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KENYA SOIL SURVEY

SOIL CONDITIONS OF JUJA ESTATE

(KIAMBU DISTRICT)

by

S.N.Wanjogu and P.T.Kamoni

SITE EVALUATION REPORT No. P79,1986

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1 INTRODUCTION

The request to survey Juja Estate was made in January 1986 by Mrs Pratt, the owner of the farm. It was thought that a site evaluation could furnish enough information on which sprinkler irrigation development decisions could be based. A quick survey which could map major soil patterns would be sufficient. Therefore, a site evaluation with emphasis on soil depth, texture, drainage, sodicity/salinity was carried out. Fieldwork was executed between 13th and 19th February 1986 by the authors together with Messrs H. Kinyanjui, T. Wachira, P. Kimotho and P. Mureithi.

2 THE ENVIRONMENT

2.1 Location and communication

Juja Estate is located in Juja at the junction of the Nairobi-Thika highway and Kenyatta road which leads to Gatundu. The Nairobi-Thika road forms the southern boundary, Theta river forms the western boundary, the eastern boundary is partly formed by the Kenyatta road. The centre of the survey area has the coordinates E36° 59.8′ and S1° 07′. The survey area covers 206ha and lies at an altitude of approximately 1520m above sea level. The estate is well served by all weather roads.

2.2 Climate

The survey area does not have a rainfall station itself but the following stations have been taken for reference. Ndarugu (91.37026), altitude 1525m; Iganjo farm (91.36031), altitude 1615m; Komina Estate (91.36005), altitude 1555m.
Ndarugu, Iganjo farm and Komina Estate are situated 6.4km E, o.4km NE and 7.6km SW of the survey area respectively. The data of these stations are considered representative for the survey area.

Annual rainfall ranges from 782mm at Ndarugu to 933mm at Komina Estate. The estimated annual rainfall of the area is 856mm. The distribution is bimodal with a major peak in April and a minor one in November. A dry period of about four months occurs between

June and October (E.A.M.D. 1974). March is the hottest month with 21.3°C and July is the coldest month with 18.4°C. Mean annual temperature is 19.7°C. Mean annual maximum is 26.1°C and mean annual minimum is 13.6°C.

Table 1. Climatic data for the Juja area

Month	Mean Temp. (°C)	Rainfall (mm)	Eo (mm)	Et (mm)	r-Et (mm)
Jan	20.3	33	186	124	-91
Feb	21.0	34	186	124	-90
March	21.3	99	186	124	-25
Apr	20.7	202	148	99	103
May	19.9	126	130	87	39
June	19.0	34	130	87	-53
July	18.4	19	111	74	-55
Aug	18.6	22	111	74	-52
Sept	19.4	21	167	74	-90
Oct	20.1	61	186	124	-63
Nov	20.1	128	148	99	29
Dec	19.9	77	167	111	-34
Year	19.7	856	1856	1238	-382

Source: E.A.M.D. (1970, 1974), Woodhead (1968), Braun (in prep)

According to Woodhead (1968), the mean potential evaporation (Eo) of the area is 1856mm. The ratio r/Eo (where r is rainfall) amounts to 46% which places the area in agro-climatic zone IV (Sombroek et al, 1982). The potential evapotranspiration or crop water requirement (Et) is estimated as 2/3 of the potential evaporation (Et ≐ 2/3 Eo). Hence the annual potential evapotranspiration of the area is 1238mm. The year is characterised by excess potential evapotranspiration (Et) over rainfall (r) except in the April - May

and November periods when some rain water surplus may be stored in the soil depending on the amount of rain water lost as runoff and as deep percolation.
The last column of table 1 gives the amount of moisture that is in excess of Et (+ sign) or that is deficient (-sign). If it is assumed that rain water which is in excess of crop water requirement (Et) is stored in the soil as soil moisture, then on average no irrigation would be required from April to August. However, irrigation is considered necessary for the period between January and March and in the months September and October.

According to Braun (1977) the probability that rainfall in the long rains (March to May) will be equal or greater than potential evapotranspiration is 82% i.e in on average four out of five seasons, the seasonal rainfall will meet the crop water requirement. For the short rains season (October to December), the probability that the seasonal rainfall will meet the crop water requirement is 23% i.e. in on average one out of five seasons, the seasonal rainfall will be equal to or greater than the potential evapotranspiration (November to December). In case where the seasonal and monthly rainfall values fall significantly lower than the values of table 1, irrigation may be expected to commence earlier than otherwise suggested.

2.3 Geology and Physiography

The survey area is covered by pyroclastic rocks which according to Saggerson (1971) form the "Middle Trachyte Division" of Tertiary age. The Lower Kerichwa Valley tuffs cover the valley of river Theta. The higher valley sides and the top areas are covered by the Middle and Upper Kerichwa Valley tuffs.

Physiographically, the survey area can be divided into two major units; a higher level structural plain and a minor valley which is made up of terraces and a valley bottom. The highest point of the survey area is formed by a flat to very gently undulating high level structural plain. Slight depressions within this plain have impeded drainage. The valley bottom has poor drainage resulting to swampy

areas. In the transition zone between the flat to very gently undulating plain a zone of more relief is found where the underlying rock is generally not very far from the surface.

3 WORKING METHODS

3.1 Office Methods

Before the excution of the fieldwork, all the necessary information relevant to the survey area was collected. This included the procurement of aerial photographs, topographical maps, geological reports and any literature from adjacent areas that could be of use in the survey area.

Large scale aerial photographs of scale 1:10,000 were interpreted and the boundaries delineated were transferred manually onto a 1:10,000 base map that had been prepared from a Survey of Kenya cadastral plan of scale 1:10,000. An aerial photo-interpretation map was prepared for the survey area.

