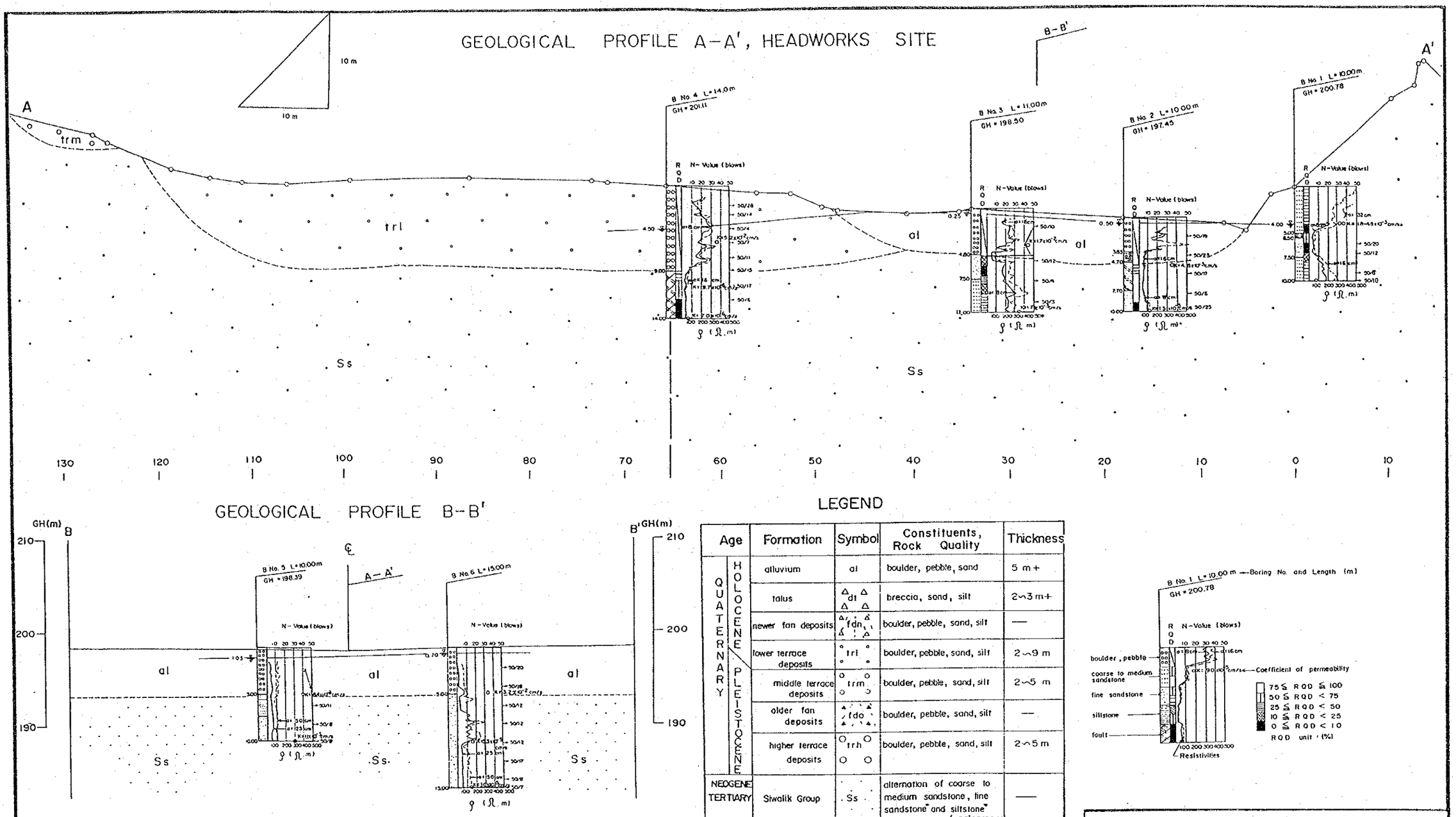


Fig. B. 1. 2 Geological Profiles at the Gudrung Headworks Site

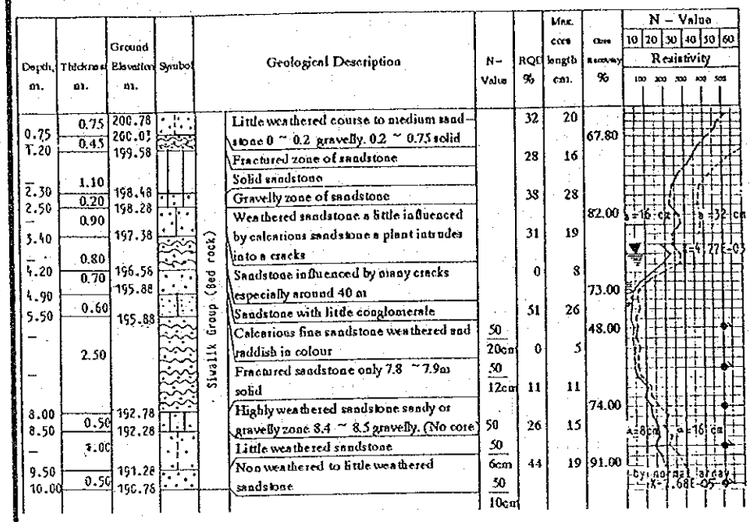
HIS MAJESTY'S GOVERNMENT OF NEPAL

FEASIBILITY STUDY ON
THE RAJKUDWA IRRIGATION
PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

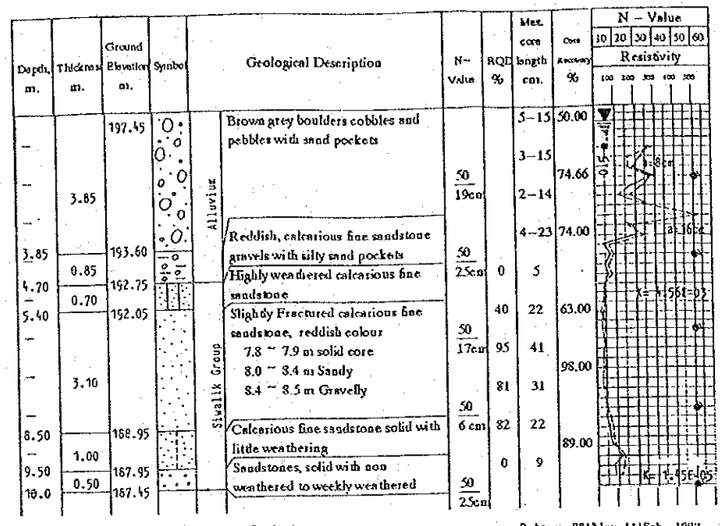
Project : Rajkudwa Irrigation Project
Location : Pattharkot, Kapilvastu
[On the centreline, 2.5 m. right of B.M.]

Borehole : B.No. 1
Elevation, m. : 200.78
Date : 26 – 27 Jan, 1993



Project : Rajkudwa Irrigation Project
Location : Pattharkot, Kapilvastu
[On the centreline, 16 m left of B.M.]

Borehole : B.No. 2
Elevation, m. : 197.45
Date : 21 – 24 Jan, 1993

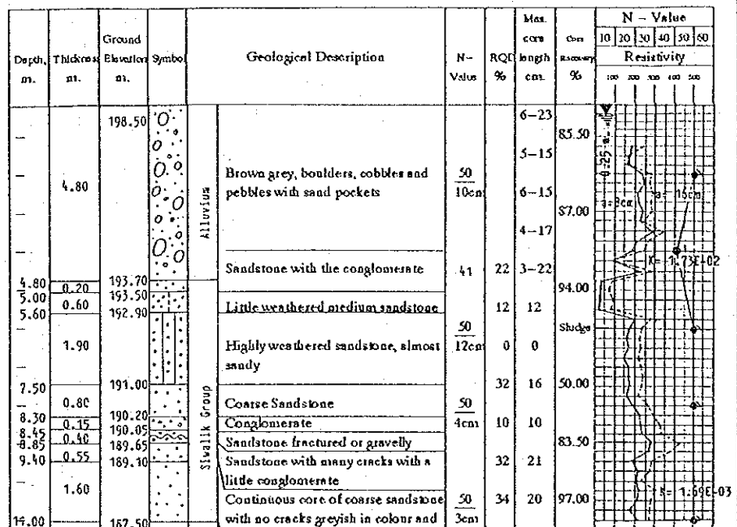


PROJECT : Rajkudwa Irrigation Project
LOCATION : 25m left of BM, 10m downstream (Pattharkot)
DRILLING RIG : KTK 300, Percussion type

Date : 28th Jan-1st Feb. 1993
Borehole No. : 6
Elevation : 198.17m

Project : Rajkudwa Irrigation Project
Location : Pattharkot, Kapilvastu
[On the centreline, 32.0 m left of B.M.]

Borehole : B.No. 3
Elevation, m. : 198.5
Date : 22–25 Jan, 1993



PROJECT : Rajkudwa Irrigation Project
LOCATION : 25m left of BM, 10m upstream (Pattharkot)
DRILLING RIG : KTK 300, Percussion type

Date : 22nd~26th Jan. 1993
Borehole No. : 5
Elevation : 198.39m

Project : Rajkudwa Irrigation Project
Location : Pattharkot, Kapilvastu
[On the centreline, 64 m left of B.M.]

Borehole : B.No. 4
Elevation, m. : 201.11
Date : 27 Jan – 1 Feb. 1993

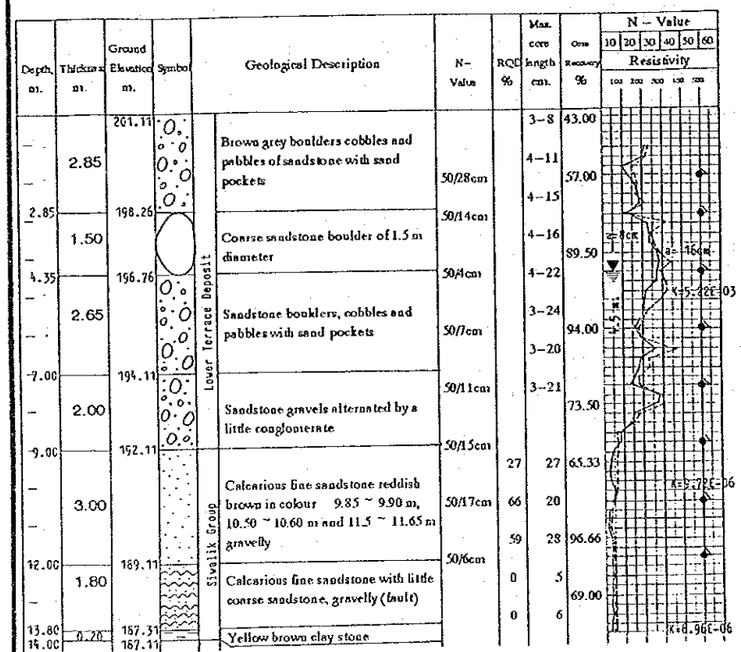
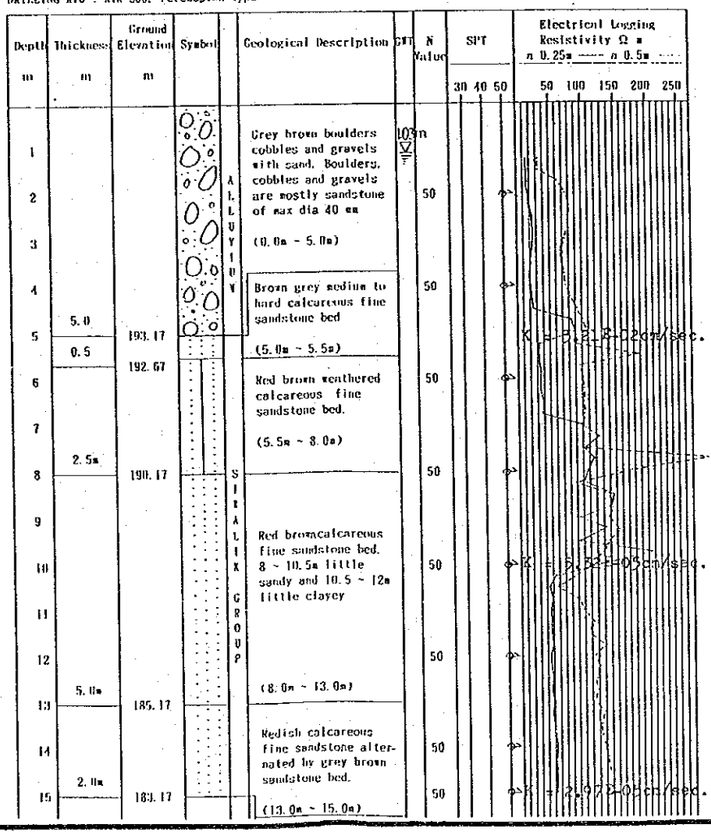
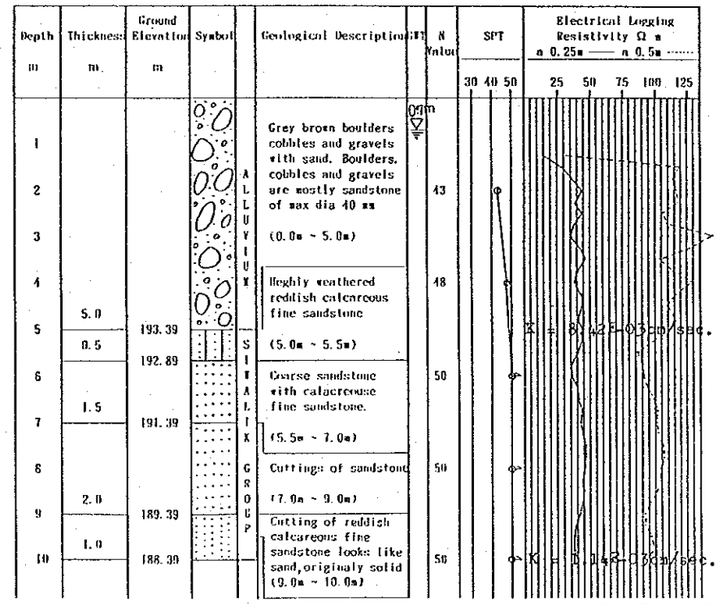


Fig. B.1.3 Log of Boreholes

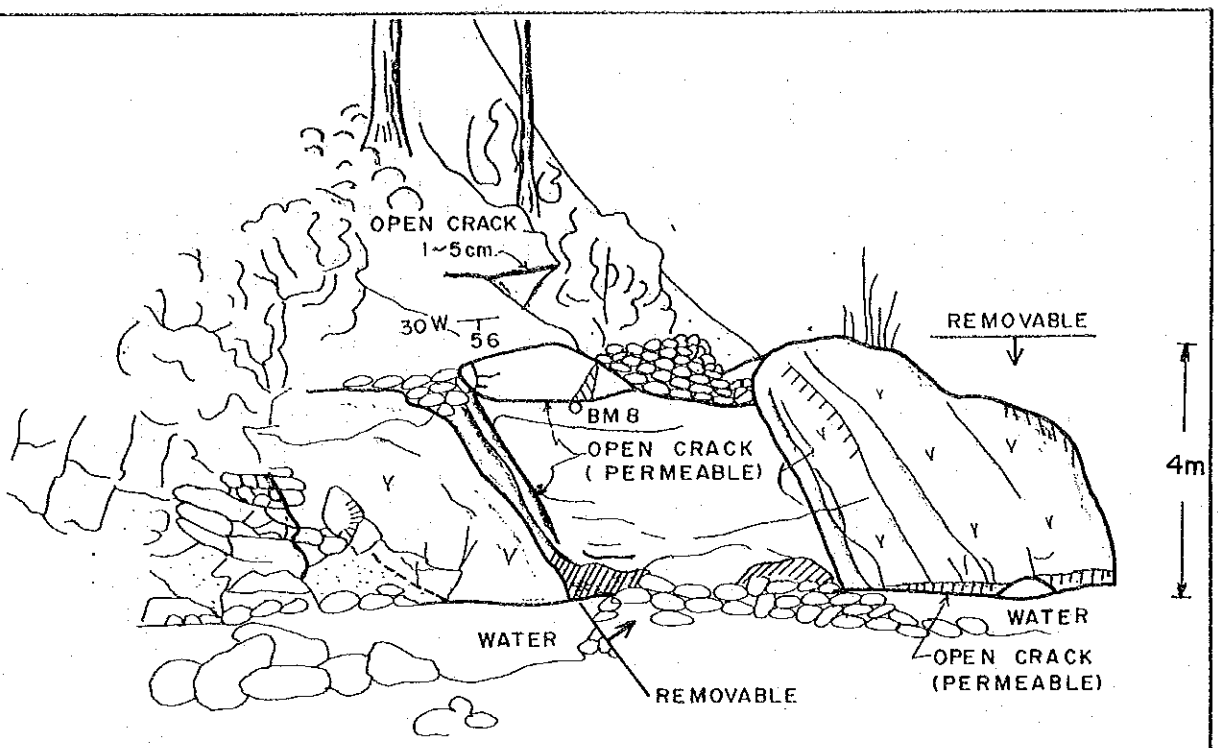




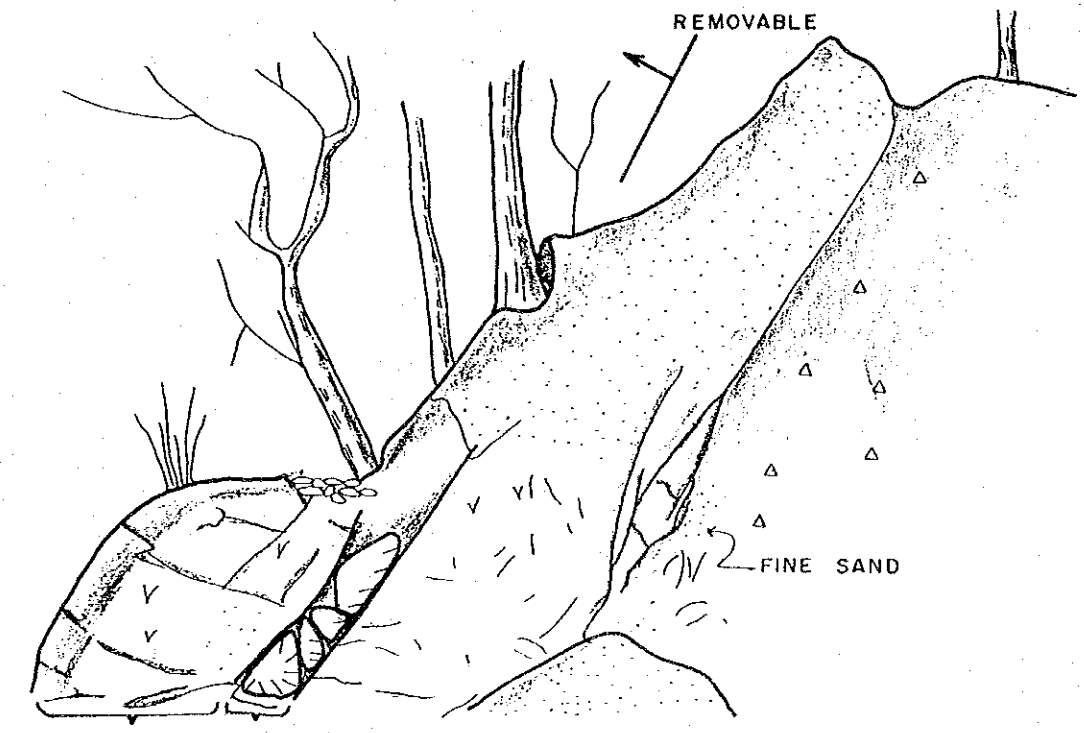
HIS MAJESTY'S GOVERNMENT OF NEPAL

FEASIBILITY STUDY ON
THE RAJKUDWA IRRIGATION
PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY



(a) FROM THE LEFT BANK



(b) FROM THE UPSTREAM

Fig. B.1.4 Schematic Sketch of the Right Bank of the Proposed Headworks Site of the Gudrung River

HIS MAJESTY'S GOVERNMENT OF NEPAL
FEASIBILITY STUDY ON THE RAJKUDWA IRRIGATION PROJECT
JAPAN INTERNATIONAL COOPERATION AGENCY

