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MINISTRY OF AGRICULTURE—NATIONAL AGRICULTURAL LABORATORIES

## KENYA SOIL SURVEY

### DETAILED SOIL SURVEY OF THE VOO RESEARCH SUB-STATION (KITUI DISTRICT)

by

C.K.K.Gachene, B.K.Waruru and T.Wachira

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**C.K.K. Gachene, B.K. Waruru and T. Wachira**

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11423

	<u>TABLE OF CONTENTS</u>	<u>Page</u>
1	INTRODUCTION .....	1
2	ENVIRONMENTAL CONDITIONS .....	1
	2.1 Location and Communication .....	1
	2.2 Climate (By A.E. Ekirapa) .....	1
	2.2.1 Average annual and seasonal rainfall .....	1
	2.2.2 Evaporation, agroclimatic zonation and temperatures .....	2
	2.2.3 Crop water requirements and seasonal rainfall deficit estimates .....	2
	2.3 Geology, Physiography and Hydrology .....	3
	2.4 Vegetation and present Land Use .....	4
3	WORKING METHODS .....	5
	3.1 Office Methods .....	5
	3.2 Field Methods .....	5
	3.3 Laboratory Methods .....	5
4	THE SOILS .....	6
	4.1 Previous Soil Investigations .....	6
	4.2 General Properties of the Soils .....	6
	4.3 Description of the Soil Mapping Units .....	6
	4.3.1 Systematics and nomenclature .....	6
	4.3.2 Soils of the Uplands .....	7
	4.3.3 Soils of the river terraces .....	16
	4.4 Soil Fertility Status .....	17
5	LAND SUITABILITY FOR RAINFED CEREALS, PULSES AND ROOT CROPS .....	18
	5.1 Introduction .....	18
	5.2 Land Qualities and their Ratings .....	18
	5.3 Land Suitability Classes and their Criteria .....	22
	5.4 Land Suitability Classification .....	23
6	CONCLUSIONS AND RECOMMENDATIONS .....	24
7	REFERENCES .....	25

TABLE OF CONTENTS

Page

APPENDICES

1	Detailed descriptions of representative profiles with analytical data .....	
2	Detailed soil map of the Voo Research Substation (Kitui District) .....	
3	Location map of profile pits and augerhole observations .....	
4	Present soil erosion status map of the Voo Research Substation .....	

TABLES

1.	Mean annual and monthly rainfall (mm) of Kitui Voo Dispensary (91.38007) .....	2
2.	Mean seasonal rainfall .....	2
3.	Simple water balance of Kitui Voo Dispensary .....	3
4.	Rainfall probabilities during the rainy season .....	3
5.	Analytical data for a water sample collected from Thua River .....	4
6.	Available nutrients (0-30 cm) .....	17
7.	Soil moisture storage capacity (SMSC) .....	19
8.	Availability of nutrients ratings .....	19
9.	Hazard of sodicity rating .....	20
10.	Rating for stoniness/rockiness and shallowness of the soils .....	21
11.	Ratings of the land qualities for the various soil mapping units .....	21
12.	Conversion table for cereals - maize, sorghum and millet .....	23
13.	Conversion table for pulses - green grams, cow peas and pigeon peas .....	23
14.	Conversion table for root crops (cassava and sweet potatoes) .....	23
15.	Potential land suitability for the various land suitability types .....	24

## 1 INTRODUCTION

At the request of the Director of the Katumani National Dryland Farming Research Station, a detailed soil survey of the proposed Voo Research Sub-station was carried out in order to assess the suitability of the soils for cereals, pulses and root crops using dryland farming methods. Fieldwork was carried out in August and September 1984 by the authors and Mr. S. Mwangi of Kenya Soil Survey.

## 2 ENVIRONMENTAL CONDITIONS

### 2.1 Location and Communication

The survey area is situated in Kitui District about 50 km SE of Kitui township. It is intersected by latitude  $1^{\circ} 40'S$  and longitude  $38^{\circ} 20'E$ . The substation covers about 575 ha. The average altitude varies between 500 m in the north to 560 m in the south-east.

The area is accessible from Mutomo Divisional Headquarters via Kinakoni shops by an all-weather road. The accessibility within the survey area is very poor due to dense bush.

### 2.2 Climate

A climatic study of the area is necessary for various agricultural purposes, such as determining agricultural potential of an area, or planning irrigation methods and procedures. One of the most important agroclimatic factors is the rainfall and its relation to the potential evaporation. Evapotranspiration is determined to show the peak water use of crops during the growing season and also to show the total volume/quantity of water required for plant growth during the growing period.

The climatic characteristics of the area are described using the data obtained from Kitui Voo Dispensary rainfall station (91.38007) which has 28 years of rainfall records, and which is located next to the farm.

#### 2.2.1 Average annual and seasonal rainfall

The average annual rainfall is about 540 mm (EAMD, 1973). The rainfall distribution is bimodal with two peaks: March-May (long rains) and October-December (short rains). The long rains account for 35% of the total annual rainfall, while the short rains account for 57%. The two dry periods, January-February and May-September, contribute 6% and 5% respectively. The driest period is June-September which recorded an

average of less than 3 mm of rainfall as shown in table 1.

Table 1. Mean annual and monthly rainfall (mm) of Kitui Voo Dispensary (91.38007)

J	F	M	A	M	J	J	A	S	O	N	D	YEAR
21	11	66	107	18	1	0	3	3	54	139	117	540

Source: EAMD (1973)

Table 2. Mean seasonal rainfall

January - February	32 mm
March - April	173 mm
May - September	25 mm
October - December	310 mm

#### 2.2.2 Evaporation, agroclimatic zonation and temperatures

Potential evaporation ( $E_o$ ) was calculated using Woodhead's (1968) equation, which is expressed as

$$E_o = 2422 - 0.358 h \text{ where,}$$

$E_o$  = potential evaporation in mm

$h$  = altitude of the station in metres.

According to this equation, the calculated potential evaporation for Kitui Voo Dispensary is about 2230 mm. The ratio between rainfall and potential evaporation  $r/E_o$  gives the agroclimatic zone in which the station lies.  $r/E_o$  is found to be 24 if expressed as a percentage. This groups the area into agroclimatic zone VI, termed as arid.

The computed mean annual, mean annual maximum and mean annual minimum temperatures are 19, 25 and 12°C respectively (EAMD, 1970).

#### 2.2.3 Crop water requirements and seasonal rainfall deficit estimates

Crop water requirement may be defined as the amount of water needed to meet the water loss through evapotranspiration of a healthy crop growing under non-restricting soil conditions including soil water and fertility, and achieving full production potential under a given growing environment (FAO, 1977). The crop water requirement during the growing season has been estimated to be  $2/3 E_o$ .

Table 3. Simple water balance of Kitui Voo Dispensary

	J	F	M	A	M	J	J	A	S	O	N	D
r	21	11	66	107	18	1	0	3	3	54	139	117
Eo	201	201	223	178	178	178	156	178	201	201	134	201
Et	135	135	149	119	119	119	105	119	135	135	90	135
r-Et	-114	-125	-83	-12	-101	-118	-105	-116	-102	-81	+49	-18

Mean monthly potential evaporation was taken as a percentage of the year's total as estimated by Braun (in prep).

This simple water balance assumes that all excess water will be stored in the soil. Losses through runoff or deep percolation are not accounted for.

From the simple water balance, it can be noted that there is moisture surplus in the soil during the November-December period. Hence, for any good crop to be realised, it must be grown during this period, and the crop(s) cycle should be less than 75 days.

Rainfall probabilities as calculated after Braun (1977) are shown in table 4.

Table 4. Rainfall probabilities during the rainy season

	rainfall (mm)	Et = 2/3 Eo	Pr(r) > 2/3 Eo
March-May	191	268	18%
October-December	310	360	10%

From table 4, it can be deduced that the rainfall will exceed the crop water requirement on average once in every 5 seasons during the March-April and once in every 10 years during the October-December periods.

### 2.3 Geology, Physiography and Hydrology

The survey area was geologically surveyed by Saggerson (1957). It is mainly composed of undifferentiated Basement System rocks.



The area has a relief intensity of about 60 m. Two physiographic units are identified, viz. uplands and river terraces. The uplands have slopes which are predominantly convex and their relief varies from gently undulating to undulating (slopes 2-8%). The river terraces are narrow (about 75 m in width) and are flat to very gently undulating (slopes 0-2%). Few rock outcrops do occur in the area.

The drainage system is not deeply incised and has a dendritic pattern. All the streams are seasonal and have a sand bed. During the dry seasons, holes are dug in the Thua river and these are used as watering points.

The analytical data for water sampled from a well in Thua river is given in table 5. The sample is classified as being of medium salinity hazard and low sodicity hazard (C<sub>2</sub>-S<sub>1</sub> of Richards, 1954). The water is suitable for irrigation and can be used on most crops without much possibilities of harm.

Table 5. Analytical data for a water sample collected from Thua River

Lab No.	7869/84
pH	9.3
Conductivity (micromhos/cm)	300
Sodium (me/litre)	2.17
Potassium (me/litre)	0.13
Calcium "	0.75
Magnesium "	0.2
Carbonates "	0.76
Bicarbonates "	1.24
Chlorides "	0.81
Sulphates "	0.2
Sodium Absorption Ratio	3.1
Class	C <sub>2</sub> S <sub>1</sub>

#### 2.4 Vegetation and present Land Use

The area is mostly covered by bushy thicket in which Acacia is the dominant species. The ground cover (perennial species) is about 25%.

Livestock keeping is the predominant land use. Some very few areas are used for the cultivation of sorghum, millet and early maturing maize.

### 3 WORKING METHODS

#### 3.1 Office Methods

The topographical map at the scale of 1:2,500 was reduced to a scale of 1:5,000 to form the base map. Aerial photographs at scale 1:12,000 were interpreted and this helped to identify boundaries between different physiographic units. The final map was produced at a scale of 1:12,500.

#### 3.2 Field Methods

Soil augerings were made to a depth of 120 cm or more (soil depth permitting). The augerings were made along the cutlines which had been made by the topo-survey team. These cutlines were not in a grid system and the soil survey team had in most cases to make observations following the photo interpretation boundaries, an exercise which turned out to be very tedious as the accessibility within the survey area was very poor. Soil information and site characteristics were recorded on the standard KSS forms which are based on the 'Guidelines for soil profile description' (FAO, 1977). Soil colour was given for moist soil and was determined using 'Munsell Color Charts' (Munsell Color Company, 1971). A total of 169 augerholes were made. These observations helped to identify different mapping units on the basis of soil depth, colour, texture etc.

Representative profile pits were dug in each of the mapping units. A total of 10 profile pits were described and sampled for physical and chemical analysis. In addition, a composite sample (0-30 cm) was taken in the vicinity of each profile pit. All these samples were analysed at the National Agricultural Laboratories (NAL). The density of observations is 1 observation per 3 ha.

#### 3.3 Laboratory Methods

Textural analysis was carried out using the hydrometer method. Electrical conductivity (EC), pH-H<sub>2</sub>O and pH-KCl were measured in 1:2.5 soil-water and soil-salt suspensions respectively. The %C and %N were determined using Walkley-Black and semi-micro Kjeldahl methods respectively. Soils were leached with 1N ammonium acetate at pH 7.0. Exchangeable cations were determined in ammonium leachates. For the available nutrients (on A-horizons only), soils were extracted with 1:5 ratio of 0.1N HCl/0.025N H<sub>2</sub>SO<sub>4</sub>. Ca, K and Na were determined by EEL flamephotometer, Mg by atomic adsorption spectrophotometer and Mn was determined colorimetrically.

For detailed information on the physical and chemical analysis, the reader is referred to Hinga et. al. (1980).