2.2 Field Methods

During fieldwork, the validity of the boundaries delineated during the photo interpretation was checked. The checking of the boundaries was done through augerhole observation which were made to a depth of 1.2m where soil depth permitted. The soil characteristics recorded were drainage condition, soil depth, colour, texture, consistence,mottling etc. Special attention was given to depth to piso - or petroplinthite (murram) and/or rock. A total of 30 augerings were made and 4 profile pits were dug and described. Samples were taken from all horizones for physical and chemical analysis in the laboratory. Composite topsoil samples for fertility analysis were taken from the area surrounding each pit. The locations of the augerings and pits are shown in appendix 2.

Soil information was recorded on standard soil profile description forms which are based on the FAO (1977) "Guidelines for Soil Profile Description", while the colours given are based on

"Munsell Soil Color Charts" (1975).

3.3 Laboratory Methods

Analysis were carried out at the National Agricultural Laboratories, Nairobi. The methods are described briefly below. For details refer to Hinga et al (1980).

Before any analysis was done, all samples were air dried, crushed and sieved through a 2mm sieve.

Survey analysis

Texture	:	hydrometer method
pH-H_2O	:	1:2.5 soil-water suspension
pH-KCL	:	1:2.5 soil-salt suspension
EC	:	1:2.5 soil-water suspension
Exchange cations	:	Successive leaching of the soil by 1N ammonium acetate (pH 7.0). Determination of Na, K and Ca by flame-photometer/atomic absorption spectrophotometer.
Cation Exchange Capacity (CEC)	:	After leaching the samples for exchangeable cations, the samples were successively leached with alcohol (95%), sodium acetate (pH 8.2) and 1N ammonium acetate (pH 7.0). The CEC was determined by measuring the Na concentration in the last leachate with a flame-photometer.

Mass analysis for available nutrients (on A-horizon only)

Extraction of soil by shaking for 1 hour with 1:5 ratio 0.1N HCl 0.025N H_2SO_4. Ca, K and Na were determined by EEL - flame-photometer after anion resin treatment for Ca. Both Mg and Mn were determined colorimetrically. P was determined by vanadomolydophosphoric yellow colorimetrically.

THE SOILS

4.1 Systematics and nomenclature

The survey area can be divided into two physiographic units: the high level structural plain and the minor valley with river terraces and a valley bottom. All the units except VAd and VPb have the same parent material (pyroclastic rocks - trachytic tuffs). The soil mapping units have been separated and described in terms of important soil profile characteristics such as drainage, depth, consistence, texture, colour etc.

Each soil mapping unit is identified on the map by a code. The first entry in the soil mapping code is the physiography denoted as;

L - High level structural plains

V - Minor valley with terraces and a valley bottom.

The second entry in the code is for the parent material (Geology) denoted as:

P - Pyroclastic rocks (trachtic tuffs)
and colluvium derived from trachytic tuffs.

A - Recent alluvial deposits.

Other entries in the code thereafter could be for depth or colour denoted as:

Depth:

M - very shallow over petroplinthite (murram)

P - shallow over rock (trachytic tuffs)

Colour

r - red

d - dark

b - brown

Four depth classes have been used in this survey taking into account the depth to underlying rock or piso - or petroplinthite (murram). The classes of depth are :

0 - 25 cm - very shallow
25 - 50 cm - shallow
80 - 120 cm - deep
>120 cm - very deep

On the soil map slope classes are also given idicated by a code underneath the mapping unit code and explained in the "Key to Slope Classes" (See appendix 2).

4.2 General properties of the soils

The soils in the survey area can broadly be subdivided into 3 main groups:

- the very shallow sandy clay soils over murram
- the shallow clay soils over trachytic tuff
- the deep clay soils

The very shallow sandy clay soils consist of mapping unit LPM. These soils are well drained with a gravelly sandy clay texture and a friable moist consistence. They are all underlain by petroplinthite (indurated murram) at depths ranging from 5 to 25 cm.

The shallow clay soils consist of mapping unit LPP. These soils are well drained with a clay texture and a friable moist consistence. They are underlain by the bedrock of trachytic tuff at depths ranging from 35 cm to 50 cm.

Deep clay soils of units LPr, LPd, VAd and VPb can be further sub-divided into the well drained deep clay soils of unit LPr and the poorly to very poorly drained clay soils of units LPd, VAd and VPb.

4.3 Description of soil mapping units

4.3.1 Soils of the high level structural plain

Mapping unit LPr

Extent and slope : 8.4ha, slopes 0 to 2%.

General : This is a flat to very gently undulating unit which forms the top of a zone of higher relief occuring as a transition between the high level structural plain and the flat bottomed river valley. The soils are derived from trachytic tuffs. Grass covers the area and grazing was the land use at the time of survey.

Soils : This unit consists of well drained, very deep, dark red (2.5 YR3/6) to dark reddish brown (2.5YR 3/4), friable clay soils. The soils have an ABC sequence of of horizons. The boundary between the A and B horizons is gradual and smooth. The B-horizon has a weak, medium to coarse, subangular blocky structure. The pH ranges from 6.8 in the top soil to 4.0 in the subsoil. The electrical conductivity (EC) ranges from 0.25mmhos/cm in the topsoil to o.35mmhos/cm in the subsoil.

Chemical properties : A horizon: Organic carbon percentage is 1.30, pH-H_2O is 6.9; pH-KCL is 4.2. The CEC of the soil is 11.0me/100g and base saturation is 30%.

; The subsoil horizon: pH-H_2O ranges from 5.1 to 5.8. The CEC of the soil ranges from 5.0 to 8.0, base saturation ranges from 14 to 20%. The soils show phosphorous deficiency.

Soil classification : rhodic FERRALSOLS

For the description of a representative profile with analytical data, see appendix 1 profile description no 3 (observation no 148/2168).

Mapping unit LPP

Extent and slope : 35.9ha, slopes from 3 to 6%.

General : This unit is gently undulating to undulating. It forms a zone of somewhat steeper slopes between the high level structural plain and the flat bottomed river valley. The soils are derived from trachytic tuffs. The vegetation is wooded grassland whereas grazing is the land use.