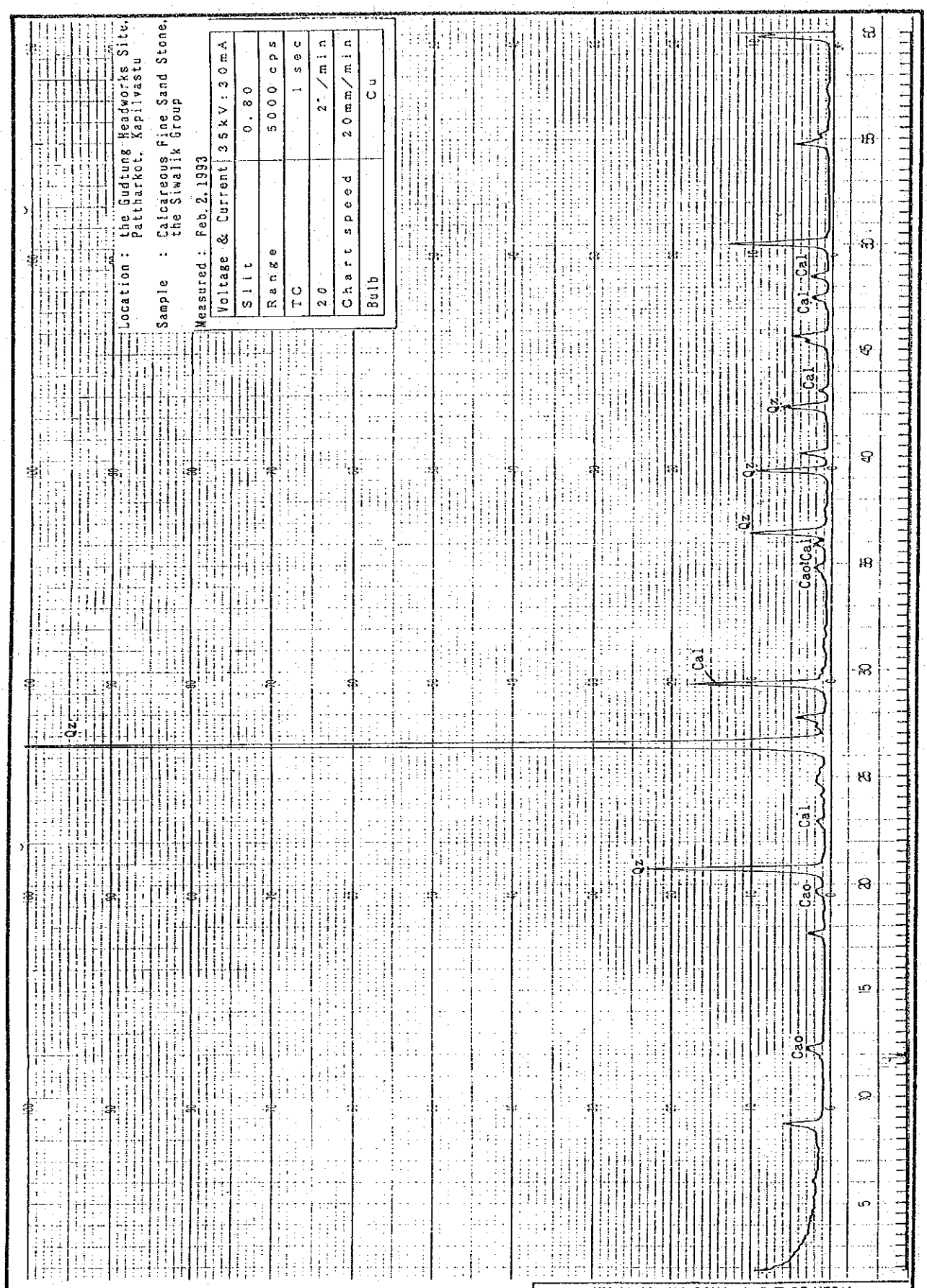


Fig. B.1.5

X-ray Test of Some Rock Samples

HIS MAJESTY'S GOVERNMENT OF NEPAL

FEASIBILITY STUDY ON
THE RAJKUDWA IRRIGATION
PROJECT

JAPAN INTERNATIONAL COORPERATION AGENCY

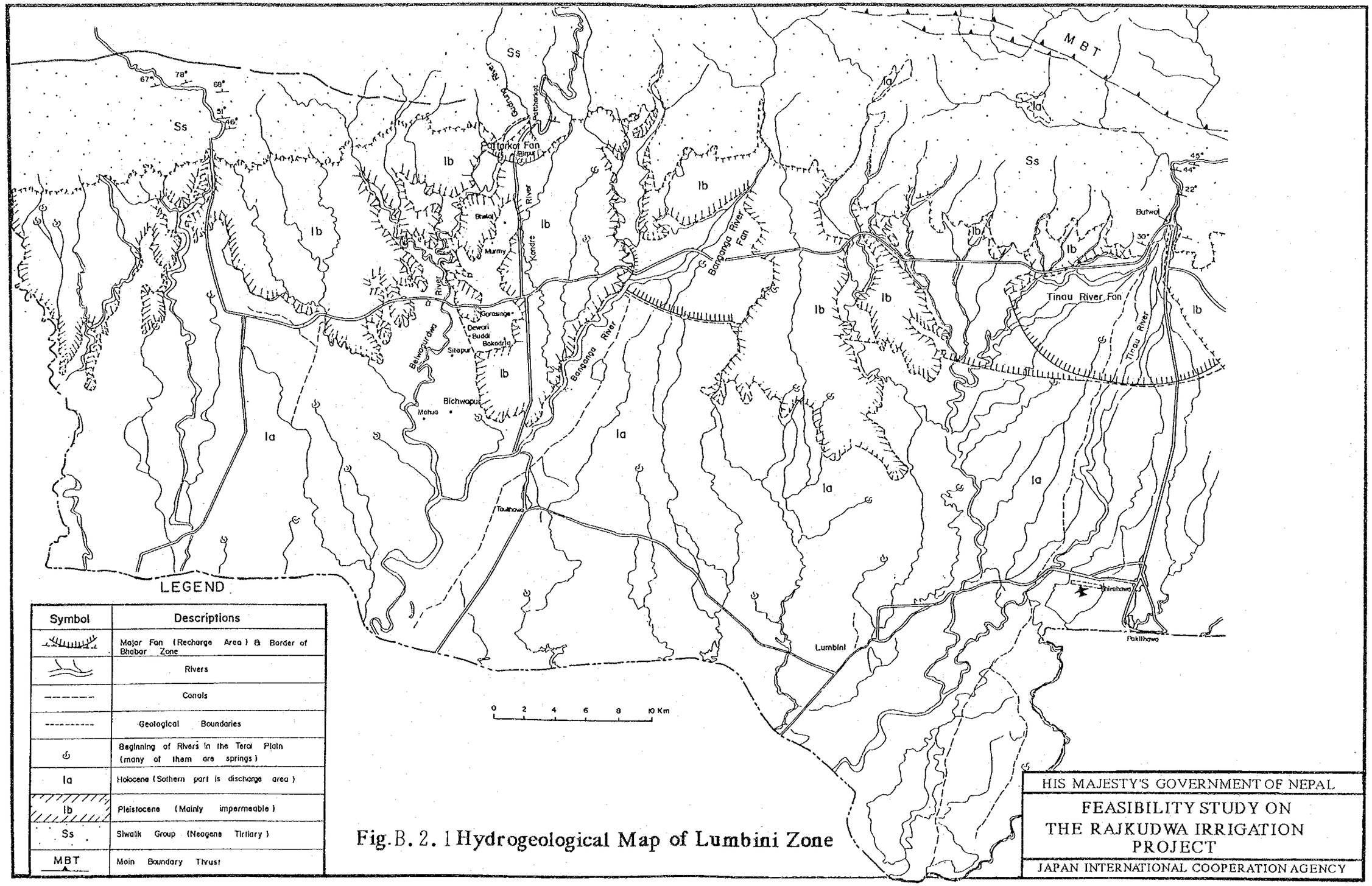


Fig. B. 2. 1 Hydrogeological Map of Lumbini Zone

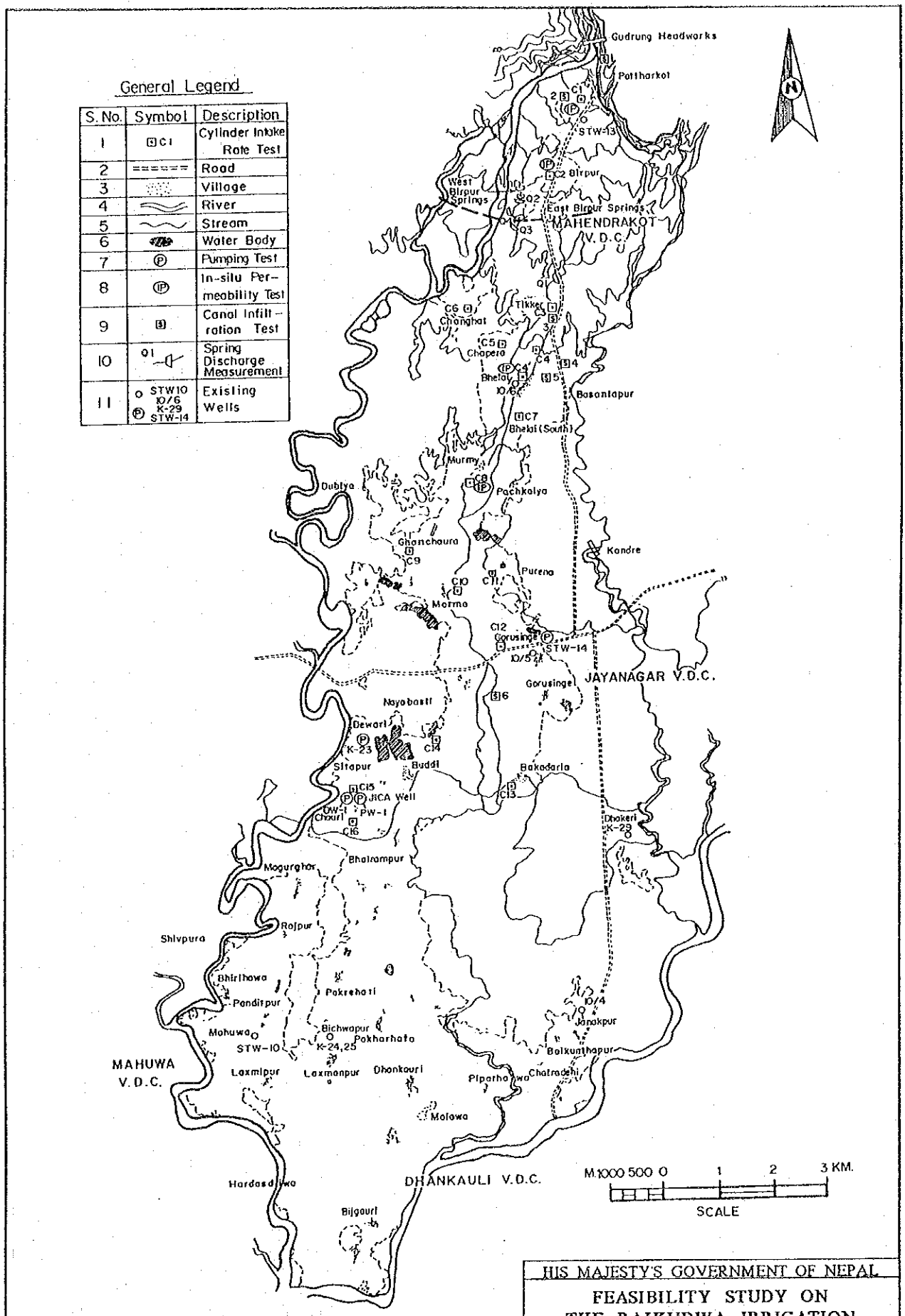


Fig. B.2.2 Location Map of Seepage and Permeability Tests

HIS MAJESTY'S GOVERNMENT OF NEPAL

FEASIBILITY STUDY ON THE RAJKUDWA IRRIGATION PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

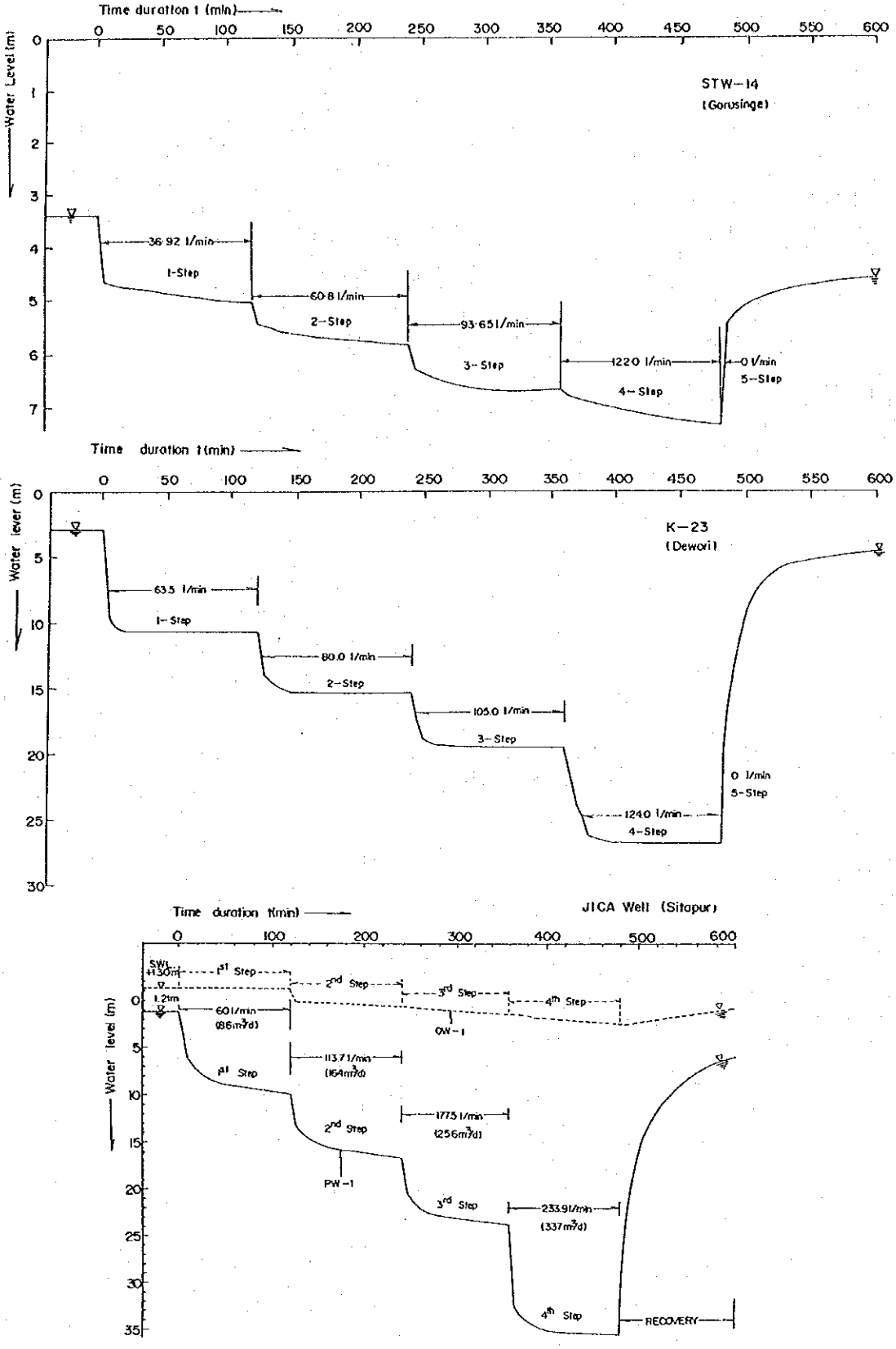


Fig. B.2.3 Step Drawdown Test

HIS MAJESTY'S GOVERNMENT OF NEPAL

FEASIBILITY STUDY ON
THE RAJKUDWA IRRIGATION
PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

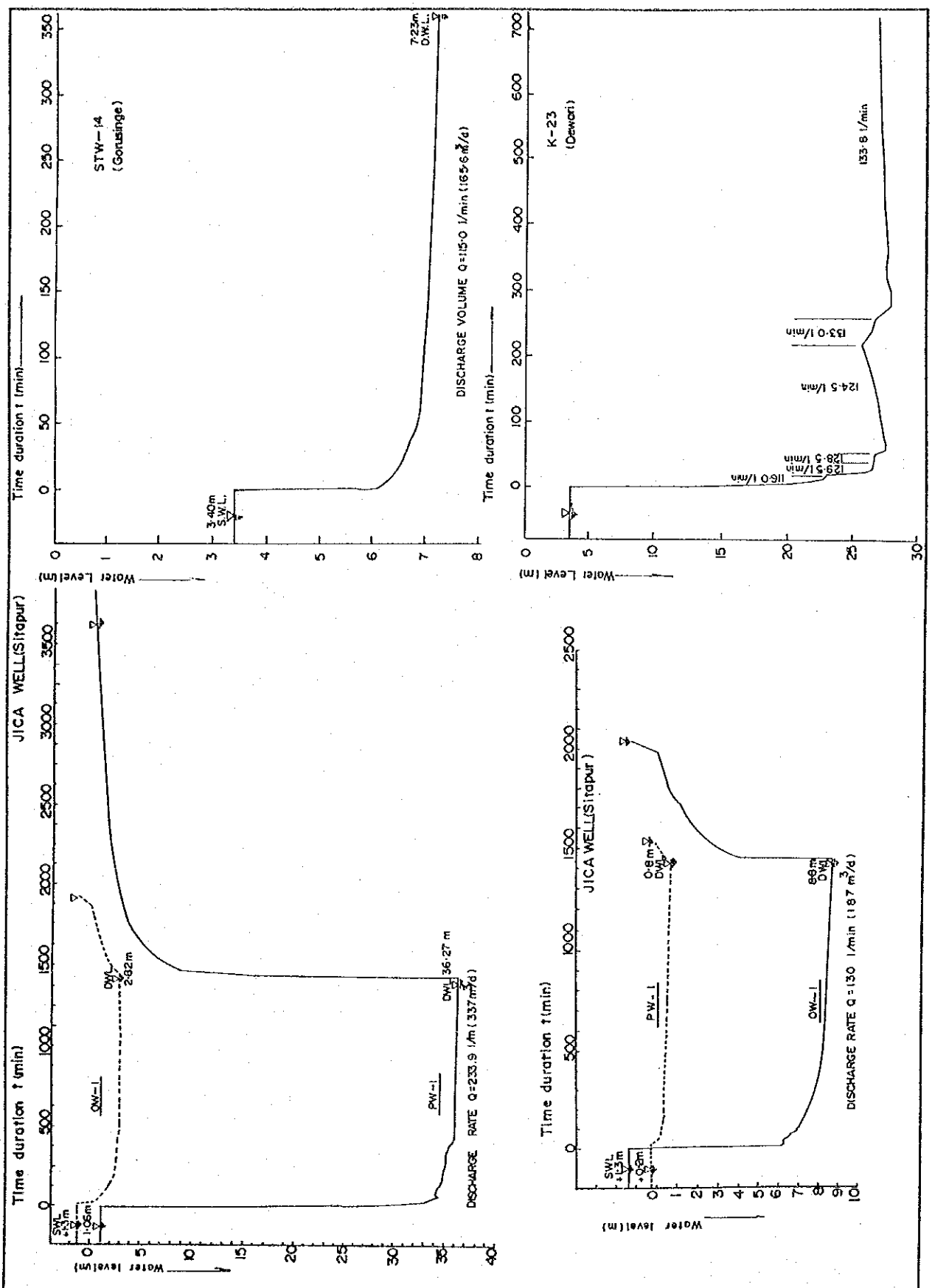


Fig. B.2.4 Continuous Test

HIS MAJESTY'S GOVERNMENT OF NEPAL
FEASIBILITY STUDY ON THE RAJKUDWA IRRIGATION PROJECT
JAPAN INTERNATIONAL COOPERATION AGENCY

ANNEX - C

SOIL AND LANDUSE

ANNEX - C

SOIL AND LANDUSE

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

ANNEX - C SOIL AND LAND USE

C.1 INTRODUCTION

The soil and landuse studies were carried out within a framework of a feasibility study for the Rajkudwa Irrigation Development Project. The study area lies on Terai plain with a total extent of 12,220 ha. The area administratively falls in the Kapilvastu District in the Lumbini Zone of the Western Development Region. The present study consists of three (3) aspects, i.e. landuse analysis, soil study and land evaluation, for which relevant thematic maps were prepared on a scale of 1:25,000. The overall survey methodology is presented in Chapter III.

Firstly, the landuse conditions were surveyed through statistical analysis of agricultural census, aerial photo-interpretation, field investigation and direct interview to local farmers. The study focused on crop selection and cropping intensity in existing farmland, which verified prevailing constraints against rational landuse and induced countermeasures required for maximum exploitation for land resources of the study area. The study results are presented in Chapter IV on Landuse.

Secondly, the soils were observed, described and tested at a laboratory according to the FAO guideline, and classified according to U.S. Soil Taxonomy. The distribution patterns and extents of major soils were illustrated on a semi-detailed soil map with aid of aerial photos. In soil map production, physiographic approach was taken since a high coincidence was recognized between soil distribution patterns and physiographic formation as well as present landuse. Chapter V gives all the details of the soil study.

As a significant step of the present study, thirdly, the results of soil and landuse studies were interpreted and assessed from the viewpoint of irrigation suitability referring to the FAO's publication, namely Framework for Land Evaluation. The land suitability was classified into four (4) grades for both upland crops and paddy. Poor drainage is the most prevailing among land limitations identified in the study area. In the project formulation, therefore, higher priority was given to drainage improvement as well as irrigation water supply. To evaluate the benefit of drainage works under the Project, the land suitability was also re-assessed by assuming that proper drainage improvement would be provided under the with-project conditions. All the study results worked out through land evaluation are presented in Chapter VI.

C.2 GENERAL DESCRIPTION OF THE STUDY AREA

C.2.1 Physiography and Topography

The study area is located between 27° 01' 12" N and 27° 26' 02" N latitudes and 82° 55' 48" E and 83° 01' 26" E longitudes. The area lies between the footslopes of the Siwalik hills in the north and the Terai plain in the south ranging from approximately EL. 200 m at Pattharkot to EL. 100 m at Bishambapur. The study area is flat to gently undulating. The terrain slightly declines from north to south. The main drain of the study area is Ghorahi Nala which flows with NS direction in the center of the study area. It is physiographically classified into active alluvial plain (depositional), recent alluvial plain (depositional and erosional) and piedmont plain apron complex (erosional).

The study area is bordered by Gudrung river in the north west, Kondre river in the east, Belwa-Grudwa river in the west, and Banganga river in the south east. The East - West Highway passes through the study area and divides it into northern and southern parts, as illustrated in Fig.C.5.1.

C.2.2 Geology

The basement rock in the study area is composed mainly of the Siwalik Group sandstone of the Neogene Tertiary. The basement is overlain by terrace deposits, fan deposits, talus deposits, and alluvial deposits of the Pleistocene to the Holocene and the Quaternary. The Siwalik group consists of alternating coarse to medium sandstone and calcareous fine sandstone to siltstone.

The study area is located on mainly the terraces, and is overlain by unconsolidated materials. The southern part of the study area is located on the alluvial plain.

C.2.3 Agro-climate

The study area falls in the subtropical monsoon zone, where the following three seasons are distinguished:

Season	Period	Characteristics
Rainy season	June - September	high temperature, humid
Winter season	October - March	low/moderate temperature, dry
Spring season	April - May	max. temperature nearly 40°C, dry

According to the records at the Taulihawa Meteorological Station, monthly mean temperature varies from 15 °C in January to 31 °C in June, while mean monthly relative humidity fluctuates between 45% and 85%. Annual evaporanspiration ranges from 1,200 mm to 1,400 mm.

Annual mean rainfall for the last 20 years is 2,236 mm in Pattharkot Station. About 86 % of annual rainfall is observed within the four (4) months from June to September. After

the rainy season, sporadic rainfall occurs in October, but a little rainfall is observed in November and December. The rainfall data are summarized as follows:

(Unit : mm)

	Jan. Mean	Feb.	Mar.	Apr..	May	Jun.	Jul.	Aug	Sep.	Oct.	Nov.	Dec.	
Mean	13	15	8	22	85	301	642	560	423	120	13	33	2,236
Max	49	63	28	52	190	655	900	855	683	266	82	79	2,716
Min	0	1	0	0	10	81	418	306	200	0	0	0	1,744

C.2.4 Vegetation and Landuse

At present, 40% of the study area is utilized for farming and the remaining 60% is covered by forests and bush. Forests are seen in the northern part of the study area and along the rivers in the study area. The forests consist entirely of hardwoods, i.e. sal and tropical mixed hardwood(TMH).

C.3 SURVEY PROCEDURE

C.3.1 Review of Previous Studies

Prior to the field investigation, the following data and reports were collected and reviewed.

(1) Land Resource Mapping Project (LRMP)
   i) Land System Report (1986)
   ii) Land Utilization Report (1986)
   iii) Land Capability Report (1986)
(2) Feasibility Study Report on the Rajkudwa Irrigation Project, (1988).
(3) Aerial photographs covering the study area on a scale of 1:25,000 (1990)

LRMP reports deal with the nationwide systematic semi-detailed land classification which provides such information as soil characteristics, landuse situation and soil suitability for major crops under irrigation on the relevant thematic maps on a scale of 1:50,000.

C.3.2 Reconnaissance Survey

In order to grasp present landuse and pedological features of the study area, a reconnaissance survey was carried out in July 1992. Through the review of previous studies, the high coincidence was recognized between physiography and soil formation. In other words, each physiographic unit implies individual geology, topography, soil characteristics, drainage conditions and even landuse. Therefore, the reconnaissance soil survey was performed using a physiographic approach.

Aerialphoto interpretation was fully applied to clarify the surface configuration of the areas as well as landuse features. They also showed the external drainage conditions and the distribution of water bodies. Following the aerialphoto interpretation, the field survey was carried out to confirm its result, and provisional landuse and soil maps were prepared at a scale of 1:25,000.

C.3.3 Field Survey

Referring to the provisional landuse and soil maps prepared through the reconnaissance survey, the landuse survey and the semi-detailed soil survey were carried out during the period from January to February, 1993. The landuse survey was conducted based on field observations and interviews of farmers. The information thus obtained was incorporated into the present landuse map. The landuse categories were defined and their spatial distribution patterns and extents were analyzed with aid of aerial photos.

The sites of soil test pit were selected on the aerial photographs and provisional soil map, taking into account of physiographic and topographic position and accessibility to the sites. Through the field survey, pits of about 100 cm deep were dug at 50 sites and observed according to the FAO publication "Guideline for Soil Profile Description". At the same time,

soil samples were collected from typical soil profiles for the later laboratory test. Finally 30 samples were taken and tested in the laboratory. In order to check the location of soil boundaries in the field, auger boring was also carried out.

C.3.4 Laboratory Test

Laboratory test aims at clarification of the physical and chemical properties of soils in the study area. All of 30 samples collected in the field were analyzed with respect to the following eleven (11) test items;

(1) Physical Analyses
   i) Particle size distribution (soil texture)
   ii) Water holding capacity

(2) Chemical Analyses
   i) pH value
   ii) Electrical conductivity (EC)
   iii) Total carbon content
   iv) Total nitrogen content
   v) Available phosphorus content
   vi) Cation exchange capacity (CEC) at pH 7
   vii) Exchangeable cations, i.e. Ca, Mg, Na and K
   viii) $CaCO_3$ content
   ix) Soluble cations and anions (Ca, Mg, Na and CO_3, HCO_3, Cl)

C.3.5 Classification and Mapping

The soils were classified into soil units according to the legend of Soil Taxonomy (USDA Soil Survey Staff, 1975, Keys of Soil Taxonomy; 1992), and soil mapping units were set up for constructing a systematic legend for the soil map. The highest category of the legend was given by physiographic terms, i.e. piedmont plain, recent alluvial plain, etc. They were further divided according to topographic conditions, drainage conditions, etc. These subdivisions represent mapping units, which consist of one or rarely more soil units. The soil map was prepared on a scale of 1:25,000.