#### 4 THE SOILS

##### 4.1 Previous Soil Investigations

The survey area has already been surveyed at reconnaissance level (Sketchley et al., 1978). The soils were mapped as well drained, moderately deep to very deep, dark red to red, friable to firm sandy clay to clay (chromic Luvisols).

##### 4.2 General Properties of the Soils

The soils of the survey area fall into two broad groups viz. those soils occurring on the uplands and those occurring on the river terraces along the Thua.

Soils of the uplands (mapping units UUr1 to UUr6 and UUb1 to UUb5) are well drained and range from shallow to very deep. Their texture varies from sandy clay loam, sandy clay to clay with a varying degree of erosion. Their colour varies from dark red (2.5YR 3/6) in the UUr units to dark yellowish brown (10YR 4/4) in the UUb units. Most of the soils have an argillic B-horizon with a moderate angular blocky structure (e.g. UUr1p, UUr4p). These are mainly the red soils. The brown soils (e.g. UUb3p, UUb4p) mainly have a weak subangular blocky structure. The organic matter content for all soils is low. With the exception of the mapping unit UUr2p, all the other units have a base saturation of more than 50% in their B-horizons.

The soils of the river terraces (mapping unit AA1) are well drained and very deep. They are of varying colour (dark brown to very dark greyish brown), consistence (friable to firm) and texture (sand to sandy clay loam). The organic matter content is low and the base saturation is more than 50% for all the horizons. The soils have a sodic topsoil.

##### 4.3 Description of the Soil Mapping Units

###### 4.3.1 Systematics and nomenclature

Each mapping unit is identified by a code. The first entry in the soil map legend is the physiography, denoted by U and A for uplands and river terraces respectively. The second entry is for the parent material

denoted by U and A for undifferentiated Basement System rocks and recent alluvial deposits respectively. The remaining letters of the code indicate certain soil characteristics like red or brown colour (r and b) or soil depth (p) or different soil units within the same physiography-geology grouping (1,2,3,4 etc.). The soil classification is according to the 1974 FAO/UNESCO legend of the "Soil Map of the World".

#### 4.3.2 Soils of the Uplands

##### Soil mapping unit UUr1p

Extent	: 100 ha
Parent material	: undifferentiated Basement System rocks
Physiography	: uplands
Macro relief	: very gently undulating to gently undulating; slopes 2-3%
Erosion	: slight rainsplash and rill wash
Land use	: grazing
Soils, general	: This unit has well drained, deep, dark red to dark reddish brown, friable, sandy clay to clay soils underlying a topsoil of 10 to 20 cm loamy sand to sandy clay loam. The soils have an ABC sequence of horizons with clear and smooth boundaries. There are clay cutans in the B-horizon. Organic matter content is low throughout the profile and the base saturation is above 50%.
colour	: A-horizon: dark reddish brown (5YR 3/4) B-horizon: dark red (2.5YR 3/6)
texture	: A-horizon: loamy sand to sandy clay loam B-horizon: sandy clay to clay
structure	: A-horizon: weak, fine, subangular blocky B-horizon: moderate, medium, angular blocky
consistence	: A-horizon: friable when moist, slightly sticky and slightly plastic when wet B-horizon: friable to firm when moist, sticky and plastic when wet.
Chemical properties	: A-horizon; %C is 0.49; pH-H <sub>2</sub> O is 8.2; pH-KCl is 7.1; CEC-soil is 2.4 me/100g and the base saturation is 100%.

B-horizon: %C is 0.17 to 0.25%; pH-H<sub>2</sub>O is 5.9 to 6.2; pH-KCl is 4.5 to 4.7; CEC-soil is 9.0 to 13.8 me/100g and the base saturation is >50%.

Diagnostic properties : an ochric A-horizon, argillic B-horizon, base saturation of >50% in the B-horizon

Classification : chromic LUVISOLS.

For a representative profile with analytical data, see appendix 1, profile description no. 1.

#### Soil mapping unit UUr2p

Extent	: 13 ha
Parent material	: undifferentiated Basement System rocks
Physiography	: uplands
Macro relief	: gently undulating; slopes 4-5%
Erosion	: slight rain splash and rill wash
Rockiness/stoniness	: in places with rock outcrops
Land use	: grazing
Soils, general	: The soils consist of well drained, deep to very deep, yellowish red to dark reddish brown, friable loamy sand to sandy loam. They have an ABC sequence of horizons with diffuse and smooth transitions. They have low organic matter content, low CEC and low base saturations, the latter mainly in the B-horizon.
colour	: A-horizon: dark reddish brown (5YR 3/4) B-horizon: yellowish red to dark reddish brown (5YR 4/8 - 5YR 3/4)
texture	: loamy sand to sandy loam throughout
structure	: porous massive, breaking into weak, medium, subangular blocky throughout
Chemical properties	: A-horizon: %C is 0.30; pH-H <sub>2</sub> O is 7.4, pH-KCl is 6.2; CEC-soil is 1.8 me/100g and the base saturation is 77% B-horizon: %C is 0.14 to 0.20%; pH-H <sub>2</sub> O decreases with depth from 6.0 to 5.2, pH-KCl is 3.6 to 4.3; CEC-soil is 3.0 to 3.5 me/100g and the base saturation is 29%
Diagnostic properties	: coarse texture, ochric A-horizon

Classification : ferralic ARENOSOLS

For a representative profile with analytical data, see appendix 1  
profile description no. 2.

Soil mapping unit UUr3p

Extent	: 210 ha
Parent material	: undifferentiated Basement System rocks
Physiography	: uplands
Macro relief	: gently undulating; slopes 5%
Erosion	: slight to moderate rainsplash and rill wash
Land use	: grazing
Soils, general	: This unit has well drained, deep to very deep, dark red, friable to firm, sandy clay soils. They have an ABC sequence of horizons with clear and smooth transitions. There are clay cutans in the B-horizons. The soils have low organic matter content throughout the profile. Base saturation is more than 50% for all the horizons.
colour	: A-horizon: dark reddish brown (2.5YR 2.5/4) B-horizon: dark red (2.5YR 3/6)
texture	: A-horizon: sandy clay loam B-horizon: sandy clay to clay
structure	: A-horizon: weak to moderate, medium, subangular blocky B-horizon: moderate to strong, medium, angular blocky
consistence	: friable to firm when moist, sticky and plastic when wet throughout
Chemical properties	: A-horizon: %C is 0.30; pH-H <sub>2</sub> O is 6.7; pH-KCl is 5.2; CEC-soil is 3.5 me/100g and the base saturation is 79% B-horizon: %C decreases with depth from 0.31 to 0.17, pH-H <sub>2</sub> O is 6.1 to 6.7; pH-KCl is 4.6 to 4.9; CEC-soil is 8.8 to 15.2 me/100g and the base saturation is 55 to 65%.
Diagnostic properties	: an ochric A-horizon, argillic B-horizon, base saturation of >50% in the B-horizon

Classification : chromic LUVISOLS.

For a representative profile with analytical data, see appendix 1 profile description no. 3.

Soil mapping unit UUr4p

Extent : 91 ha  
Parent material : undifferentiated Basement System rocks  
Physiography : uplands  
Macro relief : gently undulating to undulating, slopes 5-8%  
Erosion : very severe rainsplash and rill wash and moderate gully erosion  
Land use : grazing  
Soils, general : As in unit UUr3p but moderately deep to deep. The soils have an ABC sequence of horizons with clear and smooth transitions. In some areas parts of the A and B horizons have been truncated through erosion. The pH (field measurements) is 6.5 for the A-horizon and 6.3 for the B-horizon.

No representative profile was made for this mapping unit.

Soil mapping unit UUr5m

Extent : 66 ha  
Parent material : undifferentiated Basement System rocks  
Physiography : uplands  
Macro relief : gently undulating to undulating, slopes 5-7%  
Erosion : moderate to high rain splash and rill wash and slight to moderate gully erosion  
Soils, general : This unit has well drained, moderately deep, dark red, friable sandy clay loam to sandy clay soils. They have an ABC sequence of horizons with clear and smooth transitions. The B-horizon has clay cutans. The soils are underlain by pisoferric material (murram). Organic matter content is low and the base saturation is high at 70 cm depth.  
colour : A-horizon: dark reddish brown (2.5YR 2.5/4)  
B-horizon: dark red (2.5YR 3/6) to dark reddish brown (5YR 3/4)

texture : A-horizon: sandy loam to sandy clay loam  
B-horizon: sandy clay loam to sandy clay

structure : B-horizon: moderate, medium, angular blocky

consistence : friable to firm when moist, sticky and plastic when wet throughout

Chemical properties : A-horizon: no data due to the truncation of the A-horizon through erosion  
B-horizon: %C decreases with depth from 0.37 to 0.11; pH-H<sub>2</sub>O increases with depth from 5.2 to 8.2; pH-KCl is 3.8 to 6.0; CEC-soil increases with depth from 5.5 to 14.3 me/100g and base saturation from 36 to 84%

Diagnostic properties : an ochric A-horizon when present, argillic B-horizon, base saturation of >50% in the B-horizon

Classification : chromic LUVISOLS, pisolitic phase

Remarks: In many places, A and parts of the B-horizons have been truncated through erosion.

For a representative profile with analytical data, see appendix 1 profile description no. 4.

Soil mapping unit UUr6m

Extent : 7.5 ha

Parent material : undifferentiated Basement System rocks

Physiography : upland

Macro relief : gently undulating; slopes 5%

---

Erosion : very severe rain splash and rill wash and moderate gully erosion

Land use : grazing

Soils, general : As in unit UUr5m but shallow to moderately deep. The soils have an ABC sequence of horizons with clear and smooth transitions. Field pH measurement is 5.6 for the A-horizon and 6.1 for the B-horizon. In some places the A and parts of the B-horizon have been truncated through erosion.

No representative profile pit was made for this soil mapping unit,



Soil mapping unit UUb1p

Extent	: 0.30 ha
Parent material	: undifferentiated Basement System rocks
Physiography	: upland
Macro relief	: gently undulating to undulating; slopes 5-7%
Erosion	: severe gully erosion
Land use	: grazing
Soils, general	: This unit has well drained, deep, brown to dark brown, friable to firm, slightly sodic clay soils. The soils have an ABC sequence of horizons with clear and smooth transitions. The B-horizon underlies 20 to 40 cm sandy clay topsoil. Iron and manganese concretions occur at 40 to 110 cm depth. The organic matter content is low throughout the profile and the base saturation is >50%
colour	: A-horizon: yellowish red (5YR 4/6) B-horizon: brown to dark brown (7.5YR 5/8-10YR 4/3)
texture	: A-horizon: sandy clay B-horizon: clay
structure	: A-horizon: weak to moderate, fine to medium, subangular blocky B-horizon: moderate, medium, angular blocky
consistence	: A-horizon: friable to firm when moist, sticky and plastic when wet B-horizon: firm when moist, sticky and plastic when wet
Chemical properties	: A-horizon: %C is 0.30; pH-H <sub>2</sub> O is 7.7; pH-KCl is 4.3; CEC-soil is 7.8 me/100g and the base saturation is 66% B-horizon: %C is 0.11 to 0.17%; pH-H <sub>2</sub> O and pH-KCl increase with depth from 6.0 to 8.6 and 4.0 to 6.9 respectively. CEC-soil is 12.5 to 13.3 me/100g and base saturation is 58 to 100%.
Diagnostic properties	: ochric A-horizon, argillic B-horizon, base saturation of >50% in the B-horizon.
Classification	: orthic LUVISOLS, sodic phase.

For a representative profile with analytical data, see appendix 1 profile description no. 5.

