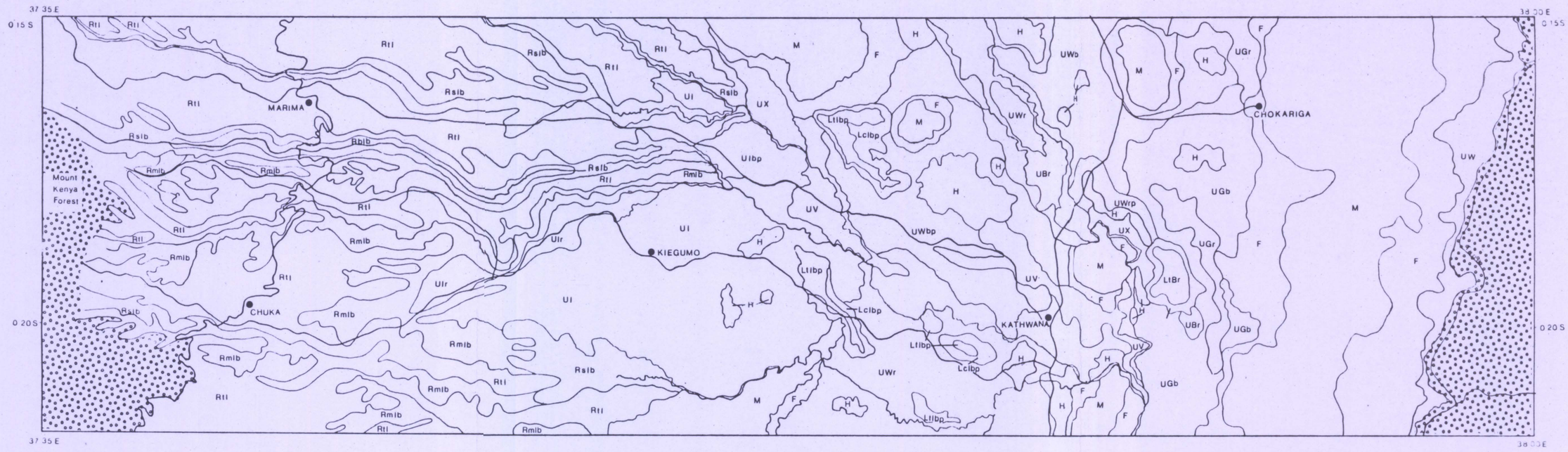
RECONNAISSANCE SOIL MAP OF CHUKA-CHIOKARIGA AREA



SCALE 1:100,000

0 1 2 3 4 5 kilometers

LEGEND

MOUNTAINS: high relief intensity, slopes in general over 16% and height over 300 m.

M Well drained, shallow, very stony and extremely rocky soils.
Dystric Regosols.

MOUNTAIN FOOTSLOPES: sloping areas with accumulation from adjacent mountains, slopes in general up to 16%.

F Well drained, shallow, very stony, very rocky, slightly gravelly sandy clay loam.
Dystric Cambisols.

HILLS: low relief intensity, slopes in general from 16 - 30%.

H Undifferentiated, shallow, very stony to rocky soils.
Dystric Regosols and Leptosols.

MOUNTAIN FOOTRIDGES: dissected footslopes of Mt. Kenya.

Soils developed from lahar/phonolite.

RtI Soils of footridge summits.
Well drained, very deep, dark red to dark reddish brown, friable, clay.
Rhodic/Mollic Nitosols.

RsIb Soils of footridge major valley sides.
Well to moderately well drained, very deep, dark reddish brown, friable, slightly gravelly clay.
Haplic Nitosols.

RbIb Soils of footridge major valley bottoms.
Well to moderately well drained, very deep, (dark) reddish brown to dark brown, very friable to firm, clay.
Chromic Luvisols.

RmIb Soils of footridges with minor valleys.
Well drained, very deep, dark brown, clay.
Haplic Acrisols.

PLATEAUS: flat or nearly flat areas, commonly bound on at least one side by an abrupt descent escarpment.

Soil developed from lahar/phonolite.

LtlBp Soils on plateau summits.
Well drained, shallow to moderately deep, dark brown, friable, moderately stony, slightly gravelly clay.
Dystric/Mollic Leptosols.

LclBp Soils on plateau escarpments.
Moderately well drained, shallow, brown, friable, stony, gravelly clay.
Haplic Phaeozem.

Soils developed from basalt.

LcBr Soils on plateau summits.
Well drained, deep, yellowish red, friable, very gravelly sandy clay loam, over petroplinthite (murram).
Dystric Cambisol.

LcBrM Soils on plateau escarpment.
Well drained, shallow, yellowish red, friable, very gravelly sandy clay loam, over petroplinthite.
Dystric Regosols.

UPLANDS: surfaces of erosion and former accumulation, undergoing erosional processes of moderate to slight intensity with deeply incised major rivers.

Soils developed from basalt.

UBr Well drained, deep, dark red, loose to very friable, clay.
Umbric Cambisols.

Soils developed from granite.

UGb Complex of:
Moderately to well drained, deep, dark reddish brown, very friable to firm, bouldery, stony, sandy clay to clay.
Chromic Cambisols/Luvisols, Umbric Acrisols, Dystric Regosols.

UGr Well drained, moderately deep, dark red, firm, stony, clay.
Chromic Luvisols, Dystric Regosols.

Soils developed from lahar/phonolite.

Ul Complex of:
Well to somewhat excessively drained, moderately deep to deep, friable to firm, clay.
Chromic/Dystric Cambisols, Umbric Acrisols.

Ulbp Well drained, moderately deep, dark reddish brown, loose, very gravelly clay.
Dystric Cambisols.

Ulr Well drained, deep, yellowish red, very friable clay.
Chromic Luvisol.

Soils developed from fluvial/colluvial materials.

UV Well drained, deep, clay.
Haplic Alisols, Dystric Cambisols.

Soils developed from gneiss complex.

UW Complex of:
Well drained, moderately deep, stony, gravelly clay.
Dystric Cambisols, Chromic Luvisols.

UWb Well drained, deep, dark red brown, very friable to friable, slightly gravelly clay.
Chromic Luvisols, Dystric Cambisols.

UWbp Well drained, moderately deep, dark reddish brown, very friable to friable, slightly gravelly sandy clay to clay.
Haplic Cambisols/Luvisols, Dystric Cambisols.

UWr Complex of:
Well drained, moderately deep to deep, red to dark red, very friable to friable, slightly gravelly clay.
Dystric Cambisols, Haplic/Chromic Luvisols.

UWrp Well drained, moderately deep, dark reddish brown, very friable to friable, slightly gravelly clay.
Dystric Cambisols.

Soils developed from colluvium of mixed or unknown composition.

UX Well drained, moderately deep to deep, friable to very friable, slightly gravelly clay.
Dystric Cambisols.

Physiography

M Mountains
F Mountain footslopes
H Hills
L Plateaus:
Lr summit
Lc escarpment
U Uplands
R Mountain footridges:
Rt summit
Rs major valley sides
Rb major valley bottoms
Rm with minor valleys

Geology

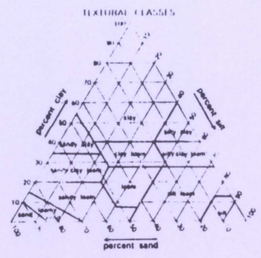
B Basalt
C Hornblende gabbro and granulite complex
G Granite
I Lahar and phonolite
W Gneiss complex
V Fluvial/colluvial material
X Colluvium of mixed or unknown composition

Colour

r red
b brown

Depth classes

Thickness	over rock	over murram	name
0 - 50	P	M	shallow
50 - 80	p	m	moderately deep
> 80	--	--	deep/very deep



KEY

physiography
geology
Ulbp
depth
colour

soil boundary
river
all weather road
town

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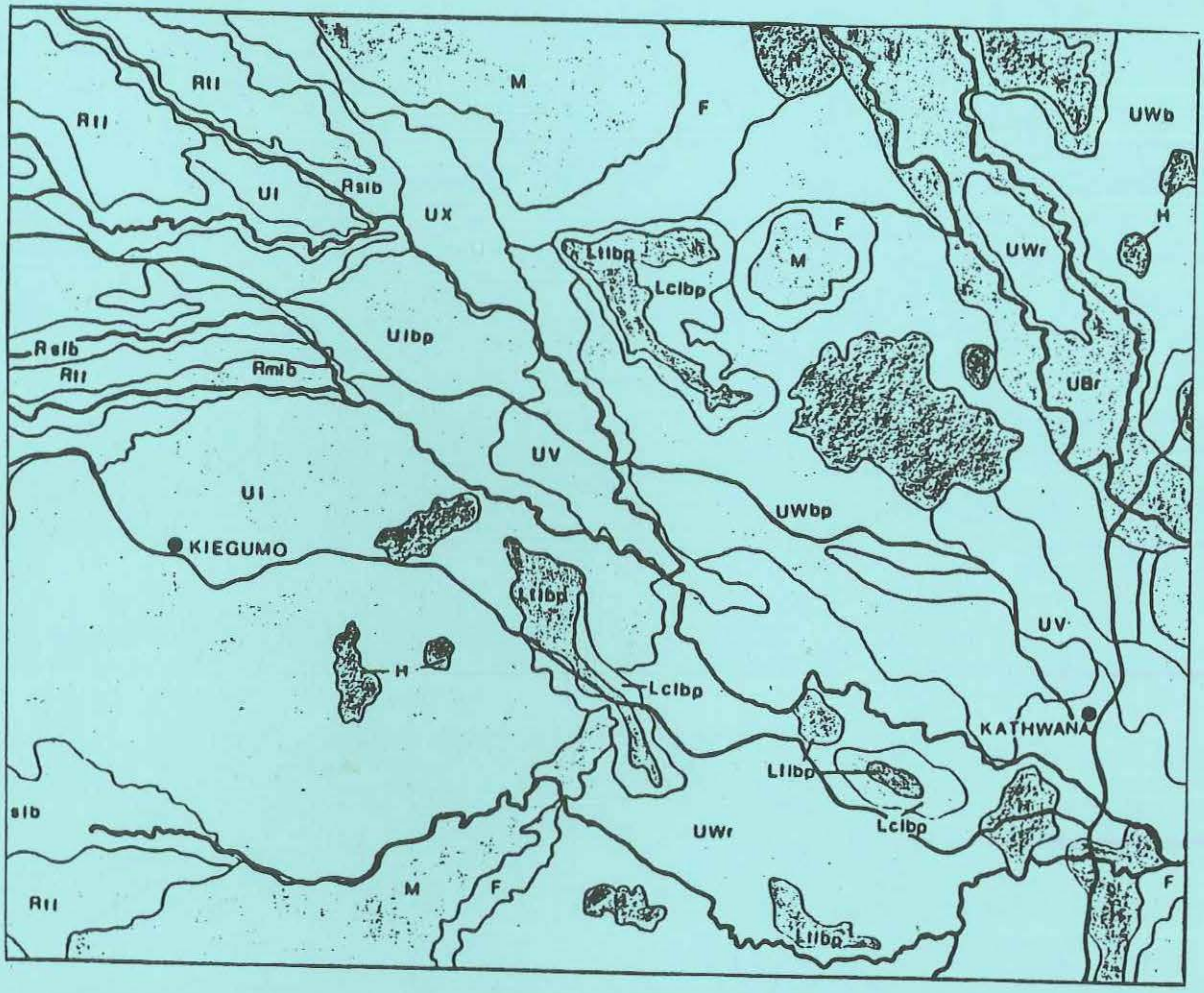
SOIL SURVEY REPORT OF CHUKA - CHOKARIGA AREA REPUBLIC OF KENYA



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SOIL SURVEY REPORT OF CHUKA - CHOKARIGA AREA REPUBLIC OF KENYA

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January, 1987

8th M.Sc. Course in Soil Science and Water Management

Agricultural University, Wageningen
The Netherlands

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Soil map of Chuka-Chiokariga area

PREFACE

This study was undertaken as a training exercise in soil survey and land evaluation in partial fulfillment of the Master of Science course in Soil Science and Water Management at the Wageningen Agricultural University, The Netherlands. As the purpose of this course is to train students in tropical soil science, the area chosen was a district in Kenya, East Africa. The study was conducted with the ultimate aim of evaluating the suitability of land for a number of major land utilization types of the area and in order to limit the work within manageable dimensions rainfed cultivation with present local technology of tea, coffee, maize, cotton, millets and sorghum were selected for land evaluation.