Soils : This unit consists of well drained, shallow, yellowish red (5YR 4/6) to dark reddish brown (5YR 3/3, friable clay soils. The soils have an AC-sequence of horizons. The colour of the topsoil ranges from dark brown (7.5YR 3/2) to dark reddish brown (5YR 3/3). The pH ranges from 6.2 in the topsoil to 5.8 in the subsoil.
The electrical conductivity (EC) ranges from 0.4mmhos/cm in the top soil to 0.25mmhos/cm in the subsoil. The bedrock starts from 35 cm depth.
The unit is stony and rocky in places.

Soil classification ; dystric CAMBISOLS, lithic and partly stony phase.

Mapping unit LPM

Extent and slopes : 105.4ha, slopes 0 to 1%

General : This is a flat area. The soils are derived from trachytic tuffs. Grass is the vegetation while grazing is the land use.

Soils : This unit consists of well drained, very shallow, dark yellowish brown (10YR 4/6) to dark brown (10YR 3/4), friable sandy clay soils. The soils have an AC-sequence of horizons with a clear and wavy boundary. The soil depth ranges from 5 cm to 20 cm upto the petro-plinthite (indurated murram). The pH ranges from 4.0 to 5.8 and the electrical conductivity from 0.25 to 0.6mmhos/cm. Some termite mounds of about 1.5m high and about 100m apart are scattered in this unit. Petroplinthite reaches the surface in places.

Chemical properties : The soils are deficient in phosphorous.

Soil classification : dystric CAMBISOLS, petroferric phase.

Mapping unit LPd

Extent and slope : 16.9ha, slopes 0 to 1%

General : This unit has a flat topography. It forms the depressions occuring in the flat to very gently undulating structural plain. The soils are derived from trachytic tuffs. Grass is the vegetation and grazing is the land use.

Soils : The soils in this unit consist of poorly drained, deep to very deep, dark grey (10YR 4/1) to very dark grey (10YR 3/1), firm to extremely firm, cracking clay. The colour of the topsoil ranges from very dark greyish brown (10YR 3/2) to very dark brown (10YR 2/2). The soils have an ABCR sequence of horizons. A friable topsoil of 5 to 15cm depth overlies a firm to extremely firm subsoil. Rock is struck at various depths beginning from 85cm. The boundary between B-horizon and the bedrock (R) is abrupt and smooth. The structure of the B-horizon is strong, medium angular blocky. The pH ranges from 5.2 to 5.8 in the topsoil and from 4.8 to 7.0 in the subsoil. The electrical conductivity ranges from 0.25mmhos/cm in topsoil to 0.6mmhos/cm in the subsoil.

Chemical properties : A horizon: Organic carbon percentage is 0.89. pH-H_2O is 5.5, pH-KCl is 4.0, the base saturation is 40% and the CEC is 21.0me/100g.

The subsoil horizons: pH-H_2O ranges from 5.4 to 6.5 increasing with depth. The CEC ranges from 28 to 31 and base saturation increases with depth from 47% to 64%. Deficiency in phosphorous is noted.

Soil classification : chromic VERTISOLS

For the description of a representative profile with analytical data, see appendix 1 profile description no. 1 (observation 148/2-66).

4.3.2 Soils of the minor valley

Mapping unit VPb

Extent and slope	:	9.2ha, slopes 0 to 2.5%
General	:	This is a flat to very gently undulating unit. The soils are derived from alluvium and colluvium from trachytic tuffs. The unit is a river terrace and is seasonally flooded. Grass covers this area and grazing is the land use.
Soils	:	The soils of this unit consist of moderately well drained to poorly drained, dark yellowish brown (10YR 4/6) to dark brown (10 YR 3/3), firm to very firm, cracking clay. The soils have an ABC sequence of horizons. The structure of the subsoil is strong to moderate, fine to medium, angular blocky. The boundary between A and B horizons is clear and smooth. The colour of the topsoil ranges from dark yellowish brown (10YR 3/4) to black (10YR 2/1). The soil is mottled in places. The pH ranges from 4.4 in the topsoil to 4.6 in the subsoil. The electrical conductivity (EC) is around 0.25mmhos/cm in the soil.
Chemical properties	:	A horizon: Organic carbon percentage is 4.01, pH-H_2O is 5.0, pH-KCl is 3.8. The CEC is 26.0me/100g and base saturation is 26%. The subsoil horizons: pH-H_2O ranges from 5.6 to 6.5 increasing with depth.

The CEC ranges from 16 to 25me/100g soil and base saturation ranges from 32 to 54% increasing with depth. The soils are deficient in phosphorous.

Soil classification : chromic VERTISOLS

For the description of a representative profile with analytical data, see appendix 1 description no 4 (observation no 148/2-69).

Mapping unit VAd

Extent and slope : 30.8ha, slopes 0 to 1%.

General : This unit forms the flat bottomed valley floor. The soils are derived from recent alluvial deposits resulting from periodic depositions by the Theta river. It forms a swampy area with a very poor drainage. Reeds and papyrus form the vegetation. The unit was not utilised during the time of survey.

Soils : This unit consists of very poorly drained, very deep, very dark grey (10YR 3/1) to black (7.5 YR 3/0), friable clay soils. The stickiness and plasticity tend to increase with increasing depth. The soil is mottled in places. Groundwater is struck at various depths ranging from 50 cm to 70cm. This unit is waterlogged in places.

Soil classification : eutric GLEYSOLS

4.4 Soil Fertility Aspects

Since the survey area does not have a wide variation in soil types it was felt that four composite topsoil samples from representative profile pits would be sufficient to give an idea of the fertility aspects of the soils. Table 3 gives the soil fertility results for the selected units. The data indicates that the soils are moderately acidic. They are deficient in phosphorous and low in nitrogen. However, the soils are rich in potassium and the other nutrients.

To improve the fertility status use double superphosphate or single superphosphate while planting and topdress with CAN.

Soil mapping unit LPr shows aluminium toxicity. To remove this toxicity application of 1500kg/ha of lime is recommended.