Soil mapping unit UUb2p

Extent : 9 ha

Parent material : uplands

Physiography : undifferentiated Basement System rocks

Macro relief : gently undulating to undulating; slopes 5-8%

Erosion : very severe rainsplash and rill wash and moderate gully erosion

Land use : grazing

Soils, general : The soils consist of well drained, deep, yellowish brown, friable to firm, slightly saline sandy clay, underlying 10 to 30 cm of loamy sand to sandy clay loam. They have an ABC sequence of horizons with gradual to abrupt transitions. The soils are low in organic matter content and have a base saturation of more than 50% throughout the profile.

colour : A-horizon: dark yellowish brown (10YR 4/4)  
B-horizon: yellowish brown (10YR 5/6)

texture : A-horizon: loamy sand  
B-horizon: sandy clay

structure : A-horizon: weak, fine to medium, subangular blocky  
B-horizon: weak, fine to medium prismatic

consistence : A-horizon: slightly sticky and non plastic when wet  
B-horizon: firm when moist, slightly sticky and slightly plastic when wet

Chemical properties : A-horizon: %C is 0.26; pH-H<sub>2</sub>O is 6.3; pH-KCl is 5.0;  
~~CEC-soil is 4.3 me/100g and the base saturation is~~  
68%  
B-horizon: %C decreases with depth from 0.29 to 0.17%; pH-H<sub>2</sub>O increases from 6.0 to 8.5; pH-KCl from 4.2 to 7.4. CEC-soil increases with depth from 3.5 to 9.5 me/100g and the base saturation from 67 to 100%

Diagnostic properties : ochric A-horizon, natric B-horizon

Classification : orthic SOLONETZ, saline phase

For a representative profile with analytical data, see appendix 1 profile description no. 6.

Soil mapping unit UUb3p

Extent	: 47 ha
Parent material	: undifferentiated Basement System rocks
Physiography	: uplands
Macro relief	: gently undulating to undulating; slopes 5-6%
Erosion	: slight to moderate rainsplash and rill wash
Land use	: grazing
Soils, general	: This unit consists of well drained, moderately deep, dark brown, friable, moderately to strongly calcareous, sandy clay loam soils. The soils have an ABC sequence of horizons with clear and smooth transitions. The soils are characterized by high pH values. They are low in organic matter content and have a high base saturation
colour	: A-horizon: very dark greyish brown (10YR 3/2) B-horizon: brown to dark brown (10YR 4/3)
texture	: sandy clay loam throughout
structure	: porous massive, breaking into weak, fine to medium, subangular blocky throughout
consistence	: friable when moist, sticky and plastic when wet throughout
Chemical properties	: A-horizon; %C is 1.60; pH-H <sub>2</sub> O is 8.0, pH-KCl is 7.1; CEC-soil is 17.5 me/100g and the base saturation is 100% B-horizon: %C decreases with depth from 0.75 to 0.43; pH-H <sub>2</sub> O is 8.5 to 9.1, pH-KCl is 7.6 to 7.9 and the base saturation is 100%
Diagnostic properties	: ochric A-horizon, cambic B-horizon
Classification	: calcic CAMBISOLS, lithic phase

For a representative profile with analytical data see appendix 1 profile description no. 7.

Soil mapping unit UUb4p

Extent	: 11 ha
Parent material	: undifferentiated Basement System rocks
Physiography	: uplands
Macro relief	: undulating; slopes 8%

Erosion : moderate rainsplash and rill wash and few gullies

Land use : grazing

Soils, general : This unit consists of well drained, shallow, dark yellowish brown, fairly rocky and stony, friable loamy sand soils. They have an ABC sequence of horizons with clear and smooth transitions. The soils are underlain by rock at 50 cm depth. The organic matter content is low and the base saturation is high.

colour : A-horizon: brown to dark brown (10YR 4/3)  
B-horizon: dark yellowish brown (10YR 4/4)

texture : loamy sand throughout

structure : porous massive breaking into weak, medium, subangular blocky throughout

consistence : friable when moist, slightly sticky and non plastic to slightly plastic when wet for all the horizons

Chemical properties : A-horizon: %C is 0.35; pH-H<sub>2</sub>O is 6.8; pH-KCl is 5.5; CEC-soil is 2.3 me/100g and the base saturation is 93%  
B-horizon: %C is 0.14; pH-H<sub>2</sub>O is 6.0; pH-KCl is 4.2; CEC-soil is 2.8 me/100g and the base saturation is 86%

Diagnostic properties : ochric A-horizon, cambic B-horizon, high base saturation in the B-horizon

Classification : eutric CAMBISOLS, lithic phase.

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For a representative profile with analytical data, see appendix 1  
profile description no. 8.

Soil mapping unit UUb5P

Extent : 0.8 ha

Parent material : undifferentiated Basement System rocks

Physiography : uplands

Macro relief : undulating; slopes 8%

Erosion : severely eroded (gullied)

Land use : grazing

Soils, general : The soils consist of well drained, shallow, strong brown, fairly rocky and stony gravelly clay. They have an ABC sequence of horizons. The A-horizon

and most parts of the B-horizon have been truncated through erosion leaving a shallow profile which consists of BC horizons. The organic matter content is low and the base saturation is >50%.

colour : B-horizon: strong brown (7.5YR 5/6)

texture : B(C)-horizon: gravelly sandy clay to clay

structure : B(C)-horizon: weak, medium, subangular blocky breaking into single grains

Chemical properties : %C is 0.17; pH-H<sub>2</sub>O is 7.6; pH-KCl is 6.3; CEC-soil is 6.5 me/100g and the base saturation is 63%

Diagnostic properties : ochric A-horizon, cambic B-horizon and base saturation is >50%

Classification : eutric CAMBISOLS, lithic and stony phase

For a representative profile with analytical data, see appendix 1 profile description no. 9.

#### 4.3.3 Soils of the river terraces

##### Soil mapping unit AA1

Extent : 2 ha

Parent material : recent alluvial deposits

Physiography : river terraces

Macro relief : flat to very gently undulating; slopes <2%

Erosion : slight rainsplash and rill wash

Land use : grazing; cultivation of bananas, pawpaws and sorghum

---

Soils, general : This mapping unit consists of well drained to moderately well drained, very deep, stratified soils of varying colour, consistence, sodicity and texture. The soils have clear and smooth transitions. The organic matter content is low and the base saturation is high. They have a high sodium content in the topsoil.

colour : very variable throughout

texture : A-horizon: ranges from sandy clay to loam  
C-horizon: ranges from loamy sand to silty clay loam

consistence : variable throughout

Chemical properties : A-horizon: %C ranges from 0.52 to 0.44; pH-H<sub>2</sub>O is 8.6; pH-KCl is 6.9 to 7.2; CEC-soil is 7.8 to

10.5 me/100g and the base saturation is 100%

B-horizon: %C ranges from 0.11 to 0.44; pH-H<sub>2</sub>O from 7.8 to 8.6; pH-KCl from 6.4 to 7.5; CEC-soil ranges from 2.8 to 18.3 me/100g depending on the clay content; base saturation ranges from 94 to 100%

Diagnostic properties : soils developed from recent alluvial deposits and showing stratification

Classification : eutric FLUVISOLS, sodic phase

For a representative profile with analytical data, see appendix 1 profile description no. 10.

#### 4.4 Soil Fertility Status

The appraisal of the soil fertility is only based on few chemical data. The fertilizer recommendations should therefore be treated with caution. The analytical data are presented in table 6.

Table 6. Available nutrients (0-30 cm)

Mapping unit	UUr1p	UUr3p	UUr5m	UUb1p	UUr2p	UUb3p	UUb2p	AA1	UUb4p
Lab. No. /84	7676	7677	7678	7679	7680	7681	7682	7683	7684
pH	7.0	6.7	4.6	6.6	6.9	8.0	6.1	8.4	6.3
Na(me/100g)	0.07	0.09	0.27	0.07	0.03	0.20	0.07	0.93	0.11
K (me/100g)	0.40	0.40	0.33	0.34	0.36	0.64	<u>0.19</u>	0.42	0.36
Ca "	<u>1.8</u>	<u>0.8</u>	<u>0.8</u>	<u>1.2</u>	<u>0.8</u>	22.0	<u>1.4</u>	6.4	<u>0.8</u>
Mg "	<u>1.4</u>	<u>0.7</u>	<u>1.2</u>	<u>1.2</u>	<u>0.4</u>	5.0	<u>1.7</u>	3.2	<u>0.9</u>
Mn "	0.30	0.34	0.14	0.24	0.26	0.02	0.20	0.50	0.10
P(ppm)	72	36	<u>15</u>	<u>10</u>	40	250	<u>15</u>	84	28
P-Olsen(ppm)	12	-	-	-	-	24	-	17	-
N(%)	<u>0.08</u>	<u>0.06</u>	<u>0.06</u>	<u>0.07</u>	<u>0.08</u>	0.21	<u>0.06</u>	<u>0.08</u>	<u>0.06</u>
C(%)	<u>0.78</u>	<u>0.40</u>	<u>0.46</u>	<u>0.49</u>	<u>0.40</u>	1.59	<u>0.43</u>	<u>0.66</u>	<u>0.37</u>
EC mmhos/cm	0.11	-	-	-	-	0.40	-	0.45	-

Remarks: Deficiencies underlined

The soil reaction varies from slightly acid to strongly alkaline. Most of these soils are low in some of the basic plant nutrients viz. Ca and Mg. Deficiency in K is being observed in only one soil (UUb2p).

The supply of Mn is generally adequate. P is adequately supplied in most soils and the deficiency is being observed in few. N is deficient in almost all of these soils, except in one where an adequate supply has been recorded (UUb3p). The organic matter content is very low as revealed by the very low %C determined.

In view of the above remarks it is therefore recommended that P and N containing fertilizers be applied to these soils. Also farm yard manure (FYM) and/or compost manure should be applied to these soils to improve their fertility status and the supply of the deficient elements to plants for better yield.

## 5 LAND SUITABILITY FOR RAINFED CEREALS, PULSES AND ROOT CROPS

### 5.1 Introduction

The suitability of the Voo Research Substation for the growing of cereals (maize, sorghum, millet), pulses (green grams, cow peas, pigeon peas) and root crops (cassava and sweet potatoes) using dry land farming methods has been considered. The suitability assessment was based on the soil physical/chemical data and other land characteristics. Therefore, this exercise gives only the ecological suitability of the area. The procedure follows the guidelines outlined in the FAO "Framework for Land Evaluation" (FAO, 1976), as well as a modified (where necessary) version of the ratings of the land qualities as outlined by Braun and van de Weg (1977). During the assessment, it was assumed that the above crops will be grown under a high level of management.

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### 5.2 Land Qualities and their Ratings

The following land qualities were considered and used as diagnostic criteria:

- (a) soil moisture storage capacity (SMSC)
- (b) availability of nutrients
- (c) presence/hazard of sodicity
- (d) possibilities of mechanization
- (e) climate (Agro-climatic zone)

#### (a) Soil moisture storage capacity (SMSC)

Crops require enough moisture supply among other things for their sustained and productive growth. The SMSC depends on soil depth, texture

and porosity of the soils. Only soil depth and texture have been considered for this land quality as there was no data for porosity. The SMSC was rated as follows (table 7).

Table 7. Soil moisture storage capacity (SMSC)

SMSC in mm/100 cm depth	rating
> 100	1 very high
75-100	2 high
50-75	3 moderate
25-50	4 low
< 25	5 very low

(b) Availability of nutrients (fert.)

Crops do require nutrients for their normal and productive growth. This land quality i.e. availability of nutrients was assessed using the available nutrients and the cation exchange capacity (CEC) of the 0-30 cm topsoil. The CEC is an indicator of the ability of the soil to hold nutrients. These were rated as follows (table 8).