Preliminary air photo interpretation started in May, 1986 in Wageningen on the basis of the physiographic legend developed by the Kenya Soil Survey for reconnaisance and exploratory soil surveys. In order to conform to local conditions and produce a document which can be developed by national land resources institutions, the standards and conventions of the Kenya Soil Survey were adhered to wherever possible. In this respect the Kenya Soil Survey, specifically the Director, Mr. F. Muchena, was very forthcoming.

Field work started towards the end of May, 1986 and continued to the end of June under the direction of Mr. E.R.Jordens of the Wageningen Agricultural University. The soil map and legend were drafted during the field work and work on them continued in the office at Wageningen. The final office work was divided among the authors of this report as follows:

- Mr. U.Karunatilake and Mr. D.Zhu prepared the draft of chapter 1;
- Miss B.Sriprasert and Mr. J.P.Magoggo wrote the chapter on soils except the part on survey methods which was done by Mr. A.Mateos.
- The soil legend was prepared by A.Szogi and E.Suluvale;
- The soil map was compiled, drafted and fine-drawn by Messrs U.Karunatilake and A.Szogi;
- The chapter on land evaluation was prepared by Mr. A. Mateos with assistance from E. Suluvale, D.Zhu, U.Karunatilake, A.Szogi.

The report was structured and edited by J.P. Magoggo assisted by B. Sriprasert. However, **the authors retain responsibility for the contents** of their respective parts of the report.

It is usually impossible to name all persons who contributed in some way or other towards the success of a job like this but our thanks are due to all those who participated in the field work, members of the Kenya Soil Survey who have not been mentioned by name in the foregoing paragraphs and those organisations and individuals who in some way enabled this work to be undertaken. Nevertheless, a few individuals deserve mention. Mr. E.R.Jordens who directed the fieldwork and was always available for consultation during the preparation of this report; Mr. F.Muchena and his staff who were so forthcoming with technical ideas; Dr. T. de Meester of the Agricultural University, Wageningen, who was at the time in charge of the Training Project In Pedology at Chuka, Kenya and provided all the material support required. Mr. R. Miedema for critically reading and commenting on this report.

Juvent P. Magoggo
Agricultural University, Wageningen
December, 1986

CHAPTER 1
THE ENVIRONMENT

This chapter presents general background information on the study area. Apart from information of a more general nature eg. location, altitude, etc. aspects of more importance in relation to soil formation and land suitability evaluation are discussed. However, most of the material has been adapted from publications of other studies. As a result some important factors may not be described in sufficient detail. Interested readers are referred to the original documents.

1.1 General description of the study area

The survey area is situated in the Eastern Province of Kenya between latitudes 0^0 15' and 0^0 22'S and longitudes 37^0 35'and 38^0 00'E. It extends from the lower slopes of Mount Kenya to the west to the river Tana in the east. The general altitude ranges from around 900 m in the east to about 1800 m in the west. The extent of the area surveyed is approximately 55,000 ha. A number of perennial rivers traverse the area, mainly from west to east. The most important of these are the rivers Tana, Nithi, Mutonga and Ruguti. The area is accessible through a bitumen road which connects it to Nairobi (the capital and the major commercial centre) and to Meru (the district headquarters). Within the survey zone itself there is a network of unsurfaced roads.

1.2 Climate

Due to the large range in altitude from east to west there is an accompanying change in climatic factors, notably temperature and rainfall distribution. The general trend observed is that average temperatures decrease towards the west while annual rainfall increases in amount. There were no meteorological stations within the survey area, but climatic data in this chapter are taken from stations presumed to be representative.

1.2.1 Rainfall

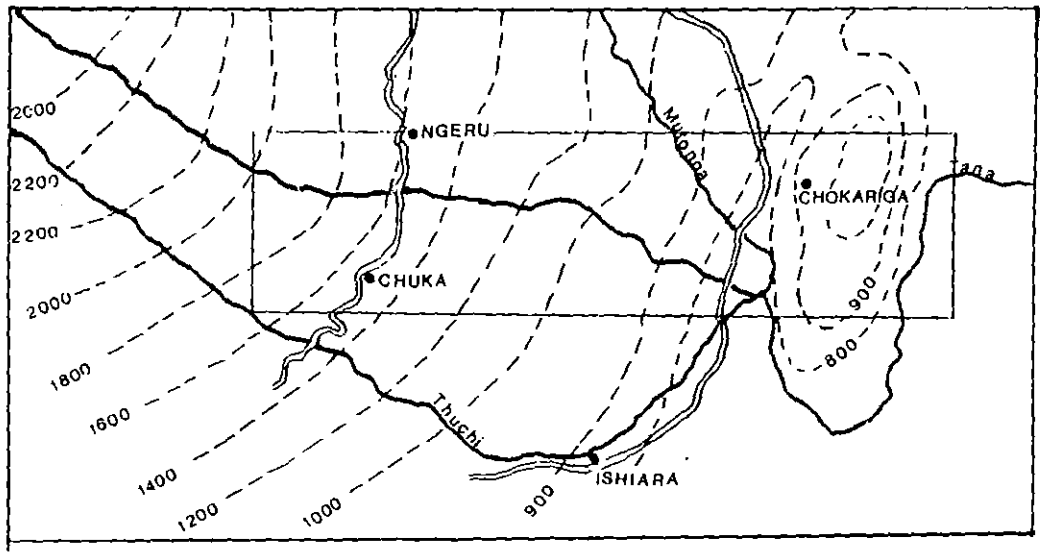
The rainfall, to a certain extent, is influenced by altitude; it decreases from Mt. Kenya towards river Tana with decreasing altitude. The average annual rainfall ranges from around 700 mm in the east to 2000 mm in the west (Fig.1). The distribution of rainfall is largely bimodal with peaks in April and November. The long rainy season is from March to May and the second short one from October to December. The dry period is more pronounced in the lower altitudes. Frequent dry spells during the rainy season are also common in these areas. The average monthly rainfall figures for some stations near the survey area are given in the table 1.

1.2.2 Temperature

The temperature shows a strong inverse relationship with altitude, i.e. the average temperature decreases with increasing altitude. The annual mean temperature in the survey area ranges from about 15^0 C in the high altitude areas to about 25^0 C in lower altitude areas (Jaetzold et al,1983).

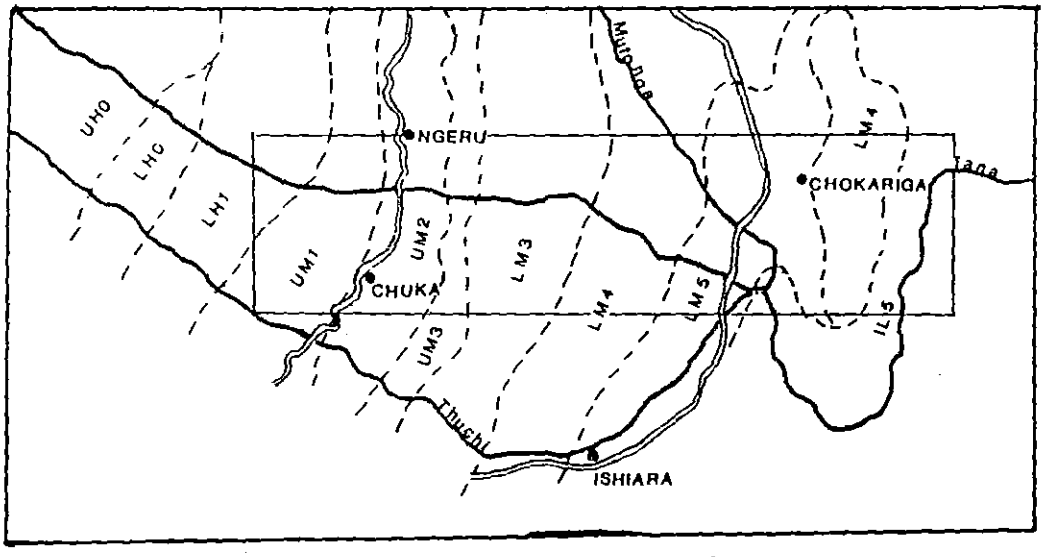
1.2.3 Evaporation

Since evaporation is strongly dependent on air temperature (as well as



Source: Jaetzold,(1983)

Fig.1: Average annual rainfall in mm



Source: Jaetzold,(1983)

Fig.2: Agro-Ecological Zones of the study area

relative humidity and wind speed), this shows a decrease with increasing altitude as a result of the increase in rainfall and decrease in temperature. The trend in annual average potential evaporation is opposite to that of rainfall, i.e. areas with lower rainfall and higher temperature have the higher evaporation and vice versa. The average annual evaporation in the survey area ranges from 1400 mm in the west to 2000 mm in the east (van de Weg et al,1975).

Table 1: Average monthly rainfall figures for some stations near the survey area.

Station	Altitude (m)	Years of record	Rainfall(mm)												
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Chuka	1494	30	43	32	134	369	177	20	30	32	25	184	332	123	1500
Chogoria	1327	18	61	41	163	482	229	55	82	71	37	315	350	91	1979
Tharaka	914	24	32	18	83	232	61	5	0	3	1	58	209	87	787

1.2.4 Agro ecological zones

Jaetzold et al (1983) have defined twenty four main agro ecological zones for the Meru district. Eight of these zones are found in the survey area (Fig.2).

The main zones are based on their probability of meeting the temperature and water requirements of the major crops. Each main agro ecological zone is characterized by altitude, temperature and rainfall. The main agro ecological zones of the survey area are described in table 2.

Table 2: Main Agro ecological zones of the survey area

Main agro ecological zones	Altitude (m)	Annual mean temperature (^{O}C)	Annual average rainfall(mm)
LH 1 (tea-dairy zone)	1830-2200	17.4-14.9	1700-2600
UM 1 (coffee-tea zone)	1520-1800	19.2-17.6	1500-2400
UM 2 (main coffe zone)	1280-1680	20.6-18.2	1500-2400
UM 3 (marginal coffee)	1280-1520	20.6-19.2	1400-2200
LM 3 (cotton zone)	910-1280	22.9-20.6	1000-1600
LM 4 (marginal cotton)	760-1200	23.7-21.0	800-1200
LM 5 (lower midland livestock-millet zone)	700-910	24.0-22.9	600-900
IL 5 (lowland livestock -millet zone)	610-700	24.7-24.1	500-850

Description of symbols:

UH: upper highland zone
LH: lower highland zone
UM: upper midland zone
LM: lower midland zone
IL: inner lowland zone

0: per humid
1: humid
2: sub-humid
3: semi-humid
4: transitional
5: semi-arid

Source: Jaetzold et al.(1983)

1.3 Natural vegetation and present land use

The natural vegetation and landuse are useful indicators of climatic and soil conditions; however these were not surveyed separately during the present study. Nonetheless a general trend was noted.