Table 2. Available Nutrients

Mapping unit	LPd	LPM	LPr	VPb
Profile pit no	148/2-66	148/2-67	148/2-68	148/2-69
Laboratory No /86	2250	2253	2252	2251
Depth (cm)	0-30	0-30	0-30	0-30
pH	5.2	5.6	5.0	5.6
Na (me/100g soil)	0.88	0.60	0.28	0.60
K "	1.28	0.56	1.50	0.56
Ca "	7.6	13.2	3.6	13.2
Mg "	3.3	3.3	1.5	3.3
Mn "	0.87	1.04	0.73	1.04
P (ppm)	12	12	12	
N (%)	0.2	0.18	0.15	0.18
C (%)	2.13	1.60	1.07	1.60
Hp (me/100g soil)	0.4	-	1.4	0.3

5 LAND SUITABILITY FOR SPRINKLER IRRIGATION

Table 3. Tentative land suitability for commonly grown crops under sprinkler irrigation

Mapping unit	Limiting factors	Current land suitability class	Potential land suitability class	Area (ha)
LPr	-	S1	S1	8.4
LPP	depth	S2 and S3	S2 and S3	35.9
LPM	depth	NS	NS	105.4
LPd	soil texture consistency and drainage	S3	S2 and S3	16.9
VPb	drainage	NS	S1	30.8
VAd	soil texture, consistency and drainage	S3	S2	9.2
			Total	206.6

Table 4 Key to land suitability classification for sprinkler irrigation

Code	Suitability classes
S1	Highly suitable
S2	Moderately suitable
S3	Marginally suitable
NS	Not suitable

Table 3 above gives the physical suitability of the land for sprinkler irrigation. The costs for layout of the pipes has not been taken into account. The column for current suitability gives the suitability of the land before any improvements, while that of potential suitability gives the possible suitability after land improvement. The improvement of the soil in soil mapping units LPd and VPd requires improving the soil structure and the drainage.

This can be slightly realised by:

1. Periodic application of manure.
2. Tilling of the land at the proper time. This should be done when the soil is neither too wet nor too dry.
3. Deep soiling/mixing of the topsoil with the lower soil. This should be done after manure application and when the soil is moist. The purpose of this treatment is to ensure that structure improvement through manure application is not limited to the topsoil only but to the whole depth of soil.

For drainage improvements, advice on the layout of drainage canals could be obtained from the Irrigation and Drainage Branch Personnel of the Ministry of Agriculture and Livestock Development. The three measures above for structure improvement will in the long run also slightly improve drainage. Periodic application of manure increases the nitrogen content of the soil thus causing imbalance of crop nutrients in the soil. For proper crop growth, a proper nutrient balance must be maintained in the soil. It is therefore advisable to be applying phosphorous containing fertilizers together with the manure.

Any attempts at planting crops in soil mapping units LPd and VAd is doomed to fail because these soils are seasonally flooded. Therefore flooding control measures must be taken. With soil and drainage improvements these soil can make a quite good agricultural production.

The soils of mapping unit LPr are highly suitable for irrigation and require no improvements. Only shallow rooted crops can do well in mapping unit LPP. These are mainly vegetable crops.

Soil mapping unit VAd requires clearing of the vegetation and improvement of drainage. It should be noted that irrigation of the river valley soils will be cheaper compared to the higher lying soils because of less capital input on pipes and water pumps and lower recurrent costs (pumping).

6. REFERENCES

Braun, H.M.H., 1977 : Seasonal and monthly rainfall probability tables for the East-Central, North-Western and coastal regions of Kenya. Misc. paper No. M13, Kenya Soil Survey, Nairobi.

Braun, H.M.H., in prep : Estimating annual and potential evaporation in Kenya. Misc Paper Kenya Soil Survey, Nairobi.

E.A.M.D., 1970 : Temperature data for stations in East Africa, Part 1 Kenya. East African Meteorological Department, Nairobi.

E.A.M.D., 1974 : Summary of rainfall in Kenya for the year 1972, East African Meteorological Department, Nairobi.

Fairburn, W.A., 1963 : Geology of the North Machakos-Thika area. Report No 59 of Geological Survey of Kenya, Nairobi.

F.A.O., 1977 : Guidelines for soil profile description FAO, Rome.

F.A.O.-UNESCO 1974 : Soil map of the world, Vol. 1 legend. UNESCO, Paris.

Munsell Color Company., 1975 : Munsell Soil Color Charts. Munsell Color Company; Baltimore, Maryland .

Saggerson, E.P., 1971 : Geology map of the Nairobi area. Report No 98. Mines and Geology Department, Nairobi.

Sombroek, W.G., H.M.H. Braun., B.J.A. van der Pouw., 1982 Exploratory soil map and agro-climatic zone map of Kenya. Report No. E1, Kenya Soil Survey, Nairobi.

Woodhead, T., 1968 : Studies of potential evaporation in Kenya. EAAFRO Ministry of Natural Resources, Nairobi.

A P P E N D I X 1

Description of representative soil profiles and analytical data.

LABORATORY DATA OF PROFILE DESCRIPTION No. 1

Observation no: 148/1-66 Mapping unit: LPd Soil classification: cromic VERTISOL

Laboratory no. /86	2259	2260	2261	2262		
Horizon	Au1	Au2	B	C		
Depth(cm)	0-5	5-15	15-52	52-85		
pH-H_2O(1: 2½ v/v)	5.5	5.4	6.8	6.5		
pH-KCl "	4.0	4.0	4.5	5.7		
EC(mmho/cm) "	0.03	0.09	0.18	0.25		
$CaCO_3$(%)						
$CaSO_4$(%)						
C (%)	0.89	0.65	0.60	0.59		
N (%)						
C/N						
CEC(me/100g), pH 8.2	21.0	30.0	28.0	31.0		
CEC " " pH 7.0	63.6	67.8	67.8	72.1		
Exch.Ca(me/100g)	17.0	22.6	24.2	33.8		
" Mg "	6.0	7.5	7.0	9.0		
" K "	2.0	0.80	0.84	1.08		
" Na "	0.8	1.2	2.4	2.4		
Sum of cations	25.8	32.1	34.4	46.3		
Base sat. %, pH 8.2	40	47	51	64		
" " %, pH 7.0						
ESP at pH 8.2						
Texture (limited pretreatment)						
Gravel % (>2.0mm)						
Sand % (2.0-0.05mm)	20	18	18	20		
Silt % (0.05-0.002mm)	13	9	11	7		
Clay % (0.002-0mm)	67	73	71	73		
Texture class	C	C	C	C		

