Olive b	Silt Clay	Mod. Coarse and Med. Angular bk.	Firm Moist	8.0	
			Subst.	Light olive b	Silty Clay Loam	Massive	Firm Moist	8.0	
	Ghior	Med. Highland Level Basin	Topsoil	G	Clay	Massive	Hard Dry	7.0	Poor
			Subsoil	Dark g b	Clay	Strong med. and Fine Angular bk	Firm Moist	7.0	
			Subst.	Olive b	Silty Clay	Mod. Coarse and Med. Angular bk	Firm Moist	8.0	

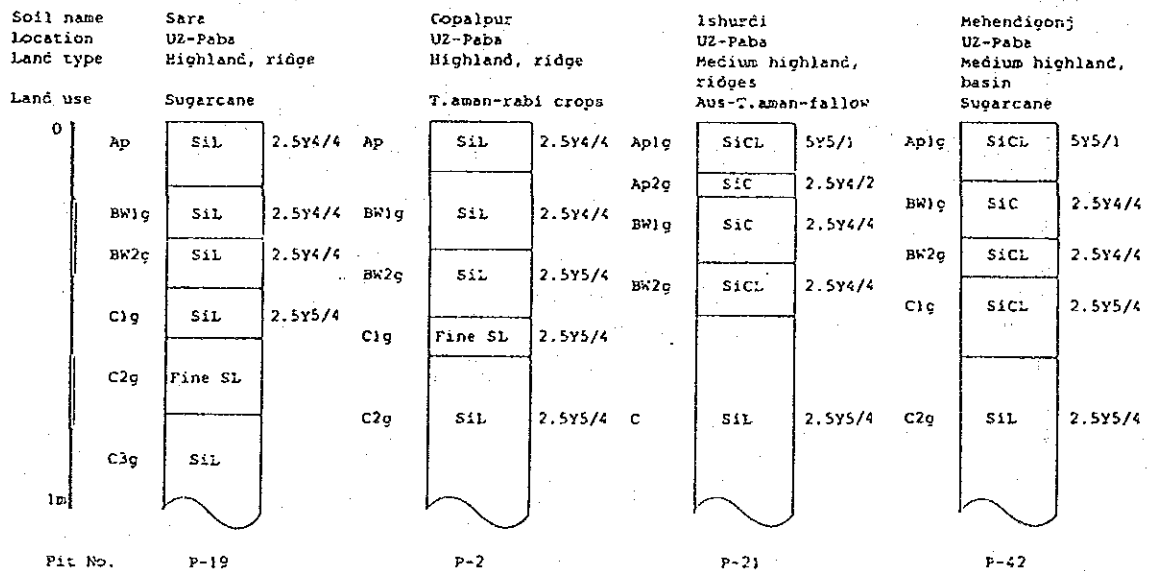
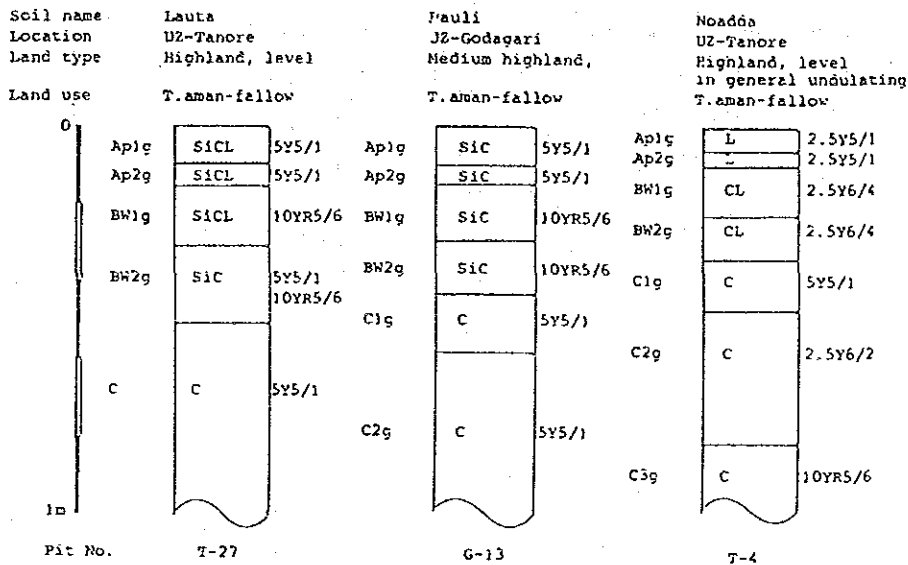
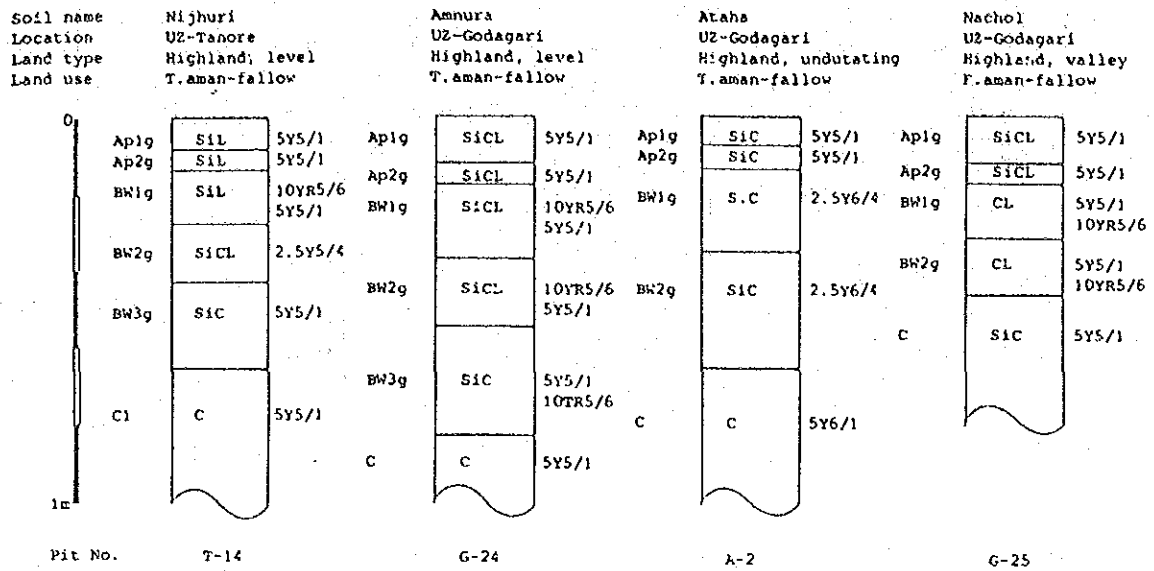
TABLE I -3-2 CHARACTERISTICS OF SOIL SERIES(3/4)

Physiography	Soil Series	Land Type	Layers/ Horizons	Colour	Texture	Structure	Consistence	pH	Drain
	Caruri	Med. Highland Level Basin	Topsoil	Dark g	Clay	Massive	Hard Dry	7.0	Poor
			Subsoil	Dark g	Clay	Strong med. and Coarse Angular bk.	Firm Moist	7.0	
			Subst.	Light olive b	Silty Clay Loam	Massive	Friable Moist	8.0	
	Santhia	Med. Highland Level Basin	Topsoil	Dark g	Clay	Massive	Very Hard Dry	7.0	Poor
			Subsoil	Dark g	Clay	Strong Coarse and Med. Angular bk.	Firm Moist	7.0	
			Subst.	Light olive b	Silty Clay	Massive	Firm Moist	8.0	
Ganges Floodplain Non Calcareone	Tahirpur	Highland Ridge	Topsoil	Olive b	Silt Loam	Massive	Friable Moist	7.0	Imperfect
			Subsoil	Olive yb	Loam	Mod. Coarse and Med. Angular bk.	Friable Moist	7.0	
			Subst.	Light olive b	Very Fine Sandy Loam	Massive	Very friable Moist	7.0	
	Maria	Med. Highland Ridge	Topsoil	G	Clay	Massive	Hard Dry	7.0	Poor
			Subsoil	Dark g b	Clay	Strong Coarse and Med. Angular bk.	Firm Moist	7.0	
			Subst.	Light olive b	Silty Clay Loam	Massive	Friable Moist	7.0	
	Teghar	Med. Highland Ridge	Topsoil	G	Silt Loam	Massive	Hard Dry	7.0	Poor
			Subsoil	Olive b t yb	Silty Clay Loam	Mod. Coarse and Med. Angular bk.	Firm Moist	7.0	
			Subst.	Olive b	Silty Clay Loam	Massive	Friable Moist	8.0	
	Gulai	Med. Highland Basin	Topsoil	G	Clay	Massive	Hard Dry	7.0	Poor
			Subsoil	Dark g b	Clay	Strong Coarse and Med. Angular bk.	Firm Moist	7.0	
			Subst.	Light olive b	Clay	Massive	Firm Moist	7.0	

TABLE I -3-2 CHARACTERISTICS OF SOIL SERIES(4/4)