C.3.6 Land Evaluation

Land evaluation is the process of interpretation of the basic information gathered through the soil and landuse survey, i.e. soil, topography, drainage condition, landuse and so on. The land suitability for irrigation farming is graded in accordance with the land classification system defined by the FAO system (Framework for land evaluation, FAO; 1976). The land classification was assessed on the basis of the specific criteria described in the Design manual for irrigation development in Nepal; M4 Soil and Land use report (1990).

On the land evaluation, the distribution and extent of each suitable class for irrigation farming were demarcated on land suitability map scaled at 1:25,000. This information will be used for selection of the many crop alternative in future development plan.

C.4 LANDUSE

C.4.1 Landuse Classification

The present landuse is categorized broadly into (1) Agricultural land and (2) Non-agricultural land. They are further divided into eight (8) landuse types on the basis of the present land situation and cropping pattern, which are associated with topographic conditions, drainage conditions, moisture conditions and farmer's preference. Details on each landuse type is described below:

C.4.1.1 Agricultural Land

Agricultural land is subdivided into the following three (3) landuse types .

(1) Lower Paddy Field
This land is composed of poorly to imperfectly drained soils of fine texture with less than 1 : 100 slope. They are small-sized fields (less than 0.01 ha) with high bunds. They are planted with paddy in the rainy season. In the dry season, most of these fields are cropped by one or two mixed winter crops (wheat, linseed or grass pea), or left as fallow due to poor drainability. To the limited extent they are cropped by winter crop (wheat) and spring crops (maize or manure).

(2) Upper Paddy Field
This is an intermediate land unit between the lower paddy field and the dry fields. These lands are often located in slightly higher areas than the lower paddy fields and the field size is also slightly larger (less than 0.02 ha). Drainability is more favourable than that of the lower paddy fields. Paddy is predominant in the rainy season. Although depending on the availability of water, such crops mustard, wheat, lentil or vegetables are cultivated in the dry season.

(3) Dry Field (Paddy and Upland Crops)
This unit occupies high terrace or gentle slope less than 1:30, and is composed mainly of moderately well drained loamy soils. They are cropped under the rainfed conditions. The dominant crops in the rainy season are paddy or maize, which are partly followed by mustard, pulses, vegetables and fallow in dry season.

C.4.1.2 Non-agricultural Land

Non-agricultural land is subdivided into (i) forest and bush, (ii) pond and swamp, (iii) grazing land, (iv) existing facilities such as small canals, drains and footpath, and (v) others including roads, houses, house yards etc.

Forest consists entirely of hardwoods, which are defined as sal (shorea robusta) and tropical mixed hardwoods (Terminalia tomentosa, Anogeissus latifolia, etc.). They have been degraded by reclamation and lopping for fuel and fodder. Some areas have been

transformed into farmland, some into bush or grassland, and some into replantation forest. At present, the total forest area are composed of high density forest (about 88%), bush or poor density forest (about 12%) and is replantation forest (about 10%)

C.4.2 Present Landuse

The distribution of each landuse type is presented in Fig. C.4.1. The extent of each landuse category is presented in Table C.4.1 and summarized as follows:

Description	North Area of the Highway		South Area of the Highway		Total	
	(ha)	(%)	(ha)	(%)	(ha)	(%)
Agricultural Land:						
Lower paddy field	770	17	2,320	33	3,080	27
Upper paddy field	340	7	1,010	14	1,350	12
Dry field	40	1	90	1	130	1
Sub-total	(1,140)	(27)	(3,420)	(48)	(4,560)	(40)
Non-agricultural Land:	3,410	73	4,250	52	7,660	60
Total	4,550	100	7,670	100	12,220	100

Of 12,220 ha of the study area, 4,560 ha (40%) is agricultural land, of which the dominant type is Lower paddy field (3,080 ha), followed by Upper paddy field (1,350 ha) and Dry field (130 ha). Non-agricultural land (7,660 ha : 60%) is made up mainly of forest and bush (6,440 ha).

C.5 SOILS

C.5.1 General

The field survey and laboratory tests were carried out in accordance with the survey procedure described in Chapter III. During the soil profile survey, 50 test pits were dug in the study area. The location of each test pit is shown in Fig. C.5.1. General information on the 50 test pits is summarized in Table C.5.1 and brief soil profile descriptions are summarized in Table C.5.2. The laboratory test results are presented in Table C.5.3. The soil profile descriptions are presented in Table C.5.4.

C.5.2 Soil Classification

The soils are classified into the following six (s) sub-groups according to Soil Taxonomy (USDA Soil Survey Staff, 1975). :

Soil order	Soil sub-order	Soil great group	Soil sub-group
Entisols	Fluvents	Ustifluvents	Typic Ustifluvents
Inceptisols	Aquepts	Endoaquepts	Aeric Endoaquepts Typic Endoaquepts
	Ochrepts	Ustochrepts	Fluventic Ustochrepts Typic Ustochrepts
Molisols	Ustolls	Haplustolis	Typic Haplustolls

The characteristics of each sub-group identified are summarized below :

Soil Units	Physiography	Topography	Soil Characteristics			Drainability	Landuse
			Color	Texture	Depth		
Typic Ustifluvents	Erosional Terrace	Flat	Olive brown	SL	Mod. deep	Well	Farm land Grassland Forest
Aeric Endoaquepts	Recent Alluvial Plain	Almost flat	Yellowish olive	CL	Deep - Mod. deep	Imperfect	Farm land
Typic Endoaquepts	Recent Alluvial Plain	Slightly concave	Graysh olive	CL	Deeep	Poor	Farm land Swamp
Fluventic Ustochrepts	Piedmont Plain	Gently undulating	Dark graysh yellow - Olive brown	SiL	Deep	Imperfect - Mod. well	Farm land Forest
Typic Ustochrepts	Old Terrace Terrace Remnant	Gently undulating Slightly convex	Brownish black - Olive brown	SiL	Deep	Imperfect - Mod. well	Farm land Forest
Typic Haplustolls	Piedmont Plain Old Terrace	Undulating	Brownish black	L	Deep	Mod. well	Forest

(1) Typic Ustifluvents

Typic Ustifluvents represent mostly recent alluvium and are in pedgenetic undevelopment on the erosional terrace (lower river terrace) which is frequent

flooded. They are moderately deep with olive brown color. The soil texture is sandy loam to sand. The drainability is generally moderately well to well.

(2) Aeric Endoaquepts
Aeric Endoaquepts are recent alluvium on the flat plain in the recent alluvail plain area. The soils of them are deep with yellowish olive color. The texture is silty loam to silty clay loam. The drainability is imperfect drainage.

(3) Typic Endoaquepts
Typic Endoaquepts are also recent alluvium on the depressional plain in the recent alluvial plain area. The soils of them are graish olive with clay texture and deep. The drainability is poor to imperfect drainage.

(4) Fluventic Ustochrepts
Fluventic Ustochrepts are made up alluvium and colluvium on the piedmont plain which has gentle solop and undulation. The soils of them are deep with loamy texture. The soil color varies from dark graysh yellow to olive brown in sub-surface horizon. The drainability ranges imperfect to moderately well, depending on the topographic condition and presence of hard pan. They are found both under forest field and cltivated field.

(5) Typic Ustochrepts
Typic Ustochrepts are made up old alluvium on the old terrace with gently undulation and on the terrace remnant with slightly convex. The soil charactors of them are very similar to Fluventic Usochrepts. They have deep effective soils and loamy texture with brownish black to olive brown color. The drainability is imperfect to moderately well drainage. They are also found both under forest field and cultivated field.

(6) Typic Haplustolls
These soils in the study area are developed under the mixed hardwood forests which are on the piedmont plain and old alluvium. The soils of them are deep with brownish black color, which varies to yelowish brown in sub-surface layer. Texture of these soils is loamy (loam to sandy loam) and drainability is moderately well to well.

C.5.3 Soil Map Legend

C.5.3.1 Legend Composition of Soil Map

The soil mapping units are grouped according to their physiographic positions and the parent materials as follows:

(1) Piedmont Plain (F)
(2) Old Terrace (Upland) (U)
(3) Alluvial Plain (P)
(4) Erosional Terraces (ET)

The four (4) physiographic units are further divided into nine (9) soil mapping units on the basis of their topographic conditions, landuse conditions and vegetation cover. The correlation between the soil units and mapping units are shown in following table, and main features of each mapping unit are explained below:

Physiographic Feature	Land types	Mapping symbol	Associated type	Correlative soil units
Piedomont Plain	Open land	F1	Consosiation	Fluventic Ustochrepts minor Aeric Endoaquepts
	Forest	F2	Association	Fluventic Ustochrepts Typic Haplustolls
Old Terrace	Open land	U1	Consosiation	Typic Ustochrepts
	Forest	U2	Association	Typic Ustochrepts, Typic Haplustolls
Recent Alluvial Plain	Terrace Remnant	P1	Consosiation	Typic Ustochrepts
	Flat plain	P21	Consosiation	Aeric Endoaquepts
	Depressional plain	P22	Consosiation	Typic Endoaquepts, minor Aeric Endoaquepts
	Old river course	P3	Consosiation	Fluventic Ustochrepts, minor Aeric Fluvaquents,
Erosional Terrace	Lower Terrace	ET	Consosiation	Typic Ustifluvents

C.5.3.2 Mapping Unit Description

(1) Piedmont Plain (F)

The soils belonging to the piedmont plain lie on the footslopes of the Siwalik hills in and around Pattharkot and Birpur area. The piedmont plain is gently sloping from north to south and partly undulating in east and west. According to the landuse condition, this unit is divided into two soil map units : Open Land (F1) and Forest Land (F2).

(2) Old Terrace (U)

Old terraces are found along Gudrung river, Kondre river and Belwa-grudwa river, and has a slightly higher elevation than the alluvial plain (P). Topography of the old terrace is slightly undulating in east and west. Old terrace also is sub-divided into two sub-units according to landuse condition: Open land (U1) and Forest land (U2).

(3) Recent Alluvial Plain (P)

The recent alluvial plain consists of four (4) physiographic units (mapping units) , i.e. Terrace Remnant (P1), Flat Plain (P21), Depressional Plain (P22) and Former River Course (P3). It is assumed that the recent alluvial plain has been formed by deposition and erosion from the floods on the old terrace. The recent alluvial plain is widely located from Tikker village to the southmost end of the study area (the confluence of Banganga river and Belwa-grudwa river).

Terrace remnant (P1) areas are the convex land which is slightly higher land in the plain. It is supposed that the terrace remnant is natural land that has not been affected by flood . Therefore, most villages and roads in the study area are located on this unit.

Flat plain (P2) areas are almost flat with gradients of less than 1%. They occupy most of the plain area, which means that they also occupy the major part of the study area. This unit is divided into two land types according to topographic and drainage conditions, i.e. level land (flat plain, P21) and slightly concave land (depressional plain, P22).

Old river course (P3) areas are old river or stream lines. Therefore, this unit is located in lower position than other plain areas and the shape, from bird's-eye view, is like one wavy line.

(4) Erosional Terrace (ET)
Erosional terrace is lower river terraces, which are frequently subjected to severe flooding.

The mapping units of the study area are shown in Table C.5.5 and the cross sections of these units are presented in Fig. C.5.2. The area and their proportional extention of the above mapping units are shown in Table C.5.6 and summarized in the following table. The soil map depicting the each mapping unit is shown in Fig. C.5.3.

Physiographic feature (map symbol)	North Area of the Highway		South Area of the Highway		Total	
	(ha)	(%)	(ha)	(%)	(ha)	(%)
Piedmont plain (F)						
Open field (F1)	150	3	0	0	150	1
Forest field (F2)	640	14	0	0	640	5
Old Terrace (U)						
Open field (U1)	70	1	130	2	200	2
Forest field (U2)	2,480	55	3,400	44	5,880	48
Recent Alluvial Plain (P)						
Terrace remnant (P1)	260	6	790	10	1,050	9
Flat plain (P21)	580	13	2,250	29	2,830	23
Depressional plain (P22)	360	8	780	10	1,130	9
Old river course(P3)	0	0	20	0	20	0
Erosional Terrace (ET)	10	0	300	4	310	3
Total	4,550	100	7,670	100	12,220	100

C.5.4 Physical and Chemical Properties of Soils

The laboratory tests for physical and chemical properties were carried out about the typical soils. The results of laboratory test are shown in Table C.5.3.

(1) Soil Textures
Soil texture classes are defined on the basis of particle size distribution. The texture is the most permanent characteristic of the soil. It influences a number of the other soil properties, e.g. structure, consistency, water holding capacity, permeability, infiltration rate, run-off rate, erodibility, workability, root penetration and fertility.

As shown in Table C.5.3, the soils of the study area have generally a fine texture, which range from fine loam to silty clay loam. The soils of the piedmont plain and old terrace are rather coarser and the soils of the plains in the recent alluvial plain are finer.

(2) Soil Reaction (pH) and Salinity (EC)

The pH values of soils in the study area generally are slightly high, ranging from 6.1 to 8.3. However, as the values have presumably resulted from the presence of earth carbonate or calcareous irrigation water, it assessed that the soils are not sodic and permissible for irrigation farming, especially paddy.

The electrical conductivity gives a measure of the soluble salts that are present in the soil solution. All samples of soils in the study area showed very low levels of salts, ranging from an EC (1:2.5) value of 0.02 to 0.34 mS/cm in situ. In addition, since the irrigation water is not saline, a salinity problem will not be expected in the study area.

(3) Cation Exchange Capacity (CEC) and Base Saturation

CEC and base saturation values represent the nutrient condition of soils. CEC is essentially a property of the colloidal fraction of soil, derived mainly from the clay and organic matter fractions, although silt-sized particles sometimes contribute significantly.

CEC of the soils in the study area ranges from 7.1 to 17.2 me/100g, indicating a low to medium cation exchange capacity. This corresponds with low organic matter and clay types. Soil texture and clay type cannot be easily changed, the main strategy to maintain higher CEC and therefore a better buffered soil system, involves the maintenance of soil organic matter.

The base saturation percentage gives the ratio of basic cations to the total exchange capacity. The values of soils in the study area are generally high, around 100%. However, these values are mainly the result of the presence of exchangeable calcium, the ratio of the other cations (Mg, K etc) is at a very low level. Therefore, to improve the nutrient condition of the soils manure and fertilizer should be applied.

C.6 LAND EVALUATION

C.6.1 General

Land classification is defined in terms of the suitability of lands for crop production. In the study area, land classification was assessed based on the kind and degree of limitation or restriction of the soils odtained from the data collected by field observation and the results of chemical and physical analyses. Prior to the land classification, the following assumptions were made :

(1) An optimum amount of water can be supplied to all the study area by the irrigation system.
(2) Inherent fertility of soils is not considered as a major factor. The soils can be made productive by the application of suitable soil management practices.
(3) Distance to market, accessibility, regional location, skill or resources of farmers are not considered in the criteria for classification ratings.

C.6.2 Classification System

Land classification for irrigation farming was carried out according to the FAO system (Framework for land evaluation, FAO, 1976). In this system, land suitability classes reflect degrees of suitability or limitation by using three categories, i.e. orders, classes, and sub-classes.

C.6.2.1 Orders

Orders are the highest categories and reflect the kind of suitability such as suitable or non-suitable.

(1) Suitable : S
Land on which the sustained use of irrigation farming are expected to yield benefits which justify the inputs and costs, without unacceptable risk of damage on the project area.

(2) Non-suitable : NS
Land which has qualities that appear to preclude use of irrigation farming.

C.6.2.2 Classes

Classes reflect degrees of suitability. The classes are numbered in sequence of decreasing degrees of suitability within the order. The suitable order is subdivided into three classes, and non-suitable order has two classes.

Class 1 : (S1 and SR1) : Highly Suitable
Land having no significant limitations to sustained irrigation farming, or only minor limitations that will not significantly reduce agricultural production or benefits and will not raise inputs and costs above an acceptable level.

Class 2 : (S2 and SR2) : Moderately suitable

Land having limitations which, in aggregate, are moderately severe for sustained irrigation farming; the limitations will reduce agricultural production or benefits, and increase required inputs and costs though an overall advantage will be gained. This class is still, however, considered.

Class 3 : (S3 and SR3) : Marginally Suitable

Land having limitations which, in aggregate, are sever for sustained irrigation farming and will greatly reduce agricultural production and benefits or increase required inputs and costs. Expenditure will be only marginally justified for this class.

Class 4 : (NS1/NSR1) : Currently Unsuitable

Land having limitations which may be surmountable in time, but which can not be corrected, at present, with existing knowledge at an acceptable cost; the limitations are so sever as to preclude successful sustained irrigation farming.

Class 5 : (NS2/NSR2) : Permanently Unsuitable

Land having limitations which appear so severe as to preclude any possibilities of successful sustained irrigation farming.

C.6.2.3 Specific Criteria (Subclasses)

Each of the above mentioned suitability classes is divided into sub-classes which reflect kinds of limitations. In other words, the land suitability classes are graded according to the limitations defined as sub-classes. These limitation factors are presented below:

(1) Soil deficiencies (Symbol "s")
  i) Soil Texture
  ii) Soil Depth
  iii) Alkalinity
  iv) Salinity
(2) Drainage (Symbol "d")
(3) Topography (slope) (Symbol "t")
(4) Vegetation (Symbol "v")
(5) Flood Risk (Symbol "fr")

Table C.6.1 gives the specific criteria for paddy and upland crops, which were adapted from Design Manuals for Irrigation Project in Nepal (M4 Soil and Landuse Manual, 1990). The following deals with further details of the land qualities concerned.

(1) Soil Texture

For paddy, the texture of the soil should be finer since low permeability is favorable. For upland crops, coarse textured soils such as sandy loam to friable clay loam, are highly suitable.

Most of the soils in the plain(P2) have favorable soil texture for paddy. On the other hand, the soils of the piedmont plain (P), old terrace (U) and terrace remnant (P1)

have a moderately coarse texture which is basically suitable for upland crops. However, because of the presence of the hard rice pan, even coarse soils are moderately suitable for paddy.

Most of the soils in the study area are thick enough for the minimum requirements of soil depth: 100 cm for upland crops and 30 cm for paddy.

(2) Alkalinity and Salinity

The soil pH is one of the most important factors for the evaluation of the land suitability. Each class is presented below:

Class	pH(H_2O)
Extremely acid	< 4.5
Strongly acid	4.5 - 5.5
Slightly acid	5.5 - 6.5
Neutral	6.4 - 7.3
Moderately alkaline	7.3 - 8..5
Alkaline	8.5 - 9.0
Very strongly alkaline	9.0 <

The pH values of top soils in the study area were tested by the field tests. The pH values were generally high and they ranged between 5.4 and 10.0. High pH value soils rarely occured in the drought lands in the south of study area. As mentioned in section C.5.4, the high pH values are resulted from the non-sodic materials which are earth carbonate or calcareous irrigation water, and they also occupy a very minor portion of the study area, therefore the alkalinity will not become a major problem in the study area.

The soil salinity is also an important factor in evaluation of the land suitability. The electrical conductivity (EC) can be used to indicate the soil salinity classes. The EC values of all samples were measured in extraction from a soil - water (1:2.5) suspension. However, ECe values, which are widely used for the interpretation of measurement, are EC values of the saturated extract. Therefore, because of the different dilution, the EC (1:2.5) values can not be interpreted directly to the salinity scale through the ECe values. By applying a rough conversion factor of 3, the salinity limitation was assessed based on the laboratory test results and field test results. Each salinity class is described below:

(Unit : mS/cm)

Class	ECe
Non-saline	0 - 2
Slightly saline	4 - 8
Moderately saline	8 - 15
Strongly saline	> 15

*1: ECe is the EC value of the saturated extract.

The ECe values calculated using the above conversion factor were very low, ranging between 0.06 and 1.5 mS/cm. All of the soils in the study area were classified as non-saline soil.

(3) Drainage

Soil drainage refers to the rapidity and extent of the removal of water from the soil especially by surface runoff (External drainage) and by flow through the soil (Internal drainage: Permeability). Six drainage classes are defined in broad terms as follows:

1. Very poorly drained	The soils are wet enough to prevent the growth of important crops (except paddy) without artificial drainage.
2. Poorly drained	Artificial drainage is generally necessary for upland crops production, provided that other soil characteristics are favorable, but suitable for paddy.
3. Imperfectly drained	The growth of upland crops is restricted to a marked degree, unless artificial drainage is provided. At the same time, the soils of these class can retain enough of water for paddy.
4. Moderately well and Well drained	The soils of these classes are suitable for upland crops in terms of the retaining optimum moisture for plant growth after rains or additions of irrigation water. But these are moderately suitable or unsuitable for paddy.
5. Somewhat excessively drained	Only a narrow range of crops can be grown on these soils, and the yields are usually low without irrigation.
6. Excessively drained	Enough precipitation is commonly lost from these soils to make them unsuitable for ordinary crop production.

In the study area, the soils of the piedmont plain, old terrace and terrace remnant are classified into classes 3 and 4. On the other hand, the soils of the plain in the recent alluvial plain are of the drainage classes of 2 and 3.

(4) Topography

This limitation is due to unfavorable relief, especially slope. This limitation indicates the possibility of the erosion and/or the necessity of soil conservation. Since the paddy field is terraced and it has the function of preventing the erosion, this limitation is mostly adapted to upland fields. The classes are described below:

Slope class (%)		Description
I	< 2 (< 1°)	Generally suitable for surface irrigation without special measures,provided that 1) microtopographic variation is not too irregular. and 2) the land is not too flat (<0.01%).
II	2 to 15 (1° to 8°)	Land that can be surface irrigated using routine soil conservation measures (bunds, contour ridges, etc) and mechanized husbandry methods without major constructions.
III	15 to 35 (8° to 20°)	Land that needs bench terracing with moderate cost for irrigated agriculture.
IV	35 to 60 (20° to 30°)	Land that needs bench terracing and other soil conservation measures involving heavy capital investment for very careful surface irrigation.
V	> 60 (> 30°)	Upper limit for all terrace cultivation; these lands should be reserved for forestry as a soil conservation measure to prevent excessive erosion.

The piedmont plain and old terrace lands have the slope of class II and the recent alluvial plain lands have the slope of class I. The present landuse in the study area are paddy field and forest. Since the bunds and counter ridges have been already constructed in cultivated land, the hazards from erosion are less. However, the management restriction is still remaining in the piedmont plain and old terrace because of steep terraced and small sized fields, therefore their lands are graded down to class II.

(5) Vegetation

This factor indicates the degree of land clearing. Vegetation covers ranges from grass to dense forest. This variation directly relates to the clearing cost and impact to the environment. Especially, since the Nepalese government regulation prohibits the cutting down of trees for new cultivation, this factor becomes the major limitation for irrigation development. Forests also play an important role in providing food for livestocks as well as timber product and fuel.

Forests cover 60% of the study area, which are on the piedmont plain and old terrace, are therefore classified into non-suitable land for irrigation development.

C.6.3 Results of Land Evaluation (Irrigation Suitability)

The appraisal of land suitability are made both for paddy and upland crops. Table C.6.2 gives the distribution of suitability classes with sub-classes. A land suitability map is presented in Fig. C.6.1. The following tables summarize them.

Paddy	(ha)	(%)	Upland Crops	(ha)	(%)
SR1	2,830	23	S1	1,070	9
SR2	2,560	21	S2	3,180	26
SR3	310	3	S3	1,450	12
Sub-total	(5,700)	(47)	Sub-total	(5,700)	(47)
NSR	6,520	53	NS	6,520	53
Total	12,220	100	Total	12,220	100

Of the study area, 5,700 ha (47%) are suitable for paddy and upland crops cultivation by irrigation. 2,830 ha (23%) are highly suitable for paddy and 1,070 ha (9%) are highly suitable for upland crops, 2,560 ha (21%) are moderately suitable for paddy, and 3,180 ha (26%) are moderately suitable for upland. 310 ha (3%) are marginaly suitable for paddy, and 1,450 ha (12%) are marginaly suitable for upland crops. Non-suitable land, which consists of forests, occupies 6,520 ha (53%) of the study area.

The poor drainability is the major limitation for irrigation farming in the study area, and it make low grads of the suitability classes, especially for upland crops.