Fertility aspects	0 - 30 cm			Laboratory no. 2250 /86	
General		Available nutrients			
pH-H_2O (1: 2.5v/v)	5.2	Na/me/100g)	0.88	Mn(me/100g)	0.87
Exch. acidity (me/100g)		K "	1.28	P (ppm)	12
C %	2.13	Ca "	7.6	P-Olsen(ppm)	
N %	0.2	Mg "	3.3		

Remarks:

PROFILE DESCRIPTION NO. 1

General site information

Mapping unit	:	LPd
Observation No./date	:	148/2-66; 17/2/86
Soil classification	:	chromic VERTISOL
Agro-climatic zone	:	IV, semi-humid to semi-arid
Parent material	:	trachytic tuffs
Physiography	:	high level structural plain
Erosion	:	none
Macro relief/slope	:	flat/0-1%
Micro/Meso relief	:	few gilgai
Land use	:	grazing
Surface stoniness/rockiness	:	none
Vegetation	:	grass
Groundwater level	:	not observed
Salinity/Sodicity	:	none
Surface sealing/cracking	:	wide cracks, 3-4cm where soil is bare
Drainage	:	poorly drained
Flooding	:	seasonal
Effective soil depth	:	very deep

Profile description

Au1 0-5cm — very dark greyish brown (10YR 3/3 dry, 10YR 3/2 when moist); clay; crumb structure; loose when dry, friable when moist, sticky and plastic when wet; few very fine pores; many very fine, few fine, very few very fine and common fine roots; clear and smooth transition to: (sample No. 148/2-1a)

Au2 5-15cm — very dark greyish brown (10YR 3/3 dry, 10YR 3/2 moist); clay; strong, medium, angular blocky structure; very hard when dry, very firm when moist, sticky and plastic when wet; few very fine pores; very few, very fine and common fine roots; clear and smooth transition to: (sample No. 148/2-1b)

B 15-52cm — very dark greyish brown (10YR 3/3 dry, 10YR 3/2 moist); clay; strong, medium, angular blocky structure; very hard when dry, very firm when moist, sticky and plastic when wet; few very fine pores; very few very fine and very few fine roots; diffuse and smooth transition to: (sample No. 148/2-2c)

C 52-85cm — very dark greyish brown (10YR 3/2 dry, 10YR 3/2 moist); clay; strong, medium, angular blocky structure; very hard when dry, very firm when moist, sticky and plastic when wet; few very fine pores; very few very fine roots; (sample No. 148/2-1d)

R 85+cm — Rock.

LABORATORY DATA OF PROFILE DESCRIPTION No. 2

Observation no: 148/2-67 Mapping unit: LPM Soil classification: dystric CAMBISOL petroferric phase

Laboratory no. /86						
Horizon						
Depth (cm)						
pH-H_2O (1: v/v)						
pH-KCl "						
EC (mmho/cm) "						
$CaCO_3$ (%)						
$CaSO_4$ (%)						
C (%)						
N (%)						
C/N						
CEC (me/100g), pH 8.2						
CEC " " pH 7.0						
Exch. Ca (me/100g)						
" Mg "						
" K "						
" Na "						
Sum of cations						
Base sat. %, pH 8.2						
" " %, pH 7.0						
ESP at pH 8.2						

Texture (limited pretreatment)

Gravel % (>2.0mm)						
Sand % (2.0-0.05mm)						
Silt % (0.05-0.002mm)						
Clay % (0.002-0mm)						
Texture class						

Fertility aspects 0 - 30 cm Laboratory no. 2253 /86

General		Available nutrients			
pH-H_2O (1: 2½ v/v)	5.6	Na/me/100g)	0.60	Mn (me/100g)	1.04
Exch. acidity (me/100g)		K "	0.56	P (ppm)	12
C %	1.6	Ca "	13.2	P-Olsen (ppm)	
N %	0.18	Mg "	3.3		

Remarks:

PROFILE DESCRIPTION NO. 2

General site information

Mapping unit	:	LPM
Observation No. /date	:	148/2-67 17/2/86
Soil classification	:	dystric CAMBISOL
Agro-climatic zone	:	IV semi-humid to semi-arid
Parent material	:	trachytic tuffs
Physiography	:	high level structural plain
Erosion	:	none
Macro relief/slope	:	flat/0-2%
Micro/meso relief	:	some termite mounds about 1.5 m high and 100 m apart
Land use	:	grazing
Surface stoniness/rockiness	:	nil
Vegetation	:	grass
Groundwater level	:	not observed
Surface sealing/cracking	:	none
Drainage	:	well drained
Flooding	:	nil
Effective soil depth	:	very shallow

Profile description

A	0-5cm	dark brown (10YR 3/4 dry, 10YR 4/3 moist); slightly gravelly sandy clay; crumbs; loose when dry, friable when moist, sticky and plastic when wet; many, very fine pores; very few medium and few fine roots; clear and wavy transition to:
C	5-16cm	dark yellowish brown (10YR 4/4 dry, 10YR 3/4 moist); gravels; granular structure; loose when dry, hard when moist, non-sticky and non-plastic when wet; common very fine roots;
16 + cm		petroplinthite