Physiography	Soil Series	Land Type	Layers/ Horizons	Colour	Texture	Structure	Consistence	pH	Drain
Tista Floodplain	Dohali	Highland Ridge	Topsoil	G	Silt Loam	Massive	Friable Moist	6.5	Imperfect
			Subsoil	G	Very Fine Sandy Loam	Weak Coarse and Med. angular bk.	Friable Moist	7.0	
			Subst	G	Very Fine Sandy Loam	Massive	Friable Moist	7.0	
	Dighi	Lowland Basin	Topsoil	Dark g	Clay	Massive	Very Hard Dry	6.5	Poor
			Subsoil	Dark g	Clay	Strong Coarse and Med. Angular bk.	Very firm Moist	6.0	
			Subst	G	Clay	Weak Coarse Angular bk.	Firm Moist	6.0	
	Jaonia	Lowland Basin	Topsoil	G	Silty Clay	Massive	Firm Moist Hard Dry	6.0	Poor
			Subsoil	Dark g	Clay	Strong Coarse and Med. Angular bk.	Firm Moist	7.0	
			Subst	Greyish g	Clay	Strong Coarse and Med. Angular bk.	Firm Moist	7.0	

FIGURE I-3-2 SOIL PROFILES OF OPEN PIT IN THE PROJECT AREA



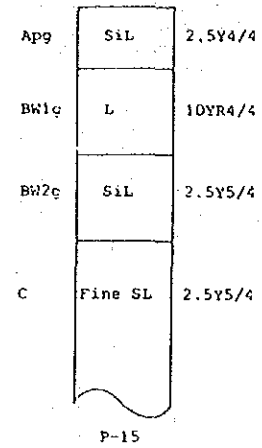
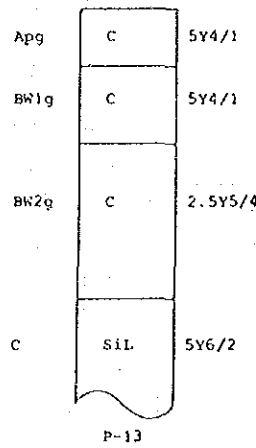
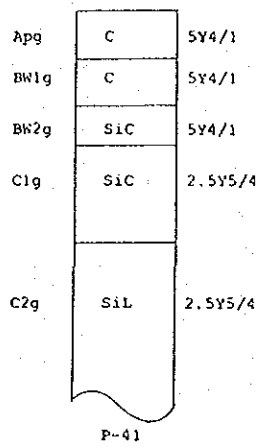
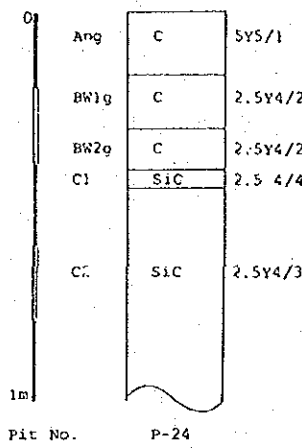
Soil name
Location
Land type
Land use

Ghior
UZ-Paba
Medium highland,
B.aman-fallow

Saruri
UZ-Paba
Medium highland,
T.aman-khesari

Santhia
UZ-Paba
Medium highland,
B.aman-fallow

Tahirpur
UZ-Paba
Highland, ridge
Aus-rabi crops,
potato, wheat

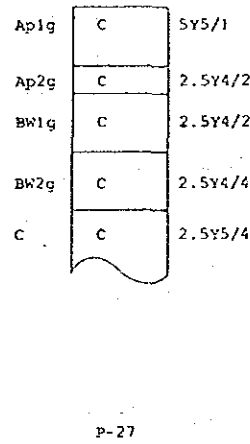
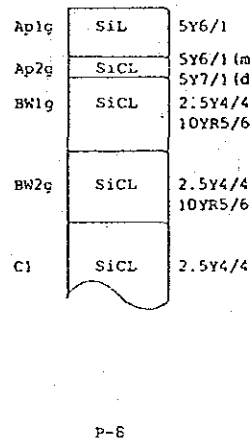
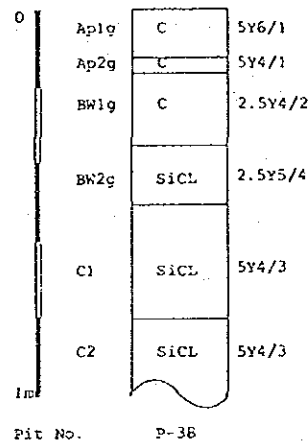


Soil name
Location
Land type
Land use

Maria
UZ-Paba
Medium highland,
ridge
T.aman-rabi crops

Teghar
UZ-Paba
Medium highland,
ridge
Aus-fallow

Gulai
UZ-Godagari
Medium highland,
basin
T.aman-fallow



Soil name
Location
Land type
Land use

Dohali
UZ-Niamatpu
Highland, ridge
Aus-rabi crops/vegetables

Digli
Tanore
Lowland, basin
Boro-fallow

Jaonia
UZ-Niamatpur
Lowland, basin
Boro-fallow

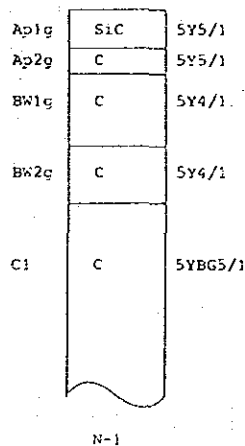
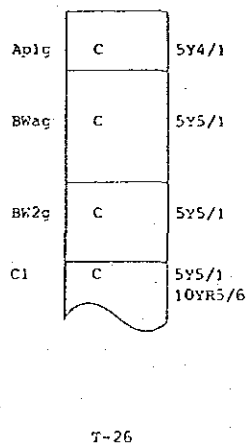
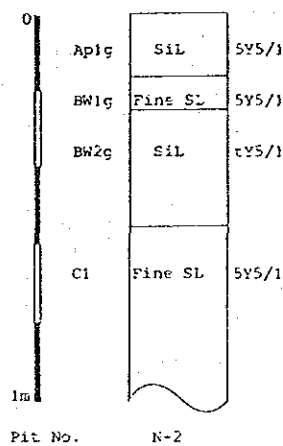


TABLE 1-3-3 LOCATION, SOIL SERIES, LAND TYPE AND LAND USE OF
SOIL AUGER SURVEY SITES IN THE PROJECT AREA (1/3)

Location	Symbol	Soil Series	Land Type	Land use	Location	Symbol	Soil Series	Land Type	Land use
Godagari	G1	Nijhuri	Highland Undulating	T. Aman with Locally Boro-	Faba	P17	Sara	Highland Level	Aus/Jute
	G2	Amnura	Highland Undulating	T. Aman with Locally Boro-		P18	Sara	Highland Level	Aus/Jute
	G3	Ataha	Highland Undulating	T. Aman with Locally Boro-		P19	Sara	Highland Level	Sugarcane
	G4	Nijhuri	Highland Undulating	T. Aman with Locally Boro-		P19	Sara	Highland Level	Sugarcane
	G5	Amnura	Highland Undulating	T. Aman with Locally Boro-		P20	Mehendinging	Medium Highland	E. Aman-Fallow
	G6	Nijhuri	Highland Undulating	T. Aman with Locally Boro-		P21	Ishurdi	Medium Highland	T. Aman-Fallow
	G7	Nachol	Valley	T. Aman with Locally Boro-		P21	Ishurdi	Medium Highland	T. Aman-Fallow
	G8	Amnura	Highland Undulating	T. Aman with Locally Boro-		P22	Ishurdi	Medium Highland	Aus, T. Aman Fallow
	G9	Nijhuri	Highland Undulating	T. Aman with Locally Boro-		P23	Ishurdi	Highland Level	Vegetables, Sugarcane
	G10	Amnura	Highland Undulating	T. Aman with Locally Boro-		P24	Gnlor	Medium Highland in blooded	E. Aman-Fallow
Faba	P1	Sara	Highland Level	Sugarcane, Chick Pea		P24	Gnlor	Medium Highland in blooded	E. Aman-Fallow
	P2	Gopalpus	Highland Level	E. Aman-Khesari		P25	Gauri	Medium Highland	E. Aman-Fallow
	P2	Gopalpus	Highland Level	E. Aman-Khesari		P26	Gnlor	Medium Highland	T. Aman, Boro- Fallow
	P3	Mehendinging	Medium Highland	E. Aman		P27	Gopalpur	Highland Level	T. Aman-Khesari
	P4	Sara	Highland	Potato as Inter Crop of Sugarcane.		P27	Gopalpur	Highland Level	T. Aman-Khesari
	P5	Sara	Highland	Potato as Inter Crop of Sugarcane.		P28	Mehendinging	Medium Highland	E. Aman-Khesari
Faba	P6	Teghar	Medium Highland Flooded	T. Aman-Fallow	Faba	P29	Amnura	Highland Disturbed	T. Aman-Fallow
	P7	Gauri	Medium Highland	T. Aman-Fallow		P30	Amnura	Highland Disturbed	T. Aman-Fallow
	P8	Gopalpur	Highland or Medium Highland	T. Aman-Fallow		P31	Teghar	Medium Highland	T. Aman-Fallow
	P8	Gopalpur	Highland or Medium Highland	T. Aman-Fallow		P32	Teghar	Medium Highland	T. Aman-Fallow
	P9	Gnlor	Medium Highland	E. Aman, Khesari as Inter Crop		P33	Teghar	Medium Highland	T. Aman-Fallow
	P10	Gnlor	Medium Highland	E. Aman, Khesari as Inter Crop		P34	Tahirpur	Highland Level	Aus and Potato
	P11	Sara	Highland Level	Potato, Wheat and Sugarcane.		P35	Teghar	Medium Highland	T. Aman and Wheat
	P12	Sara	Highland Level	Potato, Wheat and Sugarcane.		P36	Tahirpur	Highland Irregular	Aus and Wheat
	P13	Sonthia	Medium Lowland	Boro, Aman		P36	Tahirpur	Highland Irregular	Aus and Wheat
	P13	Sonthia	Medium Lowland	Boro, Aman		P37	Teghar	Medium Highland	T. Aman-Fallow
	P14	Sonthia	Medium Lowland	Boro, Aman		P38	Marie	Medium Highland Basin	T. Aman-Khesari
	P15	Tahirpur	Highland Irregular	Vegetables, Potato		P38	Marie	Medium Highland Basin	T. Aman-Khesari
	P15	Tahirpur	Highland Irregular	Vegetables, Potato		P39	Sonthia	Medium Highland	E. Aman-Fallow
	P16	Sara	Highland Level	Aus/Jute		P40	Sonthia	Medium Highland	E. Aman-Fallow with Locally Boro.
	P16	Sara	Highland Level	Sugarcane		P41	Gauri	Medium Highland	T. Aman-Fallow
						P41	Gauri	Medium Highland	T. Aman-Fallow