However, if the drainage network is provided and adequately operated and maintained, the land suitability classes of both P21 and P22 will be upgraded, e.g. from SR1/S2d to SR1/S1 and SR2d/S3d to SR1/S2d. As a result of construction of the drainage system, the land suitability can be classified as the following table, and the detales are shown in Table C.6.2.

(ha)

Paddy	With drainage system		No drainage system		Upland crops	With drainage system		No drainage system	
	(ha)	(%)	(ha)	(%)		(ha)	(%)	(ha)	(%)
SR1	3,970	32	2,830	23	S1	3,900	32	1,070	9
SR2	1,420	12	2,560	21	S2	1,490	12	3,180	26
SR3	310	3	310	3	S3	310	3	1,450	12
Sub-total	(5,700)	(47)	(5,700)	(47)	Sub-total	(5,700)	(47)	(5,700)	(47)
NSR	6,520	53	6,520	53	NS	6,520	53	6,520	53
Total	12,220	100	12,220	100	Total	12,220	100	12,220	100

The above results show the need of provision of not only an irrigation system but also a drainage system for intensive use of the study area.

C.7 THE PROJECT AREA

C.7.1 Landuse

The landuse of the project area (gross mapping area of irrigation area) is shown in Table C.4.1 and summarized below:

Landuse	Project Area*1	
	ha	%
Net Agrricultural Land		
Lower Paddy	1,340	61
Upper Paddy	450	21
Dry Field	50	2
Sub-total	(1,840)	(84)
Non-agricultural Land		
Grazing land	40	2
Existing facilities	160	7
Others(Roads, Houses House yards, etc.)	150	7
Total	2,190	100

emark:*1: Total project area is gross mapping area including non irrigated area

The development plan includs both the rehabilitation of existing ponds and construction of new ponds in natural forest area, and canal lines and drainage lines are also constructed. Hence, accompanied by the construction of them, the landuse in and around the project area will be changed as follows:

(unit : ha)

	Befor project	After project
Agricultural land	1,840	1,800
Non-agricultural land		
Forest	110	0
Ponds	50	160
Grazing	40	40
Facilities	160	200
Others	150	150
Total	2,350	2,350

C.7.2 Soils

The extent areas of each soil mapping unit are shown in Table C.5.6 and summarixed as follw:

Mapping Unit	Project Area*1	
	ha	%
F1	150	7
U1	90	4
P1	450	21
P21	960	44
P22	530	24
ET	20	0
Total	2,190	100

Remark:*1: Total project area is gross mapping area including non irrigated area

C.7.3 Land Evaluation

Land evaluation (irrigation suitability) is assessed on the basis of the above results. As the mentioned in section 6.3, the drainability is major limitation factor in the study area. Therefore, the land evaluation is also reassessed on both of the project conditions with proper drainage works and without drainage works. The result is presented in Table C.6.3, and summarized as follw:

Paddy	Without drainage system		With drainage system		Upland	Without drainage ystem		With drainage system	
	(ha)	(%)	(ha)	(%)		(ha)	(%)	(ha)	(%)
SR1	960	44	1,490	68	S1	450	20	1,410	64
SR2	1,220	56	690	32	S2	1,200	55	770	35
SR3	10	0	10	0	S3	540	25	10	0
Total	2,190	100	2,190	100	Total	2,190	100	2,190	100

TABLES

Table C.4.1 Land Use in Study Area

Landuse Category	North area of East-Weat Highway		South area of East-Weat Highway		Total		Project Area *2	
	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)
Agricultural land								
Lower paddy field	770	17	2,320	30	3,080	25	1,340	61
Upper paddy field	340	7	1,010	13	1,350	11	450	21
Dry land	40	1	90	1	130	1	50	2
Sub-total	1,140	25	3,420	44	4,560	37	1,840	84
Non-Agricultural land								
Forest & Grassland	3,090	68	3,350	44	6,440	53	0	0
Pond	30	1	50	1	80	1	0	0
Grazing land	40	1	110	1	150	1	40	2
Existing facilities*1	100	2	300	4	400	3	160	7
Others(Road, Houses, House yard, etc.)	150	3	440	6	590	5	150	7
Total	4,550	100	7,670	100	12,220	100	2,190	100

Remarks: *1 : Including existing small canal, farm foot path, field band.

*2 : Project area is gross mapping area including non-irrigated area, i.e. grazing lands, existing facilities, roads and villages.

Table C.5.1 General information of test pit sites

No.	Location	Physiography*1	Topography	Slope (%)	Drainability *3 internal	Drainability *3 external	Land use / Vegetation*2
1	Pattharkot	F	gent. undulating	<5	moderate	mod. well	P - M
2	Birpur west	F	gent. undulating	<3	moderate	mod. well	P - M
3	Birpur east	F	undulating	<5	moderate	poorly	P - F
4	Birpur east	F	undulating	<5	mod. rapid	mod. well	P - W
5	Bhelai north	P	slight. concave	<1	v. slow	poorly	P - F
6	Bhelai	T	slight. convex	<1	moderate	moderate	P - M/W
7	Basantapur east	P	almost flat	<1	slow	imperfect	P - W
8	Chefali	U	slight. convex	<2	mod. rapid	moderate	P - M
9	Bhelai southeast	P	slight. concave	<1	v. slow	poorly	P - F
10	Bhelai southwest	P	almost flat	<1	slow	imperfect	P - F
11	Mormi east	P	almost flat	<2	slow	imperfect	P - G
12	Mormi west	P	almost flat	<2	slow	poorly	P - F
13	Changhat	P	almost flat	<2	slow	imperfect	P - F
14	Changhat	ET	lower terrace	0	mod. rapid	moderate	P - U
15	Morma northeast	T	flat	0	moderate	imperfect	P - M/L
16	Morma north	P	flat	0	slow	imperfect	P - G
17	Morma northwest	P	flat	0	slow	imperfect	P - F
18	Ghanchaura north	U	undulating	<5	mod. rapid	well	Forest
19	Ghanchaura	U	undulating	<5	mod. rapid	mod. well	P - M
20	Badahara	U	convex	<5	mod. rapid	mod. well	P - M
21	Gorsinge northwest	P	flat	0	v. slow	poorly	P - F
22	Purena	T	slight. convex	<2	slow	moderate	P - M
23	Purena west	P	slight. concave	<2	v. slow	poorly	P - F
24	Gorsinge southeast	P	almost flat	<1	v. slow	imperfect	P - G
25	Gorsinge southwest	P	almost flat	<1	v. slow	poorly	P - G/L
26	Bakadaria	T	flat	0	slow	imperfect	P - W
27	Bakadaria	P	slight. concave	<2	moderate	imperfect	P - M
28	Bakadaria east	P	flat	0	v. slow	poorly	P - F
29	Gorsignee west	P	flat	0	v. slow	imperfect	P - F
30	Dewari	P	slight. concave	<1	v. slow	poorly	P - F
31	Karnaulia	T	almost flat	<1	moderate	moderate	P - W
32	Chauri	P	almost flat	<1	slow	imperfect	P - W/L
33	Rajpur	T	almost flat	<1	slow	moderate	P - W
34	Mahurgar	P	flat	0	v. slow	poorly	P - G
35	Mahuwa west	T	almost flat	<1	slow	moderate	P - M
36	Panditpur	P	flat	0	slow	imperfect	P - W
37	Pakarahati	P	flat	0	v. slow	poorly	P - F
38	Bichauwapur	P	flat	0	v. slow	poorly	P - F
39	Malwa northeast	P	flat	0	v. slow	imperfect	P - F
40	Malwa west	P	flat	0	v. slow	imperfect	P - F
41	Giddhahawa	P	flat	0	slow	imperfect	P - G
42	Pakarahata	P	flat	0	slow	imperfect	P - M/L
43	Dhankauli east	P	flat	0	v. slow	imperfect	P - F
44	Giddhahawa	P	flat	0	slow	imperfect	P - L
45	Karnaulia southeast	P	slight. undulating	<1	moderate	imperfect	P - F
46	Bhairampur	O	concave	0	mod. rapid	poorly	P - W
47	Buddi southwest	P	flat	0	slow	imperfect	P - M
48	Buddi east	P	flat	0	v. slow	poorly	P - G
49	Charmakunia	P	flat	0	v. slow	poorly	P - G
50	Gorsinge northeast	U	undulating	<5	mod. rapid	well	Forest

Remarks:

*1 : F : Piedomont fan, U : Old terrace, T : Terrace remnant, O : Old river coarse, ET : Erosional terrace

*2 : P : Paddy, W : Wheat, M : Mustard, L : Linseed, G : Grasspea, F : Fallow

*3 : Internal drainability is estimsted by both texture and structure.
External drainability is estimated by both topography and landuse caondition.

Table C.5.2 The Brief of Soil Descriptions (1/7)

Pit No.	Depth of Horizon	Boundry of Horizon	Form of Boundary	Colour		Textural Class	Structure			Consistence			Mottle		Root	Hardness (mm)	Remarks
				Wet	Dry		Grade	Type	Size	Wet	Moist	Dry	Fe	Mn			
1	0-12	a	s	2.5Y4/2	2.5Y4/3	SiL	w	sbk	vf		fr		+		2+	22	
	12-52	c	w	2.5Y4/3	2.5Y5/4	L	W	sbk	vf	ns	fr		+		+	28	
	52-73	g	w	10R4/4	10R5/6	LS	1	sbk			vfr		+			23	
	73-78	c	w	2.5Y4/4	2.5Y5/4	L	1	sbk			fr					20	
	78-100+			10YR3/2	10YR3/3	L		m			fr		2+	2+		25	
2	0-7	a	s	2.5Y3/3	2.5Y4/2	SiCL(SiL)	w	sbk			fi		+		2+	23	
	7-26	g	w	2.5Y4/2	2.5Y4/3	CL	w	sbk	vf		fr		2+		+	26	
	26-80	d	w	10YR5/6	7.5YR4/6	L	1	sbk			fr		2+		+	25	
	80-100+			2.5Y6/4	2.5Y5/6	SL	w	sbk			v.fri		2+			21	
3	0-15	g	w	5Y4/2	5Y4/2	CL	m	sbk	f		fi		2+		2+	22	
	15-33	d	w	5Y5/4	5Y4/4	SCL	m	sbk	f		fr			+	+	26	few stones(8 cm)
	33-50			5Y4/2	5Y3/2	SCL	m	sbk	f		fr					23	many stone (30cm)
4	0-7.5	g	s	5Y4/3	5Y5/3	SCL	w	sbk			fi		+		2+	21	
	7.5-60	c	w	2.5Y5/4	2.5Y5/4	L	w	sbk			fi		2+		+	26	
	60-100+			7.5YR4/4	7.5YR4/6	SL	w	sbk			fr			+		27	
5	0-10	g	w	5Y5/4		CL	w	sbk		SP			+		2+	16	reduction test : 2+
	10-32	d	w	5Y4/3		CL	w	sbk		SP			+		+	17	reduction test : +
	32-56	g	w	5Y5/3		CL		m		SP				+		13	
	56-70+			5Y5/4		CL		m		SP				2+			water table : 58 cm
6	0-10	a	s	2.5y3/3	2.5y5/3	L	W	Sbk	f			sh	2+		3+	9.5	
	10-17	c	w	2.5y4/3	2.5y6/3	L	W	Sbk			fi	fi	2+		+	26	
	17-39	d	w	2.5y6/4	2.5y5/3	L(Sil)	W	Sbk			fi	fi	3+		+	30	
	39-59	d	w	2.5y6/6	2.5y5/4	FSL	W			ns,np			3+	+		23	
	59-86	d	w	2.5y6/4		SL				ns,np				2+		20	
	86-130	d	w	2.5y6/4		SL				ns,np						16	
7	0-12	c	w	2.5y4/4	2.5y4/3	CL	w	Sbk	f	vs,vp	fi		+		2+	27	few crack up to 25 cm
	12-19	g	s	2.5y5/6	2.5y6/4	CL	m	Sbk		vs,vp	fi		2+		+	30	
	19-45	g	w	2.5y6/6	2.5y6/4	C	m	Sbk		vs,vp	fi		+	2+	+	26	
	45-70	g	s	5y6/4	5y5/3	C	m	Sbk		vs,vp	fi			2+	+	24	
	70-100+			2.5y6/6	2.5y6/4	C	m	Sbk		vs,vp	fi			2+		23	
8	0-9	c	s	2.5Y3/2	2.5Y3/3	L	w	sbk		ns,np	fi				3+	6	
	9-15	g	i	2.5Y3/1	2.5Y3/3	SL	w	sbk		ns,np	fr				+	25	
	25-45	g	w	2.5Y3/3	2.5Y4/3	SL	w	sbk		ns,np	fr		+		+	29	
	45-68	g	w	2.5Y4/6	2.5Y4/3	LS	1	sg		ns,np	fr		2+			27	
	68-113	g	w	2.5Y4/6	2.5Y5/3	LS	1	sg		ns,np	fr		2+			20	
	113-140			2.5Y5/6	2.5Y5/3	LS	1	sg		ns,np	fr					19	
9	0-12	g	w	5Y4/2		SCL	w	sbk	-	ss,sp	fi		+		2+	19	
	12-36	d	w	5Y4/3		SL-SCL	w	sbk	-	ss,sp			2+		2+	26	
	36-66	d	w	5Y4/3		CL	m	sbk	-	ss,sp			+	+	+	24	
	66-110+			5Y5/3		CL	m	sbk	-	s,p				2+	+	20	

Table C.5.2 The Brief of Soil Descriptions (2/7)

Pit No.	Depth of Horizon	Boundry of Horizon	Form of Boundary	Colour		Textural Class	Structure			Consistence			Mottle		Root	Hardness (mm)	Remarks
				Wet	Dry		Grade	Type	Size	Wet	Moist	Dry	Fe	Mn			
10	0-7	g	w	2.5Y5/3	2.5Y5/4	CL	m	sbk	-	ss,sp	fi		+		2+	27	
	7-24	g	w	2.5Y5/3	2.5Y6/3	C	m	sbk	-	s,p	fi		2+		+	27	clay illuviation : +
	24-85	c	s	2.5Y5/6	2.5Y5/6	C	w	sbk	-	s,p	fi		2+		+	23	clay illuviation : 2+
	85-105+			2.5Y5/4		fL							+	+		17	
11	0-10	c	s	2.5Y4/2	2.5Y4/3	CL	m	sbk	m	s,p	fi		+		2+	27	
	10-15	c	w	2.5Y4/2	5Y4/3	CL	m	sbk		s,p	fi		+		+	27	
	15-32	g	w	2.5Y6/4	5Y5/3(2.5Y5/6)	CL	m	sbk		s,p	fi		2+	+	+	27	
	32-94	g	s	2.5Y5/3	5Y5/2	C	m	sbk		s,p	fi		2+	+		24	some sand stones (1mm), clay illuviation : +
	94-138			2.5Y6/4		SCL	m	sbk		ss,sp			+	+		18	
12	0-15	c	w	7.5Y4/2	7.5Y3.5/2	CL	w	sbk		s,p			+		2+	16	
	15-25	g	w	7.5Y4/2	7.5Y3.5/2	CL	w	sbk		s,p			2+		+	26	
	25-50	d	w	5Y4/2	5Y5/3(5Y5/6)	CL	m	sbk		s,p			2+		+	24	
	50-81	g	s	5Y5/6	5Y5/6	CL	m	sbk		vs,vp			+	2+		20	sew sand stones
	81-118			5Y5/6		LS	m							+		16	
13	0-18	c	w	2.5Y4/3	2.5Y4/4	CL	w	sbk		s,p	fi		+		2+	26	few cracks up to 15 cm
	18-45	g	w	2.5Y5/3	2.5Y5/2	CL	w	sbk		s,p	fi		2+		+	24	
	45-65	c	w		2.5Y6/4	SicL	w	sbk		vs,vp	fi		2+	+		22	
	65-100	g			2.5Y6/4	CL	m	sbk		vs,vp	fi		2+	+		22	
	10-120+			2.5Y5/4	2.5Y6/4	fSL	m	sbk		nS,nP	fi		+			19	
14	0-14	c	S	2.5Y4/4	2.5Y4.5/4	LS	l				fr				2+	17	
	14-27	g	W	2.5Y4/4	2.5Y5/4	SL	l				fr				+	18	
	27-44	g	S	2.5Y4/4	2.5Y5/4	SL					fr					17	
	44-58	c	i	2.5Y5/6	2.5Y5/4	SL					fr					21	
	58-81+			2.5Y5/4	2.5Y5/3	fL					fr		2+			18	common river stone gravel layer below 81 cm
15	0-7	c	w	2.5Y4/3	2.5Y7/3	L	m	sbk	m			h			2+	15	
	7-14	g	w	2.5Y5/3	2.5Y6/3	L	w	sbk				sh	+		+	30	
	14-66	d	w	2.5Y6/6	2.5Y5/6	CL	m	sbk	m	ss,sp	fi		2+	+	+	33	
	66-85	d	w	2.5Y6/8	2.5Y6/6 (2.5Y,40%)	CL	m	sbk	vf	ss,sp	fi		2+	2+		29	
	85-110+			2.5Y6/8	2.5Y6/6 (10YR6/6 60%)	SCL	w	sbk	vf	s,p	fi		2+	2+		27	
16	0-10	g	w	5Y5/3	5Y6/3	CL	m	sbk		ss,sp		h	2+		2+	32	
	10-17	g	w	2.5Y5/2	2.5Y5/2(5/6 30%)	CL	m	sbk		s,p	fi		2+		+	31	
	17-39	g	i	5Y6/4	2.5Y5/2(5/6 30%)	CL	w	sbk			fr		2+	+		28	clay illuviation : 1.5+
	39-70	g	w	5Y6/4	2.5Y5/2(5/6 30%)	CL	w	sbk		vs,vp			2+	2+		24	clay illuviation : 2+
	70-105+			2.5Y6/4	5Y6/4	C	m	sbk		vs,vp			2+			23	
17	0-15	g	w	5y5/3	5Y5/2	CL	m	sbk		vs,vp	fi		2+		2+	28	cracks upto 15 cm
	15-30	g	w	5y5/2	5Y5/3 (2.5Y5/6 40%)	CL	w	sbk		vs,vp	fi		2+	+	+	30	
	30-68	d	w	2.5y6/4	5Y5/3 (2.5Y6/6 50%)	C	w	sbk		vs,vp	fi		2+	+		26	clay illuviation : 2+
	69-100+			2.5y6/4	5Y6/6	SicL(CL)	w	sbk		vs,vp	fr		2+			23	clay illuviation : 2+

Table C.5.2 The Brief of Soil Descriptions (3/7)

Pit No.	Depth of Horizon	Boundry of Horizon	Form of Boundary	Colour		Textural Class	Structure			Consistence			Mottle		Root	Hardness (mm)	Remarks
				Wet	Dry		Grade	Type	Size	Wet	Moist	Dry	Fe	Mn			
18	0-13	g	w	10YR3/3	10YR6/3	SL	m	sbk				h	+		3+	33	
	13-36	g	w	10YR4/4	10YR5/6	L	w	sbk				h	+		+	32	
	36-84	g	w	10YR5/6	10YR6/6 (5/8 40%)	fL	m	sbk				h	2+		+	33	
	84-105			2.5Y6/6	2.5Y7/4 (10YR6/8 40%)	CL-SicL	m	sbk				h	2+	+		32	
19	0-13	c	s	2.5Y4/3	2.5Y6/6	L	m	sbk				h			2+	7	
	13-24	g	w	2.5Y4/6	2.5Y6/6 (10YR6/8 20%)	L	w	sbk			fi		+		+	32	
	24-65	g	w	2.5Y6/6	2.5YR6/8 (10YR6/8 30%)	fL	w	sbk			fi		2+	+		29	clay illuviation : 1.5+
	65-80	g	s	2.5Y6/6	2.5Y6/8 (10YR6/8 40%)	fL	w	sbk			fi		3+	+		25	clay illuviation : 2+
	80-105			2.5Y6/8	2.5Y6/8	CL	m	sbk			fr		3+	+		24	
20	0-10	c	s	2.5Y5/3	2.5Y7/3	L	w	sbk				h	+		3+	7	
	10-21	c	s	2.5Y4/2	2.5Y4/3	L	m	sbk			fi		2+		+	34	clay illuviation : 1.5+
	21-67	g	s	10YR5/8(5/4)	2.5Y4/2 (10YR5/6 50%)	CL	s	sbk			vfi		3+		+	32	clay illuviation : 3+
	67-87	g	s	2.5Y5/4	2.5Y5/2 (6/6 30% 7.5YR5/8 30%)	CL	w	sbk			fi		3+	1.5+	+	30	clay illuviation : 2+
	87-110+	g	s	2.5Y6/4	2.5Y5/2 (10YR6/6 30%)	CL	w	sbk		vs,vp	fr		3+	+		29	clay illuviation : 2+
21	0-6	e	s	5Y5/4	5Y6/4	CL	m	sbk		s,p	fi		2+		2+	28	Cracks upto 20 cm
	6-20	g	w	5Y5/3	5Y5/4	CL	m	sbk		vs,vp	vfi		2+		2+	32	
	20-76	g	s	5Y4/3	5Y4/4(5/6,40%)	CL	w	pr		vs,vp	fi		2+		+	27	clay illuviation : 3+ sand stones : 3+
	76-100+	g	w	5Y5/3	5Y5/3(2.5Y5/6 50%)	CL	w	pr		vs,vp	fi		2+		+	24	(changing to clay from CL)
22	0-10	e	s	2.5Y4/3	2.5Y6/3	L	w	sbk				h	1.5+		3+	V. loose	Cracks upto 27 cm
	10-37	g	w	2.5Y5/3	2.5Y5/4(4/4)	CL	w	sbk			fi		+		2+	33	
	37-70	g	w	2.5Y6/6	2.5Y5/6(5/340%)	CL	w	sbk			fr		+	2+	+	28	
	70-100+			2.5Y6/4	2.5Y6/3(5/6 50%)	CL	w	sbk		vs,vp			2+	+		27	
23	0-14	c	s	5Y4/3	5Y4/2	CL	w	sbk		ss,sp	fi		2+		3+	17	
	14-27	g	w	2.5Y5/3	2.5Y5/2(5/6 30%)	CL	w	sbk		S,P	fr		3+		+	26	clay illuviation : +
	27-60	g	w	2.5Y5/4	2.5Y5/3(6/6 40%)	SCL	w	sbk			fr		2+	+	+	22	clay illuviation : 1.5+
	60-118	g	s	2.5Y6/4	2.5Y6/3	SCL		m			fr					19	silica concretion : 1.5+
	118-125+			2.5Y6/6	5Y5/6 (2.5Y6/6 30%)	C		m		vs,vp	fr		2+			18	
24	0-10	c	s	2.5Y4/4	2.5Y5/3	CL	m	sbk		s,p	fr		2+		3+	20	cracks upto 20cm
	10-20	g	s	2.5Y5/4	2.5Y5/3	CL	m	sbk		s,p	fi		2+		+	24	
	20-63	g	s	2.5Y5/4	2.5Y5/3	CL	w	co		s,p	fr		2+	+		30	clay illuviation : 1.5+
	60-100+			2.5Y5/4	2.5Y5/3	CL	w	Pr.		vs,vp	fi		3+	2+		26	clay illuviation : 1.5+

Table C.5.2 The Brief of Soil Descriptions (4/7)