LABORATORY DATA OF PROFILE DESCRIPTION No. 3

Observation no: 148/2-68 Mapping unit: LPr Soil classification: rhodic FERRALSOL

Laboratory no. / 86	22633	2264	2265	2266	2267	
Horizon	Ap	AB	Bw1	Bw2	Bw3	
Depth (cm)	0-10	10-30	30-50	50-140	140-160	
pH-H_2O (1: 2½ v/v)	6.9	5.5	5.8	5.6	5.1	
pH-KCl "	4.2	4.4	4.7	4.2	4.2	
EC (mmho/cm) "	0.16	0.09	0.04	0.06	0.04	
$CaCO_3$ (%)						
$CaSO_4$ (%)						
C (%)	1.30	1.19	0.83	0.59	0.36	
N (%)						
C/N						
CEC (me/100g), pH 8.2	11.0	8.0	5.0	5.0	7.0	
CEC " " pH 7.0	33.9	38.2	29.7	29.7	25.4	
Exch. Ca (me/100g)	4.2	3.4	3.0	1.2	0.6	
" Mg "	3.0	3.0	2.5	2.0	1.5	
" K "	2.76	3.24	2.60	1.44	1.28	
" Na "	0.7	0.5	0.6	0.55	0.2	
Sum of cations	10.7	10.1	8.7	5.20	3.6	
Base sat. %, pH 8.2	30	26	29	18	14	
" " %, pH 7.0						
ESP at pH 8.2						
Texture (limited pretreatment)						
Gravel % (>2.0mm)						
Sand % (2.0-0.05mm)	16	16	10	12	16	
Silt % (0.05-0.002mm)	13	11	13	7	13	
Clay % (0.002-0mm)	71	73	77	81	71	
Texture class	C	C	C	C	C	

Fertility aspects 0 - 30 cm Laboratory no. 2252 /86

General		Available nutrients			
pH-H_2O (1: 2½ v/v)	5.0	Na/me/100g)	0.28	Mn (me/100g)	0.73
Exch. acidity (me/100g)		K "	1.50	P (ppm)	12
C %	1.07	Ca "	3.6	P-Olsen (ppm)	
N %	0.15	Mg "	1.5		

Remarks:

PROFILE DESCRIPTION NO. 3

General site information

Mapping unit	:	LPr
Observation no/date	:	148/2-68 18/2/86
Soil classification	:	rhodic FERRALSOL
Agro-climatic zone	:	IV, semi-humid to semi-arid
Parent material	:	trachytic tuffs
Physiography	:	high level structural plain
Erosion	:	nil
Macro relief/slope	:	very gently undulating /0-2%
Micro, meso relief	:	nil
Land use	:	grazing
Surface stoniness/rockiness	:	nil
Vegetation	:	grass
Groundwater level	:	not observed
Salinity/sodicity	:	nil
Surface sealing/cracking	:	nil
Drainage	:	well drained
Flooding	:	nil
Effective soil depth	:	very deep

Profile description

Ap	0-10cm	dark reddish brown (5YR 3/4 dry, 2.5YR 3/4 moist); clay; moderate, fine, sub-angular blocky structure; slightly hard when dry, friable when moist, sticky and plastic when wet; many, very fine pores; many fine and few medium roots; clear and wavy transition to: (sample No. 148/2-3a)
AB	10-30cm	dark reddish brown (2.5YR 3/4 dry, 2.5YR 3/4 moist); clay; moderate, fine, subangular blocky structure; slightly hard when dry, friable when moist, sticky and plastic when wet; many, very fine to fine and common medium pores; many fine and few medium roots; clear and smooth transition to: (sample No. 148/2-3b)
Bw1	30-50cm	dark reddish brown (2.5YR 3/4, 2.5YR 3/4 moist); clay; weak, fine to moderate, subangular blocky structure; slightly hard when dry, friable when moist, sticky and plastic when wet; many, very fine to fine, common medium and few coarse pores; few medium roots; gradual and smooth transition to: (sample No. 148/2-3c)
Bw2	50-140cm	dark red (2.5YR 3/6 moist); weak, medium subangular blocky structure; slightly hard when dry, friable when moist, sticky and plastic when wet; many very fine to fine pores; few fine and few medium roots; smooth transition to: (sample No. 148/2-3d)
Bw3	140-160 +cm	dark red (2.5YR 3/6 moist); clay; massive breaking to weak, coarse, subangular blocky structure; slightly hard when dry, friable when moist, sticky and plastic when wet; many, very fine to fine pores; few medium roots, (sample No. 148/2-3e)

LABORATORY DATA OF PROFILE DESCRIPTION No. 4

Observation no: 148/2-69 Mapping unit: VPb Soil classification: chromic VERTISOL

Laboratory no. /86	2254	2255	2265	2257	2258	
Horizon	A	B	Bg	C1	C2	
Depth (cm)	0-8	8-22	22-64	64-93	93-137	
pH-H_2O (1: 2½ v/v)	5.0	5.6	5.9	5.6	6.5	
pH-KCl "	0.15	0.08	0.12	0.30	0.40	
EC (mmho/cm) "						
$CaCO_3$ (%)						
$CaSO_4$ (%)						
C (%)	4.01	1.16	0.38	0.32	0.47	
N (%)						
C/N						
CEC (me/100g), pH 8.2	26.0	19.0	16.0	20.0	25.0	
CEC " " pH 7.0	59.4	63.6	59.4	55.1	72.1	
Exch. Ca (me/100g)	8.2	11.8	14.2	16.6	22.2	
" Mg "	3.5	5.5	5.5	5.5	8.5	
" K "	2.64	1.80	1.16	0.76	1.04	
" Na "	1.20	1.5	2.4	5.2	7.0	
Sum of cations	15.5	20.6	23.3	28.1	38.7	
Base sat. %, pH 8.2	26	32	39	51	54	
" " %, pH 7.0						
ESP at pH 8.2						
Texture (limited pretreatment)						
Gravel % (>2.0mm)						
Sand % (2.0-0.05mm)	20	18	18	18	16	
Silt % (0.05-0.002mm)	23	11	3	5	5	
Clay % (0.002-0mm)	57	71	79	77	79	
Texture class	C	C	C	C	C	