TABLE I-3-3 LOCATION, SOIL SERIES, LAND TYPE AND LAND USE OF
SOIL AUGER SURVEY SITES IN THE PROJECT AREA (2/3)

Location	Symbol	Soil Series	Land Type	Land use	Location	Symbol	Soil Series	Land Type	Land use
	P'K2	Mehehdiging	Medium Highland	Sngarcane	Tanore	T20	Annura	Highland Level	T. Aman-fallow with Locally Boro.
	P'K2	Mehehdiging	Medium Highland	Sngarcane		T21	Nachol	Highland Level	T. Aman-fallow with Locally Boro.
Tanore	T1	Sonthia	Medium Lowland	T. Aman-fallow with Locally Boro.		T22	Jaonia	Medium Lowland	T. Boro-fallow
	T2	Sonthia	Medium Lowland	T. Aman-fallow with Locally Boro.		T23	Nijhuri	Highland Irregular	T. Aman-Wheat, Others
	T3	Sonthia	Medium Lowland	T. Aman-fallow with Locally Boro.		T24	Annura	Highland Level	T. Aman-fallow
	T'4	Noada	Highland Undulating	T. Aman-fallow with Locally Boro.		T25	Jaonia	Lowland	Boro-fallow
	T4	Noada	Highland Undulating	T. Aman-fallow with Locally Boro.		T26	Depli	Medium Lowland	Boro-fallow
	T'5	Nijhuri	Highland Undulating	T. Aman-fallow with Locally Boro.		T'27	Lauta	Highland Level	T. Aus-fallow
	T5	Nijhuri	Highland Undulating	T. Aman-fallow with Locally Boro.		T27	Lauta	Highland Level	T. Aus-fallow
	T6	Annura	Highland Undulating	T. Aman-fallow with Locally Boro.		T28	Nijhuri	Highland Level	T. Aman-fallow
	T7	Nijhuri	Highland Undulating	T. Aman-fallow with Locally Boro.		T29	Pauli	Highland Level	T. Aman-Mastard
	T8	Nijhuri	Highland Undulating	T. Aman-fallow with Locally Boro.		T'30	Annura	Highland Level	T. Aman-fallow
Tanore	T9	Annura	Highland Undulating	T. Aman-fallow with Locally Boro.		T30	Annura	Highland Level	T. Aman-fallow
	T10	Noada	Highland Undulating	T. Aman-fallow with Locally Boro.		T31	Nijhuri	Highland	T. Aman-fallow
	T11	Nijhuri	Highland Undulating	T. Aman-fallow with Locally Boro.		T32	Lauta	Highland Level	T. Aus-fallow
	T12	Nachol	Highland Undulating	T. Aman-fallow with Locally Boro.	Googari	G11	Nijhuri	Highland Undulating	T. Aman-fallow
	T13	Nijhuri	Highland Undulating	T. Aman-fallow with Locally Boro.		G12	Pauli	Medium Highland Valley	T. Aman-fallow
	T'14	Nijhuri	Highland Undulating	T. Aman-fallow with Locally Boro.	Googari	G'13	Pauli	Medium Highland Valley	T. Aman-fallow
	T14	Nijhuri	Highland Level	T. Aman-fallow with Locally Boro.		G13	Pauli	Medium Highland Valley	T. Aman-fallow
	T15	Nijhuri	Highland Level	T. Aman-fallow with Locally Boro.		G14	Pauli	Medium Highland Valley	T. Aman-fallow
	T16	Nijhuri	Highland Level	T. Aman-fallow with Locally Boro.		G15	Pauli	Medium Highland Valley	T. Aman-fallow
	T17	Nijhuri	Highland Level	T. Aman-fallow with Locally Boro.		G16	Nachol	Highland Undulating	T. Aman-fallow with Locally T. Aus-Mastard
	T18	Annura	Highland Level	T. Aman-fallow with Locally Boro.		G17	Ataha	Highland Undulating	T. Aman-fallow
	T19	Nijhuri	Highland Level	T. Aman-fallow with Locally Boro.		G18	Nachol	Highland Level	T. Aman-fallow
						G19	Atana	Highland Rolling	T. Aman-fallow
						G20	Atana	Highland Rolling	T. Aman-fallow
						G21	Annura	Highland Terrace	T. Aman-fallow
						G22	Annura	Highland Undulating	T. Aman-fallow
						G23	Chier	Lowland Level	T. Aman-fallow
						G'24	Annura	Highland Level	T. Aman-fallow
						G24	Annura	Highland Level	T. Aman-fallow
						G'25	Nachol	Highland Level	T. Aman-fallow

TABLE 1 -3-3 LOCATION, SOIL SERIES, LAND TYPE AND LAND USE OF
SOIL AUGER SURVEY SITES IN THE PROJECT AREA (3/3)

Location	Symbol	Soil Series	Land Type	Land use
Godagari	G25	Nashol	Highland Level	T. Aman-Fallow
	G26	Gulai	Medium Highland Level	T. Aman-Fallow
	G'27	Gulai	Medium Highland Level	T. Aman-Fallow
	G27	Gulai	Medium Highland Level	T. Aman-Fallow
	G28	Tahira pur	Highland irregular	T. Aman-Fallow
	G29	Annura	Highland Level, Disturbed	T. Aman-Fallow
	G30	Annura	Highland Level, Disturbed	T. Aman-Fallow
Niamatpur	N'1	Jaonia	Lowland	Boro-Fallow
	N1	Jaonia	Lowland	Boro-Fallow
	N2	Dohall	Highland Level	Aus-Rabi crops
	N'3	Nijhuri	Highland Level	T. Aman-Fallow with Locally Boro and Aus.
	N3	Nijhuri	Highland Level	T. Aman-Fallow with Locally Boro and Aus.
	N4	Nijhuri	Highland Level	T. Aman-Fallow with Locally Boro and Aus.
	N5	Nijhuri	Highland Level	T. Aman-Fallow with Locally Boro and Aus.
Niamatpur	N6	Annura	Highland Level	T. Aman-Fallow with Locally Boro and Aus.)
	N7	Ataha	Highland Level	T. Aman-Fallow with Locally Boro and Aus.)
	N8	Nashol	Highland Valley	T. Aman-fallow with Locally Boro and Aus.)
	N9	Jaonia	Medium Lowland Level	Boro-fallow with Some Mustard
	N10	Nijhuri	Highland Level	T. Aman-Fallow
	N11	Nijhuri	Highland Level	T. Aman-Fallow
	N12	Nijhuri	Highland Undulating	T. Aman-Fallow
	N13	Nijhuri	Highland Level	T. Aman-Fallow
	N14	Nijhuri	Highland Level	T. Aman-Fallow
	N15	Nijhuri	Highland Level	T. Aman-Fallow
	N16	Nijhuri	Highland Level	T. Aman-Fallow
	N17	Nijhuri	Highland Level, Disturbed	T. Aman-Fallow
Godagari	K2	Ataha	Highland Undulating	T. Aman-Fallow

3-3 Soil Characteristics in the Project Area

The soil samples collected for laboratory analysis are analyzed by the Department of Soil Science, University of Dhaka, in their departmental laboratory.

3-3-1 Method of Soil Analysis

- (1) Textural analysis : Hydrometer method; Organic matter is removed by H_2O_2 treatment and the soil dispersed by sodium hexametaphosphate, USDA System.
- (2) pH : At a soil : water ratio of 1 : 2.5.
- (3) Organic matter : Organic carbon is determined volumetrically by wet oxidation with chromic acid and organic matter (%) is calculated by multiplying the organic (%) with 1.72.
- (4) Total N : Kjeldahl method and alkali distillation
- (5) Available P : P is extracted by 0.5 M $NaHCO_3$ and the P in solution is determined colorimetrically by vanado-molybdate yellow colour method.
- (6) Available S : S is extracted by Ca-dihydrogen phosphate and then the S in solution is determined by turbidimetry using $BaCl_2$.
- (7) Available K : K is extracted from soil by water and then by $NH_4 OAc$ and the K in solutions is analyzed in a flame photometer; the two fractions give the available K.
- (8) OEC : Cation exchange capacity is determined by saturating the soil with NH_4 (ammonium acetate at pH 7.0), then removing the NH_4 by another cation and determining the NH_4 in solution by alkali distillation.
- (9) Exchangeable cations : Once the soils are treated with and leached with $NH_4 OAc$ and the lechate is used to analyze for Na and K in a flame photometer and Ca and Mg in an Atomic Absorption Spectrophotometer.

- (10) Available Zn : Zn is extracted by 0.1N NCl and the Zn in solution is determined in Atomic Absorption Spectrophotometer.
- (11) Bulk density : Core sampler method.
- (12) pF at different : Pressure membrane and plate method.
- (13) Permeability : Constant head method.