The natural vegetation of the survey area changes from a dense, tropical rain forest type vegetation on the footslopes of Mt. Kenya where rainfall is higher to more open shrubland or savannah type vegetation in the lower areas where rainfall is more erratic.

The major landuse types of the area are related mainly to the climate. In higher altitudes, due to higher rainfall reliability, perennial crops are grown. Seasonal cultivation of annual crops and grazing are practised in lower altitude areas. In cooler and humid areas near Mt.Kenya mainly tea is cultivated. Tea is gradually replaced by coffee as altitude decreases. Mixed farming is mainly practised in the transition zone between cool and warm extremes. In mixed farming, long term crops such as tea, coffee and fruit trees are grown together with short term crops such as maize, cassava and

vegetables. This type of landuse is gradually replaced by seasonal and shifting cultivation towards the east, where the cropping season is shorter. Cotton, maize sorghum, millets are the main crops grown here.

1.4 Geology and parent material

The two major features of the geology of Kenya are the Basement complex and the Rift Valley with its accompanying volcanism (Veldkamp & Visser, 1986). The study area extends from the basement system to the volcanics at the edge of the rift system. The eastern part of the area consists mainly of rocks of the Precambrian Basement System comprising granitic and gneissic rocks for the most part. The western part consists of the younger, predominantly Tertiary volcanic lahar flows from Mount Kenya. Quaternary colluvial and fluviatile deposits may also be found over a relatively minor part of the area. Towards the outer reaches of the basalt flows where these have filled former river beds there has been inversion of the landscape by preferential erosion of the less resistant rocks around the basalt flows in the stream beds so that at present the basalts form the higher parts of the landscape.

1.5 Geomorphology

Two broad geomorphological regions can be recognized in the area viz.the footridges associated with the volcanic rocks on the footslope of Mount Kenya and the planation surface on basement rocks at the lower altitude level. Within these broad regions the following landforms have been distinguished in this study.

(a) mountains	(M)
(b) hills	(H)
(c) mountain footslopes	(F)
(d) mountain footridges	(R)
(e) plateaux	(L)
(f) uplands	(U)

A brief description of these landforms is given below. As much as possible the definitions adapted by the Kenya Soil Survey (van de Weg, 1978) have been adhered to.

a. Mountains

Mountains are defined as elevations of land that rise more than 300 m above the adjacent land surface. They not only occur as an isolated features but may also form chains as exemplified by the long north-south oriented ridge of the Kijege-Nyamatu-Kibiro-Kierera association parallel to Tana river.

b. Hills

Hills are elevation of land that rise less than 300 m above the general level of the adjacent land. They commonly have rocky summits in the study area.

c. Mountain footslopes

This refers to the slope at the foot of the mountains and some of the bigger hills. They are transitional geomorphological units from mountains or hills to the adjacent land. They occur as elongated strips parallel to the

mountain chains or as concentric strips around solitary mountains or hills. Debris coming from corresponding mountains or hills are accumulated mainly by gravity in these units.

d. Plateaux

Plateaux are the relatively flat tracts of land bounded at least on one side by a scarp. In the study area plateaux are generally associated with remnants of volcanic rocks that are part of the volcanic infills in former river beds.

e. Mountain footridges

Mountain footridges may be defined as dissected footslopes. In the study area footridges are associated with Mount Kenya and have an east-west orintation. They are parallel ridges separated by deep valleys thus giving rise to a parallel drainage pattern.

f. Uplands

Uplands can be defined as erosional surfaces or former accumulation surfaces which are undergoing erosional processes of moderate to slight intensity. Uplands have general slope ranges of 0-16%. Some of these units within the study area can be considered as peneplains since many flat to gently sloping remnants of the former original surface are still found, more or less at the same level.

CHAPTER 2
SOILS

In this chapter the relationship of the soils to landforms and parent material is described. The various combinations of landform, parent material and soils are the mapping units recognised in the survey; 24 units were defined.

2.1 Summary of survey methods

This study was carried out in two stages. The first was the reconnaisance survey covering completely the designated area, while the second stage was a semi-detailed study of a selected part of the study area. The area for semi- detailed survey was chosen not on the basis of high agricultural potential but rather because it showed more variations. This was considered important for training purposes.

For the study, aerial photograph interpretation maps were superimposed on geological information of the area as provided by Schoeman(1951). Aerial photographs at 1:50 000 and 1:12 500 were used for the reconnaisance and semi- detailed surveys respectively.

Field traverses were planned on the basis of the preliminary interpretation of aerial photographs, and the actual locations of observation sites were selected mainly on the basis of visual evidence of soil/landscape changes.

Routine soil observations were made by auger hole descriptions. Representatives sites for the various land units were selected for profile descriptions; a total of 40 profiles were described. From these profile pits samples were collected for pH determination in 1:2.5 soil:water suspension. The soils were described according to the FAO guidelines for soil profile descriptions (FAO,1977) as adopted by the Kenya Soil Survey.

For the semi-detailed survey aerial photographs at 1:12 500 were available. However, their interpretation was difficult due to the subtle and intricate variability of the area. In general very little detail could be added to the results of the reconnaisance survey on the basis of 1:12,500 scale. Therefore in this report only the results of the reconnaisance study, published at the scale of 1:100,000, are discussed.

2.2 The soil map legend.

The soil mapping legend has a three-level hierarchical structure as follows:

level I: physiography
level II: parent material
level III: soil properties

Due to the scale of the mapping, physiography comes at the highest level. The physiography symbol comprises one or two letters depending on whether or not the major landform unit has been subdivided. The first letter (in uppercase) stands for the major landform while the second letter represents a subdivision mainly on the basis of position within the major landform unit. The following symbols are used to designate the physiographic units:

SYMBOL	MAJOR LANDFORM	SUBDIVISION	
M	Mountains		
F	Mountain footslopes		
H	Hills		
L	Plateaus:	t	summits
		c	escarpment
U	Uplands		
R	Mountain footridges:	t	summit
		s	major valley sides
		b	major valley bottoms
		m	with minor valleys

Parent material (the geological substratum) is considered at the second level. The symbols for the parent material are:

B	Basalt
C	Hornblende gabbro and granulite complex
G	Granite
I	Lahar
W	Gneiss complex
V	Fluvial/colluvial material
X	Colluvium of mixed or unknown composition

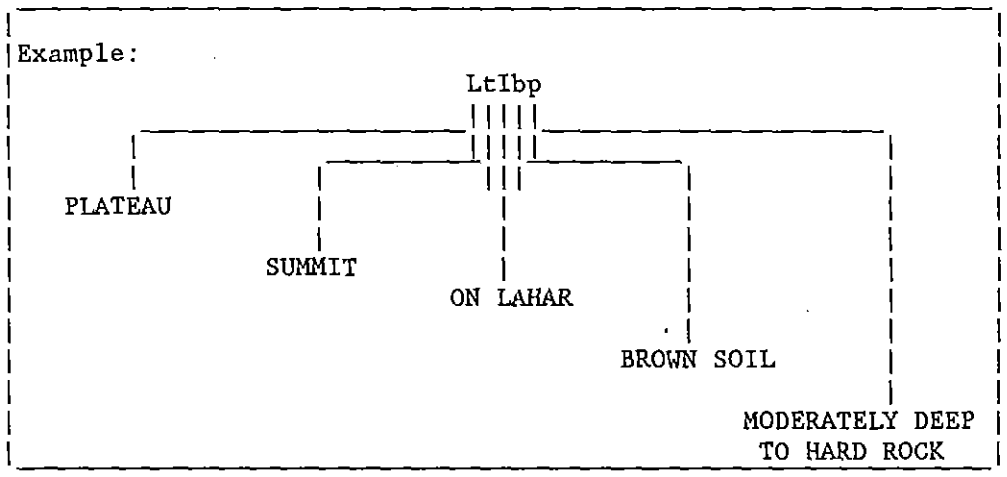
A symbol for the important differentiating chracteristics of the soil make up the last part of the legend symbol. This is a two-letter symbol where the first letter stands for the major color grouping (reflecting the drainage status of the soil) and the second for a depth class. The color symbols used are:

r	red (dark red, red, yellowish red)
b	brown (brown, dark brown, dark reddish brown, dark yellowish brown)

The symbols for the depth classes are:

THICKNESS (cm)	OVER ROCK	OVER MURRAM	DEPTH CLASS
0 - 50	P	M	shallow
50 - 80	p	m	moderately deep
> 80	--	--	deep/very deep

For deep and very deep soils the depth symbol is omitted.



2.3 General distribution of the soils

The study area falls into two major landform regions viz. the footridges (in effect the dissected footslopes of Mt. Kenya) consisting of intermediate volcanic rocks and the mostly undulating planation surface over the basement complex comprising mostly acid rocks. (Within this planation surface a number of landforms do occur such as mountains and associated footslopes, plateaux, river plains, and uplands but these do not require mention at this stage.)

The major soil areas coincide very well with these geology-landform regions. The footridges carry deep, red, well drained non-stony non-gravelly friable clays. On the planation surface the soils show marked variations in depth, stoniness, gravelliness and other characteristics. In comparison with the soils of the footridges they are in general less deep, more eroded and less gravel-free.

2.4 Description of the soil units

The account which follows presents a description of the soils within the context of physiography and parent material since these have been found to have a strong determinative influence on the distribution of soils in the area. (This statement is not meant to exclude the influence of other soil forming factors.)

Descriptions made in this chapter of soil color are based on the Munsell soil color charts. Both soil color and consistence given in this chapter refer to the moist state. For each soil unit a tentative classification in the FAO-Unesco system for the soil map of the world (FAO, 1985) is given based on soil profile descriptions and judicial estimates of some properties e.g. base saturation, amount of humus, etc.

2.4.1 Soils of the mountain footridges

The geology of the footridges is fairly constant. They all consist of intermediate lahars. Differences in soils in this landform are mainly due to the position in which where they are formed. Thus three kinds of soil-forming material have been distinguished: residual weathered parent rock on the summits, colluvial deposits at the base of major slopes and mixed colluvial and weathered parent rock on the major slopes.

2.4.1.1 Soils formed on residual weathered parent rock (RtI)

These soils are very deep (> 120 cm), well drained and porous. The topsoils are (very) dusky red and dark reddish brown, loose to friable clay with weak sub-angular blocky structure occasionally breaking into crumbs. Subsoils are (dark) red and dark reddish brown friable to firm clay with moderate (sub-)angular blocky and weak prismatic structure breaking to angular blocky structure. The soils have many shiny ped faces.

They have been classified as Nitosols and are mapped in unit RtI. The mapping unit is characterised by flat to undulating topography (0 - 7 % slope) with slight to moderate surface sealing and crusting. The unit has slight to moderate sheet and gully erosion. It covers about 12,700 ha.

2.4.1.2 Soils formed on mixture of colluvium and residual weathered parent rock (RsIb)

These soils vary in depth from skeletal to very deep and are well to excessively drained. They are generally (slightly) gravelly, bouldery or stony on the surface. Due to the very steep slopes (30% to over 100% slopes) they are highly susceptible to water erosion.