Fertility aspects 0 - 30 cm Laboratory no. 2251 /86

General		Available nutrients			
pH-H_2O (1: 2½ v/v)	5.6	Na/me/100g)	) 0.60	Mn (me/100g)	1.04
Exch. acidity (me/100g)		K "	0.56	P (ppm)	12
C %	1.60	Ca "	13.2	P-Olsen (ppm)	
N %	0.18	Mg "			

Remarks:

PROFILE DESCRIPTION NO.4

General site information

Mapping unit	:	VPb
Observation no/date	:	148/2-69; 19/2/86
Soil classification	:	chromic VERTISOL
Agro-climatic zone	:	IV, semi-humid to semi-arid
Parent material	:	alluvium and colluvium derived from trachytes
Physiography	:	alluvial and colluvial terraces
Erosion	:	nil
Macro relief/slope	:	very gently undulating /0-2%
Micro/meso relief	:	nil
Land use	:	grazing
Surface stoniness/rockiness	:	nil
Vegetation	:	grass
Groundwater level	:	not observed
Salinity/sodicity	:	none
Surface sealing/cracking	:	cracks in the whole depth of pit but not observable on surface
Drainage	:	poorly drained
Flooding	:	seasonal
Effective soil depth	:	very deep

Profile description

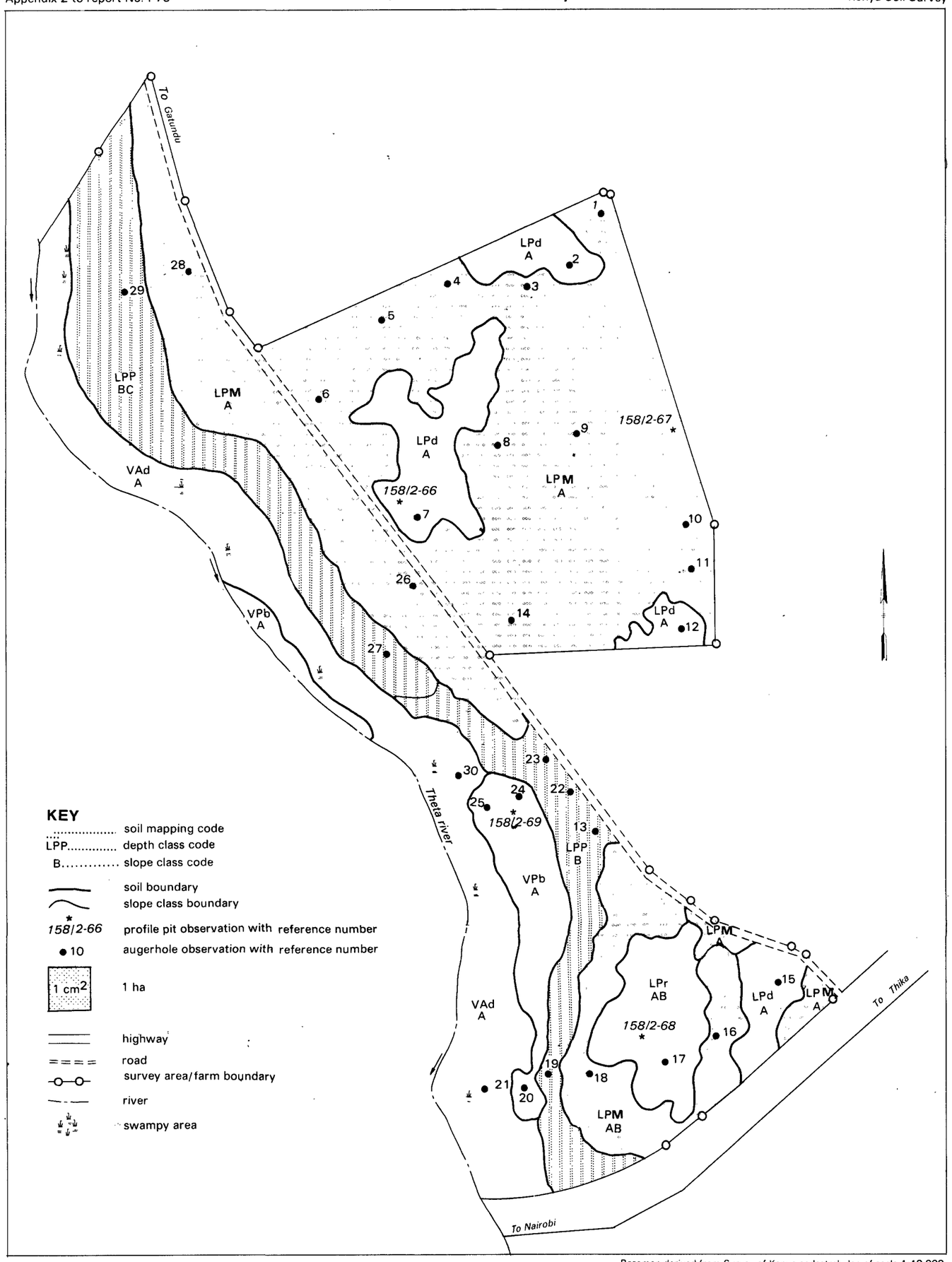
A	0-8cm	dark yellowish brown (10YR 4/4 dry, 10YR 3/4 moist); clay; crumb structure, soft when dry, friable when moist, slightly sticky and slightly plastic when wet; few, very fine pores; frequent very fine, many fine, many medium and few coarse roots; clear and smooth transition to: (sample No. 148/2-4a)
B	8-22cm	very dark greyish brown (10YR 3/4 dry, 10YR 3/2moist); clay; strong, fine to medium, angular blocky structure; very hard when dry very firm when moist, sticky and plastic when wet; very fine pores; common very fine and few fine roots; clear and smooth transition to (sample No. 148/2-4b)
Bg	22-64cm	dark yellowish brown (10YR 4/6 dry, 10YR 3/2 moist); clay; strong, fine to medium angular blocky structure; very hard when dry very firm when moist, sticky and plastic when wet; few; very fine pores; common very fine and few fine roots; clear and smooth transition to: (sample No. 148/2-4c)
C1	64-93cm	dark brown (10YR 3/3 dry, 10YR 4/3 moist); clay; moderate, medium, angular blocky structure; very hard when dry, very firm when moist, sticky and plastic when wet; few, very fine pores; very few very fine roots; clear and smooth transition to: (sample No. 148/2-4d)
C2	93-137+cm	dark brown (10YR 3/3 dry, 10YR 3/3 moist); clay; moderate, medium, angular blocky structure; very hard when dry, very firm when moist, sticky and plastic when wet; few very fine pores; very few fine roots;