3-3-2 Chemical Properties of Soils

The analysis of chemical properties includes the determination of pH, organic carbon, total nitrogen, available phosphate, sulphur and potassium, C.E.C, exchangeable Na, K, Ca and Mg and available zinc.

Soil reaction : Soil reaction ranges from pH 4.8 to 8.3 in different layers throughout the project area. 1) Barind tract soils; pH ranges from 4.8 to 6.8 with an average of pH 5.8 in the topsoils, with the subsoil average pH 6.7 and the substratum pH 6.8. 2) Ganges floodplain soils; In the calcareous soils, pH ranges from 7.2 to 7.8 with an average pH 7.6 in the topsoil, with the subsoil average pH 7.7 and substratum pH 8.1. Each layer is alkaline in reaction with calcium carbonate in the profiles and with a few nodules in some profiles. Reaction of non-calcareous soils ranges from pH 6.0 to 6.9 with an average of pH 6.6 in the topsoil, with the subsoil average pH 7.3 and the substratum pH 7.2. Many non-calcareous soils are alkaline in reaction except the topsoils. 3) Tista floodplain soils; pH ranges from 5.2 to 6.8 with an average of pH 5.7 in the topsoils, with the subsoil average pH 6.2 and the substratum pH 6.3.

Cation exchangeable capacity (CEC) : CEC of soils reflects usually a difference in a kind of clay minerals and content of organic matters. But CEC in the Project area is mainly according to clay contents. CEC of the topsoils ranges from 4.7 to 23.5 m.e. with an average of CEC 11.3 m.e. in the Barind tract, from 9.6 to 42.5 m.e. with an average of CEC 26.0 m.e. in the Ganges floodplain and from 9.7 to 32.8 m.e. with an average of CEC 25.1 m.e. in the Tista floodplain. Many soils of the Barind tract show low level in CEC in competing with others, especially in the topsoils.

Exchangeable basis : Exchangeable Ca and Mg occupy the majority of Base Saturation Percent. Its tendency is remarkable in the calcareous soils of the Ganges floodplain. Many soils are comparatively low in exchangeable Ca content in the Barind tract. It is remarkable that the

ratio of exchangeable Mg and Ca content in the soils of the project area is high in comparing with common soils, especially in the soils of the Barind tract.

Exchangeable K : Exchangeable K content in the soils is low or medium, except a few soils in the floodplain, Jaonia, Ghior, Maria and Gulai soils. Exchangeable K content of the topsoils ranges from 0.06 to 0.37 m.e. with an average to m.e. 0.17 in the Barind tract. Exchangeable K content ranges from 0.06 to 0.51 m.e. with an average of 0.32 m.e. in the topsoils of the Ganges floodplain. Also it ranges from 0.25 to 0.61 m.e. with an average of 0.41 m.e. in the Tista floodplain.

Available phosphate : Available P content ranges from 16.5 to 53.9 ppm with an average of ppm 25.4 in the topsoils of the project area. Most of the soils are low in available P content, except Methndiganj and Gauri soils which are comparatively high probably according to the application of P fertilizer. The soils below the topsoils fall usually in available P content with depth.

Organic carbon : 1) Barind tract; Barind tract soils are low in Organic carbon content, with less than 1%. Organic carbon content ranges from 0.49 to 0.85 percent with an average of percentage 0.15 and the substratum average percentage 0.10. 2) Ganges floodplain; Sara, Ishurdi, Methendiganj, Tahirpur and Tegar soils are low in organic carbon percentage, with less than 1.0% in the topsoils and the remainders are medium percentage, ranging from 1.03 - 1.33% with an average of percentage 1.17 in the topsoils. Organic carbon contents fall with depth. 3) Tista floodplain; The percentage of organic carbon contents is low in Dohali soils with 0.11% and medium in Jaonia and Digli soils with an average of percentage 1.04 in the topsoils. Organic carbon contents fall with depth.

Organic nitrogen : Organic nitrogen content is low in almost soils. 1) Barind tract; organic nitrogen content ranges from 0.03 to 0.10% with an average of percentage 0.07 in the topsoils. 2) Ganges floodplain; it ranges from 0.01 to 0.12% with an average of percentage 0.08 in the topsoils. 3) Tista floodplain; it ranges from 0.04 to 0.15% with an average of percentage 0.29 in the topsoils. The contents fall regularly with depth.

Available sulphur : The available S contents of all soils in the project area are lower than 10 ppm in the topsoils except Amnura level soils, 13.30 ppm. The averages of available S content are 6.60 ppm in the

Barind tract, 5.72 ppm in the Ganges floodplain and 8.77 ppm in the Tista floodplain without Dohali soils.

S deficiency may easily appear with no supply of S and irrigation of water which is low in S content. A few soils are very high in available S content in all layers, Amnura soils, in the subsoils, Ishurdi and Garuri soils and in the substratums, Tahirpur and Gulai soils. These are possible according to the application of S fertilizer.

Available Zinc : Available Zn content ranges from 0.22 to 7.13 ppm with an average of 3.20 ppm in the topsoils of the Project area. Zn deficiency is observed in most area of this country and the limit level of Zn content in soils is recognized to be 2 ppm. Therefore, the soils which are less than 2 ppm or similar level in Zn content have possibility to appear Zn deficiency in the Project area. Especially, the calcareous soils in the Ganges floodplain should be taken into consideration of Zn deficiency.

The data of chemical properties is shown in the TABLE I-3-4.

3-3-3 Physical Properties of Soils

The analysis of physical properties includes the determination of bulk density, water retaintivity and permeability on the six soil series. The data of physical properties is shown in the TABLE I-3-5.

Bulk density of the soils ranges from 1.41 to 1.65 g/cc with an average of bulk density 1.52 g/cc in the different layers of six soil series. There are not so differences among them. Available water ranges from 12.1 to 20.2 vol % with an average of volume percentage 15.5 in the topsoils of all soils. Nijhuri soils are relatively high in level. The differences among the soils are mainly according to texture. Permeability of Nijhuri and Sara soils in very slow, 0.2 - 0.9 mm/hour in the topsoil and subsoil and slow to moderately slow 3.7 - 6.3 mm/hour in the substratum. Jaonia and Santhia soils show slow and moderately slow permeability only in the topsoils, while Nachol and Pauli soils do not shown the permeability in any layers. These soils may show poor drainage in the field.

TABLE I -3-4 CHEMICAL PROPERTIES OF SOIL SERIES (1/2)