The topsoils are dark reddish brown, loose to friable clay with weak to moderate subangular blocky structure frequently breaking into crumbs or granules. Subsoils are (dark) reddish brown very friable to very firm clay having weak to strong (sub-)angular blocky structure.

Separation of the deep from the shallow phase has not been possible at the scale of the study so these soils are mapped as a complex association in unit RsIb. The characteristics of this unit are: rolling to mountaineous topography (10 - 60 % slope), slight surface sealing and crusting, moderate to severe sheet, rill and gully erosion. It covers about 3,400 ha.

2.4.1.3 Soils formed on colluvial deposits (RbIb, RmIb)

These soils are formed on colluvium that has accumulated in the valley bottoms from the adjacent slopes (and scree faces?). Even though they occur in valleys most of which have perennial rivers, the slopes are so steep (over 10%) that the proximity of the streams have little impact in terms of moisture additions and soil processes.

The soils are very deep (over 120 cm), moderately well to well drained and may be slightly gravelly or stony on the surface. Topsoils are dark reddish brown to dark brown loose to friable clay with strong granular structure. Subsoils are (dark) reddish brown to dark brown very friable to firm clay with weak to moderate (sub-)angular blocky structure. Soft iron/manganese concretions are common in the subsoil. They are mapped as RbIb.

The soils developed in nearly flat, wide bottomlands are deep (>80 cm) and well drained. They frequently are slightly stony on the surface.

They have loose to very friable clay topsoils with weak sub-angular blocky and moderate granular structure. Subsoils are very friable to firm clay with moderate to strong sub-angular blocky structure.

They are classified as Haplic Acrisols and occur in mapping unit RmIb.

Mapping units:
RbIb:Undulating to hilly (2 - 22 % slope), slight surface sealing, crusting and cracking, slight to moderate sheet, rill and gully erosion. Areal extent about 700 ha.

RmIb:Nearly flat to undulating (1 - 8% slope), slight to moderate surface sealing and cracking, slight sheet erosion. Areal extent about 4,200 ha.

2.4.2 Soils of hills and mountains (M and H)

Undifferentiated shallow, stony and bouldery soils.

2.4.3 Soils of the mountain footslopes (F)

These are soils occurring on the footslopes of hills and mountains. They are presumed to have developed from colluvial material derived from the tops of these hills and mountains and, to a lesser extent, may be developed as a result of residual weathering in place of the parent rock.

The geology of these hills and mountains is mostly granitic rocks and what has been described in geological studies as complexes of hornblende, gabbro and granulites (Veldkamp & Visser, 1986). These geological variations, however, are not clearly reflected in the kind of soils that have developed.

The soils are shallow (20 to 50 cm to parent material) well to somewhat excessively drained and are(slightly) gravelly, stony, bouldery or rocky on the surface. They are generally strongly eroded.

They have dark (reddish) brown, very friable to firm sandy clay to clay topsoils with weak angular blocky structure. The subsoils are dark reddish brown to dark red, very friable to firm, sandy clay to clay with moderate angular blocky structure.

They have been classified as Dystric Cambisols and mapped in unit F with undulating to rolling topography (2 - 10 % slope), slight to moderate surface sealing, crusting and cracking in some parts and slight, occasionally severe, sheet erosion. The unit has an aerial extent of about 4,700 ha.

2.4.4 Soils of the plateaux and associated escarpments (Lt, Lc)

The soils on the plateau and their escarpments are generally gravelly, occasionally right from the surface. Moreover, on the escarpments the soils tend to be quite shallow and bouldery.

2.4.4.1 Soils developed on lahars and phonolites (LtIbp, LcIbp)

They are shallow to moderately deep (depth ranges from about 20 - 90 cm to bedrock or gravel), well drained, dark (reddish) brown sandy clay to clay,

commonly gravelly to very gravelly (murram) below depths of between 15 and 100 cm. They have a moderate or weak crumb structure in the topsoil as well as in the sub-soil.

They have been classified as dystric and Mollic Leptosols and Haplic Phaeozems. They occur in mapping units LtIbp (the plateau summits) and LcIbp (the escarpments).

Mapping units:

LtIbp:Almost flat (0 - 2 % slope) with slight to moderate surface sealing, crusting and cracking, slight sheet and gully erosion. Coverage: about 200 ha.

LcIbp:Undulating (5% slope) with moderate sheet erosion. Extent: about 200 ha.

2.4.4.2 Soils developed on basalt (LtBr, LcBrM)

These are deep (over 120 cm) well drained soils having dark reddish brown topsoils and yellowish red subsoils. They are generally continuously gravelly (occasionally stony) clays with weak subangular structure which readily falls into crumbs, especially in the subsoil.

On the escarpments the soils are shallow.

These soils have been mapped as LtBr and LcBrM and are classified as Dystric Cambisols and Regosols.

Mapping units:

LtBr: Flat (slope approximately nil) with slight surface sealing. Areal extent about 200 ha.

LcBrM: Nearly flat (about 1% slope) with slight surface sealing, crusting and cracking. Slight sheet erosion. Areal extent approximately 100 ha.

2.4.5 Soils of the uplands (U)

2.4.5.1 Soils developed on granitic rocks (UG)

These soils show very marked variations due to the influence of basaltic material from the adjacent remnants of plateaux. These materials have been mixed together with the granitic material of the basement complex to various degrees. The soils, then, can only be described as a complex.

Nonetheless the soils vary from moderately deep to deep (50 - 120 cm to parent material). They are well drained to somewhat excessively drained with dark reddish friable sandy clay loam to clay topsoils having weak to moderate crumb and sub-angular blocky structure. Subsoils are dark red to reddish brown friable to firm clay with moderate sub-angular or angular blocky structure.

They are classified as Acrisols and Cambisols and occur in mapping units UGb and UGr.

Mapping units:

UGb: Flat to rolling topography (slope between 0 and 10%) with slight to moderate sheet, occasionally rill and gully erosion. Areal extent is approximately 2,100 ha.

UGr: Undulating to rolling (3 - 10% slope) with slight surface sealing, crusting and cracking. Some sheet erosion occurs in most of the mapping unit, occasionally even slight rill and gully erosion. The unit covers about 500 ha.

2.4.5.2 Soils developed on gneiss complexes (UW)

These soils are moderately deep to deep (40 to 100 cm to parent material) and well to excessively drained. Soil surfaces are (slightly) gravelly, stony or bouldery. Stone lines are common.

They have dark reddish brown (very) friable clay topsoils with weak to moderate sub-angular blocky structure occasionally breaking into crumbs. Subsoils are (dark) reddish brown to dark red, (very) friable to firm clay with weak to moderate (sub-)angular blocky structure.

They are classified mostly as Dystric Cambisols and occur in mapping units UW, UWb, UWbp, UWr and UWrp.

Mapping units:

UW: Rolling (about 10% slope) with moderate surface sealing, crusting and cracking; moderate sheet, gully and rill erosion. Areal extent about 1,200 ha.

UWb: Undulating (slope about 5%); moderate surface sealing, cracking and crusting; moderate sheet and rill erosion. Areal extent: approximately 1,100 ha.

UWbp: Nearly flat to undulating (1 - 8% slope); slight surface sealing and cracking in most of the mapping unit. Sheet, sometimes rill erosion, is common in the unit; some parts are severely affected by sheet erosion. The unit extends over about 2,200 ha.

UWr: Undulating (2 - 8% slope) with slight surface sealing in some parts. Slight gully or moderate sheet erosion. Areal extent about 2 800 ha.

UWrp: Undulating (2 - 5% slope) with slight to moderate surface sealing and cracking, slight and occasionally severe sheet erosion. Areal extent approximately 300 ha.

2.4.5.3 Soils developed on lahar and phonolites (UI)

They are deep (over 1.2 m to parent material), gravelly to very gravelly, well drained soils. Topsoils are (very) dark brown very friable or friable clay with moderate sub-angular blocky or crumb structure. The subsoil is dark reddish brown friable to firm clay having a moderate or weak sub-angular blocky structure but occasionally the deeper subsoil may be massive.

Generally these soils do not have a diagnostic horizon other than a structural or color-B horizon and are classified as Dystric Cambisols.

They have been mapped in units UI, UIbp and UIr.

Mapping units:

UI: Undulating to rolling (4 - 10% slope) with slight surface sealing and occasional cracking and moderate sheet erosion in many parts of the unit. It covers about 4,400 ha.

UIbp: Flat to rolling (0 - 12% slope); slight to moderate surface sealing and cracking. Many parts are affected by slight sheet erosion.

UIr: Undulating to rolling (6 - 14% slope); moderate surface sealing and slight cracking; slight to moderate sheet, rill and gully erosion in some parts. Areal extent: approximately 500 ha.

2.4.5.4 Soils developed on basalt (UB)

These soils are deep (over 90 cm to parent material), well drained with dark reddish brown topsoil and dark red subsoil. Topsoils are friable to very friable clay with moderate crumb or subangular and granular structure. Subsoils are friable or very friable clay having a moderate granular or sub-angular blocky structure.

They are generally gravelly from a depth of less than 50 cm.

They are classified as Dystric Cambisols occur in mapping unit UBr with undulating topography (about 3% slope) and slight surface crusting and moderate sheet erosion. The unit extends over approximately 1,000 ha.

2.4.5.5 Soils developed on colluvium of mixed or unknown composition (UX)

These soils are formed in landscapes which might be loosely described as "inter-montane plains". The adjoining higher-lying lands (hills, plateaux) consist of various geological nature and all contribute materials in these areas

The soils are moderately deep to deep (50 cm or more to bed-rock or parent material) and well drained. They may be gravelly in the subsoil and occasionally slightly stony on the surface. The topsoils are dark (reddish) brown very friable sandy clay to clay with strong to weak granular and crumb

structure; subsoils are dark reddish brown friable clay with moderate angular blocky structure. They may be slightly calcareous.

They have been classified as Dystric Cambisols. They occur in mapping unit UX. It has a nearly flat to undulating topography (1 - 8% slope), slight surface sealing and cracking in some parts. Some parts have some sheet (and rill) erosion. The unit covers about 400 ha.

2.4.5.6 Soils developed on fluviatile deposits with influence of colluvial material (UV)

These soils are formed on old river terraces. Due to the reduction of fluviatile forces in the present-day hydrological regime, the soils were later subjected to colluvial processes.

The soils are deep and well drained. They consist of dark yellowish brown friable loamy sand topsoil with weak crumb structure and dark yellowish bron firm sandy loam to sandy clay loam subsoil having moderate prismatic and angular blocky structure. They frequently have a few fine angular gravels throughout the profile and stone lines are not uncommon in profiles farther away from contemporary stream channels.

They are classified mostly as Dystric Cambisols and mapped as UV. The topography is almost flat to undulating (1 -% slope). The unit is affected by slight to moderate surface sealing and sheet and rill erosion. It covers approximately 1,200 ha.

Table 3 below gives a summary of the areas covered by the various mapping units.

Table 3: The extent of the mapping units given in hectares and as a percentage of the surveyed area.