Table 8. Availability of nutrients ratings

(R1) Subrating CEC

CEC (me/100g soil)	rating
> 16	1 very high
12-16	2 high
6-12	3 moderate
2-6	4 low
0-2	5 very low



(R2) Subrating available nutrients

Available P (ppm)	Available K (me/100g)	Available Ca (me/100g)	Available Mg (me/100g)	Rating
> 200	> 3.5	> 20	> 12	1 very high
80-200	2.0-3.5	10-20	6-12	2 high
20-80	1.0-2.0	6-10	3-6	3 moderate
0-20	0.3-1.0	2-6	1-3	4 low
0-20	0-0.3	0-2	0-1	5 very low

The sum of the subrating give the final rating for availability of nutrients.

Sum of subratings (R1+R2)	Final rating
2	1 very high
3-4	2 high
5-6	3 moderate
7-8	4 low
> 8	5 very low

(c) Hazard of sodicity (sod.)

Sodicity is caused by the presence of excess sodium in the soil and is expressed as exchangeable sodium percentage (ESP). A lot of sodium in the soil has the effect of causing poor soil structure and reducing soil permeability. The hazard of sodicity was rated as follows (table 9).

Table 9. Hazard of sodicity rating

ESP (0-30 cm)	ESP (30-100 cm)	Rating
< 6	< 6	1
6-10	6-15	2
10-15	15-40	3
15-40	> 40	4
> 40	> 40	5

(d) Possibilities of mechanization (mech.)

The land characteristics considered under this land quality is the stoniness/rockiness and shallowness of the soil. This has some influence on farm operations where mechanization is involved. The rating is as follows (table 10).

Table 10. Rating for stoniness/rockiness and shallowness of the soils

<u>Rating</u>	<u>Description</u>
1	non-stony, non to little rocky and not shallow
2	fairly stony, fairly rocky and/or shallow
3	stony-rocky and/or shallow
4	very stony, very rocky and/or very shallow
5	exceedingly stony and/or very rocky

(e) Climate

The survey area falls under one agro-climatic zone viz. VI. This is a dry area (semi-arid to arid) where the  $r/E_o$  is between 15 and 25% (see also the climate chapter). Most of the months have a moisture deficit and this will adversely affect the crops which are to be grown in the survey area. Already data in the climate chapter indicate that the crops cycle should be less than 75 days. Although climate was not rated, it is here regarded as an important land characteristic in the survey area. However, it cannot be used as a diagnostic criteria for the various land units, due to its homogeneity over the whole survey area.

The ratings for all land qualities for the different soil mapping units are given below (table 11).

Table 11. Ratings of the land qualities for the various soil mapping units

<u>Soil mapping unit</u>	<u>Land qualities/characteristics</u>			
	<u>SMSC</u>	<u>Fert.</u>	<u>Sod.</u>	<u>Mech.</u>
UUr1p	4	4	1	1
UUr2p	4	5	1	1
UUr3p	2	5	1	1

Table 11 contd.

Soil mapping unit	Land qualities/characteristics			
	<u>SMSC</u>	<u>Fert.</u>	<u>Sod.</u>	<u>Mech.</u>
UUr4p	3	5	1	1
UUr5m	4	4	3	1
UUr6M	4	4	1	1
UUb1p	3	4	2	1
UUb2p	4	5	4	1
UUb3p	4	3	1	1
UUb4P	5	5	1	2
UU5P	4	4	1	2
AA1	3	4	4	1

### 5.3 Land Suitability Classes and their Criteria

The land suitability classes have been expressed using the following classes:

- S1 highly suitable: land suitable for sustained high yields with minimum costs of development associated with the land.
- S2 moderately suitable: land of moderate productivity or requiring moderate costs for development and management because of slight to moderate limitations in land qualities/characteristics.
- S3 marginally suitable: ~~land of restricted productivity or land~~ requiring relatively high costs for development and management because of moderate to severe limitations in land qualities/characteristics.
- NS not suitable: land which has qualities/characteristics that appear to preclude sustained use.

The suitability of the mapping units was obtained through matching the rated land qualities and crop requirements through the conversion tables below.

Table 12. Conversion table for cereals - maize, sorghum and millet

Suitability class	Land qualities			
	<u>SMSC</u>	<u>Fert.</u>	<u>Sod.</u>	<u>Mech.</u>
S1	3	2	1	1
S2	4	3	2	2
S3	5	4	3	3
NS	5	5	4	4

Table 13. Conversion table for pulses - green grams, cow peas and pigeon peas

Suitability class	Land qualities			
	<u>SMSC</u>	<u>Fert.</u>	<u>Sod.</u>	<u>Mech.</u>
S1	3	3	1	1
S2	4	4	2	2
S3	5	5	3	3
NS	5	5	4	4

Table 14. Conversion table for root crops (cassava and sweet potatoes)

Suitability class	Land qualities			
	<u>SMSC</u>	<u>Fert.</u>	<u>Sod.</u>	<u>Mech.</u>
S1	3	3	2	1
S2	4	4	3	2
S3	4	5	4	3
NS	5	5	5	4

#### 5.4 Land Suitability Classification

By matching the land quality ratings of each soil mapping unit with the conversion tables, the final suitability class of the soil mapping units can be found (table 15).

Table 15. Potential land suitability for the various land utilization types

Soil mapping units	Land utilization type			Area in ha	Remarks/limitations
	cereals	pulses	rootcrops		
UUr1p	S2	S2	S1	113	moisture
UUr2p					
UUr3p	S3	S2	S2	301	
UUr4p					
UUr5m	S3	S3	S2	66	sodicity hazard
UUr6M	S2	S2	S2	7.5	moisture
UUb1p	S2	S2	S1	0.30	sodicity hazard
UUb2p	NS	NS	S3	9	sodicity hazard
UUb3p	S2	S2	S2	47	moisture
UUb4P	NS	NS	NS	11	moisture and possibility of mechanization
UUb5P	S2	S2	S2	0.8	moisture and possibility of mechanization
AA1	NS	NS	S3	2	sodicity hazard

## 6 CONCLUSIONS AND RECOMMENDATIONS

1. For any adverse effects due to climate the reader is referred to chapter 2.2. Data elsewhere (Farm Management Handbook of Kenya, Vol.II, part C pp. 213, 1983) indicate that the survey area does experience extended dry spells. However, with the dry farming methods e.g. use of early maturing crops and water harvesting, this may be compensated.
2. Due to low groundcover and overgrazing, the area has been experiencing severe soil erosion (see Appendix 4). In some areas e.g. mapping units UUr4p and UUr5m, the A-horizons and parts of the B-horizons have been truncated while in other areas e.g. UUb5P A and B-horizons have been completely removed. Soil and water conservation measures should therefore have the utmost priority.
3. About 100 ha have been considered to be suitable for rootcrops (UUr1p, and UUb1p), 156 ha are moderately suitable for cereals (UUr1p, UUr6M, UUb1p, UUb3p, UUb5P), 470 ha are moderately suitable for pulses (UUr1p, UUr2p, UUr3p, UUr4p, UUb3P, UUr6M, UUb1p, UUb5P) and 435 ha

are moderately suitable for rootcrops (UUr2, UUr3, UUr4, UUr5m, UUr6M, UUb3p, UUb5P). The availability of moisture, and sodicity hazard (AA1) are the limiting factors. 367 ha are marginally suitable for cereals, 66 ha for pulses, 11 ha for rootcrops (table 15). About 11 ha are not suitable for cereals and pulses (UUb2p and AA1) while 11 ha are not suitable for any crop under consideration (UUb4P). Sodicity hazard, availability of moisture and possibilities of mechanization are the limiting factors.

4. Application of fertilizers and manures as recommended in the fertility appraisal chapter should be carried out. As already indicated in table 6, the available nutrient levels are low for most of the soil mapping units.

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APPENDIX 1

DETAILED DESCRIPTIONS OF REPRESENTATIVE PROFILES WITH ANALYTICAL DATA

<u>Profile description No.</u>	<u>Observation No.</u>	<u>Page</u>
1	164/2-210	29
2	164/2-215	31
3	164/2-211	33
4	164/2-213	35
5	164/2-214	37
6	164/2-217	39
7	164/2-216	41
8	164/2-219	43
9	164/2-212	45
10	164/2-218	47

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PROFILE DESCRIPTION NO. 1

General Site Information

Mapping unit : UUr1p  
Soil classification : chromic LUVISOL  
Observation No. : 164/2-210  
Parent material : undifferentiated Basement System rocks  
Physiography : uplands  
Relief : very gently undulating to gently undulating; slopes 2-33  
Land use : grazing  
Erosion : slight rainsplash and rill erosion  
Surface stoniness : nil  
Surface rockiness : nil  
Surface sealing : weak  
Drainage class : well drained

Profile description

A 0-10 cm : dark reddish brown (5YR 3/4 moist); loamy medium sand; weak, fine sub-angular blocky; friable when moist, slightly sticky and non-plastic when wet; many very fine and common medium pores; common very fine and fine roots; clear and smooth transition to:  
(sample no. 164/2-210a)

AB 10-22 cm : dark reddish brown (5YR 3/3 moist); loamy sand; weak to moderate fine subangular blocky; friable when moist, slightly sticky and slightly plastic when wet; many very fine pores; few, very fine and fine roots; clear and smooth transition to:  
(sample no. 164/2-210b)

Bt1 22-45 cm : dark red (2.5YR 3/6 moist); sandy clay loam; moderate medium subangular blocky; friable when moist, sticky and plastic when wet; patchy thick clay cutans; many very fine pores; common fine roots; clear and smooth transition to:  
(sample no. 164/2-210c)

Bt2 45-75 cm : dark red (2.5YR 3/6 moist); sandy clay loam; moderate, medium to coarse angular blocky; friable when moist, sticky and plastic when wet; broken thin clay cutans; common very fine pores; common very fine roots; clear and irregular transition to:  
(sample no. 164/2-210d)

BC 75-92 cm : dark red (2.5YR 3/6 moist); gravelly sandy clay; moderate medium subangular blocky; friable when moist, sticky and plastic when wet; many very fine pores; abrupt and irregular transition to:

CR 92 cm+ weathering rock.