Soil Series	Depth cm	Sample No.	% Moisture F.F.C.	% Sand	% Silt	% Clay	Texture	pH	Org. Carbon %	Org. Mat. %	Total N %	Av. P ppm	Av. S ppm	Av. K ppm	CEC meq %	Exchangeable Cations*			Available Zn ppm	
																Na ⁺	K ⁺	Ca ⁺²		Mg ⁺² meq %
NOADDA	0-8+12	T ₁ /No-1	6.17	32.8	52.5	14.7	SiL	6.6	0.49	0.85	0.093	29.6	7.02	49.3	9.64	-	0.06	10.7	1.0	3.17
	12-26	T ₁ /No-2	13.08	35.3	45.0	19.7	L	6.6	0.17	0.29	0.038	20.9	5.56	77.8	14.04	-	0.12	0.7	1.1	2.30
	26-36	T ₁ /No-3	16.08	35.3	42.5	22.2	L	6.7	0.11	0.20	0.021	22.2	5.41	79.7	14.38	-	0.12	0.8	1.2	4.47
ATAHAR	0-8+14	A ₁	5.00	17.8	50.0	32.2	SiCL	6.3	0.54	0.84	0.097	24.3	7.02	183.3	23.51	-	0.37	4.0	4.1	2.47
	14-35	A ₂	15.85	12.8	41.2	46.0	SiC	7.2	0.06	0.11	0.011	13.2	7.02	187.1	29.05	-	0.28	2.2	6.9	1.63
	35-60	A ₃	20.35	14.0	41.2	44.8	SiC	7.4	0.01	0.02	0.005	14.4	7.46	187.2	28.35	0.02	0.28	4.8	7.8	3.15
NIJHURI-LEVEL	0-9+14	T ₁ /Nj-1	17.66	30.2	56.2	13.6	SiL	4.8	0.74	1.28	0.104	30.0	6.43	36.1	7.03	-	0.06	0.1	0.6	3.38
	14-28	T ₁ /Nj-2	14.02	30.3	45.0	24.7	L	5.2	0.15	0.26	0.021	15.0	4.37	48.5	9.50	-	0.06	0.4	1.0	1.90
	28-43	T ₁ /Nj-3	16.31	25.2	37.5	37.3	CL	6.4	0.15	0.26	0.015	15.6	6.43	75.4	14.74	-	0.13	0.8	2.2	2.07
NIJHURI-UNDULATY	0-10+15	T ₂ /N ₁ -1	8.24	22.8	55.0	22.2	SiL	4.8	0.85	1.46	0.087	20.6	6.14	68.8	9.73	-	0.13	0.6	0.9	2.83
	15-30	T ₂ /N ₁ -2	10.97	23.5	57.5	19.0	SiL	6.2	0.12	0.20	0.031	18.9	5.12	75.4	19.66	-	0.13	0.7	2.2	1.17
	30-48	T ₂ /N ₁ -3	17.10	22.2	37.5	40.3	C	6.1	0.04	0.07	0.003	16.0	5.86	78.9	9.49	0.37	0.12	1.2	0.8	2.13
AMNURA	0-15	T ₃₀ -1	4.11	18.5	66.3	15.2	SiL	5.1	0.65	1.12	0.057	20.6	5.70	67.4	9.59	0.05	0.12	0.4	3.8	5.08
	15-45	T ₃₀ -2	21.97	13.5	38.7	47.8	C	6.7	0.11	0.20	0.037	15.6	7.46	175.0	24.45	0.27	0.38	3.5	4.8	2.03
	45-65	T ₃₀ -3	31.45	17.3	30.0	52.7	C	6.6	0.06	0.11	0.004	15.6	6.14	191.8	24.21	0.32	0.41	5.5	6.2	1.52
AMNURA LEVEL	0-12+17	G ₂₄ -1	6.27	14.7	55.0	30.3	SiCL	6.8	0.62	1.09	0.071	28.4	16.25	161.0	14.17	0.21	0.28	3.7	3.1	3.00
	17-36	G ₂₄ -2	12.21	12.3	46.7	39.0	SiCL	7.0	0.22	0.38	0.021	15.6	17.40	126.4	16.87	0.40	0.26	3.3	3.3	3.21
	36-53	G ₂₄ -3	19.85	12.3	45.0	42.7	SiC	6.8	0.08	0.14	0.013	15.2	14.04	121.3	14.60	0.58	0.25	3.2	3.2	3.00
LAUTA	0-14	T ₃₇ -1	8.56	28.5	48.8	22.7	L	6.0	0.62	1.06	0.056	20.2	6.13	71.8	4.88	0.05	0.12	0.5	1.0	2.21
	15-40	T ₃₇ -2	15.43	19.8	38.7	41.5	C	6.4	0.09	0.17	0.013	14.0	7.75	101.6	14.45	0.21	0.19	2.0	3.8	1.87
	40-65	T ₃₇ -3	18.94	21.0	36.2	42.8	C	6.9	0.15	0.26	0.036	13.2	6.70	140.2	23.85	0.64	0.28	2.2	3.5	2.71
NACHOL	0-12+16	G ₂₅ -1	7.33	16.0	61.2	22.8	SiL	6.1	0.81	1.40	0.062	23.0	7.46	76.7	4.84	0.21	0.13	3.5	4.4	2.77
	16-30	G ₂₅ -2	17.05	13.5	46.3	40.2	SiCL	6.7	0.33	0.57	0.062	15.6	6.14	140.0	19.46	0.21	0.25	2.7	3.2	5.28
	30-45	G ₂₅ -3	20.27	13.5	43.8	42.7	SiL	6.8	0.18	0.32	0.038	15.6	5.12	141.6	19.27	0.21	0.25	2.6	4.8	1.72
PAULI	0-11+16	C ₁₁ -1	16.49	12.8	46.2	41.0	SiC	6.8	0.67	1.15	0.054	16.5	6.87	146.5	18.72	0.31	0.24	3.4	4.4	3.86
	16-30	C ₁₁ -2	16.88	9.0	50.0	41.0	SiC	7.7	0.13	0.23	0.015	14.8	3.51	125.6	19.27	0.43	0.25	3.0	6.0	2.90
	30-45	C ₁₁ -3	21.98	14.0	47.5	38.5	SiCL	7.8	0.15	0.26	0.030	15.2	3.36	145.6	21.39	0.55	0.25	2.8	4.7	2.05
DOHALI	0-16	N ₇ -1	19.74	32.8	53.8	13.4	L	6.8	0.11	0.20	0.044	30.0	13.31	148.5	9.89	0.43	0.25	0.8	1.3	2.71
	16-25	N ₇ -2	23.98	31.5	57.5	11.0	SiL	6.6	0.09	0.17	0.018	21.8	5.85	93.2	9.73	0.21	0.13	0.5	1.6	2.13
	25-50	N ₇ -3	27.72	21.5	56.3	22.2	SiL	6.4	0.15	0.26	0.046	24.7	9.15	160.0	14.17	0.52	0.25	0.7	0.9	3.16
JAONIA	0-10+16	N ₁ -1	22.03	6.3	37.5	57.2	C	6.3	1.03	1.77	0.098	26.7	9.21	281.1	32.75	0.42	0.61	4.1	6.1	3.46
	16-35	N ₁ -2	29.63	4.0	50.8	45.2	SiC	6.0	0.61	0.97	0.087	22.6	7.16	235.9	19.17	0.48	0.44	2.5	8.7	5.46
	35-50	N ₁ -3	38.49	5.2	27.5	67.3	C	6.3	0.56	0.97	0.071	25.9	8.19	252.4	32.91	1.04	0.49	3.2	4.3	3.30
DIGLI	0-15	T ₃₈ -1	11.62	17.7	27.5	54.8	C	6.2	1.05	1.80	0.152	24.7	8.33	170.4	32.75	0.42	0.37	1.1	5.7	2.21
	15-30	T ₃₈ -2	17.79	24.7	36.8	38.5	CL	6.0	0.44	0.75	0.038	18.5	6.00	129.3	14.45	0.21	0.22	1.4	2.5	1.00
	30-60	T ₃₈ -3	23.65	26.5	30.0	43.5	C	6.1	0.31	0.54	0.037	15.0	4.68	126.5	21.49	0.34	0.25	1.2	3.7	1.50

* Contains water soluble cations also.

TABLE I-3-4 CHEMICAL PROPERTIES OF SOIL SERIES (2/2)

Soil Series	Depth cm	Sample No.	% Moisture F. F. C.	% Sand	% Silt	% Clay	Texture	pH	Org. Carbon %	Org. Mat. %	Total N %	Av. P ppm	Av. S ppm	Av. K ppm	CBC meq %	Exchangeable Cations *			Available Zn ppm	
																Na ⁺	K ⁺	Ca+2		Mg+2 meq %
SARA LEVEL	0-16	P-19/Sn-1	17.26	31.0	50.0	19.0	SIL	7.8	0.36	0.63	0.044	18.9	3.07	133.9	14.97	-	0.23	26.2	3.2	0.22
	16-30	P-19/Sr-2	19.54	36.0	41.2	22.8	L	8.1	0.24	0.41	0.005	20.5	3.36	145.5	14.04	-	0.24	23.3	3.3	0.43
	30-42	P-19/Sr-3	22.80	37.2	41.3	21.5	L	8.3	0.08	0.14	0.005	25.9	3.51	163.3	14.74	-	0.26	26.9	3.1	0.43
GOPALPUR	0-12	P-2/g-1	15.33	18.5	47.5	34.0	SICL	7.4	1.03	1.77	0.094	24.7	6.14	144.2	23.51	-	0.31	7.7	4.3	3.55
	12-32	P-2/g-2	19.06	19.8	40.0	40.2	SIC	7.9	0.49	0.85	0.090	17.3	6.43	156.2	28.21	-	0.31	18.9	4.6	2.97
	32-50	P-2/g-3	23.42	26.0	50.0	24.0	SIL	8.1	0.20	0.36	0.016	15.6	12.58	114.2	14.11	-	0.21	36.1	4.6	0.13
ISHURDI	0-18	P-21/wh-1	11.38	11.0	42.5	46.5	SIC	7.5	0.79	1.37	0.043	19.3	7.46	183.8	26.76	-	0.38	3.3	2.0	7.13
	18-38	P-21/wh-2	21.75	9.8	45.0	45.2	SIC	7.4	0.37	0.69	0.025	16.9	103.24	178.6	27.94	-	0.37	9.9	5.3	2.95
	35-49	P-21/wh-3	25.31	9.8	42.5	47.7	SIC	8.0	0.31	0.54	0.021	14.0	11.70	165.4	28.76	-	0.31	39.7	7.5	0.07
MEHENDI-GANJ	0-15	P-42/M-1	32.52	21.0	43.8	35.2	CL	7.8	0.92	1.58	0.099	40.3	6.73	190.7	28.31	-	0.37	9.5	3.8	3.50
	15-30	P-42/M-2	27.28	18.5	45.0	36.5	SICL	7.9	0.86	1.46	0.071	21.0	6.29	141.6	28.90	-	0.28	28.0	6.6	3.55
	30-40	P-42/M-3	26.47	17.2	42.5	40.3	SICL	7.7	0.82	1.06	0.057	19.3	4.93	199.0	29.19	0.05	0.38	7.0	3.8	3.38
GARURI	0-12	P-41/gr-1	31.56	13.5	45.0	41.5	SIC	8.0	1.33	2.29	0.108	53.9	4.83	180.3	38.92	0.05	0.38	11.5	6.8	3.97
	12-25	P-41/gr-2	26.91	9.8	45.0	45.2	SIC	7.8	0.51	0.87	0.054	17.3	82.18	148.7	33.23	-	0.31	8.1	3.6	0.35
	25-35	P-41/gr-3	30.94	9.8	65.0	25.2	SICL	8.3	0.20	0.35	0.023	14.8	5.26	114.7	18.90	0.05	0.22	38.8	6.4	0.10
SANTHIA	0-15	P-13/Sn-1	25.51	14.8	50.0	35.2	SICL	7.5	1.22	2.10	0.110	20.6	6.14	118.6	23.28	-	0.24	5.4	0.6	4.13
	15-30	P-13/Sn-2	22.53	11.0	37.5	51.5	C	8.1	0.38	0.66	0.026	25.1	4.99	127.4	33.23	0.21	0.25	5.2	7.6	2.13
	35-75	P-13/Sn-3	21.12	7.2	40.0	52.8	SIC	8.2	0.26	0.45	0.026	23.9	4.09	144.2	42.32	0.31	0.25	5.1	8.0	1.80
GHOR	0-16	P-24/gh-1	36.30	17.2	30.0	52.8	C	7.2	1.24	2.14	0.013	17.3	3.14	232.5	42.52	-	0.53	4.1	8.1	2.20
	16-30	P-24/gh-2	27.53	14.8	18.8	66.4	C	7.7	0.53	0.91	0.011	15.6	4.39	220.1	40.68	-	0.50	11.1	7.9	1.88
	30-40	P-24/gh-3	26.70	7.2	31.3	61.5	C	7.8	0.31	0.54	0.051	15.6	17.99	196.2	37.80	-	0.43	10.3	6.3	2.05
TAHURPUR	0-16	P-15/ta-1	11.84	42.3	36.2	21.5	L	6.7	0.40	0.69	0.066	26.7	5.12	61.6	14.45	-	0.13	2.11	2.3	3.87
	16-38	P-15/ta-2	14.68	39.8	35.0	25.2	L	6.8	0.20	0.35	0.044	22.6	5.55	80.8	24.57	-	0.13	1.9	2.5	5.21
		P-15/ta-3	18.14	42.3	36.2	21.5	L	6.1	0.09	0.17	0.008	37.9	48.40	59.7	14.74	-	0.05	1.2	1.2	3.30
TECHAR	0-17	P-8/T-1	4.80	19.8	60.0	20.2	SIL	6.8	0.42	0.72	0.064	23.9	5.26	42.9	9.59	-	0.06	1.3	1.4	2.55
	17-36	P-8/T-2	20.19	17.2	51.3	31.5	SICL	7.7	0.11	0.20	0.0312	17.7	4.39	85.4	19.08	-	0.12	3.1	3.2	3.38
	36-55	P-8/T-3	21.03	16.0	56.2	27.8	SICL	7.9	0.18	0.32	0.025	19.3	2.92	71.5	29.19	0.05	0.13	3.9	3.8	5.06
MARIA	0-16	P-38/Mr-1	7.18	16.0	35.0	49.0	C	6.0	1.14	1.95	0.097	21.0	7.75	191.4	32.75	-	0.43	5.1	6.5	3.63
	16-35	P-38/Mr-2	17.84	13.5	27.5	59.0	C	7.1	0.49	0.84	0.054	16.0	4.83	171.6	28.76	0.02	0.38	8.0	8.3	2.21
	35-50	P-38/Mr-3	19.65	9.0	43.8	47.2	SIC	7.2	0.51	0.87	0.066	15.2	4.68	141.0	31.13	-	0.28	6.4	6.8	2.88
GULAI	0-15	P-27/gul-1	9.11	9.0	36.3	54.7	C	6.9	1.05	1.80	0.115	23.0	7.31	231.2	29.34	0.22	0.51	16.5	7.2	2.88
	22-37	P-27/gul-2	10.84	10.2	26.3	63.5	C	7.7	0.44	0.75	0.051	16.9	7.75	187.8	34.23	0.65	0.38	7.7	7.1	1.80
	37-52	P-27/gul-3	25.31	11.5	28.2	62.3	C	7.7	0.37	0.63	0.038	15.2	37.87	197.0	35.54	0.96	0.38	0.6	7.4	2.05