Mapping unit	Symbol	Classification	Acreage (ha)	Percentage (of total area)
1. Mountain Footridges				
Soils on				
-- weathered parent rock	RtI	Nitosols	12 700	23
-- mixture of colluvium and residual weathered rock	RsIb	Nitosols	3 400	6
-- colluvial deposits	RbIb		700	1
	RmIb	Haplic Acrisols	4 200	8
2. Mountain Footslopes	F	Dystric Cambisols	4 700	9
3. Plateax and associated Escarpments.				
Soils on				
-- lahars and phonolites	$LtIb_p$	Mollic Leptosol	200	0.4
	LcIb	Haplic Phaeozem	200	0.4
-- basalt	LtBr	Dystric Cambisol	200	0.4
	LtBrM	Regosols	100	0.2
4. Uplands				
Soils developed on				
-- granitic rocks	UGb	Acrisols	2 100	4
	UGr	Cambisols	500	1
-- gneiss complex	UW	Dystric Cambisols	1 200	2
	UWb	"	1 100	2
	UWb_p	"	2 200	4
	UWr	"	2 800	5
	UWr_p	"	300	1
-- lahar and phonolites	UI	Dystric Cambisols	4 400	8
	UIb_p	"	?	?
	UIr	"	500	1
-- basalt	UBr	Dystric Cambisols	1 100	2
-- colluvium of mixed or unknown composition	UX	Dystric Cambisols	400	1
	UV	"	1 200	2
5. Mountains and Hills			4 000	8

Total (estimated) survey area : 48 200ha.

CHAPTER 3:
LAND EVALUATION.

3.1 Concepts and methodology

Land evaluation is the process of estimating the land performance when put to certain kinds of use. Soil surveys provide the basic information about soil and land characteristics to facilitate comparison of the requirements of land use types and the resources offered by the land.

Due to limited data availability the method of evaluation adopted for this survey is a simplified qualitative land suitability evaluation for single-crop land use alternatives based on current suitability.

The land use alternatives are based on labor-intensive rainfed farming of the present major crops of the area by smallholders with low capital resources, using intermediate levels of technology where certain inputs like fertilizers, insecticides and mechanical land preparation are employed on a modest scale. Measures against erosion may be taken but with low efficiency.

The present land use is a mixed type where charcoal-burning, and grazing may be carried out on the same parcels of land used for crops. Moreover, specially in the low-altitude areas, mixed cropping is common. Notwithstanding this complexity in land use, however, land evaluation in this report has been carried out for single crop land utilization types using five of the most important crops in the survey area. These five are:

1. tea (Camelia sinensis),
2. coffee (Coffea arabica, C. canephora),
3. cotton (Gossypium hirsutum),
4. maize (Zea mays) and
5. sorghum (Sorghum ssp.)

The classification in this report follows the structure proposed in the framework for land evaluation of FAO (1976). The two suitability orders viz. suitable (S) and not suitable (N) are sub-divided into three suitability classes as follows:-

Class S1: Highly suitable.
Land having no significant limitations for sustained use, or having only minor limitations that will not significantly reduce productivity.

Class S2: Moderately or Marginally suitable.
Land having moderately severe to severe limitations for sustained use which will reduce productivity or increase the costs.

Class N: Not suitable.
Land having severe limitations which can not be corrected by the defined level of management, or they are so severe as to prevent any possibility of suscessful sustained use.

Land suitability sub-classes are identified by the nature of the limitations that determined the classification.

The study area falls under several distinct agro-ecological zones (chapter 1) and on the basis of these a broad land suitability classification can be done. For this reason, as well as to make the data management easier, a hierarchical approach has been adopted resulting in the following partial land suitability classifications:-

stage 1: Agroecological suitability
stage 2: Soil physical suitability
stage 3: Soil fertility suitability.

A comparison of the results of the partial suitabilities allows determination of the final land suitability for the land use alternatives under consideration.

The final land suitability classification has been arrived at using the following basic principles:-

1. The most limiting factor determines the suitability at any stage and the most limiting classification of the three partial suitabilities determines the final suitability class.

2. The land mapping units M (mountains) and H (hills) are excluded from the evaluation for their clearly low agricultural potential.

3. For the mapping units where representative soil profile descriptions are not available relevant land qualities have been estimated from augerhole observations and aerial photo interpretation.

3.2 Agroecological suitability.

For suitability classification on the basis of the agroecological zones the following land characteristics were compared against the land use requirements:- altitude, mean daily temperature and annual rainfall.

The agro-ecological zones have been described in chapter 1. The general crop requirements are presented in table 4 and table 5 shows the suitability classification of the agro-ecological zones. The consequent suitability classification of the land mapping units in the context of the agro-ecological zones only is presented in table 6.

Table 4: General crop requirements.

Requirements for:	Tea	Coffee	Cotton	Maize	Sorghum
Altitude (m)	1500-2200	1300-2000	< 1800	< 2400	< 2400
Mean Daily Temp. (C): optimum	21-28	18-25	21-30	20-25	25
acceptable range	(13-30)	(13-30)	(15-40)	(>15)	(20-35)
Annual Rainfall	1500-1750	1500-2000		600-1200	600-800
pH optimal:	4.5-5.5	5.3-6.0	7.0-8.0	5.5-7.0	5.5-6.5
acceptable range:	4.0-6.0	4.5-7.0	6.0-8.0	5.5-8.0	5.0-8.0
Soil depth (cm)	>180	>180	>100	50-100	40-150

Table 5: Agroecological suitability classification.

Agro ecological zone	Tea	Coffee	Cotton	Maize	Sorghum, millet
LH1	S1	S2	N	N	N
UM1	S1	S1	--	--	--
UM2	S2	S1	--	--	--
UM3	--	S1	S2	S2	--
LM3	--	S2	S1	S1	S2
LM4	--	--	S1	S1	S2
LM5	--	--	S2	S1	S1
IL5	--	--	S2	S2	S1

Table 6. Agroecological land suitability classification

Mapping units	AEZ's	Agroecological Suitability				
		Tea	Coffee	Cotton	Maize	Sorghum, millet
M,H	LM3	N	S2	S1	S1	S2
	LM4	N	N	S1	S1	S2
	LM5	N	N	S2	S1	S1
F	LM3	N	S2	S1	S1	S2
	LM4	N	N	S1	S1	S2
	LM5	N	N	S2	S1	S1
	IL5	N	N	S2	S2	S1
RtI,RsIb	IH1	S1	S2	N	N	N
	UM1	S1	S1	N	N	N
	UM2	S2	S1	N	N	N
	UM3	N	S1	S2	S2	N
	LM3	N	S2	S1	S1	S2
RbIb,RmIb	UM1	S1	S1	N	N	N
	UM2	S2	S1	N	N	N
	UM3	N	S1	S2	S2	N
	LM3	N	S2	S1	S1	S2
LtIbp,LcIbp,UBr,	LM4	N	N	S1	S1	S2
UWb,UWbp,UWr,UV	LM5	N	N	S2	S1	S1
UGb,UGr	LM5	N	N	S2	S1	S1
	IL5	N	N	S2	S2	S1
LtBr,LcBrM,UWrp	LM5	N	N	S2	S1	S1
UI	UM3	N	S1	S2	S2	N
	LM3	N	S2	S1	S1	S2
	LM4	N	N	S1	S1	S2
UIbp,UX	LM3	N	S2	S1	S1	S2
	LM4	N	N	S1	S1	S2
UIr	UM2	S2	S1	N	N	N
	UM3	N	S1	S2	S2	N
	LM3	N	S2	S1	S1	S2
UW	LM4	N	N	S1	S1	S2
	IL5	N	N	S2	S2	S1

3.3 Soil physical suitability.

The classification of land suitability based on the physical properties of the land mapping units depends on many land qualities, but in the context of the survey area and in view of the detail of the data available the following land qualities have been considered relevant:-

1. rootability
2. availability of water, and
3. resistance to erosion

3.3.1 Rootability.

The land quality rootability can be inferred from the soil properties observed in the profile descriptions. Root growth in the soil may be limited by several physical and chemical factors. However, bearing in mind what has been said above concerning data availability, only the following factors have been used for rating this land quality:

a. depth to substratum (soil depth)
b. presence of physically restricting layer
c. presence of layer with low moisture holding capacity e.g. sand or gravelly layers.

Other root limiting factors like high ground water table, swelling clays, toxic chemical layers, etc. are not considered because they have not been found to be relevant in the survey area. Rooting depth is considered to be limited by the shallowest of any of the above phenomena when they occur.

3.3.2 Availability of water.

The availability of water to the plant is determined by the precipitation and evaporation during the growing season, by the soil water holding capacity and supply by capillary rise (Dijkerman, 1981). Rainfall has been used in the estimation of water availability. The rain was regarded as falling in one rainy season. However, for the necessary quantitative data, water holding capacities have been estimated on the basis of field judgement as being either low (L), moderate (M) or high (H).

Table 7: Determination of the expected rooting depth.

Mapping Units	S o i l depth (cm)	Depth to physically restricting layer (cm)	Layer With Low Moisture Holding Capacities	Expected Rooting Depth (cm)
F	45	No	No	45
RtI	>(130-150)	No	No	>(130-150)
RsIb	>140	No	No	>140
RbIb	>140	No	No	>140
RmIb	>130	No	NO	130
LtIbp	45-64	No	No	25-64
LcIbp				<60
LtBr	>120	No	No	120
LcBrM				<120
UBr	>160	No	No	120
UGb	105-120	stones at 65 cm	No	65-120
UGr	80	No	No	80
UI	85-120	No	No	85-120
UIbp	>120	No	at 30 cm	30-80
UIr				120
UV	>135-150	No	No	135-150
UW				80
UWb	75-90	No	No	75-90
UWbp	50-80	No	No	50-80
UWr	>160	No	at 120 cm	120
UWrp	46-55	No	No	55-100
Ux	>50	No	No	>50

Table 8 gives the rating of the land quality **water availability** based on texture, content of gravel and stones, the expected rooting depth and the estimated levels of soil water holding capacity. A combination of these factors results in one of three rating levels: high (1), moderate (2) and low (3).

Table 8. Estimation of water holding capacity of each mapping unit

Mapping unit	Texture	Expected rooting depth (cm)	Content of gravel and stones	Water holding capacity estimate
F	SC	45	sgr	L
RtI	C	>140	--	H
RsIb	C	>140	--	H
RbIb	C	140	--	H
RmIb	C	>130	--	H
LtIbp	C,SiCl	45	gr	L
LcIbp	C	<50	gr,st	L
LtBr	SCL	120	gr	L
LcBrM	SCL	<50	vgr	L
UBr	C	120	gr,st	L
UGb	SC	90	sgr	L
UGr	C	80	sgr	L
UI	C	100	sgr	M
UIbp	C	65	vgr	L
UIr	C	120	--	H
UV	C	140	sgr	M
UW	C	80	gr,st	M
UWb	C	80	--	M
UWbp	C,SCL	65	sgr	L
UWr	C,SC	100	sgr	L
UWrp	C	80	gr	L
UX	SC	80	sgr	L

3.3.3 Resistance to erosion.

This land quality is considered as the capacity of the bare soil to resist erosion by water. Wind erosion is of minor relevance in the survey area.

The intensity of erosion by water depends on rainfall erosivity, slope length and steepness, protective plant cover, soil erodibility and the use of conservation practices. Soil erodibility is a complex quality dependent on organic matter content, floculation index, silt/clay ratio, bulk density, etc., and since no data is available it has not been considered for rating this land quality.