PROFILE DESCRIPTION NO. 2

General Site Information

Mapping unit : UUr2p  
Soil classification : ferralic ARENOSOL  
Observation No. : 164/2-215  
Parent material : undifferentiated Basement System rocks  
Physiography : uplands  
Relief : gently undulating; slopes 4-5%  
Land use : grazing  
Erosion : slight rainsplash and rill wash  
Surface stoniness : nil  
Surface rockiness : biotite gneiss outcrops  
Surface sealing : weak  
Drainage class : well drained

Profile Description

A	0-12 cm	: dark reddish brown (5YR 3/4 moist); sand; porous massive, breaking into weak, fine subangular blocky; friable when moist, slightly sticky and non-plastic when wet; many micro pores; many very fine and fine common medium, very few coarse roots; gradual and smooth transition to:  (sample no. 164/2-215a)
AB	12-35 cm	: strong brown (5YR 4/6 moist); sand/loamy sand; porous massive, breaking into weak, fine subangular blocky; friable when moist, slightly sticky and non-plastic when wet; many micro pores; common very fine to medium, very few coarse roots; gradual and smooth transition to:  (sample no. 164/2-215b)
Bu1	35-55 cm	: dark brown (7.5YR 3/4 moist); sandy loam; porous massive breaking into weak fine medium subangular blocky; friable when moist, slightly sticky and non-plastic when wet; many micro pores; few very fine, common medium roots; gradual and smooth boundary to:  (sample no. 164/2-215c)
Bu2	55-95 cm	: dark reddish brown (5YR 3/4 moist); sandy clay loam; weak medium subangular blocky; friable when moist, slightly sticky and slightly plastic when wet; many micro pores; very few fine, common medium roots; clear and irregular transition to:  (sample no. 164/2-215d)
BC	95-125 cm	: dark reddish brown (5YR 3/3 moist); coarse sandy clay loam to sandy clay; weak fine subangular blocky; friable when moist; slightly sticky and slightly plastic when wet; many micro pores; very few medium roots; abrupt and irregular transition to:  (sample no. 164/2-215e)
C	125 cm+	quartz gravels

Laboratory no.	/84	7636	7637	7638	7639	7640
Horizon	A	Bu1	Bt1	Bt2	BC	
Depth(cm)	0-15	15-34	34-60	60-108	108-130	
pH-H <sub>2</sub> O(1:2.5 v/v)	6.7	6.6	6.2	6.1	6.7	
pH-KCl "	5.2	5.0	4.7	4.6	4.9	
EC(mmho/cm) "	0.05	0.02	0.03	0.06	0.03	
CaCO <sub>3</sub> (%)						
CaSO <sub>4</sub> (%)						
C (%)	0.31	0.25	0.31	0.28	0.17	
N (%)						
C/N						
CEC(me/100g), pH 8.2	3.5	3.5	8.8	15.2	14.0	
CEC " " pH 7.0						
Exch.Ca(me/100g)	1.2	1.0	2.0	3.7	3.5	
" Mg "	1.0	1.1	2.9	4.9	3.8	
" K "	0.36	0.43	0.60	0.55	0.25	
" Na "	0.20	0.31	0.25	0.30	0.15	
Sum of cations	2.76	2.84	5.75	9.45	7.7	
Base sat. %, pH 8.2	79	81	65	62	55	
" " %, pH 7.0						
ESP at pH 8.2						
<u>Texture (limited pretreatment)</u>						
Gravel % (>2.0mm)						
Sand % (2.0-0.05mm)	84	84	66	46	54	
Silt % (0.05-0.002mm)	6	6	8	6	6	
Clay % (0.002-0mm)	10	10	26	48	40	
Texture class	LS	LS	SCL	SC	SC/C	
<u>Fertility aspects</u>		O - 30 cm		Laboratory no. 7677 /84		
<u>General</u>		<u>Available nutrients</u>				
pH-H <sub>2</sub> O (1:2.5 v/v)	6.7	Na/me/100g)	0.09	Mn(me/100g)	0.34	
Exch. acidity (me/100g)		K "	0.40	P (ppm)	36	
C %	0.4	Ca "	0.8	P-Olsen (ppm)		
N %	0.06	Mg "	0.7			
<u>Remarks:</u>						

PROFILE DESCRIPTION NO. 3

General Site Information

Mapping unit : UUr3p  
 Soil classification : chromic LUVISOL  
 Observation No. : 164/2-211  
 Parent material : undifferentiated Basement System rocks  
 Physiography : uplands  
 Relief : gently undulating; slopes 3-5%  
 Land use : grazing  
 Erosion : slight to moderate rainsplash and rill wash  
 Surface stoniness : nil  
 Surface rockiness : nil  
 Surface sealing : strong  
 Drainage class : well drained

Profile Description

A	0-15 cm	: dark reddish brown (2.5YR 2.5/4 moist); sandy clay loam; moderate fine and medium subangular blocky; friable to firm when moist, sticky and slightly plastic when wet; many very fine, few medium pores; few very fine to medium roots; clear and smooth transition to:  (sample no. 164/2-211a)
Bu1	15-34 cm	: dark red (2.5YR 3/6 moist); sandy clay loam; moderate fine and medium subangular blocky; friable when moist, sticky and plastic when wet; many very fine and few fine pores; few very fine to medium roots; clear and smooth transition to:  (sample no. 164/2-211b)
Bt1	34-60 cm	: dark red (2.5YR 3/6 moist); sandy clay; moderate to strong fine to medium angular blocky; friable when moist, sticky and plastic when wet; patchy, thin clay cutans; many very fine pores; few very fine to medium roots; gradual and smooth transition to:  (sample no. 164/2-211c)
Bt2	60-108 cm	: dark red (2.5YR 3.6 moist); clay; strong medium to coarse angular blocky; friable when moist, sticky and plastic when wet; common moderately thick clay cutans; many very fine, common fine pores; few very fine to medium roots; clear and smooth transition to:  (sample no. 164/2-211d)
BC	108-130 cm	: dark red (2.5YR 3/6 moist); gravelly clay; strong fine angular blocky; friable when moist, sticky and plastic when wet; patchy thin clay cutans; abrupt and irregular transition to:  (sample no. 164/2-211e)
C	130 cm+	: quartz gravels

Observation no: 164/2-213 Mapping unit: UUr5m Soil classification: sodic and pissoferric phase

Laboratory no.	/84	7642	7643	7644	7645		
Horizon		Bu1	Bu2	Bt1	Bt2		
Depth (cm)		0-20	20-36	36-68	68-80		
pH-H <sub>2</sub> O (1:2.5 v/v)		5.2	5.7	5.7	8.2		
pH-KCl "		4.1	4.0	3.8	6.0		
EC (mmho/cm) "		0.06	0.15	0.25	1.30		
CaCO <sub>3</sub> (%)							
CaSO <sub>4</sub> (%)							
C (%)		0.37	0.28	0.23	0.11		
N (%)							
C/N							
CEC (me/100g), pH 8.2		5.5	11.3	12.8	14.3		
CEC " " pH 7.0							
Exch. Ca (me/100g)		0.6	1.8	2.0	3.8		
" Mg "		1.0	2.8	3.4	4.9		
" K "		0.35	0.45	0.55	0.86		
" Na "		0.05	0.25	0.22	2.50		
Sum of cations		2.0	5.3	6.2	12.1		
Base sat. %, pH 8.2		36	47	48	84		
" " %, pH 7.0							
ESP at pH 8.2					17		

Texture (limited pretreatment)

Texture (limited procedures)						
Gravel % (>2.0mm)						
Sand % (2.0-0.05mm)	78	64	60	50		
Silt % (0.05-0.002mm)	8	6	6	10		
Clay % (0.002-0mm)	14	30	34	40		
Texture class	SL	SCL	SCL	SC/C		

### Fertility aspects

0 - 30 cm

Laboratory no. 7678 /84

Fertility aspects		Available nutrients			
pH-H <sub>2</sub> O (1:2.5 v/v)	4.6	Na(me/100g)	0.27	Mn(me/100g)	0.14
Exch. acidity (me/100g)		K	0.33	P (ppm)	
C %	0.46	Ca	0.8	P-Olsen (ppm)	
N %	0.06	Mg	1.2		

Remarks:

PROFILE DESCRIPTION NO. 4

General Site Information

Mapping unit : UUr5m  
Soil classification : chromic LUVISOL, sodic and pisolitic phase  
Observation No. : 164/2-213  
Parent material : undifferentiated Basement System rocks  
Physiography : uplands  
Relief : undulating; slopes 5%  
Land use : grazing  
Erosion : moderate to severe rainsplash and rill wash and slight to moderate gully erosion  
Surface stoniness : nil  
Surface rockiness : nil  
Surface sealing : strong  
Drainage class : well drained

Profile Description

Bu1 0-20 cm : dark reddish brown (5YR 3/4 moist); sandy clay loam; weak, medium subangular blocky; friable when moist, slightly sticky and slightly plastic when wet; many very fine pores; clear and smooth transition to:  
(sample no. 164/2-213a)  
Bu2 20-36 cm : reddish brown (5YR 4/4 moist); sandy clay loam; weak to moderate, medium subangular blocky; friable when moist, slightly sticky and slightly plastic when wet; many very fine pores; abrupt and smooth transition to:  
(sample no. 164/2-213b)  
Bt1 36-68 cm : dark reddish brown (5YR 3/4 moist); sandy clay loam; moderate, medium to coarse angular blocky; friable to firm when moist, sticky and plastic when wet; patchy thin clay cutans; clear and smooth transition to:  
(sample no. 164/2-213c)  
Bt2 68-80 cm : dark reddish brown (5YR 4/4 moist); sandy clay to clay; moderate fine subangular blocky; friable when moist, sticky and plastic when wet; patchy thin clay cutans; many very fine pores; frequent iron and manganese concretions; abrupt and smooth transition to:  
(sample no. 164/2-213d)  
Bcs 80 cm+ : pisolitic material



Laboratory no.	/84	7646	7647	7648	7649	7650	
Horizon		Au	AB	Bts1	Bts2	Cck	
Depth (cm)		0-18	18-43	43-73	73-89	89-110	
pH-H <sub>2</sub> O (1:2.5 v/v)		7.7	6.1	6.0	8.6	8.6	
pH-KCl	"	4.3	3.9	4.0	6.6	6.9	
EC (mmho/cm)	"	0.04	0.05	0.10	0.20	0.19	
CaCO <sub>3</sub> (%)							
CaSO <sub>4</sub> (%)							
C (%)		0.31	0.25	0.14	0.17	0.11	
N (%)							
C/N							
CEC (me/100g), pH 8.2		7.8	10.8	12.5	13.3	12.8	
CEC " " pH 7.0							
Exch. Ca (me/100g)		2.9	1.8	2.5	7.2	5.9	
" Mg "		1.7	2.8	3.8	4.9	5.1	
" K "		0.48	0.36	0.37	0.55	0.46	
" Na "		0.05	0.35	0.55	0.95	1.50	
Sum of cations		5.13	5.31	7.22	13.60	12.96	
Base sat. %, pH 8.2		66	49	58	100+	100+	
" " %, pH 7.0							
ESP at pH 8.2				4	7	12	

Gravel % (>2.0mm)						
Sand % (2.0-0.05mm)	72	66	62	58	62	
Silt % (0.05-0.002mm)	6	6	6	8	10	
Clay % (0.002-0mm)	22	28	32	34	28	
Texture class	SCL	SCL	SCL	SCL	SCL	

General		Available nutrients			
pH-H <sub>2</sub> O (1: 2.5 v/v)	6.6	Na/me/100g)	0.07	Mn (me/100g)	0.24
Exch. acidity (me/100g)		K "	0.34	P (ppm)	10
C %	0.49	Ca "	1.2	P-Olsen (ppm)	
N %	0.07	Mg "	1.2		

Remarks:

PROFILE DESCRIPTION NO. 5

General Site Information

Mapping unit : UUp1p  
 Soil classification : orthic LUVISOL, sodic phase  
 Observation No. : 164/2-214  
 Parent material : undifferentiated Basement System rocks  
 Physiography : uplands  
 Relief : gently undulating to undulating; slopes 5-7%  
 Land use : grazing  
 Erosion : severe gully erosion  
 Surface stoniness : nil  
 Surface rockiness : nil  
 Surface sealing : strong  
 Drainage class : well drained

Profile Description

Au	0-18 cm	: yellowish red (5YR 4/6 moist); sandy clay loam; weak to moderate, very fine to medium subangular blocky; friable when moist, slightly sticky and slightly plastic when wet; many very fine, common fine and few medium pores; very frequent very fine, frequent fine roots; gradual and smooth transition to: (sample no. 164/2-214a)
AB	18-43 cm	: yellowish red (5YR 4/6 moist); sandy clay loam; moderate, fine to coarse subangular blocky; friable when moist, sticky and plastic when wet; many very fine, few fine and medium pores; few medium, very few coarse roots; clear and smooth transition to: (sample no. 164/2-214b)
Bts1	43-73 cm	: dark brown (10YR 4/3 moist); common fine to medium distinct yellowish red (5YR 5/6) mottles; clay; strong fine to very coarse angular blocky; firm when moist, sticky and plastic when wet; common to many very fine pores; very few fine and dead roots; clear and smooth transition to: (sample no. 164/2-214c)
Bts2	73-89 cm	: brown to dark brown (7.5YR 4/4 moist); clay; moderate very fine and fine angular blocky; friable when moist, sticky and plastic when wet; slightly calcareous (localized); many very fine pores; abrupt and smooth transition to: (sample no. 164/2-214d)
Ccks	89-110 cm	: dark yellowish brown (10YR 4.4 moist); very gravelly clay; massive, friable when moist, sticky and plastic when wet; strongly calcareous; very frequent iron and manganese concretions; abrupt and smooth transition to: (sample no. 164/2-214e)
	110 cm+	: petroferric material (murram)