* Contains water soluble cations also.

TABLE I-3-5 WATER RETAINIVITY OF SOILS

Location	soils	Pit No.	Depth cm	Bulk Density g/cc	*Moisture content at			**Avail-able water	Permeability mm/hr.
					PF 2.0	PF 2.5	PF 4.2		
Barind tract	Nijhuri	T14	0-10+15	1.50	24.4	22.2	4.2	20.2	0.6
			15-30	1.65	20.2	18.4	6.7	13.5	0.8
			30-45	1.55	21.3	19.0	12.0	9.3	6.3
Barind tract	Nachol	G25	0-12+16	1.45	27.6	25.5	11.6	16.0	0
			16-30	1.42	28.4	26.3	26.3	11.5	16.0
			30-45	1.53	25.3	23.8	16.1	9.2	0
Barind tract	Pauli	G13	0-11+16	1.47	28.0	26.6	15.0	13.0	0
			16-30	1.64	23.2	22.0	16.5	6.7	0
			30-45	1.60	23.7	22.5	16.5	7.2	0
Tista Floodpla in	Jaonia	N1	0-10+16	1.42	32.9	31.4	20.8	12.1	4.5
			16-35	1.45	32.2	31.0	15.7	16.5	0
			35-50	1.41	32.9	32.2	24.4	8.5	0
Ganges Floodpla in	Santhia	P13	0+15	1.41	29.7	28.4	13.1	16.6	10.7
			15-35	1.56	25.8	24.6	17.2	8.6	0
			35-75	1.59	24.5	23.6	14.8	9.7	0.2
	Sara	P19	0+16	1.52	29.6	28.0	14.4	15.2	0.2
			16-30	1.60	25.8	24.0	17.3	8.5	0.9
			30-42	1.56	25.6	22.2	11.9	13.7	3.7

* Vol. % ** PF 2.0 - PF 4.2

3-4 Description of 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. During mapping proper consideration is given to land type, and therefore, level land, undulating/rolling land are mapped separately, though the soils are similar. Also highland or medium highland are mapped separately. Detail description of mapping units are shown in. TABLE I-3-6, I-3-7. The soils in the Study area and the Project area are shown in FIGURE I-3-3 and FIGURE I-3-4, respectively.

Description of soil mapping units

Mapping unit No. 1 (Nijhuri-Amnura-level phase)

This unit occurs mainly in Tanore, Niamatpur area, occupying 12,940 ha. Minor area (less than 5%) is occupied by scattered settlements.

Land type and soils

The area comprises level Barind Tract. It is above flood level but rain water is kept in the field by small boundary bunds for growing T.aman crop. It belongs to the land type highland.

Nijhuri soils comprise imperfectly drained, mixed yellowish brown and grey silt loam/silty clay loam subsoil, overlying red mottled substratum within one meter from the surface. Amnura soils occupy about 20 percent of the area. Amnura soils are more or less similar with Nijhuri soils, but differ in their yellow mottle in the substratum. Lauta soils occupy about 10 percent of the area. Lauta soils have mixed yellowish brown and grey, clay loam/silty clay loam subsoil, overlying a grey substratum within one meter from the surface.

Present land use

This unit belongs to land use mapping unit 4a. Mainly single with some double cropped land. Present land use is given in tabular form.

Land type	Soil	Cropping pattern	Percent	Area
Highland	Nijhuri	T.aman - fallow	60	7,760
	Amnura	Aus-T.aman - fallow	20	2,590
	Lauta	T.aman - boro	20	2,590

Limitations and development possibilities

Low organic matter, low nutrient content and shortage of available moisture in the rabi season restrict the cultivation of rabi crops.

Droughtiness even sometimes affects kharif rice crops. With irrigation and application of organic and chemical fertilizers along with improved variety of seeds and cultural practices all the soils of this unit could produce high yield of two transplanted rice crops including boro or one rice crop and wheat per year. Introduction of green manuring

crops in cropping pattern will improve the soil conditions. This soils are highly suitable for irrigation but round the year soils should not kept wet.

Mapping unit No. 2 (Nijhuri-Amnura, undulating phase)

This unit occurs throughout the project area and occupy 24,500 ha. about 5 percent of the area is occupied by settlements and ponds.

Land type and soils

This unit comprises a landscape of undulating topography where usually the summits are level and the slopes are terraced. The area is not flooded but rain water is kept in the terrace by small boundary bunds. The area belongs to the land type - highland.

This area is mainly occupied by Nijhuri soils, about 60 percent. Amnura soils occupy about 20 percent and Atahar and Nachol soils occupy about 10 and 5 percent respectively. Nijhuri and Amnura soils are described in unit I. Atahar soils comprise yellowish brown, silty clay loam to silty clay subsoil, overlying a grey mottled yellow and brown clayey substratum. Nachol soils comprise grey and yellowish brown, clay loam subsoil over a clayey substratum. Locally some disturbed dark greyish brown soil occur in an around the settlements. Minor area is occupied by Noadda soils in Tanore area having brown, clay loam subsoil.

Present land use

This unit belongs to land use mapping unit 4b. Mainly single with some double cropped land. Present land use is given in the tabular form.

Land type	Soil	Cropping pattern	Percent	Area
Highland	Nijhuri	T.aman - fallow	50	12,880
	Amnura	Aus-T.aman - fallow	20	5,160
			10	2,580
	Atahar	Aus-Rabi crops	10	2,580
Nachol	T.aman - fallow	5	1,300	

Limitations and development possibilities

Low organic matter, low nutrient content and shortage of available moisture in the rabi season restrict the cultivation of rabi crops. Droughtiness sometimes even affects kharif rice crop. Undulating topography is an additional limitations. With small scale irrigation and use of organic and chemical fertilizers and improved variety of seeds and cultural practices this soil could produce two rice crop per year or one rice crop followed by wheat. Introduction of green manuring crops in the cropping pattern will improve the soil condition. These soils are moderately suitable for irrigation according to its undulation.

Mapping unit No. 3 (Amnura-Nachol, slopping phase)

This unit mainly occurs along the basins and big valleys. It occupies about 1,540 ha.

Land type and soils

The area comprises mainly slopping land and usually terraced. They are not flooded but rain water is kept in the filed by small boundary bund. They belong to highland.

This unit is mainly occupied by Amnura soils, about 60 percent. Nachol soil occupy about 30 percent and Nijhuri occupies about 10 percent of the area. Brief description of the soils is given in unit No. 1 & 2.

Present land use

This unit is included in land use mapping unit 5a. Predominantly single cropped land. Present land use is given in following table.

Land type	Soil	Cropping pattern	Percent	Area
Highland	Amnura	T.aman - fallow	80	1,230
	Nijhuri			
	Nachol	T.aman - boro	20	310

Limitations and development possibilities

Low organic matter, low nutrient content and shortage of available moisture restrict the cultivation of rabi crops.