11420a

PRELIMINARY SOIL MAP OF THE JUJA ESTATE (KIAMBU DISTRICT)

Appendix 2 to report No. P79

Ministry of Agriculture
Kenya Soil Survey



KEY

soil mapping code
LPP..... depth class code
B..... slope class code

soil boundary
slope class boundary

158/2-66 profile pit observation with reference number

● 10 augerhole observation with reference number

1 cm² 1 ha

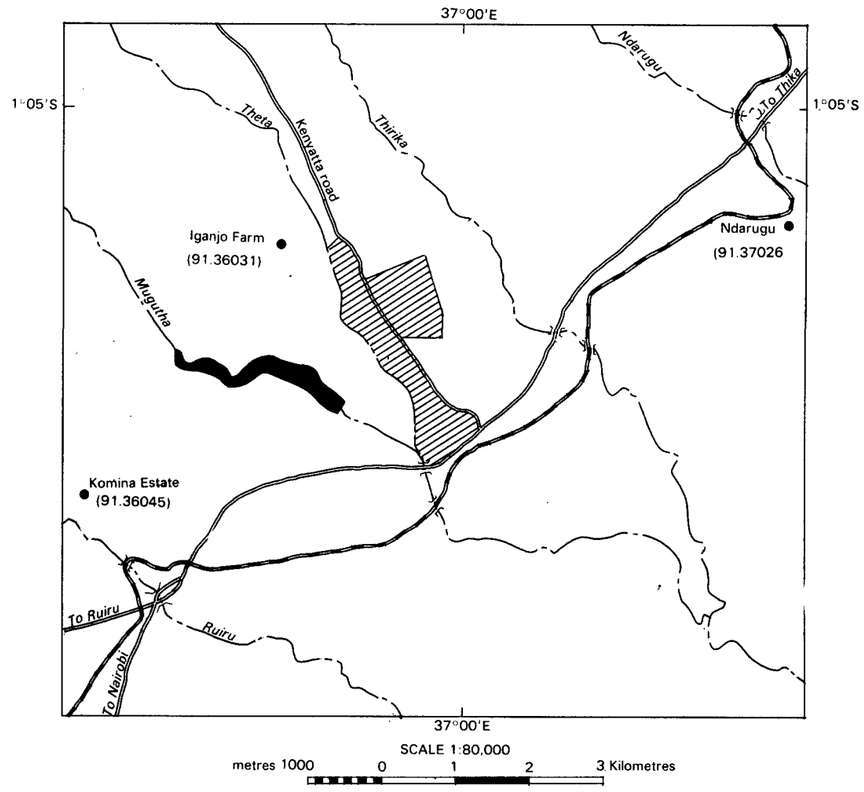
highway
road
survey area/farm boundary
river
swampy area

Basemap derived from Survey of Kenya cadastral plan of scale 1:10,000

SCALE 1:10,000

0 50 100 200 500 1000 m

LOCATION MAP



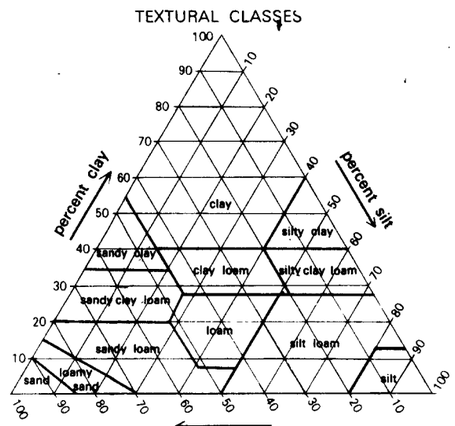
SCALE 1:80,000

metres 1000 0 1 2 3 Kilometres

KEY

survey area
road, bridge
railway
watercourse, dam
rainfall station

TEXTURAL CLASSES



LEGEND

L HIGH LEVEL STRUCTURAL PLAINS (slope 6%)

Soils developed on trachytic tuffs

LPr well drained, very deep, dark red to dark reddish brown, friable clay (rhodic FERRALSOLS)

LPP well drained, shallow, yellowish red to dark reddish brown, friable clay; in places stony (dystric CAMBISOLS, lithic and partly stony phase)

LPM well drained, very shallow, dark yellowish brown to dark brown, friable, gravelly sand clay; over petroplinthite (murram) (dystic CAMBISOLS)

LPd poorly drained, deep to very deep, dark grey to very dark grey, firm to extremely firm, cracking clay (chromic VERTISOLS)

V MINOR VALLEYS

Soils developed on alluvium and colluvium derived from trachytic tuffs

VPb moderately well drained to poorly drained, very deep dark yellowish brown to dark brown, firm to very firm, cracking clay (chromic VERTISOLS)

Soils developed on recent alluvial deposits

VAd very poorly drained, very deep, very dark grey to black, friable clay (eutric GLEYSOLS)

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 and code: over rock	symbol and code: over murram	name
0-25		M	very shallow
25-50	P		shallow
50-80			moderately deep
80-120			deep
more than 120			very deep

SOIL SURVEY AND MAP PREPARATION (1986)

soil survey ..... P.T. Kamoni, S.N. Wanjogu, H.C.K. Kinyanjui, T.J. Wachira, P.W. Kimotho, P. Mureithi

map compilation ..... P.T. Kamoni and S.N. Wanjogu

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

cartography ..... P.M. Maingi

Drawing No. 86043