Table 9. Resistance to water erosion

Mapping unit	Slope %	Slope length (m)	Physiographic unit	Observed field erosion
F	6	300	F	slight
RtI	1-2	150-2000	Rt	none
RsIb	10	50	Rs	moder.
RbIb	0-4	50	Rb	moder.
RmIb	1	--	Rm	none
LtIbp	0-2	700	Lt	none-slight
LcIbp	10-30	--	Lc	moder.-severe
LtBr	0	--	Lt	none
LcBrM	10-30	--	Lc	moder.-severe
UBr	3	300	U	moder.
UGb	2-10	100-500	U	moder.
UGr	5	300	U	slight
UI	4-10	200-500	U	none-moder.
UIbp	2	300	U	none
UIr	4-10	--	U	--
UV	2-6	100-200	U	slight-moder.
UW	2-5	--	U	--
UWb	3-5	200	U	moder.-severe
UWbp	2-4	200-500	U	slight-moder.
UWr	1-8	100-300	U	none-slight
UWrp	3	200	U	slight-moder.
UX	5-9	--	U	moder.

3.4 Result of the soil physical suitability.

The last step in the physical suitability is the matching of the land qualities with the requirements of the crops in terms of soil depth, drought tolerance, water availability and erosion hazard.

The physical land suitability classification is given in table 10.

Table 10. Estimation of soil physical suitability

Mapping unit	AEZ	Physical land qualities			Soil physical suitability				
		Expected rooting depth(cm)	Water avail.	Resist. to erosion	Tea	Coffee	Cotton	Maize	Sorghum
F	LM3	45	L	L	Ndw	Ndw	Ndwe	Nde	Ne
	LM4		L	L				Nde	Ne
	LM5		L	M			Ndw	Nd	S2de
	IL5		L	M				Nd	S2de
RtI	LH1	>130	H	M	S1	S1	S1-S2e	S1-S2e	S1-S2e
	UM1	-150	H	M	S1	S1			
	UM2		H	M	S1	S1			
	UM3		H	H	S1	S1	S1	S1	S1
	LM3		M	H	Nw	S2w	S1	S1	S1
RsIb	LH1	>140	H	L	S1	S1-S2e	Ne	Ne	Ne
	UM1		H	L	S1	S1-S2e			
	UM2		H	L	S1	S1-S2e			
	UM3		H	M	S1	S1	S1-S2e	S1-S2e	S1-S2e
	LM3		M	M	Nw	S1	S1-S2we		
RbIb	UM1	>140	H	M	S1	S1	S1-S2e	S1-S2e	S1-S2e
	UM2		H	M	S1	S1			
	UM3		H	M	S1	S1			
	LM3		M	H	Nw	S2w	S1	S1	S1
RmIb	UM1	>130	H	M	S1	S1	S1-S2e	S1-S2e	S1-S2e
	UM2		H	M	S1	S1	S1-S2e		
	UM3		H	H	S1	S1	S1	S1	S1
	LM3		M	H	Nw	S2w	S1	S1	S1
LtIbp	LM4	25-65	L	M	Ndw	Ndw	Ndw	Nd	S2de
	LM5		L	H					S2d
LcIbp	LM4	<60	L	L	Ndw	Ndw	Ndwe	Ndwe	Nde
	LM5		L	L					
LtBr	LM5	120	L	H	Nw	Nw	Nw	S2w	S1
LcBrM	LM5	<120	L	L	Nw	Nw	Nwe	Nwe	Ne
UBr	LM4	120	L	M	Nw	Nw	Nw	S2we	S1-S2e
	LM5		L	M					

table 10. (cont)

Mapping unit	AEZ	Physical land qualities			Soil physical suitability				
		Expected rooting depth(cm)	Water avail.	Resist. to erosion	Tea	Coffee	Cotton	Maize	Sorghum
UGb	LM5	65-	L	M	Nw	Nw	Nw	S2we	S1-S2e
	IL5	120	L	M					
UGr	LM5	80	L	M	Ndw	Ndw	Nw	S2dwe	S2d
	IL5		L	M					
UI	UM3	85-	M	L	Nw	Nw	Ne	Ne	Ne
	LM3	120	M	M			S2de	S1-S2de	S1-S2e
	LM4		L	M			Nw	S2we	S1-S2e
UIbp	LM3	30-	L	M	Ndw	Ndw	Nw	S2dw	S2d
	LM4	80	L	M					
UIr	UM2	120	H	L	S2d	S2de	Ne	Ne	Ne
	UM3		H	L	S2d	S2de	Ne	Ne	Ne
	LM3		M	M	Nw	S2dw	S1-S2e	S1-S2e	S1-S2e
UV	LM4	135-	M	M	Nw	S2dw	S1-S2e	S1-S2e	S1-S2e
	LM5	150	L	M		Nw	Nw	S2we	S1-S2e
UW	LM4	80	M	M	Ndw	Nd	S2de	S2de	S2d
	IL5		L	H		Ndw	Nw	S2dw	
UWb	LM4	75-	M	M	Ndw	Nd	S2de	S2de	S1-S2d
	LM5	90	L	M		Ndw	Nw	S2dwe	
UWbp	LM4	50-	M	M	Ndw	Nd	S2de	S2de	S2d
	LM5	80	L	M		Ndw		S2dwe	
UWr	LM4	75-	L	M	Nw	Nw	Nw	S2we	S1-S2e
	LM5	125	L	M					
UWrp	LM5	55-	L	M	Ndw	Ndw	Nw	S2dwe	S2d
		100							
UX	LM3	>50	L	M	Ndw	Ndw	Nw	S2we	S1-S2de
	LM4		L	M					

The symbols used in table 10 are as follows:

S1 : Highly suitable d : Limitations in rooting depth
S2 : Marginaly suitable w : Limitations in water availability
N : Not suitable e : Limitations in resistance
L : low M : moderate H : high

3.5 Soil chemical suitability

The soil chemical suitability assessment is based on characteristics of major diagnostic horizons. Their characteristics are very much related to parent material, degree of weathering, pH, organic matter content. Therefore, it is possible to infer the natural fertility, toxicity problems, phosphorus fixation, etc. from these factors. Table 10 shows the diagnostic horizons, fertility characteristics and fertility grade.

Table 11: Fertility characteristics of some diagnostic horizons

Diagnostic horizon	Fertility characteristics	Grade
SURFACE HORIZONS		
Mollic	O.M.>1%, B.S.>50%, neutral,	1
Umbric	O.M.>1%, B.S.<50%, acidic, Al. toxicity is probable.	3
Ochric	low in O.M.	4
SUBSURFACE HORIZONS		
Argillic	low activity clay	4
Cambic	contains some easily weatherable minerals.	2-3

Each mapping unit was assessed in the following way:

* Each soil profile was evaluated separately. A fertility grade was assigned by grouping the dominant soils of each mapping unit using the information of table 10.

* The assessment of mapping units which occur as complexes was made by rough estimation, evaluating each profile separately and taking into account observed performance of the crops etc.

* The matching with crop requirements was done bearing in mind those land characteristics which are critical for the land quality nutrient availability. These are listed in table 11.

* The chemical land suitability classification is given in table 12. This table shows the matching of the land qualities for each mapping unit with the land use requirements. The crop requirements related to nutrient availability are shown in table 11.

Table 12. Fertility requirements of the crops

Crop	pH range	pH optimum	tolerance to acid conditions	specific requirem.	soil fert.
SORGHUM	5.0-8.0	5.5 - 6.5	moderate	nitrogen	MF-F
TEA	4.0-6.0	4.5 - 5.5	high	nitrogen	MF
COFFEE		5.3 - 6.0	moderate		VF
MAIZE	5.5-8.0		low	nitrogen	MF-F
COTTON	6.0-8.0	7.0 - 8.0	low		MF-F

Explanation of symbols:

MF : moderately fertile F : fertile VF : very fertile

Table 13: Chemical land suitability classification

Mapping unit	Classif.	Land charact.	Suitability: Sorghum	Tea	Coffee	Maize	Cotton
RtI	Rhodic/ mollic nitosol	O.M.>1% B.S.>50% pH 6.5, manured soils.	S1	S1	S1	S1	S1
RsIb	haplic Nitosol	ditto.	S1	S1	S1	S1	S1
RbIb	haplic Acrisol	O.M.>1%, manured soils.	S1	S2	N	S1	S1

Table 13 (cont...)

Mapping unit	Classif.	Land charact.	Sorghum	Tea	Coffee	Maize	Cotton
RmIb	Haplic Acrisol	ditto.	S1	S2	S2	S1	S1
LtIbp	Mollic Leptosol	O.M.>1% B.S.>50% neutral dark surface horizon.	S1	N	S1	S1	S1
LcIbp	Haplic Phaeozem	ditto.	S1	N	S1	S1	S1
LtBr	Dystric Cambisol	Low O.M., low B.S., acid.	S2	N	N	N	N
LcBrM	Dystyric Regosol	ditto.	S2	N	N	N	N
UBr	Umbric Cambisol	O.M.>1% B.S.<50% contains weather. minerals.	S1	S2	N	S2	S1
UCb	Chromic Luvisol/ Cambisol (*)	Low %O.M., low B.S., contains weather. minerals (*).	S2	N	N	N	N
UCr	Chromic Luvisol	Low %O.M., low B.S.	N	N	N	N	N
UI	Chromic Luvisol/ Cambisol (*)	O.M.>1%, manured soils, contains weatehr. minerals (*).	S1	S2	N	S1	S2
UIbp	Dystric Cambisol	Low %O.M.	S1	S2	N	S2	S2

Table 13 (cont...)

Mapping unit	Classif.	Land charact.	Sorghum	Tea	Coffee	Maize	Cotton
UIr	Chromic Luvisol	O.M.>1%, manured soils.	S1	S2	N	S1	S1
UV	Haplic Alisol/ Chromic Cambisol (*)	Low %O.M., low B.S., acid, contains weather. minerals (*.	S2	N	N	N	N
UW	Dystric Cambisol/ Chromic Luvisol	Low %O.M.	N	N	N	N	N
UWb	Chromic Luvisol	Low %O.M., low B.S., low activ. clay.	S2	N	N	S2	S2
UWbp	Haplic Cambisol/ Luvisol. Dystric Cambisol	Low %O.M.	S2	N	N	S2	S2
UWr	Chromic Luvisol/ Cambisol. Dystric Cambisol (*)	Low %O.M., low activ. clay, contains weather. minerals (*).	S2	N	N	S2	S2
UWrp	Dystric Cambisol	Low %O.M.	S1	S2	N	S2	S2
UX	Dystric Cambisol	Low %O.M.	N	N	N	N	N
M		ditto.	N	N	N	N	N
F		ditto.	N	N	N	N	N
H		ditto.	N	N	N	N	N

Table 14. Final land evaluation for single crop LUTs

Mapping unit	AEZ	Suitability				
		Tea	Coffee	Cotton	Maize	Sorghum
F	LM3	Nafdw	Nfdw	Nfdwe	Nfde	Nfe
	LM4	Nafdw	Nafdw	Nfdwe	Nfde	Nfe
	LM5	Nafdw	Nafdw	Nfdw	Nfd	Nfde
	IL5	Nafdw	Nafdw	Nfdw	Nfd	Nfde
RtI	LH1	S1	S2a	Na	Na	Na
	UM1	S1	S1	Na	Na	Na
	UM2	S2a	S1	Na	Na	Na
	LM3	Naw	S2aw	S1	S1	S2a
RsIb	LH1	S1	S1-S2e	Nae	Nae	Nae
	UM1	S1	S1-S2e	Nae	Nae	Nae
	UM2	S2a	S1-S2e	Nae	Nae	Nae
	UM3	Na	S1	S1-S2e	S1-S2e	Na
	LM3	Naw	S1	S1-S2we	S1-S2e	Na
RbIb	UM1	S2f	Nf	Na	Na	Na
	UM2	S2a	Nf	Na	Na	Na
	UM3	Na	Nf	S2ae	S2ae	Na
	LM3	Naw	Nf	S1	S1	S2a
RmIb	UM1	S2f	S2f	Na	Na	Na
	UM2	S2af	S2f	Na	Na	Na
	UM3	Na	S2f	S2a	S2a	Na
	LM3	Naw	S2fw	S1	S1	S2a
LtIbp	LM4	Nafdw	Nadw	Ndw	Nd	S2ade
	LM5	Nafdw	Nadw	Ndw	Nd	S2d
LcIbp	LM4	Nafdw	Nadw	Ndwe	Ndwe	Nde
	LM5	Nafdw	Nadw	Ndwe	Ndwe	Nde
LtBr	LM5	Nafw	Nafw	Nfw	Nfw	S2f
LcBrM	LM5	Nafw	Nafw	Nfwe	Nfwe	Na
UBr	LM4	Naw	Nafw	Nw	S2fwe	S2a
	LM5	Naw	Nafw	Nw	S2fwe	S1-S2e
UGb	LM5	Nafw	Nafw	Nfw	Nf	S2fe
	IL5	Nafw	Nafw	Nfw	Nf	S2fe

Table 14 (cont...)