Pit No.	Depth of Horizon	Boundry of Horizon	Form of Boundary	Colour Wet	Colour Dry	Textural Class	Structure Grade	Structure Type	Structure Size	Consistence Wet	Consistence Moist	Consistence Dry	Mottle Fe	Mottle Mn	Root	Hardness (mm)	Remarks
25	0-12	c	s	2.5Y5/4	2.5Y6/3	CL	w	sbk			fr		2+		3+	15	cracks upto 20cm
	12-21	g	s	2.5Y5/4	2.5Y5/3	CL	m	sbk			vfi		2+	+	2+	32	
	21-40	g	s	2.5Y5/3	2.5Y5/4	CL	w	co			fr		2+	2+		23	clay illuviation : 1.5+
	40-69	c	s	2.5Y5/6	2.5Y6/8	CL	w	sbk		s,p	fi		2+	2+		24	clay illuviation : 1.5+
	69-105+			2.5Y5/6	2.5Y6/4	CL	w	Pr.			vfi		2+	2+		25	
26	0-10	a	s	2.5Y5/3	2.5Y6/3	SiL	w	sbk				h	2+		2+	9	
	10-20	g	s	2.5Y5/6	2.5Y5/2 (5/6 50%)	CL	m	sbk				h	2+		+	36	clay illuviation : +
	20-65	g	w	2.5Y5/4	2.5Y5/2 (6/6 50%)	CL	m	co			fi		2+	2+		15	clay illuviation : 1.5+
																	lime concretion : +
	65-120+			5Y6/4 (2.5Y6/8 30%)	5Y6/4 (2.5Y6/8 30%)	L-SCL		m		ss,sp	fr		+			15	lime concretion : + (sand stones?)
27	0-10	c	s	2.5Y2/2	2.5Y4/3	L	w	sbk				sh			2+	8	
	10-25	c	w	2.5Y4/2	2.5Y4/3	L	w	sbk				h	+		+	35	
	25-53	g	s	2.5Y5/6	2.5Y6/8 (5/2 30%)	SCL	w	sbk			fi		2+	+		27	illuviation : 1.5+
	53-105+			2.5Y6/6		FSCL		m		ss,sp				+		14	sand (lime) concretion : +
28	0-10	g	w	2.5Y5/4	2.5Y5/3	CL	w	sbk			fi		2+		2+	25	
	10-21	c	w	2.5Y4/6	2.5Y5/2 (10YR5/8 40%)	CL	w	sbk		s,p	fi		2+		+	28	clay illuviation : +
	21-50	c	w	2.5Y5/3	2.5Y5/2 (6/6 40%)	SCL	w	sbk			fi		2+	+	+	29	clay illuviation : +
	50-70	g	w	2.5Y5/4	2.5Y6/6 (5/2 40%)	CL	w	co		s,p	fr		2+		+	26	clay illuviation : +
	70-105+			2.5Y6/4	2.5Y6/2 (6/6 50%)	CL		m		s,p	fr		2+	2+		24	
29	0-7	c	w	5Y5/4	5Y5/2 (2.5Y5/6 30%)	FL-CL	w	sbk			fi		2+		2+	28	
	7-11	g	w	2.5Y5/3	2.5Y5/3 (6/8 40%)	CL	w	sbk	vf		fi		2+		+	31	
	11-30	g	w	5Y6/3	5Y5/3 (5/8 30%)	CL	w	sbk			fi		2+	+	+	28	
	30-68	g	s	2.5Y6/6	2.5Y6/6 (5Y5/2 20%)	CL	w	sbk			fr		3+	2+		26	clay illuviation : +
	68-105+			2.5Y6/6	2.5Y6/6 (5Y6/4 30%)	CL	w	co		ss,sp			2+	2+		20	105-160 cm fine sand layer clay illuviation : +
30	0-5	a	i	5Y4/2	_	CL		m		s,p			2+		2+	16	reduction test : +
	5-15	a	w	7.5Y3/2	_	CL		m		vs,vp			2+		2+	19	reduction test : 2+
	15-41	c	w	5Y5/2 (3.5Y6/6 60%)	_	CL		m		vs,vp			2+	+	+	21	clay illiviation : 1.5+
	41-64	c	s	2.5Y6/6 (6/2 30%)	_	L		m		ss,sp			2+	+	+	24	clay illiviation : 2+
	64-76	g	s	2.5Y4/2 (6/6 40%)	_	L		m		s,p			2+	+	+	12	
	76-95	g	s	2.5Y6/4 (6/8 30%)	_	SCL		m		s,p			2+	2+	+		
	95-110+			2.5Y6/4 (6/7 50%)	_	CL		m		s,p			2+	2+			
31	0-11	c	s	2.5Y4/3	2.5Y4/3	CL	w	sbk	f		fr				2+	8	
	11-17	g	s	2.5Y4/3	2.5Y5/3	CL	m	sbk			fr=fi		2+	+	+	27	
	17-30	g	i	2.5Y5/4	2.5Y5/2 (6/6 60%)	SCL	w	sbk			fr		2+	2+	+	24	clay illuviation : 2+
	30-72	g	s	2.5Y6/6	2.5Y6/6	LS		sg			vfr		2+	2+	+	19	
	72-100+			2.5Y6/6	2.5Y7/8 (6/2 20%)	L		sg			vfr		+	2+		19	clay illuviation : 1.5+

Table C.5.2 The Brief of Soil Descriptions (5/7)

Pit No.	Depth of Horizon	Boundry of Horizon	Form of Boundary	Colour		Textural Class	Structure			Consistence			Mottle		Root	Hardness (mm)	Remarks
				Wet	Dry		Grade	Type	Size	Wet	Moist	Dry	Fe	Mn			
32	0-9	c	s	2.5Y5/2	2.5Y5/2	CL	w	sbk			fi		2+		2+	26	
	9-15	c	s	2.5Y4/3	2.5Y5/3	CL	w	sbk		ss,sp	fi		2+		+	31	clay illuviation : 1.5+
	15-38	g	s	2.5Y5/4	2.5Y6/6 (6/2, 30%)	SCL-CL	w	sbk			fr		+	+		31	clay illuviation : 1.5+
	38-70	g	s	2.5Y6/4	2.5Y6/2 (6/6, 50%)	SCL(L)	w	sbk			vfr-fr		+	2+		26	clay illuviation : 1.5+
	70-110+			2.5Y6/4	2.5Y6/2 (6/4, 70%)	fl		sbk			l		+	1.5+		19	sand (lime) concretion : +
33	0-10	c	s	2.5Y5/3	2.5Y6/3	L	w	sbk				sh			2+	7	
	10-30	g	i	2.5Y5/4	2.5Y6/4 (6/6, 30%)	L	w	sbk			fr		2+		+	25	integrated layer from AP is between 10-15 cm, the hardness is 32 mm
	30-55	g	w	2.5Y6/6	2.5Y6/5 (7/8, 50%)	L(SCL)	vw	sbk	vf	ss,sp	fr		2+	+	+	18	clay olluviation : +
	55-105	d	w	2.5Y6/6	2.5Y6/4 (7/8, 40%)	L(SCL)	vw	sbk	vf	ss,sp	vfr-fr		2+	2+	+	18	from 80 cm wet condition
	105-110+			2.5Y7/6		SL	vw	sbk	vf	ns,np	vfr-fr		2+	2+		17	
34	0-10	c	s	5Y4/4	5Y4/3	CL-SCL	w-m	sbk	vf	ss,sp	fr		2+		2+	25	cracks upto 16 cm
	10-29	g	s	2.5Y6/4	5Y6/3	CL-SCL	w	co-sbk	f	ss,sp	sfi		2+	2+	+	27	clay illuviation : 1.5+
	29-65	g	s	2.5Y5/4	2.5Y6/4 (6/6, 50%)	CL-SCL	w	co-sbk	f	ss,sp	fr		2+	2+	+	23	clay illuviation : 1.5+
	65-100+			2.5Y5/4	2.5Y5/2 6/6, 50%)	CL-SCL	w	co	f		fr		2+	1.5+	+	24	clay illuviation : 1.5+
35	0-10	c	s	2.5Y6/2	2.5Y7/1	fSL-L					fr				2+	V. loose	
	10-30	g	w	2.5Y5/2	2.5Y4/2	L	w	sbk			vfr		2+		+	25	Hardness of hardpan layer is 35 mm
	30-57	g	w	2.5Y6/4	2.5Y6/4 (7/8, 50%)	L	lw	sbk			vfr		2+		+	23	
	57-79	g	s	2.5Y6/6	2.5Y6/4 (6/6, 50%)	L	lw	sbk			vfr		2+	+		18	
	79-110+			2.5Y6/6	2.5Y6/4 (6/6, 40%)	SCL		m		ss,sp	fr		2+	2+		19	
36	0-5	c	s	2.5Y5/3	2.5Y5/2	CL	w	sbk		ss,sp	fi		2+		2+	V. loose	
	5-9	c	s	2.5Y5/3	2.5Y5/3	CL	m	sbk		vs,vp	fi		2+		+	26	
	9-61	c	w	2.5Y5/6	2.5Y6/6 (6/4 30%)	CL	w	sbk		s,p			2+	+		24	clay illuviation : 1.5+
	61-90	g	w	2.5Y5/4	2.5Y5/2 (6/6 30%)	L	w	sbk			fr		2+	2+		19	clay illuviation : +
	90-105+			2.5Y6/6	2.5Y7/4 (6/8 30%)	L		m			fr		2+			18	
37	0-9	g	s	.5Y4/3	.5Y5/3	CL (lic)	m	sbk		s,p	fi		2+		2+	26	reduction test : +
	9-18	g	s	7.5Y4/2	7.5Y4/2	CL (lic)	m	sbk		s,p	fi		2+		+	28	reduction test : 2+
	18-42	d	w	5Y5/4	5Y5/2 (6/4 40%)	CL (lic)	w	Pr		s,p	fi		2+	+	+	29	clay illuviation : 2+, sand stone : +
	42-75	d	w	2.5Y6/3	5Y5/2 (2.5Y6/6 50%)	CL	w	Pr		s,p	fi		2+	+	+	25	clay illuviation : 3+, sand stone : 2+
	75-115+			2.5Y6/4	2.5Y6/6(5/2 30%)	CL	w	Pr		s,p	fr		2+	+		23	clay illuviation : 1.5+
38	0-11	c	w	5Y5/3	5Y5/2	CL	m	sbk		s,p	fi		2+		2+	29	
	11-50	d	w	2.5Y5/3	2.5Y5/2 (6/6 40%)	CL	m	sbk		s,p	fi		2+	+	+	31	clay illuviation : 2+
	50-79	g	w	2.5Y5/4	2.5Y5/2 (6/6 50%)	CL	w	Pr		s,p	fi		2+	+	+	24	clay illuviation : 2+
	79-105+			2.5Y6/4	2.5Y6/2 (6/6 50%)	SCL-CL	w	sbk	m	ss,sp	fr		2+	+	+	21	under 100cm Mn mottle 2+
39	0-6	c	w	2.5Y5/3	2.5Y7/2	CL	w	sbk		ss,sp		h	2+		3+	34	
	6-17	c	w	2.5Y5/3	2.5Y6/6 (6/2 50%)	CL	vw	sbk		s,p		h	2+		2+	34	
	17-38	g	i	2.5Y5/6	2.5Y6/2 (6/6 50%)	CL	w	sbk		vs,vp		h	2+	2+	+	33	clay illuviation : 1.5+
	38-63	g	w	2.5Y6/4	2.5Y6/6 (6/3 40%)	CL	w	Co		vs,vp	fi		2+	2+	+	30	clay illuviation : 3+
	63-100+			2.5Y6/4	2.5Y6/3 (6/6 50%)	CL	w	CO		vs,vp	fi		2+	2+		25	clay illuviation : 3+

Table C.5.2 The Brief of Soil Descriptions (6/7)

Pit No.	Depth of Horizon	Boundry of Horizon	Form of Boundary	Colour		Textural Class	Structure			Consistence			Mottle		Root	Hardness (mm)	Remarks
				Wet	Dry		Grade	Type	Size	Wet	Moist	Dry	Fe	Mn			
40	0-7	c	w	5Y5/3	5Y7/2	CL	m	sbk		ss,sp		h	2+		2+	31	
	7-19	c	s	5Y5/3	5Y6/2	CL	m	sbk		ss,sp		h	2+		1.5+	33	
	19-53	g	w	2.5Y5/4	5Y6/3 (6/6 50%)	CL	m	sbk		s,p	fi		2+	2+	+	32	clay illuviation : 2+
	53-82	g	s	2.5Y6/6	2.5Y6/6 (6/3 50%)	CL	w	sbk		vs,vp	fi		2+	1.5+		24	clay illuviation : 2+, sand concretion
	82-105+			2.5Y6/6	2.5Y6/6 (6/3 30%)	CL	w	sbk		s,p	frfi		2+	2+		24	clay illuviation : +, sand concretion +
41	0-10	c	s	5Y5/3	5Y6/2	L	w	sbk				h	+		2+	10	
	10-42	g	w	2.5Y5/2	2.5Y5/1 (5/6 40%)	CL	w	Pr		s,p		h	2+	+	+	31	clay illuviation : +
	42-80	g	w	2.5Y5/6	2.5Y6/6 (5/1 30%)	fL	vw	sbk			fr		2+	1.5+	+	23	clay illuviation : 1.5+
	80-113	g	s	2.5Y6/8	2.5Y7/8 (6/2 20%)	L-CL					fr		2+	+		20	clay illuviation : +
	113-128+			2.5Y6/8	2.5Y6/3 (7/8 50%)	fSL					vfr		2+	1.5+		18	
42	0-9	c	w	2.5Y4/4	5Y5/3	CL	w	sbk	v.f	s,p	fi		2+		2+	25	
	9-40	g	s	2.5Y5/4	2.5Y6/6 (5/1 40%)	CL	w	Pr	f	s,p	fi		2+	2+	+	30	clay illuviation : +
	40-77	g	s	2.5Y5/3	2.5Y6/6 (6/2 30%)	CL	w	Pr	f	vs,vp	fi		2+	2+		25	clay illuviation : +, sand stone : +
	77-124+			2.5Y5/4	2.5Y6/6 (6/2 50%)	C	W	Pr	f	vs,vp	fi		2+	2+		23	clay illuviation :2+, sand stone :1.5+
43	0-5	c	s	5Y6/3	5Y7/2	CL	w	sbk		s,p		h	2+		2+	30	cracks upto 15 cm
	5-15	g	s	5Y6/3	5Y6/2 (2.5Y6/6 40%)	CL	m	sbk		vs,vp		h	2+	+	+	34	
	15-60	g	w	2.5Y5/3	2.5Y5/2 (6/6 50%)	CL	w	Pr		s,p	fi		2+	+	+	29	clay illuviation : 2+
	60-105+			2.5Y6/4	2.5Y5/2 (6/8 50%)	C	m	Pr		vs,vp			2+	2+	+	24	clay illuviation :3+, sand stone :1.5+
44	0-7	c	s	5Y5/3	5Y6/3	CL	w	sbk		s,p	fr		2+		2+	27	
	7-15	g	s	2.5Y5/3	2.5Y6/3 (6/6, 20%)	CL	w	sbk		s,p	fi		+	+	+	32	clay illuviation : 1.5+
	15-37	g	s	2.5Y5/3	2.5Y5/1 (6/6, 50%)	CL	w	pr		s,p	fr		+	+	+	28	clay illuviation : 2+
	37-75	g	s	2.5Y6/4	2.5Y7/6 (6/2, 50%)	CL-SiL	w	pr		s,p	fr		+	2+	+	22	clay illuviation : 1.5+
	75-105+			2.5Y6/4	2.5Y6/4 (5Y6/3, 7/3, 50%)	CL	w	pr		s,p	fr		+	+		22	clay illuviation : +, sand stone :2+
45	0-7	c	s	5Y5/3	5Y6/4	CL	m	sbk				h	2+		2+	30	cracks upto 13 cm
	7-12	g	w	5Y5/3	5Y6/4	CL	m	sbk				h	2+		+	31	
	12-37	g	s	2.5Y5/4 (7/6)	2.5Y6/6 (5/1, 40%)	CL	w	pr			fi		2+	1.5+	+	28	clay illuviation : 2+
	37-62	g	s	2.5Y6/4	2.5Y6/6 (6/2, 30%)	CL	w	pr			fi		2+	1.5+	+	26	clay illuviation :2+, sand stone :1.5+
	62-85	g	w	2.5Y6/2	2.5Y6/1 (6/6, 30%)	L-SCL	vw	pr			fr		2+	1.5+	+	21	
	85-125+			2.5Y6/6	2.5Y6/6	L		m			fr		2+	2+		16	
46	0-11	g	w	2.5Y4/3	2.5Y4/4	L	w	sbk			fr		2+		2+	25	
	11-32	g	w	2.5Y4/3	2.5Y5/4 (7/6 30%)	L	w	sbk			fr		2+		+	25	clay illuviation : 2+
	32-62	g	w	2.5Y5/2	2.5Y5/1 (6/4 30%)	CL-L	w	sbk			fr		+		+	22	clay illuviation : 2+
	62-93	g	w	2.5Y7/4	2.5Y7/4	S		m			fr		2+	1.5+		18	
	93-150+			2.5Y6/2	2.5Y6/2	S		m			fr		2+	+		17	114-132 : sand stone 2+

Table C.5.2 The Brief of Soil Descriptions (7/7)

Pit No.	Depth of Horizon	Boundry of Horizon	Form of Boundary	Colour		Textural Class	Structure			Consistence			Mottle		Root	Hardness (mm)	Remarks
				Wet	Dry		Grade	Type	Size	Wet	Moist	Dry	Fe	Mn			
47	0-10	c	w	5Y5/3	5Y5/2	L	w	sbk			fi		2+		2+	24	
	(10-15	g	s	2.5Y5/4	5Y5/2(2.5Y6/6 50%)	CL (SiL)	w	sbk		ss,sp	fi		2+		+	30	clay illuviation : +)
	15-35	c	w	2.5Y6/4	2.5Y5/3(2.5Y6/6 40%)	CL (SiL)	w	sbk		ss,sp	sfi		2+	+	+	27	clay illuviation : 1.5+
	35-50	g	w	2.5Y5/3	2.5Y5/2(2.5Y7/6 30%)	CL	w	pr		s,p	fr		2+		+	24	clay illuviation : 3+
	50-66	g	w	2.5Y6/4	2.5Y5/2(2.5Y6/6 40:60)	CL	w	pr		ss,sp	fi		2+	+	+	23	clay illuviation : 2+
	66-90	g	w	2.5Y4/3(B10YR5/3)	2.5Y5/2(10YR5/8 30%)	CL	w	pr		s,p	fi		2+	+	+	24	clay illuviation : 3+
	90-110	g	s	2.5Y5/4	2.5Y5/4(2.5Y5/2 30%)	CL	w	sbk		s,p	sfi		2+	2+		24	clay illuviation : 1.5+
	110-125	g	s	2.5Y6/4	2.5Y6/3(2.5Y6/6 50:50)	L-SCL	w	sbk		ss,sp	sfi		2+	2+		22	clay illuviation : 2+
48	0-14	c	s	5Y5/3	5Y6/3	CL	w	sbk		s,p	fi		+		2+	36	
	14-29	g	w	2.5Y5/3	5Y5/2(2.5Y6/6 40%)	CL	w	Pr		s,p	fi		3+	+	+	30	clay illuviation : 2+
	29-65	g	i	5Y5/3	5Y5/2(2.5Y6/8 30%)	CL	(w-m)	Pr		s,p	fi		2+	1.5+	+	27	clay illuviation : 3+
	65-109	g	w	5Y6/4	5Y6/1(2.5Y7/6)	CL	m	Pr		s,p	fi		2+	2+	+	25	clay illuviation :2+, sand stone : +
	109-124	g	s	3.5Y6/4	5Y6/3(2.5Y6/6 50%)	CL-sic	w	sbk	m	vs,vp	fi		2+	2+		22	clay illuviation : +, sand stone : +
	124-130+			3.5Y6/4	5Y6/3(2.5Y6/6 50%)	sic-CL	w	sbk	m	s,p	fi		2+	2+		20	clay illuviation : +, sand stone : 2+
49	0-8	c	s	5Y5/4	5Y7/4	CL	m	sbk		s,p	vfi		2+		2+	26	cracks upto 25 cm
	8-26	g	w	2.5Y5/4	5Y5/2(2.5Y6/6 50%)	CL	m	sbk		s,p	fi		2+	+	+	31	clay illuviation : 1.5+
	26-82	g	w	3.5Y5/3	5Y5/2(2.5Y5/6 30%)	CL	w	pr		s,p	fi		2+	2+	+	28	clay illuviation :3+, sand stone :1.5+
	82-113	g	w	5Y6/4	5Y6/2(5Y6/6 40%)	SiC-SiCL	m	pr		s,p	fi		2+	2+	+	23	clay illuviation :2+, sand stone : 2+
	113-125			5Y6/4	5Y5/2(5Y6/6 40%)	CL-SiCL	w	sbk		s,p	fi		2+	+		24	clay illuviation :2+, sand stone :2+
50	0-18	g	w	2.5Y5/6	2.5Y6/8	L (SiL-CL)	w	sbk		ss,sp	fi				3+	31	roots: dia. 2.5cm(max)
	18-41	g	w	2.5Y6/6	2.5Y6/8(2.5Y7/8 50%)	CL	w	sbk		(ss,sp	fi		+		2+	30	clay illuviation : +
	41-69	g	w	2.5Y6/6 to 6/4	2.5Y6/2(2.5Y7/8 60%)	CL-L	w	sbk		s,p	fi		2+	+	+	29	clay illuviation : 1.5+
	69-90	c	s	2.5Y5/4	2.5Y6/2(2.5Y6/6, 2.5Y7/8, 60:60:20%)	CL-L	w	sbk		s,p	fi		2+	+	+	31	clay illuviation :1.5+, sand stone : 2+
	90-105			2.5Y7/4	2.5Y8/4(2.5Y6/8 30%)	fL	w	sbk			fr		2+	1.5+	+	31	