Saline phase						
Laboratory no.	/84	7660	7661	7662	7663	7664
Horizon		A	AB	E	Bt1	Bt2
Depth (cm)		0-10	10-26	26-42	42-70	70-92
pH-H <sub>2</sub> O (1: 2.5 v/v)		6.3	6.6	6.0	6.5	8.5
pH-KCl	"	5.0	4.2	4.2	5.5	7.4
EC (mmho/cm)	"	0.04	0.02	0.02	0.28	1.00
CaCO <sub>3</sub> (%)		+	+	+	++	+
CaSO <sub>4</sub> (%)		0.28	0.23	0.29	0.20	0.17
C (%)						
N (%)						
C/N						
CEC (me/100g), pH 8.2		4.3	4.3	3.5	5.8	9.5
CEC " " pH 7.0						
Exch. Ca (me/100g)		1.2	0.8	1.0	1.8	6.1
" Mg "		1.4	1.3	1.4	1.4	2.5
" K "		0.17	0.05	0.10	0.04	0.07
" Na "		0.17	0.30	0.15	0.62	1.37
Sum of cations		2.92	2.45	2.65	3.86	10.04
Base sat. %, pH 8.2		68	57	76	67	100+
" " %, pH 7.0						
ESP at pH 8.2						14
<u>Texture (limited pretreatment)</u>						
Gravel % (>2.0mm)						
Sand % (2.0-0.05mm)		80	84	84	80	30
Silt % (0.05-0.002mm)		10	6	8	8	52
Clay % (0.002-0mm)		10	10	8	12	18
Texture class		LS/SL	LS	LS	SL	SL
<u>Fertility aspects</u>		0 - 30 cm			Laboratory no. 7682 /84	
General		Available nutrients				
pH-H <sub>2</sub> O (1:2.5 v/v)	6.1	Na (me/100g)	0.07	Mn (me/100g)	0.20	
Exch. acidity (me/100g)		K "	0.19	P (ppm)	15	
C %	0.43	Ca "	1.4	P-Olsen (ppm)		
N %	0.06	Mg "	1.7			
<u>Remarks:</u>						

PROFILE DESCRIPTION NO. 6

General Site Information

Mapping unit : UUb2p  
 Soil classification : orthic SOLONETZ, saline phase  
 Observation No. : 164/2-217  
 Parent material : undifferentiated Basement System rocks  
 Physiography : uplands  
 Relief : gently undulating to undulating; slopes 5-8%  
 Land use : grazing, wood cutting  
 Erosion : very severe rainsplash and rill wash and moderate gully erosion  
 Surface stoniness : nil  
 Surface rockiness : nil  
 Surface sealing : strong  
 Drainage class : moderately well drained

Profile Description

A 0-10 cm : dark yellowish brown (10YR 4/4 moist); coarse loamy sand to sandy loam; weak, very fine to fine subangular blocky; friable when moist; slightly sticky and non-plastic when wet; many very fine pores; few very fine to fine medium and coarse roots; gradual and smooth transition to:  
 (sample no. 164/2-217a)

AB 10-26 cm : dark yellowish brown (10YR 4/4 moist); coarse sandy clay loam; weak, fine to medium subangular blocky; friable when moist, slightly sticky and slightly plastic when wet; many very fine pores; few medium and coarse roots; clear and smooth transition to:  
 (sample no. 164/2-217b)

E 26-42 cm : yellowish brown (10YR 5/6 moist); coarse loamy sand to sand; moderate, very fine and fine subangular blocky; friable when moist, slightly sticky and non-plastic when wet; many very fine pores; very few very fine and fine, common medium, few coarse roots; abrupt and smooth transition to:  
 (sample no. 164/2-217c)

Bt1 42-70 cm : yellowish brown (10YR 5/4 moist); few red iron mottles; coarse sandy clay loam; weak, fine to medium prismatic breaking into weak, medium to coarse subangular blocky; friable to firm when moist, slightly sticky and slightly plastic when wet; few fine roots; gradual and smooth transition to:  
 (sample no. 164/2-217d)

Bt2 70-92 cm : yellowish brown (10YR 5/6 moist); coarse sandy clay; moderate, fine to medium angular and subangular blocky; friable when moist, sticky and slightly plastic when wet; many very fine pores; clear and smooth transition to:  
 (sample no. 164/2-217e)

92 cm+ : profile very difficult to dig

## LABORATORY DATA OF PROFILE DESCRIPTION No. 7

Observation no.: 164/2-216      Mapping unit: UUb3p      Soil classification: calcic CAMBISOL  
lithic phase

Laboratory no.	/ 84	7656	7657	7658	7659		
Horizon		A	AB	Bck1	Bck2		
Depth (cm)		0-14	14-34	34-62	62-80		
pH-H <sub>2</sub> O (1: 2.5 v/v)		8.0	8.5	8.5	9.1		
pH-KCl	"	7.1	7.4	7.6	7.9		
EC (mmho/cm)	"	0.20	0.16	0.21	0.22		
CaCO <sub>3</sub> (%)		+++	+++	+++	+++		
CaSO <sub>4</sub> (%)		1.60	0.75	0.58	0.43		
C (%)							
N (%)							
C/N							
CEC (me/100g), pH 8.2		17.5	15.0	14.3	15.2		
CEC " " pH 7.0							
Exch. Ca (me/100g)		18.6	16.6	19.0	18.6		
" Mg "		5.5	3.5	3.9	1.3		
" K "		1.45	1.28	1.85	3.73		
" Na "		0.25	0.20	0.35	0.35		
Sum of cations		25.80	21.50	25.10	23.98		
Base sat. %, pH 8.2		100+	100+	100+	100+		
" " %, pH 7.0							
ESP at pH 8.2							

Texture (limited pretreatment)

Gravel % (>2.0mm)						
Sand % (2.0-0.05mm)	60	64	60	58		
Silt % (0.05-0.002mm)	20	16	18	18		
Clay % (0.002-0mm)	20	20	22	24		
Texture class	SL/SCL	SL/SCL	SCL	SCL		

### Fertility aspects

0 - 30 cm

Laboratory no. 7681 /84

General		Available nutrients			
pH-H <sub>2</sub> O (1: 2.5 v/v)	8.0	Na(me/100g)	0.20	Mn(me/100g)	0.02
Exch. acidity (me/100g)		K "	0.64	P (ppm)	250
C %	1.59	Ca "	22.0	P-Olsen (ppm)	24
N %	0.21	Mg "	5.0		

## Remarks:

PROFILE DESCRIPTION NO. 7

General Site Information

Mapping unit : UU<sub>h</sub>3p  
Soil classification : calcaric cambisol, lithic phase  
Observation No. : 164/2-216  
Parent material : undifferentiated Basement System rocks  
Physiography : uplands  
Relief : gently undulating to undulating; slopes 4-6%  
Land use : grazing  
Erosion : slight to moderate rainsplash and rill wash  
Surface stoniness : nil  
Surface rockiness : nil  
Surface sealing : weak  
Drainage class : well drained

Profile Description

A 0-14 cm : very dark greyish brown (10YR 3/2 moist); sandy loam to sandy clay loam; porous massive, breaking into weak, fine subangular blocky; friable when moist, sticky and plastic when wet; strongly calcareous; many very fine and fine pores; many very fine, very fine and fine pores; many very fine and fine, common medium roots; clear and smooth transition to:  
(sample no. 164/2-216a)

AB 14-34 cm : dark brown (10YR 3/3 moist); sandy loam to loam; porous massive, breaking into weak, medium subangular blocky; friable when moist, sticky and plastic when wet; strongly calcareous; many very fine and fine pores; common very fine to medium roots; clear and smooth transition to:  
(sample no. 164/2-216b)

Bck1 34-62 cm : brown to dark brown (10YR 4/4 moist); sandy clay loam; porous massive, breaking into weak medium subangular blocky; friable when moist, slightly sticky and slightly plastic when wet; strongly calcareous; many very fine pores; frequent (4 mm diameter) calcium carbonate concretions; very few very fine and medium, few fine roots; clear and smooth transition to:  
(sample no. 164/2-216c)

Bck2 62-80 cm : dark yellowish brown (10YR 4/4 moist); sandy clay loam; porous massive, breaking into weak, fine and medium subangular blocky; friable when moist, sticky and plastic when wet; strongly calcareous; many very fine and fine pores; frequent (10 mm diameter) calcium carbonate concretions; very few medium roots; clear and irregular transition to:  
(sample no. 164/2-216d)

Cck 80 cm+ : parent rock with calcium carbonate concretions.

[illegible]

PROFILE DESCRIPTION NO. 8

General Site Information

Mapping unit : UUb4p  
Soil classification : eutric CAMBISOL, lithic phase  
Observation No. : 164/2-219  
Parent material : undifferentiated Basement System rocks  
Physiography : uplands  
Relief : gently undulating to undulating  
Land use : grazing  
Erosion : moderate rainsplash and rill wash and few gullies  
Surface stoniness : moderately stony  
Surface rockiness : nil  
Surface sealing : weak to moderate  
Drainage class : well drained

Profile Description

A 0-13 cm : brown to dark brown (10YR 4/3 moist); coarse loamy sand; porous massive, breaking into weak medium subangular blocky; friable when moist, non-sticky and non-plastic when wet; many very fine and fine pores; common very fine, few fine and medium roots; clear and smooth transition to:  
(sample no. 164/2-219a)  
AB 13-31 cm : dark yellowish brown (10YR 4/4 moist); coarse loamy sand; porous massive, breaking into weak medium to coarse subangular blocky; friable when moist, slightly sticky and non-plastic when wet; many very fine and fine pores; few very fine and medium, common coarse roots; abrupt and irregular transition to:  
(sample no. 164/2-219b)  
Bc 31-50 cm : dark yellowish brown (10YR 4/4 moist); very gravelly sandy loam; porous massive, breaking into single grains; friable when moist, slightly sticky and non-plastic when wet; many fine pores; few very fine and medium roots; transition to:  
(sample no. 164/2-219c)  
50 cm+ : rock





PROFILE DESCRIPTION NO. 9

General Site Information

Mapping unit : UUb5p  
Soil classification : eutric CAMBISOL, lithic and stony phases  
Observation No. : 164/2-212  
Parent material : undifferentiated Basement System rocks  
Physiography : uplands  
Relief : gently undulating; slopes 4-5%  
Land use : grazing  
Erosion : severely eroded (gullies)  
Surface stoniness : moderately stony  
Surface rockiness : localized rock outcrops  
Surface sealing : strong  
Drainage class : well drained

Profile Description

BC 0-45 cm : strong brown (7.5YR 5/6 moist); gravelling sandy clay; weak, coarse subangular blocky, breaking into single grains; firm when moist, sticky and plastic when wet; moderately calcareous; many macro pores; transition to:  
(sample no. 164/2-212a)  
C 45 cm+ : weathering rock.