Mapping unit	AEZ	Suitability				
		Tea	Coffee	Cotton	Maize	Sorghum
UGr	LM5	Naf	Nafdw	Nfdw	Nfw	Nf
	IL5	Naf	Nafdw	Nfdw	Nfw	Nf
UI	UM3	Naw	Nfw	Ne	Ne	Nae
	LM3	Naw	Nfw	S2fde	S1-S2de	S2ae
	LM4	Naw	Nafw	Nw	S2we	S2ae
UIbp	LM3	Nadw	Nfdw	Nw	S2fdw	S2ad
	LM4	Nadw	Nafdw	Nw	S2fdw	S2ad
UIr	UM2	S2afd	Nf	Nae	Nae	Nae
	UM3	Na	Nf	Ne	Ne	Nae
	LM3	Naw	Nf	S1-S2e	S1-S2e	S2ae
UV	LM4	Nafw	Naf	Nf	Nf	S2afe
	LM5	Nafw	Nafw	Nfw	Nf	S2fe
UW	LM4	Nafdw	Nafd	Nf	Nf	Nf
	IL5	Nafdw	Nafdw	Nfw	Nf	Nf
UWb	LM4	Nafdw	Nafd	S2fde	S2fde	S2afd
	LM5	Nafdw	Nafdw	Nw	S2fde	S2fd
UWbp	LM4	Nafdw	Nafd	S2fde	S2fde	S2afd
	LM5	Nafdw	Nafdw	S2afde	S2fdwe	S2fd
UWr	LM4	Nafw	Nafw	Nw	S2fwe	S2afe
	LM5	Nafe	Nafw	Nw	S2fwe	S2fe
UWrp	LM5	Nadw	Nafdw	Nw	S2fdwe	s2d
UX	LM3	Nafdw	Nfdw	Nfw	Nf	Nf
	LM4	Nafdw	Nafdw	Nfw	Nf	Nf

S1 : Highly suitable
S2 : Marginaly suitable
N : Non suitable
f : Limitations in fertility
w : Limitations in water availability
a : Limitations in agroecology
d : Limitations in rooting depth
e : Limitations in resistance to erosion

3.6 Result of the land suitability evaluation.

The final land suitability classification is given in Table 14. It is arrived at by comparison of the results obtained in the agroecological, soil physical and soil chemical partial suitabilities. The final suitability class is determined by the most limiting partial suitability. For suitability classes oter than S1 sub-classes are identified by their kind of limitation(s). The type of limitation are indicated by the following lower-case letters:

a : Agroecological limitation
f : Low nutrient availability.
d : Shallow rooting depth.
w : Low availability of water.
e : Erosion hazard.

Agroecological limitations were not separately indicated because their improvement requires substantial capital investments not considered in the defined land use alternatives considered in this report.

Although this study does not consider the improvement of the limiting factors indicated in the suitability subclasses, their interpretation may prove useful by showing the nature of the limitations that have to be corrected in order to improve the land suitability.

3.7 Conclusions

The results of the land suitability evaluation give an indication of the best land use alternatives to which the lands of the survey area can be put. It should be reiterated that this is a qualitative land evaluation based only on physical and environmental factors, and the selection between alternative land uses must be determined by an evaluation which includes socio-economic considerations. Such an analysis is beyond the scope of the present study.

Additionally, this study has been based on a limited data base, necessitating a high level of simplification and qualitative or subjective estimations in several steps of the evaluation procedure.

The survey area clearly demonstrated the altitude-related zonation of the best suitable land use alternative(s) (crops) from the upper slopes of Mount Kenya to the lower lands in the eastern part of the area. The sequence of suitable crops with decreasing altitude is tea, coffee, cotton, maize, sorghum and millet. The suitability zones frequently overlap, especially in the lower altitudes.

These findings seem to agree very well with the present land use which is presumably adapted to the soils and climatic conditions.

This last remark would seem to indicate that improvement of management levels is the fundamental point for agricultural productivity in the survey area.

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PROFILE DESCRIPTION

Date/ season	:25/6/86; end of rainy season
Observation No.	:A3
Coordinates	:3572 E, 99683 N
Elevation	:1180 m
Authors	:Suluvale,Magoggo,Zhu
Soil mapping unit	:RsIb
Soil classification	:Haplic nitosol
Geology	:Mt Kenya volcanics
Local petrography (Parent material)	:Lahar?
Physiography	:Mountain footridge
Macro-relief	:Rolling
Slope (length, shape and pattern)	:50 m,straight,regular
Slope gradient	:10%
Position on slope	:Middle
Meso- and micro-relief	:none
Vegetation/ Landuse	:Arable land
Erosion	:Moderate slight
Rock outcrops	:none
Surface stoniness	:none
Overwash	:none
Surface runoff	:Very slow
Surface sealing/crusting/cracking	:none
Drainage class	:Well drained
Flooding	:none
Groundwater level (actual)	:> 1.40 m
Presence of salts/ alkali	:none
Soil fauna	:Termites
Expected rooting depth	:>140 m

Horizons :

Ap 0-6 cm dark reddish brown (5 YR 3/3 moist, 5 YR 3/4 dry); clay; weak coarse subangular blocky breaks into strong very fine crumbs; slightly hard, very friable, slightly sticky and slightly plastic; many micro, many fine, common medium pores; many fine, common medium, few coarse roots; pH = 5.8; abrupt smooth boundary to:

Bt1 6-35 cm dark reddish brown (5 YR 3/3) moist; clay; strong fine subangular blocky; hard, firm, sticky and plastic; many shiny ped faces; common micro, few fine pores; many fine, few medium, few coarse roots; pH = 5.9; gradual smooth boundary to:

Bt2 35-94 cm dark reddish brown (2.5 YR 3/4) moist; clay; moderate coarse angular blocky; hard, firm, sticky and plastic; continuous moderately thick clay and manganese cutans; common micro, few fine, few medium pores; few fine, few medium, few coarse roots; pH = 6.0; gradual smooth boundary to:

BC 94-140+ cm reddish brown (2.5 YR 4/4) moist; clay; moderate coarse subangular blocky; hard, firm, sticky and plastic; broken moderately thick clay and manganese cutans; common fine, common medium pores; few fine, few medium, few coarse roots; pH = 5.9 .

PROFILE DESCRIPTION

Date/ season	:4/6/86; end of rainy season
Observation No.	: A2
Coordinates	:3556 E, 99694 N
Elevation	: 1190 m
Authors	:Sulu,Buss,Magoggo,Szogi,Udaya,Mateos,Zhu
Soil mapping unit	:RtI
Soil classification	:Rhodic nitosol
Geology	: Mt. Kenya volcanics
Local petrography (Parent material)	:Lahar
Physiography	:Mountain footridge
Macro-relief	:Flat
Slope (length, shape and pattern)	:>2000 m,convex,single
Slope gradient	:1%
Position on slope	:Summit
Meso- and micro-relief	:none
Vegetation/ Landuse	: Arable land, coffee
Erosion	:none
Rock outcrops	:none
Surface stoniness	:none
Overwash	:none
Surface runoff	:slow
Surface sealing/crusting/cracking	:Slight sealing
Drainage class	:Well drained
Flooding	:none
Groundwater level (actual)	:> 1.5 m
Presence of salts/ alkali	:none
Soil fauna	:_
Expected rooting depth	:>150

Horizons:

Ap 0 -20 cm dusky red (2.5 YR 3/2) moist; clay; weak fine subangular blocky; hard, friable, sticky and plastic; many micro, many very fine, many fine, common medium pores; many fine, common roots; pH = 6.3; clear and smooth boundary to:

Bt1 20-62 cm dark reddish brown (2.5 YR 3/4) moist; clay; medium moderate subangular blocky; friable, sticky and plastic; broken thin clay cutans, common shiny ped faces; many micro, many very fine, many fine, common medium, few coarse pores; common fine and few medium roots; pH = 4.9; gradual and smooth boundary to:

Bt2 62-150+ cm red (10 YR 4/6) moist; clay; weak coarse compound rough prisms breaks into weak medium angular blocky; friable, sticky and plastic; broken thin clay cutans, common shiny ped faces; many micro, many very fine, common medium pores; few fine, few medium roots; pH = 5.4; presence of charcoal.

PROFILE DESCRIPTION

Date/ season	:6/6/86; end of rainy season
Observation No.	: A5
Coordinates	:3567 E, 99673 N
Elevation	: 1120 m
Authors	:Sulu,Buss,Magoggo,Udaya,Zhu
Soil mapping unit	:RbIb
Soil classification	:Haplic acrisol
Geology	:Mt Kenya volcanics
Local petrography (Parent material)	:Colluvium (lahar)
Physiography	:Mountain footridge, major valley bottom
Macro-relief	:Hilly
Slope (length, shape and pattern)	:50 m,linear,single
Slope gradient	:22%
Position on slope	:lower
Meso- and micro-relief	:none
Vegetation/ Landuse	: Arable land, maize, sorghum, beans Erosion :Moderate sheet & rill
Rock outcrops	:none
Surface stoniness	:Fairly stony
Overwash	:Very slight
Surface runoff	:Rapid
Surface sealing/crusting/cracking	:Slight cracking
Drainage class	:Well drained
Flooding	:none
Groundwater level (actual)	:> 1.40 m
Presence of salts/ alkali	:none
Soil fauna	:none
Expected rooting depth	:140 cm

Horizons:

Ap 0 -15 cm dark brown (7.5 YR 3/2) moist, brown (7.5 YR 4/4) dry; clay; strong fine granular; soft, friable, slightly sticky and plastic; many fine, common medium pores; many fine roots; pH = 5.6; abrupt smooth boundary to:

Bt1 15 -60 cm dark reddish brown (5 YR 3/3) moist, reddish brown (5 YR 4/3) dry; clay; weak coarse angular blocky breaks into moderate fine subangular blocky; slightly hard, firm, sticky and plastic; patchy thin clay cutans; many very fine, few medium pores; few fine roots; pH = 5.6; gradual smooth boundary to:

Bt2 60-100 cm dark reddish brown (5 YR 3/4) moist; clay; moderate medium subangulr blocky; soft, friable, slightly sticky and plastic; broken thin clay cutans; many fine, few medium pores; few fine roots; rounded pieces of weathered volcanic rock; pH = 5.4; clear smooth boundary to:

BC 100-140+ cm brown (7.5 YR 4/4) moist; clay; moderate medium subangular blocky; soft, friable, slightly sticky and plastic; broken thin clay cutans; many fine, few coarse pores; rounded pieces of weathered volcanic rock; pH = 5.3.