With irrigation and application of organic and chemical fertilizers along with improved seeds and cultural practices these soils could produce high yield of two transplanted rice crops per year. Introduction of green manuring crop in cropping pattern will improve the soil condition, also soils should not be kept wet round the year by irrigation water. The soils of the unit are moderately suitable for irrigation.

Mapping unit No. 4 (Nijhuri-Atahar-Nachol, rolling phase)

This unit occurs in Godagari upazila where it occupies 2,780 ha. About 5 percent of the area is occupied by settlements and ponds.

Land type and soils

The area comprises a rolling landscape having more or less level summits and terraced slopes. The area is not flooded but rain water is kept in the field by boundary bunds. It belongs to the land type-highland.

The soils occur in the area comprise Nijhuri soils, about 50 percent. Atahar and Nachol soils occupy about 20 and 15 percent respectively. Amnura soils occupy about 10 percent of the area. Atahar soils occupy the highest part of the landscape. Brief description of soil series is given in unit No. 1 and 2.

Present land use

This unit is included in land use mapping unit No. 5b. Predominantly single cropped land. Present land use is given in the tabular form.

Land type	Soil	Cropping pattern	Percent	Area
Highland	Nijhuri Atahar Amnura Nachol	T.aman - fallow	95	2,780

Limitations and development possibilities

Low organic matter, low nutrient content and shortage of available moisture restrict the cultivation of rabi crops. Rolling topography is an additional limitation. Large scale irrigation is not possible.

With small scale irrigation and with the application of organic and chemical fertilizers this soil can produce high yield of T.aman crop followed by wheat or any other crop which needs less amount of water. This soils are marginally suitable for irrigation according to its rolling topography.

Mapping unit No. 5 (Nachol, highland)

this unit occurs throughout the project area and it occupy 2,400 ha.

Land type and soils

The area comprises shallow valleys in between the uplands. They are not flooded but rain water is kept in the field by boundary bunds. Part of the rain water passes to the lower valley sites. The area belongs to highland.

The soils comprise predominantly Nachol, a mixed grey and yellowish brown clay loam overlying clayey substratum. Minor area may be occupied by Ayda soils having silt loam subsoils over-lying a clayey substratum.

Present land use

This unit belongs to land use mapping unit 5b. Predominantly T.aman - fallow. Present land use is given in the following table.

Land type	Soil	Cropping pattern	Percent	Area
Highland	Nachol	T.aman - fallow	100	2,400

Limitations and development possibilities

Low organic matter, low nutrient content and shortage of available moisture restrict the cultivation of rabi crops. Narrow extension also provide additional limitations.

With irrigation and with the application of organic and chemical fertilizers along with improved seeds and cultural practices these soils can produce high yield of two transplanted rice crop per year. Introduction of green manuring crop in cropping pattern will improve the soil condition. The soils are moderately suitable for irrigation but round the year soil should not kept wet.

Mapping unit No. 6 (Nachol-Pauli)

This unit occurs throughout the project area where it occupies 4,770 ha.

Land type and soils

This unit mainly comprises broad valleys lying in between the uplands. Major part, about 60 percent, is not flooded but rest 40 percent is flooded by rain water by less than 1 meter in the rainy season. It belongs to the land type both highland and medium highland.

The highland is occupied by Nachol soils having mixed grey and brown clay loam subsoil. Medium highland is occupied by Pauli soils (about 30 percent) having yellowish brown, mottled grey silty clay subsoils over a clayey substratum. Rest 10 percent of the medium highland is occupied by Nachol soils.

Present land use

This unit is included in land use mapping unit 5a. Predominantly T.aman - fallow and locally some boro is followed by T.aman are grown. The present land use is given in the tabular form.

Land type	Soil	Cropping pattern	Percent	Area
Highland	Nachol	T.aman - fallow	50	2,380
		T.aman - boro	10	480
Medium highland	Nachol	T.aman - fallow	10	480
		Pauli	T.aman - fallow	20
		T.aman - boro	10	480

Limitations and development possibilities

Low organic matter, low nutrient content and shortage of moisture restrict the cultivation of rabi crops.

With irrigation and application of organic and chemical fertilizers along with improved seeds and cultural practices these soils could produce high yield of two transplanted rice crop per year. Introduction of green manuring crop in cropping pattern will improve the soil. This unit is highly suitable for irrigation but it should not kept wet round the year.

Mapping unit No. 7 (Sara-Gopalpur level phase)

This unit occurs on the highest part of Ganges floodplain area occupying about 4,460 ha. Minor area of the unit is occupied by settlements.

Land type and soils

The area comprises level ridges and inter ridge depressions. The ridges are above flood level and belong to highland while the inter ridge depressions are shallowly flooded in the monsoon season and belong to medium highland.

The area is mainly occupied by Sara soil, about 60 percent. Sara soils include imperfectly drained, pale brown, friable calcareous silt loam subsoils with weak to moderate structure in the B-horizon. Gopalpur soils occupy about 30 percent and include imperfectly drained pale brown, calcareous, silty clay loam subsoil with moderate structure. Ishurdi soils occupy about 10 percent of the area. They occur mainly in the lower part of ridges and inter ridge depressions. They are pale brown in colour, silty clay in texture with moderate to strong structure in the subsoil. They are usually calcareous but sometimes topsoil may be on calcareous.

Present land use

This unit is included in land use mapping unit 3. Double and single cropped land. Present land use is given in the following table.

Land type	Soil	Cropping pattern	Percent	Area
Highland	Sara	Sugarcane	30	1,330
		Aus/jute-rabi crops	30	1,330
	Gopalpur	Sugarcane	10	450
		Aus-T.aman - fallow	10	450
		Aus-T.aman-rabi crops	10	450
	Medium highland	Ishurdi	Aus-T.aman - fallow	10

Limitations and development possibilities

Low organic matter, low nutrient content and shortage of soil moisture in the month of January-February 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 Sara and Gopalpur soil can produce high yield of sugarcane, aus, jute, wheat, mustard, vegetable, tobacco and lentil. With open field drains Sara soils could be used for horticulture crops. Ishurdi soils can produce two transplanted rice crop or one rice crop and wheat per year. These soils are moderately suitable for irrigation.

Mapping unit No. 8 (Sara-Gopalpur, irregular phase)

The area comprises mainly man-made raised platforms occupying 480 ha. About 5 percent area of the unit is occupied by settlements.

Land type and soils

The raised platforms are not flooded by rain or river waster and they belong to highland. The lands between the platforms are shallowly (less than 1 m) flooded by rain water and they belong to medium highland. The raised platforms and the lands between the platforms give rise to a landscape of irregular topography in the area.

The soils occur in the area are predominantly Sara about 80 percent, about 20 percent of the area is occupied by Gopalpur soils. Brief description of soils are given in unit no I.

Present land use

This unit is included in land use mapping unit 2. Double with some rabi and kharif vegetables and single cropped land. Present land use is given in the following table.

Land type	Soil	Cropping pattern	Percent	Area
Highland	Sara	Aus/jute-rabi crops	45	230
	Gopalpur	Rabi and Kharif vegetables	20	100
		Sugarcane	20	100
Medium highland	Gopalpur	T.aman - fallow	10	50

Limitations and development possibilities

Low organic matter, low nutrient content and shortage of soil moisture in the month of January-February reduce the yield of rabi crops.

With small scale irrigation along with the application of organic manure and chemical fertilizers and improved seeds and cultural practices highland soils can produce high yield of aus/jute, vegetables, cotton, mustard and sugarcane. Medium highland Gopalpur soil can produce two transplanted rice crop per year. These made land soils are highly suitable for Fruit trees and vegetables. This soils are marginally suitable for irrigation.

Mapping unit No. 9 (Mehendigonj, medium highland)

This unit occupies shallow small basins in the southern part of the project area. It occupies an area of 300 ha.

Land type and soils

The area comprises small basins which are usually shallowly flooded (less than 1 m) by rain or river water. The basins are gently sloping towards the centre. They belong to medium highland.

The soils occurred in the basins are predominantly Mehendigonj series. They include poorly drained, pale brown, calcareous, silty clay to clay soils. Some light textured soils such as Sukdebpur may occur in the basin margin.

Present land use

This unit belongs to the land use mapping unit 1b. Predominantly double cropped land. Present land use is given in the table.

Land type	Soil	Cropping pattern	Percent	Area
Medium highland	Mehendigonj	Mixed aus and braod-cast aman.	80	240
		Broadcast aman fallow/Rabi crops	20	60

Limitations and development possibilities

Flooding in the rainy season restricts the cultivation of T.aman. Wet in the early and shortage of moisture in the late rabi season does not

allow to grow any other rabi crops except khesary which are grown as a relay crop.

With irrigation along with the application of organic and chemical fertilizers along with improved seeds and cultural practices this soil could produce high yield of boro (MV).

Mapping unit No. 10 (Ghior-Garuri, medium highland)

This unit occupy broad basins in Paba and Godagari upazila. It occupies area of 1,970 ha.

Land type and soils

The area comprises broad basins which are shallowly (less than 1 m) to moderately deeply (1 m - 2 m) flooded by rain and river water. The basins are gently sloping towards the centre. About 80 percent of the area belong to medium highland which 20 percent of the area belong to medium lowland.

The area is mainly occupied by Ghior soils about 60 percent. It comprises poorly drained, dark grey/dark greyish brown, non calcareous clayey soils overlying calcareous loamy or clayey substratum. Garuri soils occupy about 30 percent. Garuri soils comprise poorly drained, dark grey, non calcareous clayey soils overlying calcareous loamy/clayey soils. Rest 10 percent is occupied by Santhia soils. Santhia soils are more or less similar with Garuri soils but with higher clay content.