Table C.5.3 Physical and Chemical Analysis of Representative Soil

Pit No.	Location	Depth (cm)	Partical Size			Texture Class	pH (1:25)		E.C. mm/cm 0.0431	Water Holding Capacity	Total CaCo3	O.C.	Total N	Avg. p ppm	Exchange Cation				CEC	Base sat.	Soluble Cations and Anions					
			Sand	Silt	Clay		H2O	Kcl							Ca	Ma	Na	K			Ca	MG	Na	CO3	HCO3	CL
																	(me/100g.ds)				%	%	ppm	%	%	%
			(%)	(%)	(%)					(%)	(%)	(%)	(%)							(%)						
i	Patherkot	0 - 12	34	50	16	Sil/L	8.0	6.9	0.20	39.9	2.44	1.75	0.15	8.0	23.4	2.35	0.16	0.15	17.2	151.5	1.22	0.11	68	Nil	2.03	0.14
		12- 52	24	60	16	Sil/L	8.2	7.5	0.08	35.1	1.10	0.70	0.06	4.4	24.4	1.61	0.16	0.09	16.6	159.2	0.78	0.08	74	Nil	1.35	0.28
		52 - 79	55	34	11	SL	8.2	7.5	0.08	24.9	1.10	0.35	0.03	3.2	17.7	0.66	0.11	0.08	16.0	117.1	0.50	0.08	76	Nil	0.32	0.07
		73 - 78	14	62	24	Sil	8.3	7.5	0.10	33.3	1.10	0.43	0.03	3.4	25.0	2.08	0.11	0.13	15.2	179.8	0.90	0.11	52	Nil	1.42	0.21
		78 - 100	32	40	28	L	8.1	7.2	0.12	26.7	Nil	0.62	0.05	4.0	10.9	2.21	0.11	0.14	7.3	184.0	0.22	0.01	72	Nil	0.36	0.18
10	Velahi	0 - 7	20	49	31	CL/SCL	7.0	6.4	0.03	48.3	Nil	1.79	0.17	4.0	6.2	1.74	0.11	0.22	8.3	100.7	0.06	0.06	74	Nil	Nil	0.32
		7 - 24	14	57	39	Sicl	7.8	6.4	0.07	38.7	Nil	0.55	0.05	2.0	7.8	2.76	0.11	0.10	7.1	150.8	0.14	0.04	178	Nil	0.12	0.25
		24 - 85	5	56	39	Sicl	7.8	6.6	0.10	30.9	Nil	0.35	0.04	1.2	10.9	2.99	0.16	0.13	7.5	188.8	0.30	0.01	72	Nil	0.35	0.25
		85 - 105	30	45	25	L	7.8	6.7	0.08	20.9	0.08	0.12	Nil	N	7.8	1.99	0.16	0.06	7.2	139.0	0.10	0.06	70	Nil	0.17	0.02
12	Mormi	0 - 15	20	49	31	CL/SiCL	6.9	5.8	0.16	53.2	0.08	2.22	0.17	4.4	15.6	3.19	0.11	0.41	15.5	124.6	0.26	0.06	128	Nil	0.62	0.11
		15 - 25	22	43	35	CL	7.8	6.5	0.12	34.5	Nil	0.93	0.07	3.2	13.0	2.96	0.16	0.23	12.8	131.8	0.22	0.04	118	Nil	0.39	0.18
		25 - 50	28	35	37	CL	7.8	6.8	0.13	33.6	0.08	0.39	0.04	1.2	13.0	2.97	0.16	0.12	12.5	129.2	0.58	0.06	116	Nil	1.25	0.21
		50 - 81	12	49	39	SiCL	7.8	7.5	0.19	33.5	3.92	0.39	0.04	N	27.0	4.12	0.16	0.13	12.2	257.5	2.30	0.11	118	Nil	3.52	0.25
		81 - 118	74	23	3	LS	7.8	7.7	0.13	29.9	0.84	Nil	Nil	N	13.5	2.19	0.11	0.04	8.3	191.1	0.66	0.04	98	Nil	1.10	0.11
19	Ghunchaura	0 - 13	28	53	19	SiL	7.3	6.6	0.11	32.8	Nil	1.09	0.09	4.4	7.8	2.76	0.05	0.27	9.7	112.0	0.18	0.01	70	Nil	0.07	0.25
		13 - 24	24	51	25	SiL	7.3	6.1	0.06	32.0	Nil	0.78	0.07	3.6	5.7	2.52	0.05	0.19	8.4	101.6	0.10	0.01	68	Nil	0.22	0.11
		24 - 65	30	43	27	L/CL	7.4	5.9	0.06	29.9	Nil	0.23	0.02	1.2	6.2	2.26	0.05	0.13	8.3	105.2	0.04	0.05	14	Nil	0.17	0.04
		65 - 80	25	41	34	CL	7.3	5.7	0.06	27.5	Nil	0.16	0.02	Nil	8.1	3.27	0.05	0.19	7.5	153.9	0.10	0.06	70	Nil	0.18	0.07
		80 - 105	42	23	35	CL	7.3	5.5	0.08	21.0	Nil	0.16	Nil	Nil	9.6	3.00	0.05	0.12	7.8	163.6	0.10	0.06	32	Nil	0.16	0.11
23	Purena	0 - 14	20	53	27	SiL/SiCL	7.8	6.8	0.17	30.9	Nil	1.51	0.12	4.4	9.9	2.22	0.11	0.13	11.5	107.1	0.18	0.01	74	Nil	0.34	0.11
		14 - 27	20	50	30	SiL/SiCL	7.9	6.9	0.12	31.0	0.15	0.43	0.04	2.8	8.3	2.12	0.11	0.08	10.2	104.2	0.10	0.13	76	Nil	0.20	0.32
		27 - 60	42	25	33	CL	7.9	7.2	0.15	25.6	0.68	0.16	0.02	1.6	26.0	2.84	0.16	0.10	15.3	190.2	0.46	0.04	84	Nil	0.10	0.11
		60 - 118	40	28	32	CL	7.9	7.5	0.15	22.2	0.78	0.16	Nil	Nil	27.6	3.08	0.11	0.05	16.2	190.1	1.44	0.19	118	Nil	2.51	0.14
		118 - 125	8	57	35	SiCL	8.1	7.6	0.16	21.0	0.34	-	Nil	Nil	29.1	3.06	0.11	0.09	16.9	191.5	2.69	0.08	82	Nil	3.50	0.14
50	Gorusinge Forest	0 - 18	28	43	29	CL	6.9	5.8	0.03	30.8	Nil	0.43	0.04	4.8	6.8	3.28	0.00	0.17	10.3	98.9	0.06	0.06	66	Nil	Nil	0.32
		18 - 41	14	45	41	SiC	7.4	6.5	0.34	30.0	Nil	0.35	0.03	3.2	12.0	4.01	0.05	0.08	10.2	157.8	0.18	0.08	62	Nil	0.42	0.21
		41 - 69	19	40	41	SiC/C	7.4	6.5	0.34	27.9	0.29	0.20	0.02	Nil	15.6	4.50	0.05	0.09	12.1	166.9	0.26	0.08	62	Nil	0.51	0.21
		69 - 90	19	34	47	C	8.3	7.5	0.13	28.8	1.43	0.39	0.04	1.2	25.5	3.36	0.11	0.13	15.3	190.6	0.86	0.11	80	Nil	0.32	0.18
		90 - 105	29	44	27	L/CL	8.4	7.5	0.08	26.0	0.41	0.12	Nil	Nil	8.3	3.01	0.11	0.08	8.4	137.1	0.14	0.04	70	Nil	0.06	0.25

Table C.5.4 Profile Description (1/5)

Soil unit:	Fluventic Ustochrepts
Test pit No:	1
Location:	Patharkot
Physiography:	Peidmont Fan (F1)
Topography:	Gently Undylating
Slope:	< 5%
Parent material:	Old alluvium
Drainage:	Moderaely well drained
Ground water:	Over 1.5m
Permeability:	Moderately Slow
Moisture:	Dry
Present land use or Vegetation:	Mustard surrounding Lentil, wheat

HORIZON	DEPTH	DESCRIPTION
AP	0-12	2.5Y4/2 (wet) dark grayish yellow (dry 2.5Y4/3 olive brown), silt loam; common fine faint (Fe) mottles (7.5YR5/6); very fine weak sub angular blocky; friable; common fine roots; gley test 2+;pH 8.0; Hardness 21mm; abrupt and smooth boundary.
BAg1	12-52	2.5Y4/3 (wet) olive brown (dry2.5Y5/4 yellowish brown) ; silt loam; few, fine diffuse Fe mottles (7.5YR5/6); very fine weak subangular blocky; friable;; few fine roots; pH 8.2; Hardness 28mm; clear & wavy boundary.
IIBg2	52-73	10YR 4/4 (wet) brown (dry 10YR5/6 yellowish brown; sandy loam; few fine faint (Fe) mottles (10YR5/6); very weak sub angular blocky; very friable. pH 8.2; Hardness 23 mm; gradual and wavy boundary.
IIIBg	73-78	2.54/4 (wet) olive brown (dry 2.5Y5/4 yellowish brown); silt loam; common, fine, faint mottles (10YR4/4); very weak sub angular blocky; friable; pH 8.3; hardness 20mm; clear and wavy boundary.
IIICg	78-100+	10YR3/2 (wet) brownish black (dry 10YR3/3 dark brown) Loam; common, fine, faint Fe mottles (7.5YR5/6); massive; friable; pH 8.1; Hardness 25mm.

Table C.5.4 Profile Description (2/5)

Soil unit:	Typic Ustochrepts
Test pit No.:	19
Location :	GHANCHOURA
Physiography :	Terrace remnant (P1) or Upland (U1)
Topography :	slightly upland(undulating)
Slope :	< 3%
Parent material :	Old alluvial soil
Drainage :	well
Ground water :	Deep
Permeability :	Moderately Rapid
Moisture :	Dry
Present land use or Vegetation :	Mustard, Lentil

HORIZON	DEPTH	DESCRIPTION
Ap	0 -13	2.5Y6/6(dry) Bright yellowish brown (wet:2.5Y4/3 Olive brown), silt loam, Common fine faint (Fe) mottle(7.5YR5/6), Moderate subangular blocky, ard, Dry, Common fine roots, Hardness 10mm, pH7.3 Clear smooth boundary:
AB	13 -24	2.5Y6/6(moist) Bright yellowish brown(10YR6/8 Bright yellowish brown 20%) (wet:2.5Y4/6 Olive brown), silt loam, Few fine faint (Fe) mottle(7.5YR5/6), Few (Mn) mottle & concretion, Weak subangular blocky, Firm, Moist, Few fine roots, Hardness 32mm, pH7.3 Gradual wavy boundary:
Bg1	24 - 65	2.5Y6/8(moist) Bright yellowish brown(10YR6/8 Bright yellowish brown 30%) (wet:2.5Y6/6 Bright yellowish brown), loam to clay loam, Common fine faint (Fe) mottle(7.5YR5/6), Common (Mn) mottle & concretion, Some clay illuviation, Weak subangular blocky, Firm, Moist, Common pores, Hardness 29mm, pH7.4 Gradual wavy boundary:
Bg2	65 - 80	2.5Y6/8(moist) Bright yellowish brown(10YR6/8 Bright yellowish brown 40%) (wet:2.5Y6/6 Bright yellowish brown), clay loam, Many fine faint (Fe) mottle(7.5YR5/6), Common (Mn) mottle & concretion, Some clay illuviation, Weak subangular blocky, Firm, Moist, Common pores, Hardness 26mm, pH7.3 Gradual smooth boundary:
Btg3	80 - 105+	2.5Y6/8(moist) Bright yellowish brown(10YR6/8 Bright yellowish brown 50%) (wet:2.5Y6/8 Bright yellowish brown), Clay loam, Many fine faint (Fe) mottole(7.5YR5/6), Common (Mn) mottle & concretion, Common clay illuviation, Massive, Friable, Moist, Common pores, Hardness 24mm.pH7.3

Table C.5.4 Profile Description (3/5)

Soil unit:	Typic Endoaquepts
Test pit No.:	12
Location :	MORMI south
Physiography :	Recent Alluvial Fan (E22)
Topography :	Almost flat(Slightly convex)
Slope :	< 2%
Parent material :	Old alluvial soil
Dranage :	poor(Imperfect)
Ground water :	Shallow
Permeability :	Very Slow
Moisture :	wet
Present land use or Vegetation :	Fallow, surrounding fallow,Linseed(oil seed),wheat, grasspea

HORIZON	DEPTH	DESCRIPTION
Apg	0 -15	7.5Y3.5/2(moist) Grayish olive (wet:7.5Y4/2 Graysh olive), Clay loam, Few fine faint (Fe) mottole (10Y5/6), Weak subangular blocky, Friable (S&P), Moist, Common fine roots, Gley test +, Hardness 16mm, pH 6.9, Clear wavy boundary:
ABg	15 -25	7.5Y3.5/2(moist) Graysh olive (wet:7.5Y4/2 Grayish olive), Clay loam, Common fine faint (Fe) mottle (10YR5/6), Weak subangular blocky, Friable (S&P), Moist, Few fine roots, Gley test +-, Hardness 26mm, pH 7.8, Gradual wavy boundary:
Bg1	25 - 50	5Y5/3(wet) Grayish olive (5Y5/6 Olive 30%) (wet:5Y4/2 Grayish olive), Clay loam, Common fine faint (Fe) mottole(10YR4/6) concretion, Few clay illuviation, Friable (Sticky & Plastic), Massive, Moist, Hardness 24mm, pH 7.8, Diffuse wavy boundary:
Bg2	50 - 81	5Y5/6(moist-wet) Olive (5Y6/4 Olive yellow) (wet:5Y5/6 Olive), Silty Clay loam, Few fine faint (Fe) mottle(10Y5/6), Common fine distinct (Mn) mottle and concretion from 65cm, Few clay illuviation, Massive, Very sticky & very plastic, Wet, Hardness 20mm, pH 7.8, Gradual smooth boundary:
C	81 - 118+	5Y5/6(wet) Olive, Loamy sand, Few Mn mottle, Non-sticky & non-,plastic, Structureless, Wet, Hardness 16mm, pH 7.8, From 100cm water seepage

Remark: (S&P) means sticky and plasticky in wet condition.

Table C.5.4 Profile Description (4/5)

Soil unit:	Aeric Endoaquepts
Test pit No.:	10
Location :	VELAHI south, east of road
Physiography :	Recent Alluvial Plain (P21)
Topography :	Almost flat
Slope :	< 1%
Parent material :	Old alluvial soil
Dranage :	Imperfect
Ground water :	Moderate shallow
Permeability :	Slow
Moisture :	Dry
Present land use or Vegetation :	Fallow, surrounding Linseed(oil seed), Mustard, Grasspea, Vegetables, Wheat

HORIZON	DEPTH	DESCRIPTION
Ap	0 -7	2.5Y5/4(dry) Yellowish brown (wet:2.5Y5/3 Yellowish brown), Clay loam, Few fine faint (Fe) mottle (10YR6/6), Moderate subangular blocky, Hard(Sticky & Plastic), Common fine roots, Few cracks (upto 20cm), Hardness 27mm, pH 7.0 Gradual wavy boundary:
Bg1	7 -24	2.5Y6/3(moist) Dull yellow (wet:2.5Y5/3 Yellowish brown),(Silty clay loam), Common fine faint (Fe) mottle(10YR5/6), Few (Mn) concretion, Moderate subangular blocky, Firm(Sticky & Plastic), Moist, Few fine roots, Hardness 28mm, pH 7.8 Gradual wavy boundary:
Btg2	24 - 85	2.5Y5/6(moist) Yellowish brown (2.5Y5/3 Dull yellow 30%) (wet:2.5Y5/6 Yellowish brown), (Silty clay loam), Common fine faint (Fe) mottle(10YR5/6), Few (Mn) concretion, Weak subangular blocky, Firm(Sticky & Plastic), Moist, Few fine roots, Common clay illuviation, Hardness 24mm, pH 7.8 Gradual smooth boundary:
IIBC	85-105+	2.5Y5/4(wet) Yellowish brown (wet:2.5Y5/6 Yellowish brown), Fine loam, Few fine faint (Fe) mottle(10YR5/6), Few (Mn) concretion, Structureless, Non-sticky & non-plastic, Wet to moist, Hardness 17mm.pH 7.8

Table C.5.4 Profile Description (5/5)

Soil unit:	Typic Ustifluvents
Test pit No.:	14
Location :	CHANGHAT west
Physiography :	Erosional Terrace (ET)
Topography :	Lower terrace
Slope :	Flat
Parent material :	Newly alluvial soil
Dranage :	Well
Ground water :	Moderately Shallow (depend on river discharge)
Permeability :	Moderately Rapid
Moisture :	Dry(Moist)
Present land use or Vesetation :	Maize, Radish vegetable,surrounding Chickpea, wheat, Mustard, Lentil

HORIZON	DEPTH	DESCRIPTION
AP	0 -14	2.5Y4.5/4(moist) Olive brown (wet:2.5Y4/4 Olive brown), Loam sand, Structureless, Friable, Moist, Common fine roots, Fraiable, Hardness 18mm, Clear smoooth boundary:
BA	14 -27	2.5Y5/4(moist) Yellowish brown (wet:2.5Y4/4 Olive brown), Sandy loam , Structureless, Friable, Moist, Few fine roots, Hardness 18mm, Graduale wavy boundary:
B2	27 - 44	2.5Y5/4(moist) Yellowish brown (wet:2.5Y4/4 Yellowish brown), Sandy loam, Few clay illuviation(wide 30cm, hight 5cm), Structureless, Friable, Moist, Hardness 17mm, Graduale smooth boundary:
B3	44 - 58	2.5Y5/4(moist) Yellowish brown (wet:2.5Y5/6 Yellowish brown), Sandy loam, Few Fe&Mn concretion(mottle)(10YR4/4), Structureless, Friable, Moist, Hardness 22mm, Clear irriegular boundary:
IIC	58 - 81	2.5Y5/3(moist) Dull yellowish brown (wet:2.5Y5/4 Olive brown), Fine loam, Common fine faint (Fe&Mn) mottole (2.5Y4/4), Many river stone Massive, Friable, Moist, Hardness 18mm.

Table C.5.5 Mapping Unit of the Study Area

Land Form	Map Unit	Dominant soil	Dominant Slope	Dominant Texture*1	Drainage	Landuse / Vegetation
Allubial Fan(F)						
Open field	F1	Fluventic Ustochrepts Aeric Endroaquepts	1-5%	L-F.L	Variable (depend on topography)	Paddy Field
Forest land	F2	Fluventic Ustochrepts Typic Haplustolls	1-5% (Occasionally >60%)	L	Variable (depend on topography)	Forest
Upland(U)						
Open field	U1	Typic Ustochrepts	1-5%	L-F.L	Well	Paddy Field Upland crop
Forest land	U2	Typic Ustochrepts Typic Haplustolls	1-5% (Occasionally >60%)	L-F.L	Well	Forest
Recent Alluvial Plain(P)						
Terrace remnants	P1	Typic Ustochrepts	<2%	L-F.L	Moderatly well	Paddy Field House yard
Plain(P2)						
Higher	P21	Aeric Endroaquepts	<1%	F.L-C	Imperfect to poor	Paddy Field
Lower	P22	Typic Endroaquepts Aeric Endroaquepts	<1%	F.L-C	Poor	Paddy Field
Old river course	P3	Fluventic Ustochrepts Aeric Fluvaquents	<2%	L	Imperfect	Paddy Field
Erosional Terrace(ET)	ET	Typic Ustifulvents,	<2%	S.L-L	Variable: subject to occational river flooding	Paddy Field Grazing, Forest

Remarks: *1: L : Loam, F.L : Fine Loam, S.L : Sandy Loam, C : Clay

Table C.5.6 The Extent Area of Soil Map in Study Area

Physiographic Feature	Map Unit	North area of East-Weat Highway		South area of East-Weat Highway		Total		Project Area *1	
		(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)
Alluvial Fan									
Open Field	F1	150	3	0	0	150	1	150	7
Forest	F2	640	14	0	0	640	5	0	0
Upland (Old Terrace)									
Open Field	U1	70	2	130	2	200	2	90	4
Forest	U2	2,480	55	3,400	44	5,880	48	0	0
Recent Alluvial Plain									
High land	P1	260	6	790	10	1,050	9	450	21
Flat	P21	580	13	2,250	29	2,830	23	960	44
Depresional	P22	360	8	780	10	1,140	9	530	24
Old River	P3	0	0	20	0	20	0	0	0
Erosional Terrace (Low Terrace)	ET	10	0	300	4	310	3	10	0
Total		4,550	100	7,670	100	12,220	100	2,190	100

Remarks : *1 : Project area is gross mapping area including non-irrigated area, i.e. grazing lands, existing facilities, roads and villages.

Table C.6.1 Land suitability criteria (for Paddy) (1/2)

Land Characteristics (deficiency categories)	SR1	SR2	SR3	NSR1	NSR2
Soil characteristics (s)					
Top soil texture	Fine to medium texture that can be puddled : (C, SiC, SC, SCL, CL, SiCL, L, SiL, Si)	Medium textures: (fSL, SL)	Coarse textures : (cSL)	Very coarse textures : (S)	Gravel, stones and rocks
Effective soil depth	20 cm <	-	-	-	-
Alkalinity (pH)	< 7.5 for non-calcareous soils and < 8.6 for calcareous soils	< 9.0 unless soil is calcareous and non-sodic	< 9.0 unless soil is calcareous and non-sodic	> 9.0 and < 4.0	-
Salinity (ECe) (mmhos/cm)	< 3.0	> 3.0 and < 8.0	-	> 8.0	-
Slopes (t)					
unterrace land (%)	<1	>1 and <15	>15 and <60	>30 and <60	>60
terrace land (%)	<20	-	>20 and <30	-	>60
Drainability (d)	Poor to imperfect	Imperfect to moderately well Very poor drained	Moderately well to well	-	Excessively
Vegetation (v)	Clear or non vegetation	Woody cover less than 20% : clearing cost small cost	Woody cover less than 40% : clearing required but at moderate	Woody cover less than 80% : expensive clearing required	-
Flood risk (f)	none	-	Occasional	-	Frequent

Table C.6.1 Land suitability criteria (for Upland crops) (2/2)

Land Characteristics (deficiency categories)	S1	S2	S3	NS1	NS2
Soil characteristics (s)					
Top soil texture	Medium fSL, SL, L, friable CL	Moderately fine to fine, or moderately coarse. Permeable SCL to C or cSL, LfS.	Coarse, fine or high Si. Moderately permeable to poorly permeable SCL to C or LS to SiL with capping problem.	Very coarse or very fine. Impermeable C, S and fresh alluvial Si	Gravel, stones and rocks
Sub soil texture	Medium to fine fSL, SL, L and finer texture as class S2 topsils	Moderatery coarse cSL, LfS	As class S3 and N1 topsoils	-	-
Rice pan depth	No pan, or only very weekly developed	Moderately well developed at between 10 and 15 cm depth.	Moderately well developed at between 10 and 15 cm depth. or strongly developed	-	-
Effective soil depth	> 100 cm	< 100 cm and > 75 cm	< 75 cm and > 50 cm	< 50 cm and > 25 cm	< 25 cm
Alkalinity (pH)	> 6.0 and < 8.3 (H2O)	< 6.0 and > 4.5 (H2O) > 8.3 and < 8.5 (H2O)	< 4.5 and > 4.0 (H2O) > 8.5 and < 9.0 (H2O)	< 4.0 and > 9.0	-
Salinity (ECe)	< 2.0	> 2.0 and < 4.0	> 4.0 and < 8.0	> 8.0	-
Fertility (f)					
Top soil CEC	> 15	< 15 and > 10	< 10 and >5	< 5	-
Slope (t)					
unterrace land (%)	<1	>1 and <15	>15 and <60	-	>60
terrace land (%)	<20	-	>20 and <30	>30 and <60	>60
Drainability (d)	Well drained to moderately well drained	Moderately well to imperfect drained	Imperfectly to poor drained or mod. excessively drained	Poor to very poor drained	Excessively
Vegetation (v)	Clear or non vegetation	Woody cover less than 20% : clearing cost small cost	Woody cover less than 40% : clearing required but at moderate	Woody cover less than 80% : expensive clearing required	-
Flood risk (f)	none	-	Occasional	-	Frequent

Table C.6.2 The Land Evaluation (Irrigation Suitability) in the Study Area (Paddy) (1/2)

Paddy Suitability Classes	Correlative mapping unit	Study Area without Drainage System		Study Area with Drainage System	
		(ha)	(%)	(ha)	(%)
SR1	P21	2,830	23	3,970	32
SR2d	P22	1,140	9	0	0
SR2s	P1	1,050	9	1,050	9
SR2st	F1, U1	350	3	350	3
SR2sd	P3	20	0	20	0
SR3fs	ET	310	3	310	3
NSR1	F2, U2	5,520	45	5,520	45
NSR2	U2	1,000	8	1,000	8
Total		12,220	100	12,220	100

Table C.6.2 The Land Evaluation (Irrigation Suitability) in the Study Area (Upland crops) (2/2)

Paddy Suitability Classes	Correlative mapping unit	Study Area without Drainage System		Study Area with Drainage System	
		(ha)	(%)	(ha)	(%)
S1	P1, P3	1,070	9	3,900	32
S2d	P21	2,830	23	1,140	9
S2t	F1, U1	350	3	350	3
S3d	P22	1,140	9	0	0
S3fs	ET	310	3	310	3
NSR1	F2, U2	5,520	45	5,520	45
NSR2	U2	1,000	8	1,000	8
Total		12,220	100	12,220	100

Table C.6.3 The Land Evaluation (Irrigation Suitability) in the Project Area (Paddy) (1/2)

Paddy Suitability Classes	Project Area *1 without drain		Project Area *1 with drain	
	(ha)	(%)	(ha)	(%)
SR1	960	44	1,490	68
SR2d	530	24	0	0
SR2s	450	21	450	21
SR2st	240	11	240	11
SR3fs	10	0	10	0
Total	2,190	100	2,190	100

Remarks : *1 : Project area is gross mapping area including non-irrigated area ,i.e. grazing lands, existing facilities, roads and villages.

Table C.6.3 The Land Evaluation (Irrigation Suitability) in the Project Area (Upland crops) (2/2)

Upland Crops Suitability Classes	Project Area *1 without drain		Project Area *1 with drain	
	(ha)	(%)	(ha)	(%)
S1	450	21	1,410	64
S2d	960	44	530	24
S2t	240	11	240	11
S3d	530	24	0	0
S3fs	10	0	10	0
Total	2,190	100	2,190	100

Remarks : *1 : Project area is gross mapping area including non-irrigated area ,i.e. grazing lands, existing facilities, roads and villages.