Observation no: 164/2-218	Mapping unit: AA1	Soil classification: eutric FLUVISOL sodic phase
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Observation no: 164/2-218		Mapping unit: AAI		Soil class: AAI		Soil phase: AAI	
Laboratory no.	/84	7665	7666	7667	7668	7669	
Horizon		Au1	Au2	Cu1	Cu2	Cu3	
Depth (cm)		0-10	10-28	28-43	43-54	54-72	
pH-H <sub>2</sub> O (1: v/v)		8.7	8.5	7.8	7.9	8.2	
pH-KCl	"	7.2	6.9	6.4	6.9	7.5	
EC (mmho/cm)	"	0.25	0.09	0.04	0.15	0.24	
CaCO <sub>3</sub> (%)		+	+	-	+	+	
CaSO <sub>4</sub> (%)							
C (%)		0.52	0.44	0.11	0.38	0.41	
N (%)							
C/N							
CEC (me/100g), pH 8.2		7.8	10.5	3.5	16.5	18.3	
CEC " " pH 7.0							
Exch. Ca (me/100g)		4.3	6.4	1.6	9.4	11.6	
" Mg "		2.5	3.2	1.4	5.7	6.0	
" K "		0.07	0.11	0.03	0.15	0.18	
" Na "		1.85	1.05	0.25	0.60	0.80	
Sum of cations		8.72	10.76	3.28	15.85	18.58	
Base sat. %, pH 8.2		100+	100+	94	96	100+	
" " %, pH 7.0							
ESP at pH 8.2		124	10	7	4	4	
Texture (limited pretreatment)							
Gravel % (>2.0mm)							
Sand % (2.0-0.05mm)		50	52	86	44	50	
Silt % (0.05-0.002mm)		40	34	10	38	26	
Clay % (0.002-0mm)		10	14	4	18	24	
Texture class		L	SL/L	S/LS	L	SCL	
Fertility aspects		0 - 30 cm			Laboratory no. 7683 /84		
General		Available nutrients					
pH-H <sub>2</sub> O (1: v/v)	84	Na (me/100g)	0.93	Mn (me/100g)	0.50		
Exch. acidity (me/100g)		K "	0.43	P (ppm)	84		
C %	0.66	Ca "	6.4	P-Olsen (ppm)	17		
N %	0.08	Mg "	3.2				
Remarks:							

PROFILE DESCRIPTION NO. 10

General Site Information

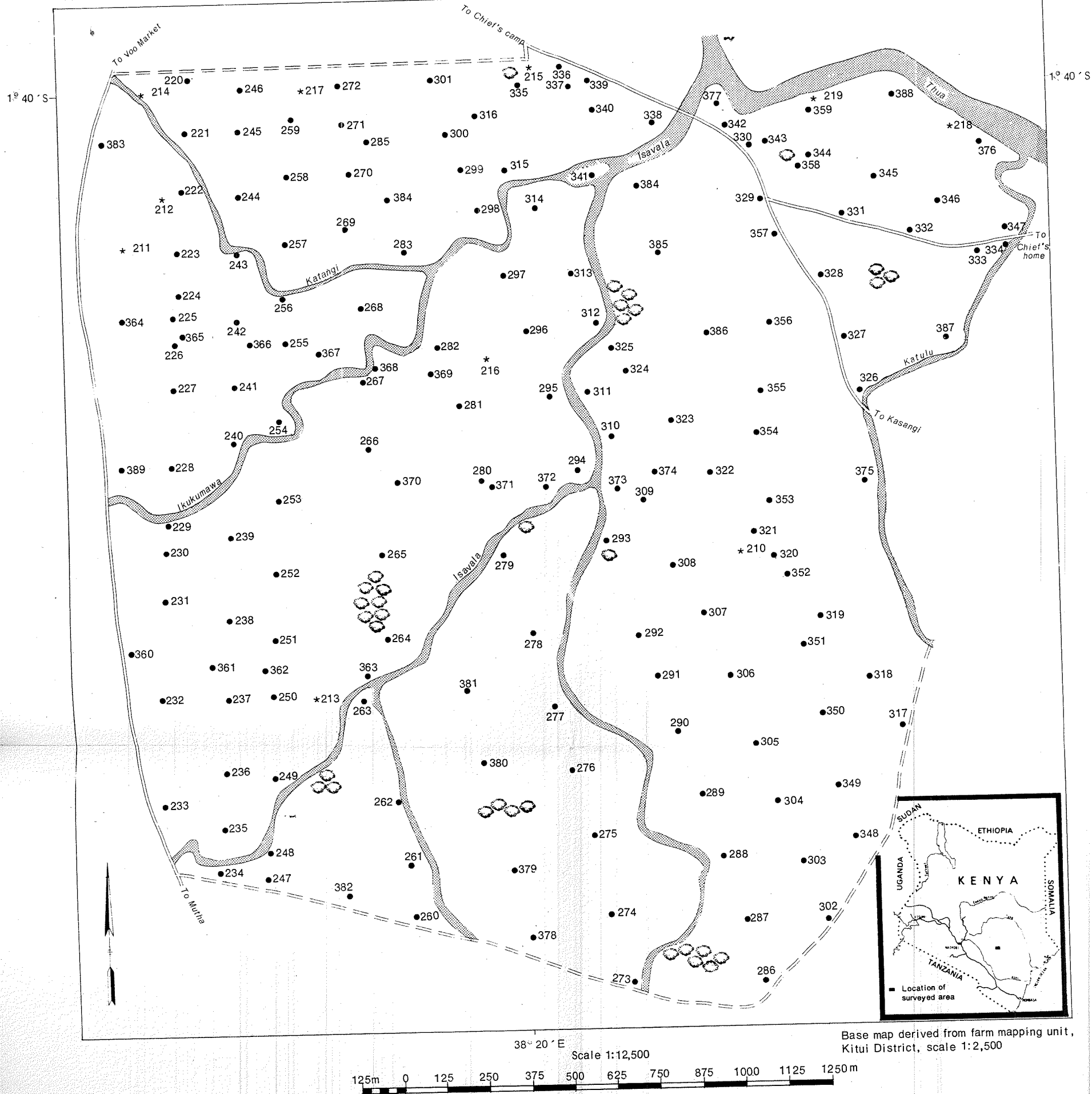
Mapping unit : AA1  
Soil classification : eutric FLUVISOL, sodic phase  
Observation No. : 164/2-218  
Parent Material : recent alluvial deposits  
Physiography : river terrace  
Relief : flat to very gently undulating; slopes 2%  
Land use : open grazing  
Erosion : slight rainsplash and rill wash  
Surface stoniness : nil  
Surface rockiness : nil  
Surface sealing : weak  
Drainage class : well drained

Profile Description

- Au1 0-10 cm : dark yellowish brown (10YR 3/4 moist); silty clay loam; porous massive breaking into weak fine subangular blocky; friable when moist, slightly sticky and non-plastic when wet; moderately calcareous; many very fine pores; common very fine, many fine and medium roots; clear and smooth transition to:  
(sample no. 164/2-218a)
- Au2 10-28 cm : brown to dark brown (10YR 4/4 moist); common fine distinct yellowish red (5YR 5/8) mottles; silty clay; weak fine to medium subangular blocky; friable when moist, slightly sticky and slightly plastic when wet; slightly calcareous; many very fine to fine pores; common, fine distinct yellowish red (5YR 5/8) mottles; common fine and medium roots; clear and irregular transition to:  
(sample no. 164/2-218b)
- Au3 28-43 cm : dark brown (10YR 3/3 moist); common fine distinct yellowish red (10YR 4/6) mottles; fine loamy sand; weak fine to medium subangular blocky; non-sticky and non-plastic when wet; many fine pores; common fine to medium, few coarse roots; clear and smooth transition to:  
(sample no. 164/2-218c)
- Cu2 43-54 cm : brown to dark brown (10YR 4/3 moist); common fine distinct yellowish red (5YR 5/8) mottles; silty clay; weak fine subangular and platy; friable when moist, slightly sticky and non-plastic when wet; moderately calcareous; many fine pores; few fine, very few medium and coarse roots; clear and smooth transition to:  
(sample no. 164/2-218d)
- Cu3 54-72 cm : very dark greyish brown (10YR 3/2 moist); sandy clay; porous massive breaking into weak coarse subangular blocky; friable when moist, slightly sticky and slightly plastic when wet; moderately calcareous; many fine pores; very few fine roots; clear and smooth transition to:  
(sample no. 164/2-218e)
- Cu4 72-82 cm : dark yellowish brown (10YR 3/4 moist); silty clay loam; weak coarse subangular blocky; friable when moist, slightly sticky and non-plastic when wet; slightly calcareous; many very fine to fine pores; common fine (dead) roots; clear and smooth transition to:  
(sample no. 164/2-218f)
- Cu5 82-94 cm : dark yellowish brown (10YR 4/4 moist); loamy sand; weak coarse subangular blocky; friable when moist, non-sticky and non-plastic when wet; many fine pores; very few medium roots; clear and irregular transition to:  
(sample no. 164/2-218g)
- Cu6 95-145 cm : dark yellowish brown (10YR 3/4 moist); silty clay loam; weak coarse subangular blocky; friable when moist, slightly sticky and non-plastic when wet; strongly calcareous; many fine pores; very few medium roots.

Location of observations in the Voo Research Substation  
38° 20' E (Kitui District)

Appendix 3 to report No. D 39



KEY

== road  
- - - cutline

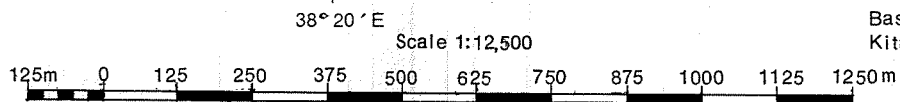
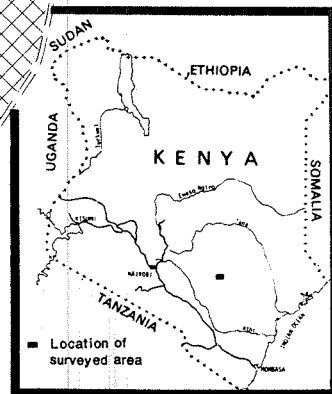
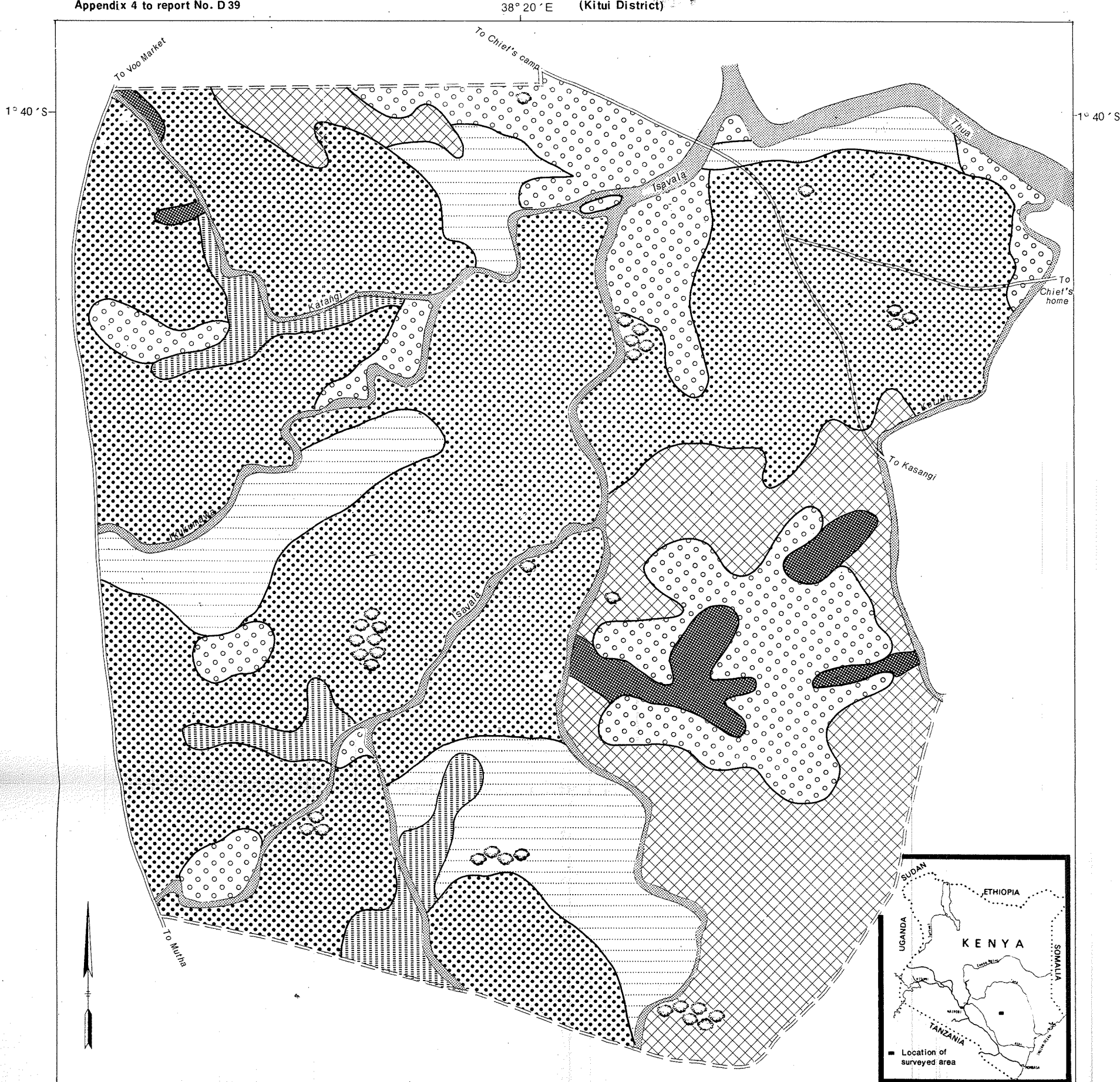