Present land use

This unit belongs to the land use mapping unit 1a. Predominantly double cropped land. Present land use is given in the following table.

Land type	Soil	Cropping pattern	Percent	Area
Medium highland	Ghior	Aus-T.aman - fallow	20	390
		T.aman - boro	30	590
		B.aman - khesari	15	300
		Sugarcane	5	100
Medium lowland	Santhia	B.aman - khesari	30	590

Limitations and development possibilities

Monsoon flooding restricts the cultivation of T.aman locally in the area. Wet in the early and shortage of moisture in the late rabi season do not allow any rabi crops to grow except khesari.

With irrigation and application of organic and chemical fertilizers along with improved seeds and cultural practices, these soils can produce high yield of boro (MV).

Mapping unit No. 11 (Santhia-Ghior, Medium lowland)

This unit occupies broad basins in the north-western part of Paba upazila, south-eastern part of Godagari upazila and southern part of Tanore upazila. It occupies 5,730 ha.

Land type and soils

The area comprises broad basins which are moderately deeply (1 - 2 m) to deeply (more than 2 m) flooded by rain and river water. The basins appear to be almost level though they are gently sloping towards the centre. About 70 percent of the area belong to medium lowland while 30 percent is lowland.

"Santhia" soils occupy about 70 percent and "Ghior" soils occupy about 30 percent of the area.

Present land use

This unit belongs to land use mapping unit 5a. Predominantly single cropped land. Present land use is given in the following table.

Land type	Soil	Cropping pattern	Percent	Area
Medium lowland	Santhia	Boro -fallow	50	2,870
	Ghior	Broadcast aman-fallow/ khesari	20	1,140
Lowland	Ghior Santhia	Boro -fallow	30	1,720

Limitations and development possibilities

Moderately deep to deep flooding restrict the cultivation of T.aman. Early wetness and late droughtiness also do not allow to grow any rabi crop except khesari.

With irrigation and application of organic and chemical fertilizers along with improved seeds and cultural practices, this soils could produce high yield boro (MV).

Mapping unit No. 12 (Tahirpur-Teghar, made land)

This unit occurs in the middle and northern part of Paba upazila. Minor area occur in south-eastern part of Godagari upazila. This unit occupies 1,070 ha. About 5 percent of the area is occupied by settlements and ponds.

Land type and soils

This unit comprises predominantly man made raised platforms which are above flood level and belong to highland. The lands between the platform are shallowly (less than 1 m) flooded by rain water and belong to medium highland. The raised platforms and the lands in between them give rise to a landscape of irregular topography.

The soils occur in the area are predominantly Tahirpur about 80 percent. It comprises imperfectly drained, pale brown, friable, non calcareous silt loam with weak to moderate structure in subsoil. Rest 15 percent is occupied by Teghar series. Teghar soils comprise imperfectly to poorly drained, mixed yellowish brown and grey, non-calcareous clay loam with moderate structure in the subsoil.

Present land use

This unit belongs to land use mapping unit 2. Double with some rabi and kharif vegetables and single cropped land. Present land use is given the following table.

Land type	Soil	Cropping pattern	Percent	Area
Highland	Tahirpur	Aus/jute-rabi crops	45	500
	Teghar	Rabi and kharif vegetables	20	230
		Sugarcane	20	230
Medium highland	Teghar	T.aman - fallow	10	110

Limitations and development possibilities

Similar to unit - 8.

Mapping unit No. 13 (Teghar-Maria, medium highland)

This unit occurs in the northern part of Paba upazila where it occupies 470 ha.

Land type and soils

This unit comprises level low ridges and inter ridge depressions. They are shallowly (less than 1 m) flooded mainly by rain water. It belongs to land type medium highland.

Teghar soils occupy about 80 percent of the area while 20 percent is occupied by Maria soils. Maria soils comprise olive brown, non-calcareous silty clay soils with moderate structure in subsoil. Minor area is occupied by Tahirpur soils.

Present land use

This unit belongs to land use mapping unit 4c. Mainly single with some double cropped land. Present land use is given in the following table.

Land type	Soil	Cropping pattern	Percent	Area
Medium highland	Teghar	T.aman - fallow	50	240
		T.aman - rabi crops	20	90
	Maria	T.aman - fallow	20	90
		T.aman - rabi crops	10	50

Limitations and development possibilities

Low organic matter, low nutrient content and shortage of soil moisture in rabi season restrict the cultivation of rabi crops.

With irrigation and application of organic and chemical fertilizers along with improved seeds and cultural practices the soils can produce high yield of two transplanted rice crop or one rice crop and wheat per year.

Mapping unit No. 14 (Gulai, medium highland)

This unit occurs in the south east of Godagari upazila where they occupy 140 ha.

Land type and soils

This unit comprises shallow basins, which are flooded upto 1 m in the rainy season. It belongs to medium highland.

Gulai series occupy the whole of unit. It comprises poorly drained dark grey clay soils over Madhupur clay. Minor area may be occupied by Ghior soils.

Present land use

This unit belongs to land use mapping unit 6b. Predominantly single cropped land. Present land use is given in the following table.

Land type	Soil	Cropping pattern	Percent	Area
Medium highland	Gulai	T.aman - fallow	100	140

Limitations and development possibilities

Shortage of soil moisture in the rabi season restricts the cultivation of any rabi crop.

With irrigation and application of organic and chemical fertilizers along with improved seeds and cultural practices this soils could produce high yield of two rice crops including boro per year.

Mapping unit No. 15 (Digli-Jaonia, medium lowland)

This unit occurs in Tanore, Niamatpur and Manda upazila where it occupies 480 ha.

Land type and soils

The area comprises basins in between or adjacent to Barind tract. They are mainly moderately deeply (1 - 2 m) flood, part of the unit is deeply flooded (more than 2 m). The basins are mainly sloping towards east or south east direction. They are flooded by rain and river water. Moderately deeply flooded basins belong to medium lowland while the deeply flooded basins belong to lowland.

The soils occur in the area are Digli about 60 percent. It comprises poorly drained, dark grey, clay soils over Madlupur clay. Jaonia soils occupy about 40 percent of the area. It included dark grey clay soils with strong structure in the subsoils.

Present land use

This unit is included in land use mapping unit 5c. Predominantly single cropped land. present land use is given in the following table.

Land type	Soil	Cropping pattern	Percent	Area
Medium	Digli	Mustard - boro	10	50
highland	Jaonia	Boro - fallow	70	330
Lowland	Jaonia	Boro - fallow	20	100

Limitations and development possibilities

Similar to unit - No. 11.

Mapping unit No. 16 (Jaonia, lowland)

This unit occur in Tanore, Manda and Niamatpur upazila where it occupies an area of 2,340 ha.

Land type and soils

The area comprises board basin which area deeply (more than 2 m) flooded during the monsoon season. The flooding is by both rain and river water. The landscape belongs to the land type lowland.

Jaonia soils occupy the whole of unit. Minor area in the basin margin is occupied by Dohali soils.

Present land use

This unit is included in land use mapping unit 5c. Predominantly single cropped land. Present land use is given in the following table.

Land type	Soil	Cropping pattern	Percent	Area
Lowland	Jaonia	Boro - fallow	90	2,110
Medium lowland	Jaonia	Mustard - boro	10	230

Limitations and development possibilities

Deep flooding restricts the cultivation of T.aman crop.

With irrigation and application of organic and chemical fertilizers along with improved seeds and cultural practices these soils can produce high yield of boro. Early drained soils can be used for mustard before boro cultivation.

Miscellaneous Mapping Unit

Miscellaneous unit includes settlements, water bodies, big ponds and rivers. All the settlements are not possible to separate into mapping units. Same is the case with ponds, rivers and other permanent water bodies. However, settlements, big ponds, water bodies and rivers are separated as mapping units as far as possible.

Settlements occupy about 860 ha., as an independent unit but in unit No. 2, 4, 8 and 12 occupies about 7,450 ha. Therefore total settlements is about 8,310 ha. Very minor part of the land within

settlements are used for agricultural purposes such as homestead garden or fuel production of for fruit trees. Permanent water bodies occupy about 1,190 ha. They occur mainly in the bottom of the high basin areas. Ponds occupy about 720 ha. They are used for supplementary irrigation as well as domestic purpose. Rivers occupy about 410 ha. in the project area.

Total miscellaneous land including settlements, water bodies, big and small ponds and rives occupies together about 10,630 ha.

TABLE I-3-6 SOIL MAPPING UNIT, PERCENTAGE AND AREA (1/3)
STUDY AREA

Mapping unit	Physio-graphy	Area	Non-Agri.	Land type		Agricultural land		Irrigation suitable
				Highland level	Percent	Soil	Percent	
1	Barind Tract	23,920	Minor	Highland level	100%	Nijhuri Ammura Lauta	70% 20 10	Highly suitable
2		58,270	3,070	Highland undulating	95	Nijhuri Ammura Atahar Nachol	60 20 10 5	Moderately suitable
3		3,310	Nil	Highland slopping	100	Ammura Nachol Nijhuri	60 30 10	Moderately suitable
4		12,350	650	Highland rolling	95	Nijhuri Atahar Nachol Ammura	50 20 15 10	Marginally suitable
5		6,900	Nil	Highland valley	100	Nachol	100	Moderately suitable
6		9,120	Nil	Highland valley Medium highland valley	60 40	Nachol Pauli Nachol	60 30 10	Highly suitable