FIGURES

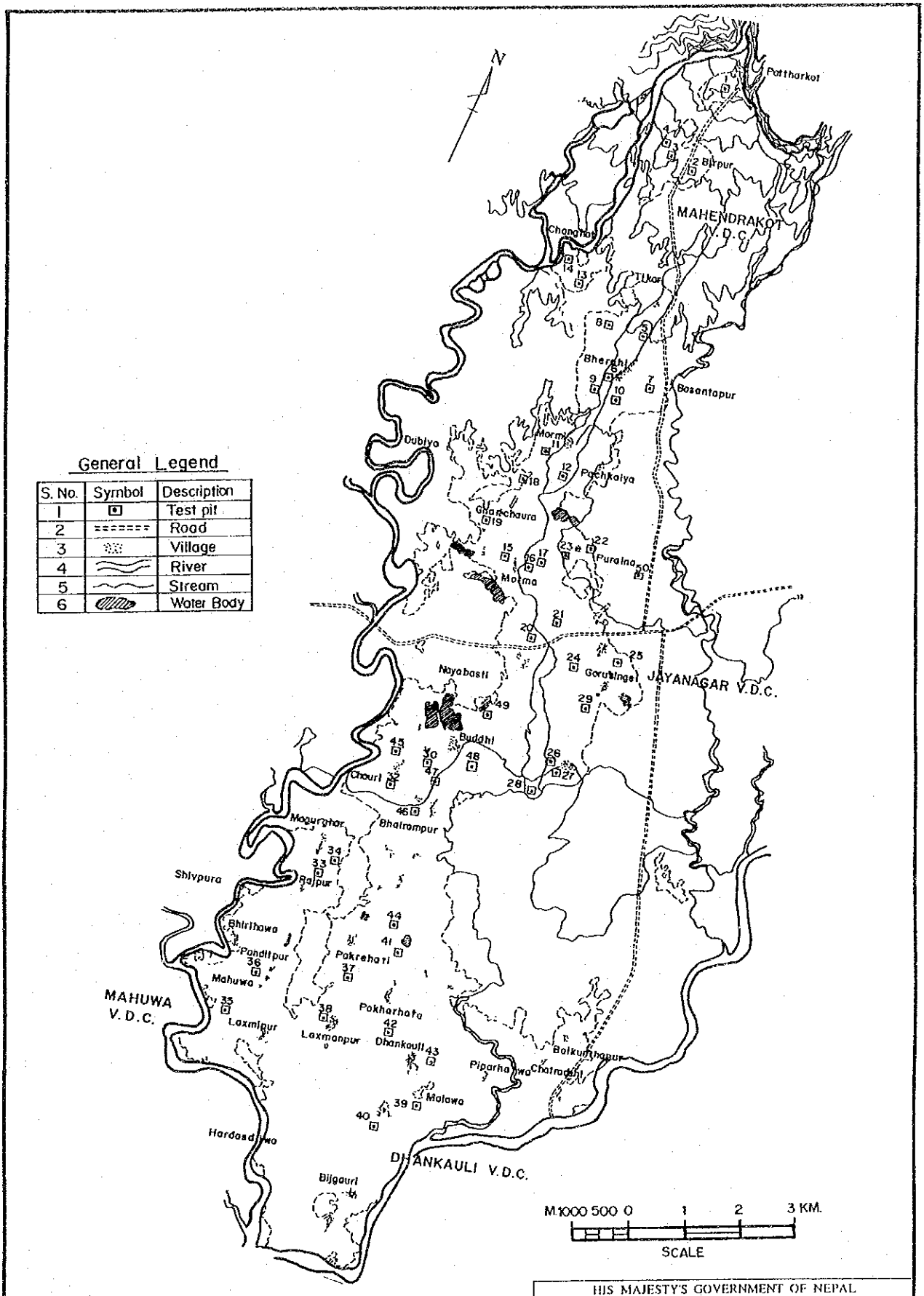
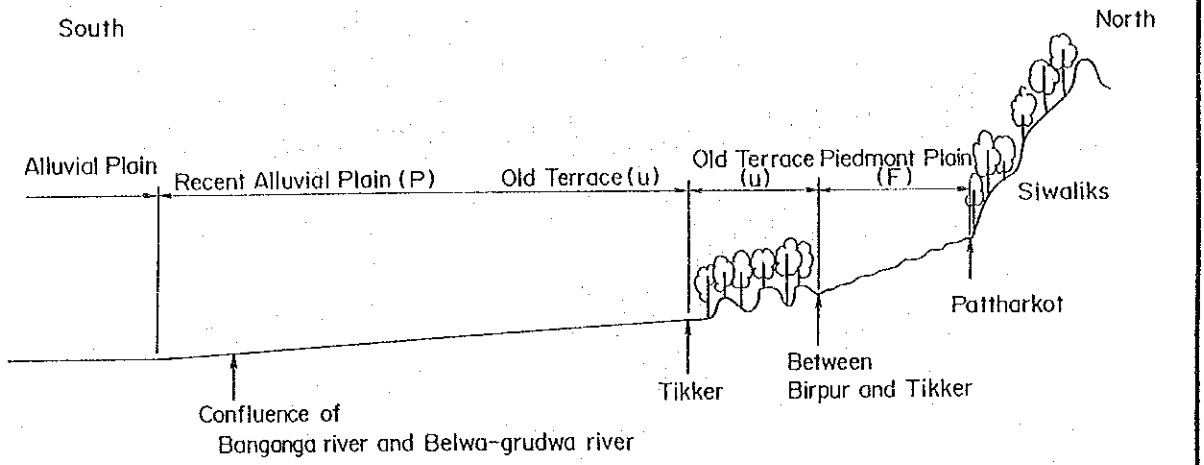
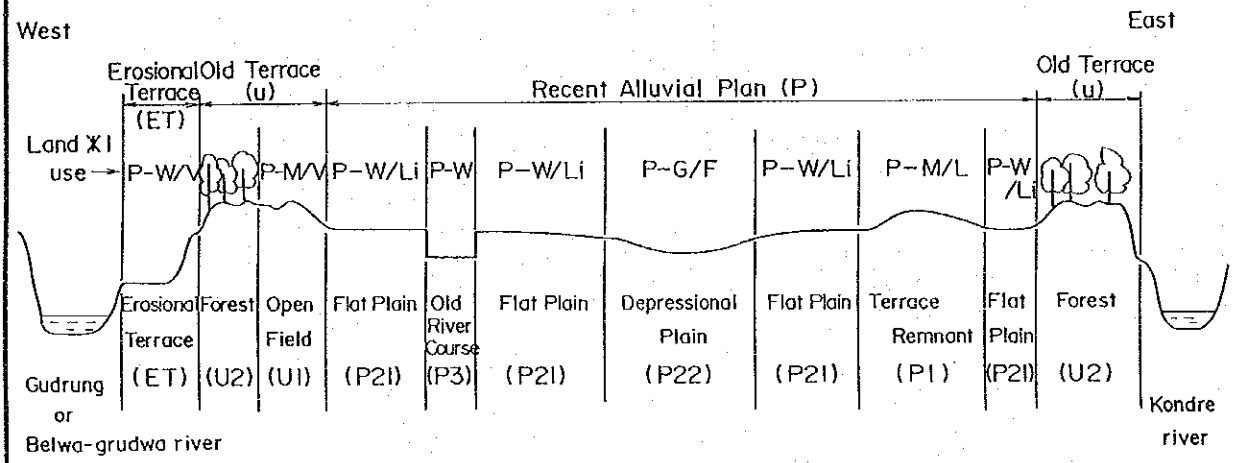


Fig. C.5.1 Location of the Test Pit Sites





※ 1. Land use : P : Paddy, W : Wheat, M : Mustard,
L : Lentil, Li : Linseed, G : Grasspea, F : Fallow

Fig. C.5.2 Cross Section of Physiographic Units in the Study Area

HIS MAJESTY'S GOVERNMENT OF NEPAL
FEASIBILITY STUDY ON THE RAJKUDWA IRRIGATION PROJECT
JAPAN INTERNATIONAL COOPERATION AGENCY

(Unit : ha)

Symbols	Landuse Categories	Study Area	Project Area
LP	Lower Paddy Field	3,080	1,340
UP	Upper Paddy Field	1,350	450
D	Dry Field	130	50
F	Mixed Forest & Bush	-	-
W	Pond & Swamp	-	-
V	Villege	-	-
Total*1		4,560	1,840

*1: Total area represents the net cultivated area.

Project Area

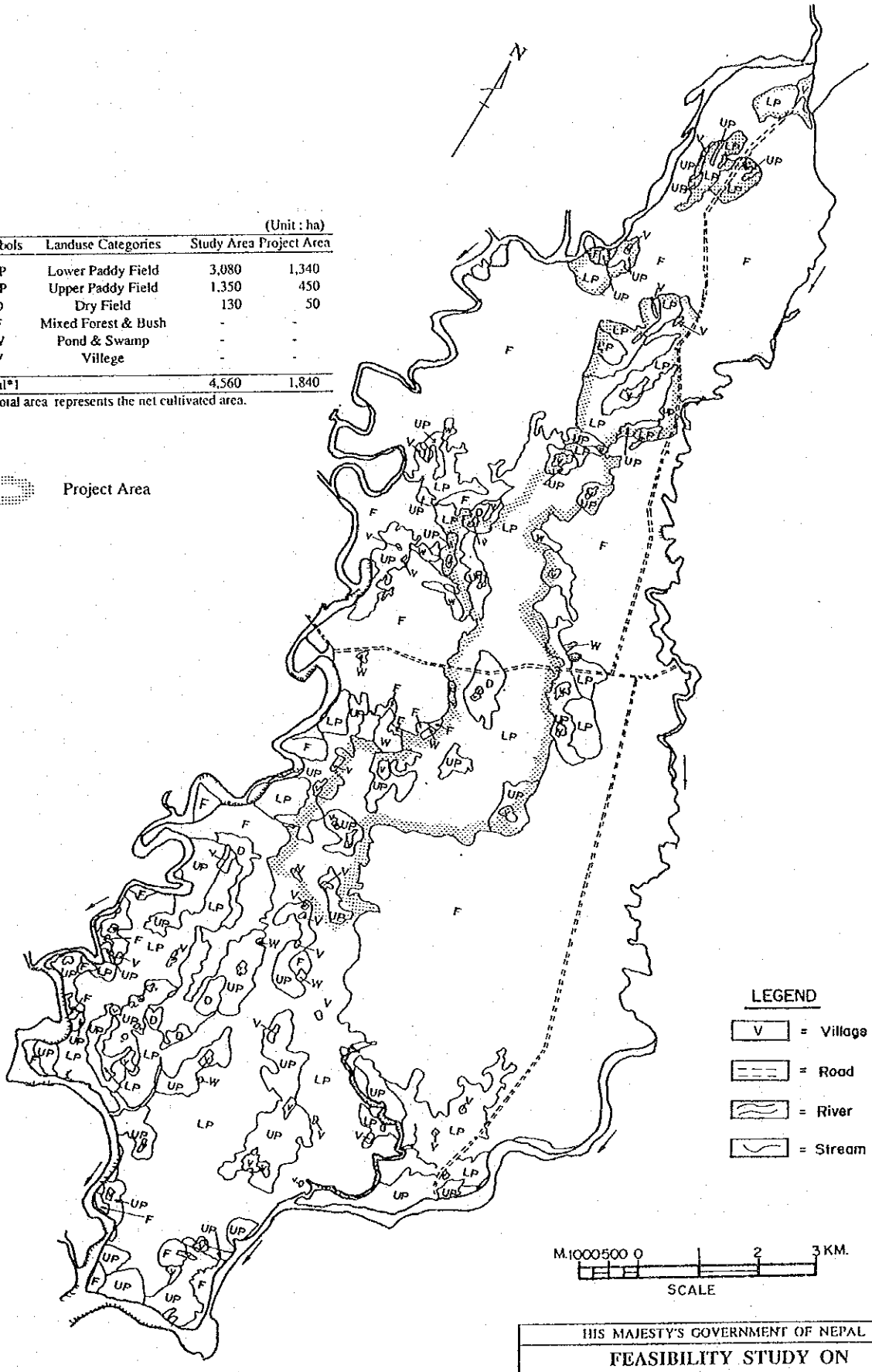
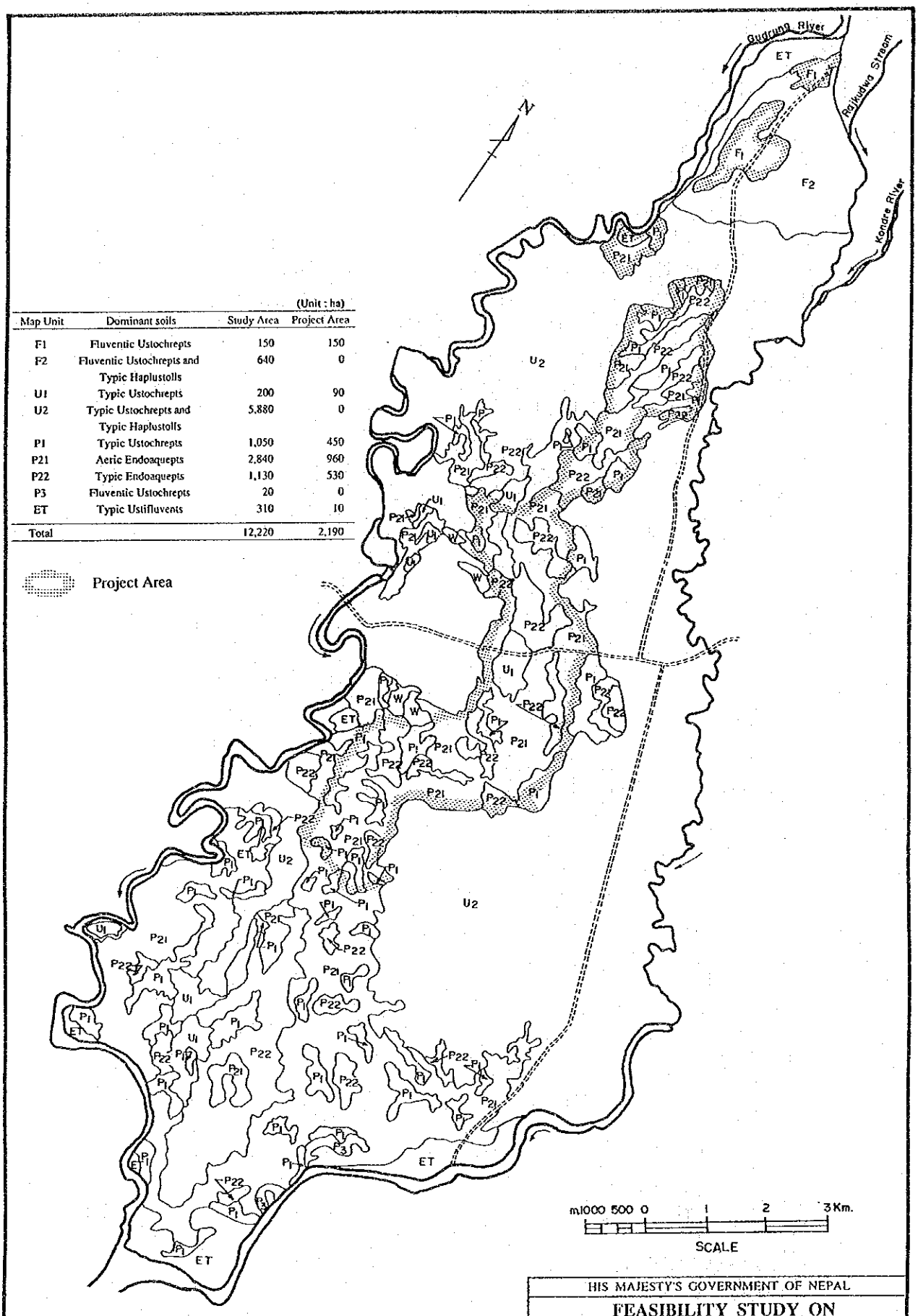


Fig. C.5.3 Present Landuse Map

HIS MAJESTY'S GOVERNMENT OF NEPAL

FEASIBILITY STUDY ON
THE RAJKUDWA IRRIGATION
PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY



(Unit : ha)

Map Unit	Dominant soils	Study Area	Project Area
F1	Fluventic Ustochrepts	150	150
F2	Fluventic Ustochrepts and Typic Haplustolls	640	0
U1	Typic Ustochrepts	200	90
U2	Typic Ustochrepts and Typic Haplustolls	5,880	0
P1	Typic Ustochrepts	1,050	450
P21	Aeric Endoaquepts	2,840	960
P22	Typic Endoaquepts	1,130	530
P3	Fluventic Ustochrepts	20	0
ET	Typic Ustifluvents	310	10
Total		12,220	2,190

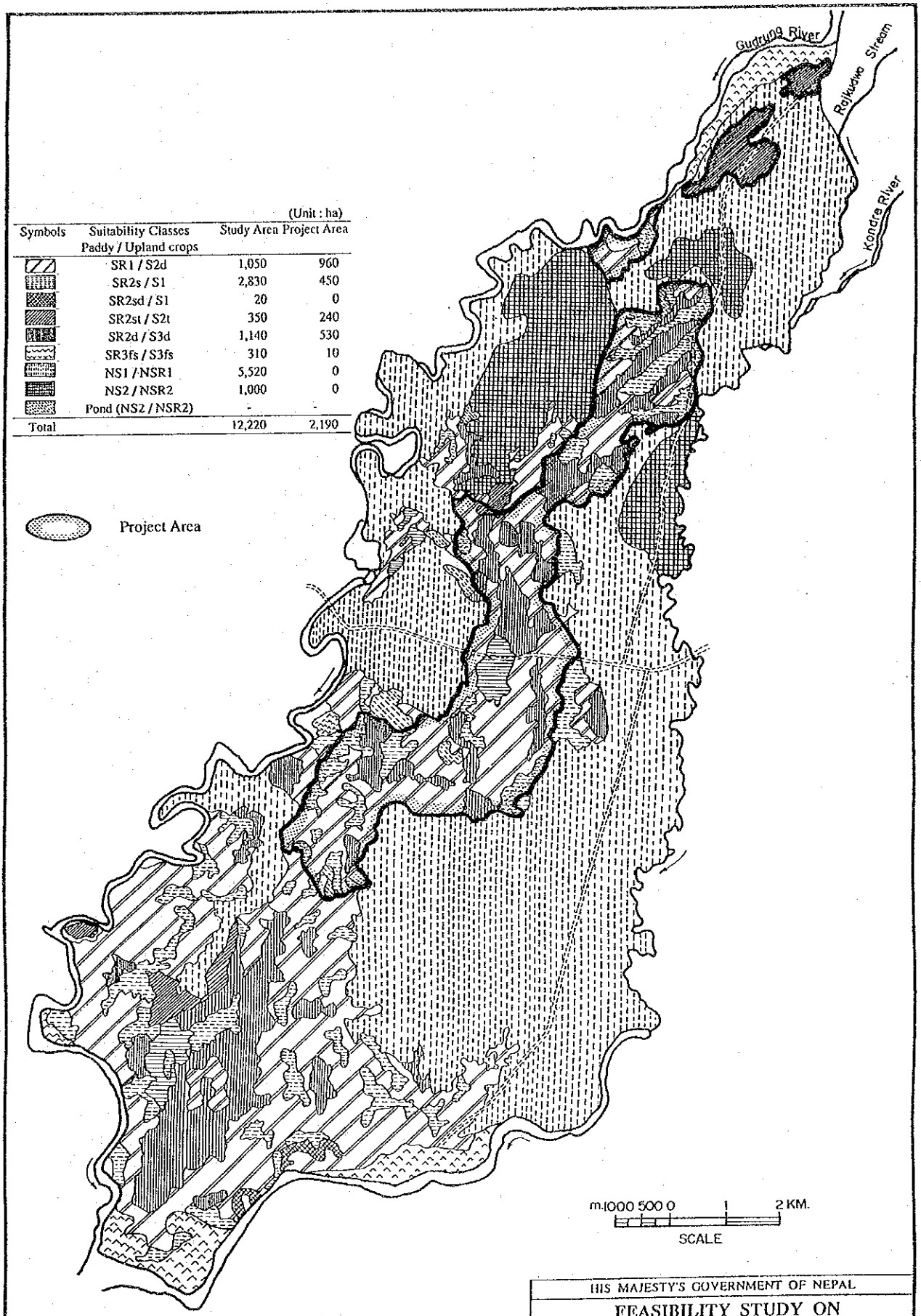
Project Area

Fig. C.5.4 Soil Map

HIS MAJESTY'S GOVERNMENT OF NEPAL

FEASIBILITY STUDY ON
THE RAJKUDWA IRRIGATION
PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY



(Unit : ha)

Symbols	Suitability Classes Paddy / Upland crops	Study Area	Project Area
	SR1 / S2d	1,050	960
	SR2s / S1	2,830	450
	SR2sd / S1	20	0
	SR2st / S2t	350	240
	SR2d / S3d	1,140	530
	SR3fs / S3fs	310	10
	NS1 / NSR1	5,520	0
	NS2 / NSR2	1,000	0
	Pond (NS2 / NSR2)	-	-
Total		12,220	2,190

Fig. C.6.1 Land Suitability Map

HIS MAJESTY'S GOVERNMENT OF NEPAL

FEASIBILITY STUDY ON
THE RAJKUDWA IRRIGATION
PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

ANNEX - D

AGRICULTURE, FARMERS' ORGANIZATION AND AGRICULTURAL SUPPORT SERVICES

ANNEX - D

AGRICULTURE, FARMERS' ORGANIZATION AND AGRICULTURAL SUPPORTING SERVICES

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ANNEX - D AGRICULTURE, FARMERS' ORGANIZATION AND AGRICULTURAL SUPPORT SERVICES

D.1 INTRODUCTION

The Rajkuduwa irrigation project aims to increase agricultural production by providing irrigation facilities, improving farmers' organizations and providing agricultural support services. The study has focused on measuring the present situation of agricultural production, agricultural support services and farming practices, as well as estimating the effect of the project.

The main objectives are as follows :

(i) To study the present condition of agricultural activities and crop production in the project area;

(ii) To find a suitable cropping pattern in the project area and evaluate the development potential in agricultural production;

(iii) To estimate the effect of using improved agricultural inputs under the project condition; and

(iv) To propose a strengthened and improved plan of farmers' organizations and agricultural support services.

The following field surveys and data collection were made in the project area to support and clarify the above-mentioned objectives.

(i) Survey on farming practices for each crop, cropping pattern (calendar), crop unit yield and production.

(ii) Survey on existing farmers' organizations and agricultural support services including agricultural extension and research.

Information and data were collected from the government authorities concerned such as the District Agricultural Development Office (DADO) reorganized from both the former District Agriculture Office (DAO) and the former District Cooperative Office (DCO), etc.. A survey of 110 farm households was carried out to obtain more practical and reliable information on the present agricultural activities and farming practices.

D.2. PRESENT CONDITION OF AGRICULTURE

D.2.1 General Condition

The study area is located in the northern and southern belt of the East-West Highway (EWH) which is west of Banganga and east of Belwagurdwa river. The total study area is 12,220 ha which consist 4,550 ha on the north of EWH and 7,670 ha on the south. The study area, administratively, belongs to the Kapilvastu District, Ilaka No. 6. It covers 59 wards in seven Village Development Committees (VDCs). The number of farm households is about 4,950 which is about 95% of the total households (5,150). The average family size in the study area is about 6.5 persons. The average land holding size is 1.0 ha, ranging from 7.4 ha to 0.36 ha.

D.2.2 Present Landuse

About 37% or 4,560 ha of the study area is farmland, almost all of which is paddy fields. The farmlands are cultivated to a large extent for both paddy (97%) and upland crops (3%). Most of the paddy fields are under rainfed condition though there are some irrigated fields. The southern part of the study area is completely rainfed area, while in the northern part some parts of Patharkot, Birupur, Tikkar, Basantapur and Phachkaiya are partially irrigated by the Ranikuduwa Farmers' Irrigation System. Hence, cultivation area and crop production in the study area change from year to year due to rainfall patterns and available water.