seasonal river  
rock outcrops

●258 augerhole observation, with reference number  
★214 profile pit observation, with reference number

SOIL SURVEY AND MAP PREPARATION (1984-1985)  
map compilation.....C.K.K. Gachene and T.W. Wachira  
map correlation..... P.T. Gicheru and J.K. Kanake  
cartography D.M. Olulo

Present soil erosion status map of Voo Research Substation  
(Kitui District)



Base map derived from farm mapping unit,  
Kitui District, scale 1:2,500

KEY

- road
- cutline
- seasonal river
- rock outcrops

LEGEND

- slight rainsplash and rill wash
- slight to moderate rainsplash and rill wash
- moderate rainsplash, rill wash and slight gully erosion
- severe rainsplash, rill wash and moderate gully erosion
- very severe rainsplash, rill wash and moderate gully erosion
- severely gullied

SOIL SURVEY AND MAP PREPARATION (1984-1985)

map compilation.....C.K.K. Gachene and T.W. Wachira

map correlation..... P.T. Gicheru and J.K. Kanake

cartography D.M. Olulo

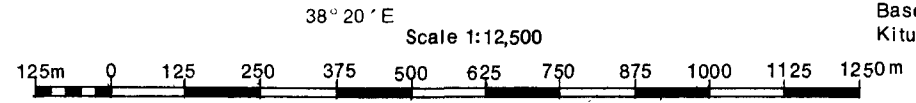
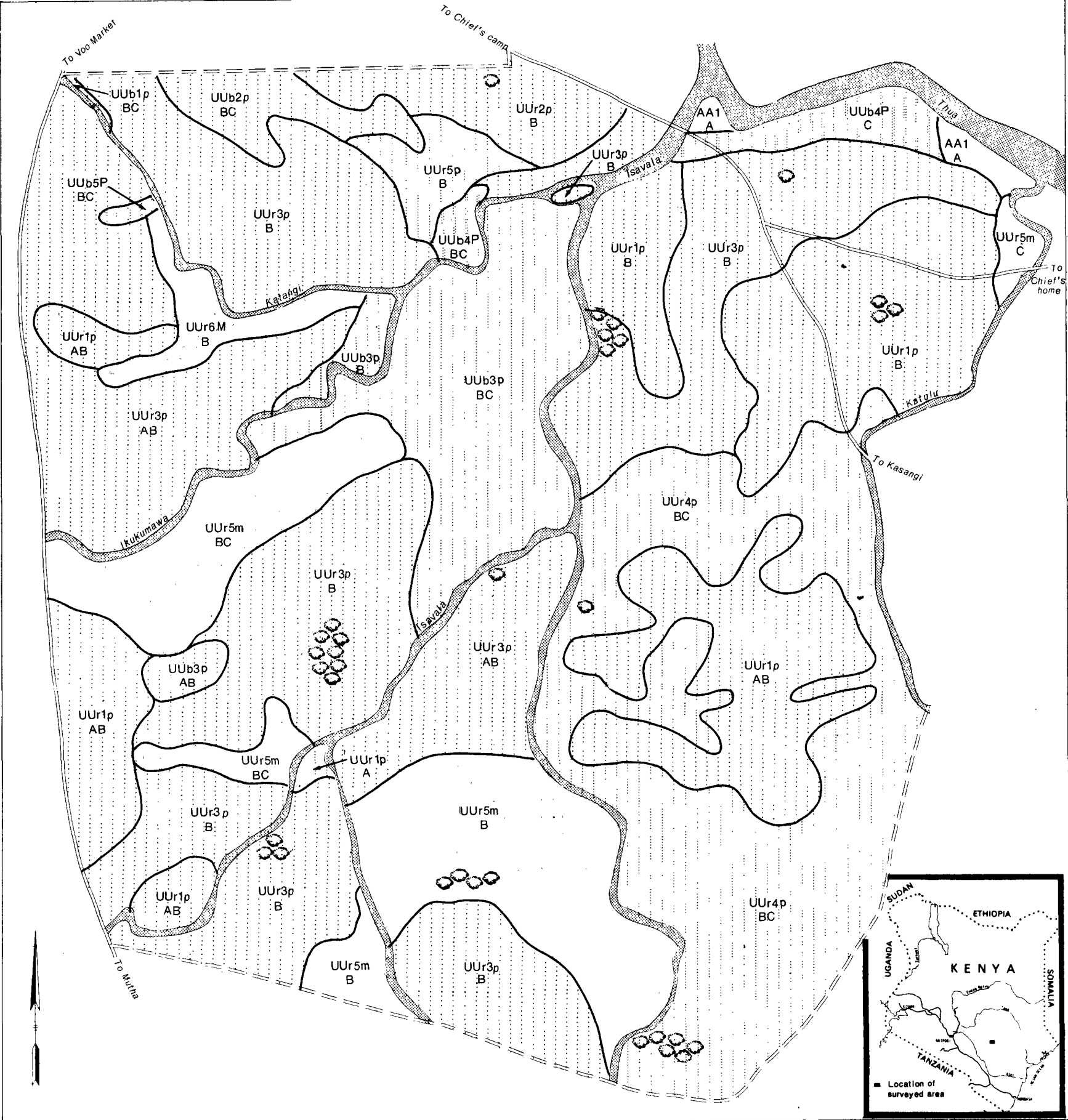
11423a

DETAILED SOIL MAP OF THE VOO RESEARCH SUB-STATION  
(KITUI DISTRICT)

Appendix 2 to report No. D 39

38° 20' E

1° 40' S



**KEY**  
— road  
— cutline  
— seasonal river  
○ rock outcrops

**LEGEND**

**U UPLANDS** (slopes 2–8%)

- UU soils developed on undifferentiated Basement System rocks**
- UU1p well drained, deep, dark red to dark reddish brown, friable to firm, sandy clay to clay, underlying 10 to 20cm of loamy sand to sandy clay loam (chromic LUVISOLS)
- UU2p well drained, deep to very deep, yellowish red to dark reddish brown, friable, loamy sand to sandy loam; in places with rock outcrops (ferralic ARENOSOLS)
- UU3p well drained, deep to very deep, dark red, friable to firm clay; in places with quartz stoniness (chromic LUVISOLS)
- UU4p as in unit UU3p, but moderately deep to deep
- UU5m well drained, moderately deep, dark red to dark red-dish brown, friable to firm, sandy clay loam to sandy clay, over pisolitic material (murrum) or rock (chromic LUVISOLS, pisolitic phase)
- UU6m as in unit UU5m, but shallow to moderately deep; in places with quartz stoniness
- UUb1p well drained, deep, brown to dark brown, firm, slightly sodic clay, underlying 20 to 40cm of yellowish red, friable, sandy clay (orthic LUVISOLS, sodic phase)
- UUb2p well drained, deep, yellowish brown, firm, slightly saline sandy clay, underlying 10 to 30cm of loamy sand to sandy clay loam (orthic SOLONETZ, saline phase)
- UUb3p well drained, moderately deep, dark brown, friable, moderately to strongly calcareous, sandy clay loam (calic CAMBISOLS, lithic phase)
- UUb4p well drained, shallow, dark yellowish brown, fairly rocky and stony, friable loamy sand (eutric CAMBISOLS, lithic phase)
- UUb5p well drained, shallow, strong brown, fairly rocky and stony, moderately calcareous, gravelly clay (eutric CAMBISOLS, lithic and stony phase)

**A RIVER TERRACES** (slopes 1–2%)

- AA Soils developed on recent alluvial deposits**
- AA1 well drained, very deep stratified soils of varying colour, consistence, sodicity and texture (eutric FLUVISOLS, sodic phase)

**KEY TO SLOPE CLASSES**

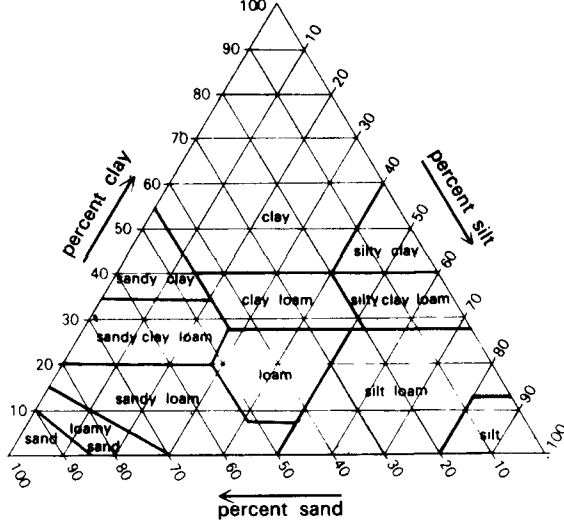
slope %	slope class code	name of the macrorelief
0-2	A	flat to very gently undulating
2-5	B	gently undulating
5-8	C	undulating

**KEY TO DEPTH CLASSES**

thickness soil in cm	symbol +	name
	over rock	over petro-plinthite or pisolitic material
0-25		very shallow
25-50	P M	shallow
50-80	p m	moderately deep
80-120	p	deep
more than 120		very deep

+ if a complex of depth classes occurs within one unit, only the symbol of the shallowest depth class is indicated

**TEXTURAL CLASSES**



**KEY**

- UU1p soil mapping code  
UU4p depth class code  
BC slope class code  
— soil boundary  
1 cm<sup>2</sup> 1.56 ha

**SOIL SURVEY AND MAP PREPARATION (1984–1985)**

soil survey..... C.K.K. Gachene, B.K. Waruru, T.W. Wachira and S. Mwangi  
map compilation..... C.K.K. Gachene and T.W. Wachira  
map correlation..... P.T. Gicheru and J.K. Kanake  
cartography ..... D.M. Olulo

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