The present condition of farmland in the study area is as follows:

(Unit: ha)

Name of VDCs	Paddy Field			Upland	Total
	Irrigated	Non-irrig.	Sub-total		
Mahendrakot	400	110	510	0	510
Dubiya	150	220	370	30	400
Jayanagar	60	570	630	40	670
Buddi	240	210	450	0	450
Rajpur	300	500	800	20	820
Mahuwa	50	640	690	40	730
Dhankauli	100	880	980	0	980
Total	1,300	3,130	4,430	130	4,560

Ref. : Table D.2.1

D.2.3 Present Cropping Pattern and Cropping Intensity

The lands of the study area are good for growing paddy and diversified crops. Among the irrigated area, Patharkot village has almost three crops a year because of year-round irrigation whereas in other areas less than 10 percent of farmers cultivate three crops a year. Most farmers in the irrigated lands cultivate at least two crops in a year. The staple crop of the study area is paddy followed by wheat and maize. Vegetables are grown only for family consumption in the garden or house yard area. The present cropping calendar is as follows:

Crops	Seedling/ planting	Harvesting
Summer Crops :		
Paddy, maize	June / July	October / November
Winter Crops :		
Wheat, pulses, oilseeds, vegetables	October / December	March / April
Spring Crops :		
Maize, pulses	March / April	June / July

The dominant summer crop in the rainy season is paddy which represents 95% of the total cultivated area, other crops are maize and pulses. During the dry season in winter, wheat is predominant and pulses (lentil, pigeon pea, chick pea, black gram), oilseeds (mustard) and vegetables (potato, cabbage, cauliflower, leaf mustard, onion, garlic, radish, tomato, etc.) are also planted to some extent. After winter crops, spring crops (maize, pulses for green manure crops, etc.) are planted. However, production of the spring crops are marginal due to little rainfall, hence used for animal feeds and/or green manure.

Present multi-cropping intensity is estimated at 132% in the study area including more than 200% in the existing irrigation area. According to the agricultural survey carried out over the study area, the present cropping patterns, cropping intensity and cropping area could be classified into seven types as shown in the following table:

Cropping Pattern	Cropping Intensity	Cropping Area
Irrigated Paddy Field	(%)	(ha)
A-1 : Paddy - Wheat/ Oilseeds - Maize/ Pulses	300	40
A-2 : Paddy - Wheat/ Oilseeds/Pulses/Vegetables	200	480
A-3 : Paddy - Wheat/ Oilseeds/ Pulses	180	340
A-4 : Paddy - fallow	96	440
Sub-total		1,300
Non-irrigated Paddy Field		
B-1 : Paddy - Wheat/ Oilseeds/ Pulses	170	940
B-2 : Paddy - fallow	100	2,190
Sub-total		3,130
Upland		
C : Maize/ Pulses - Pulses/ Fallow	94	130
Total	132 (Ave.)	4,560

Ref. : Table D.2.2

Pattern A-1 is observed in the upstream parts of the existing irrigation areas. Pattern A-2 and A-3 are prevailing in the irrigated paddy fields, which occupies about 63% of the existing irrigation areas. Due to insufficient irrigation water and rainfall in the dry season, very limited areas are planted with winter crops. Pattern A-4 is allocated in the lower parts of the existing irrigation area which have no irrigation water due to the poor irrigation facility. Pattern B-1 of double cropping of paddy and winter crops is observed in non-irrigated fields, but the cultivation area is small. Pattern B-2 is common practice on lowland in existing paddy fields along small streams where the soil moisture content is high due to the high groundwater table.

Pattern C is found in dry fields and upland fields. These present cropping patterns and cropping areas are illustrated in Table D.2.2 and Figure D.2.1.

D.2.4 Present Farming Practices and Farm Inputs

The present farming practices in the study area are labor intensive throughout the growing period from seeding to harvesting. Nursery bed preparation, plowing, harrowing and paddling in paddy fields are carried out before transplanting both manually and with animal power. Hand weeding is common practice in the fields. Harvesting is carried out using sickles and the harvested paddy, wheat, mustard and lentil are dried in the fields or house yard. After threshing, cleaning and drying, grains are stored for home consumption or selling in local markets.

According to the farm survey, about 19% of the farmers used seed of improved varieties. Most of the farmers used farm yard manure (FYM) at the time of land preparation, but the application quantity depends on the land holding areas and the number of cattle owned by the farmers. About 38% of the farmers also used chemical fertilizers, mostly compost and urea, but the application is still small. Out of all the farmers, about 8% applie fungicides, about 24% use herbicides and 42% spray insecticides.

In general, the traditional farming practices are prevailing in the study area. The land preparation is carried out using a pair of bullocks and simple farm implements, while the other farming works depend mainly upon human labor.

(1) Paddy :

Paddy is the most important crop in the study area. Cultivation practice is labor intensive from seeding to harvesting and threshing. The variety mostly grown is Mansuli. All the adult members of the family contribute their labor to paddy farming. Animal power (draft animals), mainly bullock is extensively used for land preparation, ploughing and harrowing before transplanting.

Nursery bed is prepared for sowing in June and July. Seed is sown at the rate of 55 to 65 kg/ha in the nursery which is about 1/20 to 1/25 of the paddy field. Seedlings are ready for transplanting in 25 - 30 days.

Land is prepared by ploughing two or three times with bullocks. Compost is usually applied. Cowdung, shrubs, grasses and weeds are used to make compost. Seedlings are manually transplanted. Random transplanting is done and the number of seedlings for transplanting is generally low (40 - 50 per m^2).

Farmers are willing to use chemical fertilizers, but the application has been restricted by the high cost and the shortage of water. Only one weeding is carried out after 30 - 40 days of transplanting. Presently, farmers are utilizing river water for irrigation which is managed by water users' group. The water is allocated equally in the time of need. Paddy is harvested in October/November. The average female labor requirement is 40 man-day (MD) and male labor is 90 MD per ha in the overall farming of paddy.

Draft animal use is 40 MD per ha. Harvesting is generally carried out by sickle. The harvested paddy is dried on the ground in the fields and threshed manually.

(2) Wheat :

Wheat is the main winter crop which is mostly grown in the lowlands and irrigated fields. It is normally broadcasted in the month of November, just after the summer crop is cleared. Land is preparated by twice ploughing followed by leveling. It is manured with compost, i.e. farm yard manure. Chemical fertilizer is rarely used and weeding is uncommon. The seed rate is 125 - 130 kg/ha. Ears are harvested in March/April. Threshing is done by beating the ears with sticks and then threshed grains are winnowed, dried and stored. Also, there is practice of storing dried ears and threshing is done according to the family needs. In some of the study area, winnowing work is done by machine or wheat thresher. Labor requirement per ha on average is 70 MD for males and 25 MD for females. Draft animal use is 30 MD per ha.

(3) Maize :

Maize is cultivated two times a year. Summer season maize is sown in May and harvested in August while spring season maize is sown in March and harvested in June. It is generally rainfed and grown mostly in non-irrigated areas. Local varieties are used and seeds are either broadcasted or drilled in rows.

Land is prepared in about one to two months before sowing by ploughing two to three times. It is common practice to grow maize rather densely and to thin it in four to six weeks after sowing (to be used for fodder) followed by weeding. A second weeding is done five to seven weeks after the first. The plant is suppuorted with soil to prevent bending during the second weeding. FYM is spread relatively heavily during the land preparation.

Harvesting is done by removing the matured cobs from the standing plants in the field. Cobs are dried in the sun, fully or partially shelled and stored loose or stocked either inside or outside the house. Male labor requirement is 70 MD per ha and female labor requirement is 20 MD per ha on average.

(4) Oilseeds (mustard) :

Mustard is the major oilseed crop grown in the winter season under non-irrigated and partially irrigated condition. It is broadcasted in the field after harvesting paddy. Planting is taken place in October/ November and harvesting is carried out in February/March. The seed spread rate is 10 to 14 kg/ha and traditional local varieties are used. Male labor requirement is 60 MD per ha and female labor requirement is 20 MD per ha. It is harvested, before full maturity, by hand or cut with a sickle. Drying is done for some days after the harvest and seeds are removed by beating with sticks. This crop is grown to meet domestic oil requirements as well as for commercial purpose.

(5) Pulses (lentil) :
Lentil is the most common pulse grown in the study area. The varieties are still traditional and local ones The seed spread rate is 35 to 40 kg/ha. Lentil is generally cropped in upland field. It is harvested by hand, dried in the field and threshed with sticks. This crop is also grown as a mixed crop.

(6) Vegetables :
Potato, the major vegetable crop, is normally grown for home consumption purpose in the home yard area. Other vegetables grown in the study area are cauliflower, cabbage, leaf mustard, garlic, radish, onion, eggplant, tomato, okra, etc.. These vegetables are grown in small areas particularly in household gardens. Farmers grow both local and improved varieties of vegetables. Most of the improved varieties are obtained from neighboring border areas in India. Farmers use very little of agro-chemicals for plant protection. The vegetables are harvested over a wide period by hand or sickles according to the need for home consumption.

The farm inputs and labor requirement for cultivation of paddy, wheat, maize, oilseeds, pulses and vegetables under present conditions were estimated on the basis of statistical data collected and results of the farm survey, as shown in Table D.2.3.

D.2.5 Present Crop Yields and Production

The annual planted area, unit yield and production of major crops in the study area were estimated from the agricultural statistics in the Kapilvastu District and the farm survey (ref. Table D.2.4). The unit yield of major crops remains extremely low not only due to shortage of irrigation water but also insufficient agricultural inputs and traditional farming practices.

Over the last 10years, the average total planted area of summer crops was estimated at 4,100 ha. The average planted area of paddy from 1982/83 to 1991/92 was 3,980 ha which is concentrated in the rainy season. The planted area of winter crops is about 1,880 ha on average, corresponding to 40% of the total paddy field. The low cropping area and intensity is basically attributable to shortage of water.

The average annual planted area, unit yield and production of major crops in the study area are tabulated below.

Crops	Planted Area (ha)	Unit Yield (ton/ha)	Production (tons)
Summer Crops			
Paddy (partially irrigated)	1,280	2.20	2,820
Paddy (non-irrigated)	2,700	1.42	3,840
Maize (upland)	90	1.33	120
Pulses (upland)	30	0.56	20
Winter Crops			
Wheat (partially irrigated)	470	1.70	800
Wheat (non- irrigated)	380	0.98	370
Oilseeds (partially irrigated)	120	0.71	85
Oilseeds (non-irrigated)	95	0.46	40
Pulses (partially irrigated)	120	0.66	80
Pulses (non-irrigated)	620	0.56	350
Spring Crops			
Maize (partially irrigated)	40	1.72	70

Ref. : Table D.2.5

D.2.6 Livestock and Fishery Production

Livestock plays an important role in tilling and transportation and also as a source of protein. Bullocks (cow) and buffaloes are used for land preparation, threshing and transportation. Animal products are used for home consumption and sold for cash. Most livestock are grazed in forest areas and around paddy fields. Farmers have 5.9 cows and/or buffaloes on average, about 42% of farmers keep goats, about 17% breed pigs and about 37% grow chickens. The number of livestock in the study area tabulated as follows:

(Unit: head)

Village	Cow	Buffalo	Goat	Sheep	Pig	Chicken
Mahendrakot	2,804	1,357	2,474	127	12	2,000
Dubiya	1,340	661	247	48	41	900
Jayanagar	2,487	1,481	1,509	10	62	1,664
Buddi	3,478	2,195	158	122	132	3,000
Rajpur	3,003	816	605	25	48	570
Mahuwa	2,421	965	1,982	-	535	400
Dhankauli	2,817	1,047	2,853	10	9	480
Total	18,350	8,522	9,828	342	839	9,014
Average per farmer	4.0	1.9	2.1	0.1	0.2	2.0

Aqua-culture (pond fishery) is carried out in the irrigation cum domestic water ponds surrounding the villages. Fish are an important source of protein for farmers in the study area. The extension services are provided by fishery extension workers of the District Agricultural Development Office (DADO), Taulihawa. Fingerlings are supplied mainly by the Fishery Development Centre at Bhairahawa and partly by the private sector. Production of aqua-culture is still low due to the shortage of in-pond water during the dry season.

D.3 FARMERS' ORGANIZATION AND AGRICULTURAL SUPPORT SERVICES

D.3.1 General

The following government agencies and farmers' organizations in the study area are directly involved in agricultural support services for increasing productivity and improving the living standards of the farmers.

(i) District Agriculture Development Office (DADO), Taulihawa
(ii) Agriculture Development Bank, Nepal (ADB/N), Branch Office, Taulihawa
(iii) Agriculture Inputs Corporation (AIC), Branch Office, Taulihawa
(iv) District Irrigation Office (DIO), Taulihawa
(v) District Cooperative Office (DCO), Taulihawa
(vi) District Cooperative Union, Taulihawa
(vii) Arniko Cooperative Society, Gorusinge
(viii) Janasewa Cooperative Society, Dhankauli

The district officers of DADO, ADB/N, AIC and DCO situated in Taulihawa support the agricultural development in the study area from the institutional aspects. The Agriculture Service Centre (ASC) in Buddi is the main organization that supports the farmers in the study area. Besides, there exist two cooperative farmer societies at Gorusinge and Dhankauli to carry out the credit services and agricultural input supply.

In 1993, the District Livestock office and Agricultural Statistics office joined DADO. The livestock and statistic services are performed by DADO staff. The Chief District Administration Office (CDAO) is indirectly involved because of the main administrative body of the whole district.

D.3.2 Agricultural Extension

(1) DADO

DADO, a district office of the Department of Agricultural Development (DOAD) is located in the district headquarters, Taulihawa and is responsible for the extension of cereal crops, cash crops, horticulture, vegetables, livestock and fisheries. It is the main governmental body for transferring the agricultural technologies developped in the research stations to farmers. DADO has seven service centers in the Kapilubastu district. ASC, Buddi is a sole service center in the study area. The training and visit (T&V) system is used as one of the extension services under the assistance of the World Bank Agriculture Extension Project. The T&V system aimed to diffuse the technologies from the research stations to the farmers and feedback the results to the stations in order to solve the problems in the application. However, the T&V system was altered to a group approach in 1993.

The major works of DADO are as follows:

(i) Demonstration : Agriculture extension workers demonstrate tha modern farming methods, practices and production techniques in the fields for the extension of the modern or new technologies The demonstration is one of the best ways convincing the farmers for the extension of the technologies.

(ii) Farmers' field visit and tour : Selected farmers are taken to the research farms and stations, demonstration plots and efficiently managed fields to let them learn the new technologies.

(iii) Training programs : Junior Technicians (JTs) and Junior Technical Assistants (JTAs) conduct the seasonal trainings on crops, vegetables, fruits, and livestock for the farmers. DADO regularly holds training courses for JTs/JTAs to refresh their technology. They are sent to the regional training centers for the in-service training on various farming topics. Some of the leader farmers are also sent to the centers.

(iv) Production Programs : DADO is responsible to achieve the production and acreage targets of various crops specified in the annual programs. The farmlands are classified as the special, pocket and general production areas by the availability of the irrigation water and the farm inputs.

(v) Crop Competition : Yield competition is held by DADO to promote higher production of major crops. Prizes are given to the better producer at the agricultural fairs and exhibitions. Seesling distribution for the kitchen gardening and orchard nursery is the other regular activity of DADO.

(2) ASC, Buddi

In ASC located at Buddi one assistant production officer (APO) assists and advises 3 JTs and 4 JTAs. This ASC covers 9 VDCs: Mahendrakot, Dubiya, Jayanagar, Buddi, Rajpur, Mahuwa, Dhankauli, Hariharpur and Barkalpur. One JTA works at the Centre office and the other 3 work at 3 of VDCs. APO supervises and manages all the work of ASC. A staff meeting is arranged once a month. Monthly training is conducted for leader farmers. Seasonal training is also conducted. This Centre provides agriculture services as stated in the annual targets of the DADO office.

(3) Livestock Service Centre

There are nine livestock service centres in the district. The centres are situated in Ganeshpur, Motipur, Bahadurgunj, Buddi, Maharajgunj, Kajarahawa, Harnampur, Pakadi and Gotihawa. One JTA and two other supporting clerical staff are mainly responsible for the centres. There is one livestock cooperative in Gorusinge.

In the study area, the livestock service centre is located in Taulihawa where one assistant veterinary doctor, one laboratory assistant, three stock supervisors and four peons are assigned. It was established in 1971 and called the "Animal Hospital". In 1982, the name was changed to "Animal Aushadhalaya" (hospital). The livestock service extension program has been running since 1988. The staff are responsible for implementing livestock service

activities for the farmers. The livestock services include animal husbandry, health care, vaccination and sanitation and distribution of cattle and buffalo in the villages for breeding purposes.

D.3.3 Agricultural Research

The agricultural research works in the country fall under the umbrella of the National Agricultural Research Council (NARC). There are several research stations which carry out commodity research programs under NARC. In Kapilubastu district, there is no agricultural research station or farm.

The national commodity research program consists of :

(i)	Rice Development Program	;	Parwanipur, Bara in the Central Region
(ii)	Wheat Development Program	;	Bhairahwa, Rupendehi in the Western Region
(iii)	Maize Development Program	;	Rampur, Chitawan in the Central Region
(iv)	Oilseeds Development Program	;	Nawalpur, Sarlahi in the Central Region
(v)	Pulses Development Program	;	Khumaltar

Research on crops is limited to mostly biological aspects of crop production such as breeding and varietal investigation, disease and pest identification and control measures, soil and fertilizer aspects, seed storage, crop husbandry aspects and some activities on irrigation. Some headway has been made on major cereal crops such as rice, wheat and maize. But in other cereals such as millet and barley, very little research work has been done and increased production technology is not available. Research on pluses and oilseeds are still in early stages and considerable effort is required to strengthen the activities.

The adaptive cropping systems research done in farmers' field under the Block Production Program is a product of interdisciplinary teamwork. The commodity program research activity has led to the release of a number of varieties and corresponding of practices. There has been a number of varieties of rice and wheat recommended for general cultivation by the farmers in the study area. New agronomic practices and cropping patterns have been effective in exploiting yield potentials of the new crop varieties.

The research organizations maintain very close and effective links with the extension agents at the district level. The service centers are not doing research, but they are conducting adoptive or verification studies in the farmers' fields, to generate basic data. The service center is also surveying each crop yield of different crops by crop cutting.

D.3.4 Agricultural Inputs Supply

(1) Agriculture Input Corporation(AIC), Zonal Office, Bhairahawa
The AIC zonal office consists of six administrative offices which are as follows:

Main Branch	Branch	Sub-branch	Unit branch
Taulihawa	Bahadurgunj	Palpa	Gulmi
Nawalparasi		Arghakhanchi	

The AIC office is responsible for supplying agricultural inputs (fertilizer, insecticides, seeds and agricultural tools) to the cooperative. It also sells directly to the farmers. Transport subsidization is provided in hilly areas. Price subsidization is nationwide. Insecticides, vegetable seeds and agricultural tools are also sold through this office from time to time. There is less demand for agro-chemicals from AIC, most farmers use private dealers and shopkeepers at the nearest Indian border market.

The office has the following equipment :

Name of Equipment	No.	Capacity
Drying plants	1	5 0 mt/hr.
Processing Plant	2	1.3 mt/hr
Seed Cleaner	1	8 0 mt/hr.

Basically, AIC has a seed multiplication target to produce good quality seeds. It buys seeds from the farmers and then sells treated and quality controlled seeds to the farmers as and when needed. RR 21, NL 297, UP 262, NL 251 and Binayak varieties of wheat are mostly used for seed multiplication in this Lumbini Zone. 600 ha are covered by wheat seed multiplication in Rupandehi district. It has only one 5-ton cold storage facility for vegetable seeds and one small seed laboratory which is used for seed germination tests. Generally, seeds which have a germination rate of 85% are recommended. The demand of wheat seeds is more than the supply. Radha-9, Masuli and Sabitri varieties of rice are demanded by the farmers of the area. AIC can not meet the demand for different rice varieties. While the project is concerned with a particular area of the Kapilvastu district, information on the distribution of inputs in the whole district is needed, however this information is not available.

Farmers usually buy improved seeds from the Indian border markets due to the easily and timely availability. Also, such seeds are cheaper in these markets. Farmers are habituated to use these seeds. Chemical fertilizer is cheaper in Nepal due to subsidization. Chemical fertilizer is sometimes supplied to India illegally through private dealers. The stock of chemical fertilizer is sufficient during the season. The major issue is irrigated crop cultivation area. Farmers continuously use improved seeds and fertilizer if irrigation is provided. There is more demand for complex 20: 20: 0. The supply of DAP is more readily available but farmers are not habituated to use DAP.

D.3.5 Agricultural Cooperative

New political change has enhanced in the cooperative movement in Nepal. Cooperative institutions, at any level, will be self-emerging, voluntary and democratic institutions based on universal cooperative principles.

DOAD under the Ministry of Agriculture has the responsibility for the registration, promotion, monitoring and supervision of the cooperative societies or unions. The role of DOAD is to facilitate organizing the societies or unions. No intervention is to be lodged upon the movement.

The cooperative Act 2048 has already come into effect. The National Cooperative Development Board (NCDB) establishes the link between the government and cooperative movement and will make the movement more effective and strong.

DOAD, at present, has registered the following cooperative societies with multipurpose objectives

(i) Consumer cooperative
(ii) Saving and credit cooperative
(iii) Milk producer cooperative
(iv) Veterinary service cooperative
(v) Coffee cooperative
(vi) Housing cooperative
(vii) Agriculture cooperative

Generally, the cooperatives work on supplying inputs, purchasing products, selling produced and processed rice. Some of the cooperatives work on mobilization of saving.

(1) District Cooperative Office (DCO)
DCO is responsible for guidance, supervision and auditing of the cooperative societies. Loan approval, which should be authorized by ADB/N, should come through this office. This office has a more active role at the time of repayment of the loan by the farmer. It supervises and supports the election of members of cooperative societies. This office has the authority to control administratively the union and societies by the rules and regulations provided by HMG.

At the moment, the District Cooperative Executive Committee (DCEC), consisting of one appointed coordinator and Agriculture Development officer, Manager/ADB/N, Land Reform officer, Manager/ Cooperative Union and DCO, the members' secretary, has been set up as the adhoc committee to look after the cooperative movement at the district level for interim period. Its main work is to hold elections for the management body (unit) of cooperative institutions in the district. In addition, an union of 7 members from among the shareholders has been set up to monitor the general daily activities of the cooperative societies and to hold elections in accordance to new acts, laws and by - laws.

Recently, HMG has made a new agricultural policy in order to establish a separate autonomous organization for making cooperative societies more effective for the farmers. The cooperative act has been formulated and the bill will be passed very soon.

(2) District Cooperative Union (DCU)

DCU is a secondary united body of the cooperative societies with social workers and farmers for the betterment of the total villagers. There are 19 cooperative societies which make up DCU in Taulihawa, Kapilvastu. It generates its income from membership fees, commission on fertilizers, its own business activities and loans from ADB/N, if necessary.

This union provides services to its members by solving district level problems. DCU speaks on behalf of all the societies in the district to guard the interests of member societies and coordinate with other supporting allied agencies at the district level. Besides, it looks after the promotional activities of the cooperatives in the whole district. It is able also to run its own separate business in the district.

At the moment, this union has a 7-member interim working committee to look after day-to-day activities and to hold elections in accordance with new acts, laws and by-laws. The working committee meeting is held once a month with the general assembly meeting of all the shareholders while the executive committee meeting is held once a year.

As this union represents many of the social workers, farmers and others from all the areas of the district, it can generate the idea of overall development of the district. The union is not bound to the supply of farm inputs, it can undertake commercial activities for supporting the community as a whole such as establishment of small cottage industries, cooperative shops, etc.

Among the 19 cooperative societies under DCU, the Amiko Cooperative Society and Janasewa Cooperative Society exist in the study area.

D.3.6 Agricultural Credit

ADB/N is a autonomous body which works for the benefit of the farmers in providing short-term and long-term loans with a low interest rate for agricultural activities such as crop production, livestock production and horticulture.

Administratively, ADB/N is under MOF, but all decisions regarding the bank activities are made through the board itself. The ADB/N district office works under the policy and directions of the central office and the regional office. It is an organization for providing loans for agricultural purpose in the district area.

About 1.4 % of the farmers have loans from ADB/N and out of the total loan disbursement 84% of the loan is not repaid. Regarding the irrigation facilities, 75% subsidy is given to the group and 40% subsidy to the individuals.

Regarding the agriculture loan, there exist two banks, namely Rastriya Banijya Bank (RBB) and Nepal Bank Limited (NBL) except for ADB/N. In the study area, there is a branch of NBL located at Pattharkot. The branch commands Bhelai, Dubiya, Buddi, Jayanagar and