PROFILE DESCRIPTION

Date/ season	:25/6/86; end of rainy season
Observation No.	: A14
Coordinates	:3577 E, 99649 N
Elevation	: 1110 m
Authors	:Suluvale,Magoggo,Zhu
Soil mapping unit	:RmIb
Soil classification	:Haplic acrisol
Geology	:Mt Kenya volcanics
Localpetrography (Parent material)	:Lahar colluvium
Physiography	:Minor valley/Mountain footridge
Macro-relief	:Flat
Slope (length, shape and pattern)	:-
Slope gradient	:1%
Position on slope	:Valley bottom
Meso- and micro-relief	:none
Vegetation/ Landuse	: Arable land
Erosion	:none
Rock outcrops	:none
Surface stoniness	:none
Overwash	:none
Surface runoff	:Very slow
Surface sealing/crusting/cracking	:Slight cracking
Drainage class	:Well drained
Flooding	:none
Groundwater level (actual)	:> 1.30 m
Presence of salts/ alkali	:none
Soil fauna	:-
Expected rooting depth	:> 130 cm

Horizons:

Ap 0-20 cm dark reddish brown (5 YR 3/2) moist, dark reddish grey (5 YR 4/2) dry; clay; soft, very friable, sticky and plastic; many micro, many very fine, many fine, common medium, few coarse pores; many fine, many very fine, few medium roots; pH = 5.9; clear smooth boundary to:

Bt1 20-40 cm dark redish brown (5 YR 3/2) moist; clay; moderate coarse subangular blocky and moderate fine granular;very friable, sticky and plastic; patchy thin clay cutans; many micro, many very fine, common fine, common medium pores; common fine, many medium roots; few stones; pH = 5.7; gradual smooth boundary to:

Bt2 40-72 cm dark reddish brown (5 YR 3/2) moist; clay; strong medium subangular blocky; firm, styicky and plastic; broken thin clay cutans; many micro, many very fine, many fine, common medium pores; common fine, many medium, few coarse roots; pH = 5.9; gradual smooth boundary to:

BC 72-130+ cm dark reddish brown (5 YR 3/3) moist; clay; strong medium subangular blocky; firm; broken thin clay cutans; common micro, common very fine, few medium pores; few fine, few medium, few coarse; quartz gravel; pH = 5.7 .

PROFILE DESCRIPTION

Date/ season	:4/6/86; end of rainy season
Observation No.	:A8
Coordinates	:3602 E, 99705 N
Elevation	:1100 m
Authors	:Sulu,Buss,Magoggo,Szogi,Mateos,Udaya,Zhu
Soil mapping unit	:RtI
Soil classification	:Rhodic nitosol
Geology	:Mt Kenya volcanics
Local petrography (Parent material)	:Lahar
Physiography	:Mountain footridge
Macro-relief	:Undulating
Slope (length, shape and pattern)	:-
Slope gradient	:2%
Position on slope	:Middle
Meso- and micro-relief	:none
Vegetation/ Landuse	:Arable land
Erosion	:Slight sheet
Rock outcrops	:none
Surface stoniness	:none
Overwash	:none
Surface runoff	:Very slow
Surface sealing/crusting/cracking	:Moderate sealing
Drainage class	:Well drained
Flooding	:none
Groundwater level (actual)	:> 130 m
Presence of salts/ alkali	:none
Soil fauna	:-
Expected rooting depth	:>130

Horizons:

Ap 0-18 cm dusky red (2.5 YR 3/2) moist; clay; weak medium subangular blocky breaks into moderate fine crumbs; friable, sticky and slightly plastic; many micro, many very fine, many fine, few medium pores; many fine roots; pH = 5.4; clear smooth boundry to:

Bt1 18-54 cm dark reddish brown (2.5 YR 3/4) moist; clay; moderate coarse angular blocky; friable, slightly sticky and slightly plastic; broken thin clay cutans, common shiny ped faces; many micro, many very fine, many fine, common medium pores; common fine roots; pH = 5.8; gradual smooth boundry to:

Bt2 54-130+cm dark red (10 R 3/6) moist; clay; moderate medium angular blocky; friable, sticky andslightly plastic;broken fine clay cutans, many shiny ped faces; many micro, many veryfine, many fine pores; pH = 5.2 .

PROFILE DESCRIPTION

Date/ season	:25/6/86; end of rainy season
Observation No.	:B15
Coordinates	:3697 E, 99633 N
Elevation	:800 m
Authors	:Suluvale,Magoggo,Zhu
Soil mapping unit	:UWr
Soil classification	:Chromic cambisol
Geology	:Basement
Local petrography (Parent material)	:Gneiss complex
Physiography	:Upland
Macro-relief	:Undulating
Slope (length, shape and pattern)	:100 m,convex,irregular
Slope gradient	:8%
Position on slope	:Lower
Meso- and micro-relief	:none
Vegetation/ Landuse	:Grassland
Erosion	:none
Rock outcrops	:none
Surface stoniness	:none
Overwash	:none
Surface runoff	:Slow
Surface sealing/crusting/cracking	:Slight sealing
Drainage class	:Well drained
Flooding	:none
Groundwater level (actual)	:> 1.10 m
Presence of salts/ alkali	:none
Soil fauna	:-
Expected rooting depth	:90 cm

Horizons:

A 0-10 cm dark brown (7.5 YR 3/2 moist, 7.5 YR 4/4 dry); sandy loam; weak coarse subangular blocky breaks into strong very fine crumbs; slightly hard, very friable, slightly sticky and slightly plastic; many micro, many very fine, many fine, common medium pores; many fine roots; pH = 6.4; abrupt smooth boundary to:

Bw1 10-60 cm dark red (2.5 YR 3/6) moist, red (2.5 YR 4/6) dry; sandy clay; moderate coarse angular blocky; hard, very friable, slightly sticky and slightly plastic; many micro, many fine, common medium, few coarse pores; few fine, few coarse roots; small angular quartz gravel; pH=6.6; gradual smooth boundary to:

Bw2 60-90 cm dark reddish brown (2.5 YR 3/4) moist, dark red (2.5 YR 3/6) dry; sandy clay; moderate coarse angular blocky; hard very friable, slightly sticky and slightly plastic; many micro, many very fine, many medium pores; few fine, few medium roots; small angular quartz gravels; pH = 7.4; abrupt broken boundary to:

C 90-110+ cm gravelly sandy clay; structureless, single grain; very friable, slightly sticky and slightly plastic; weathered gneiss rock; pH = 7.7 .

PROFILE DESCRIPTION

Date/ season	:21/6/86; end of rainy season
Observation No.	:B18
Coordinates	:3702 E, 99658 N
Elevation	:780 m
Authors	:Mateos,Suluvale,Szogi
Soil mapping unit	:Uwbp
Soil classification	:Chromic cambisol
Geology	:Basement
Local petrography (Parent material)	:Gneiss
Physiography	:Upland
Macro-relief	:Undulating
Slope (length, shape and pattern)	:200 m,convex,irregular
Slope gradient	:3%
Position on slope	:Upper
Meso- and micro-relief	:none
Vegetation/ Landuse	:Grasses & shrubs. Grazing
Erosion	:Slight sheet and rill
Rock outcrops	:Fairly rocky
Surface stoniness	:Stony
Overwash	:none
Surface runoff	:Rapid
Surface sealing/crusting/cracking	:Slight sealing
Drainage class	:Well drained
Flooding	:none
Groundwater level (actual)	:> 1.0 m
Presence of salts/ alkali	:none
Soil fauna	:Termites
Expected rooting depth	:50 cm

Horizons:

A 0-8 cm dark reddish brown (5 YR 3/2 moist, 5 YR 3/4 dry); sandy clay loam; weak fine subangular blocky; soft, very friable, non-sticky and slightly plastic; many micro, common fine,few coarse pores; many fine, few medium, few coarse roots; pH = 6.6; clear smooth boundary to:

Bw 8-50 cm dark reddish brown (2.5 YR 2.5/4 moist, 2.5 YR 3/4 dry); slightly gravelly sandy clay loam; soft, very friable, non-sticky and slightly plastic; many micro, common fine, few coarse pores; many fine, few medium, few coarse roots; pH = 6.9; abrupt irregular boundary to:

C 50-100+ cm Rotten rock (Gneiss)

PROFILE DESCRIPTION

Date/ season	:6/6/86; end of rainy season
Observation No.	:B1
Coordinates	:3589 E, 99693 N
Elevation	:1120 m
Authors	:Sulu,Buss,Magoggo,Szogi,Udaya,Mateos,Zhu
Soil mapping unit	:RtI
Soil classification	:Mollic Nitosol
Geology	:Mt. Kenya volcanics
Local petrography (Parent material)	:Lahar
Physiography	:Mountain footridge
Macro-relief	:Undulating
Slope (length, shape and pattern)	:>150 m,convex,regular
Slope gradient	:2%
Position on slope	:middle slope
Meso- and micro-relief	:none
Vegetation/ Landuse	:Arable land
Erosion	:none
Rock outcrops	:none
Surface stoniness	:none
Overwash	:Very slight
Surface runoff	:Slow
Surface sealing/crusting/cracking	:Slight sealing
Drainage class	:Well drained
Flooding	:none
Groundwater level (actual)	:> 1.50 m
Presence of salts/ alkali	:none
Soil fauna	:Ants
Expected rooting depth	: > 1.50 m

Horizons:

Ap 0 -10 cm dark reddish brown (5 YR 3/2 moist, 5 YR 3/3 dry); clay; weak medium compound rough prisms breaks into strong fine crumbs; hard, friable, sticky and plastic; many micro, many very fine, many fine , many medium, common coarse pores; many very fine, many fine, few coarse roots; pH = 5.6; clear mooth boundary to:

AB 10 -64 cm dark reddish brown (5 YR 3/2 moist, 5 YR 3/3 dry); clay; moderate medium subangular blocky; hard, friable, sticky and plastic; patchy thin clay cutans, common shiny ped faces; many micro, common very fine, many fine, few medium pores; many fine, common coarse roots; pH = 5.0; clear and smooth boundary to:

Bt1 64-102 cm dark reddish brown (2.5 YR 3/4) moist, dark red (2.5 YR 3/6) dry; clay; moderate medium subangular blocky; very hard, firm, sticky and plastic; patchy clay cutans, common shiny ped faces; many micro, common fine, few medium pores; common fine, few medium roots; pH = 5.9; clear smooth boundary to:

Bt2 102-155+ cm dark reddish brown (2.5 YR 3/4) moist, dark red (2.5 YR 3/6) dry; clay; moderate coarse angular blocky; hard, firm, slightly plastic and very sticky; common shiny ped faces; many micro, many very fine, common fine, common medium, few coarse pores; few small soft black nodules; few fine, common medium roots; pH = 6.3.

PROFILE DESCRIPTION

Date/ season	:21/6/86; end of rainy season
Observation No.	:B17
Coordinates	:3685 E, 99665 N
Elevation	:900 m
Authors	:Mateos,Suluvale,Szogi
Soil mapping unit	:Uwbp
Soil classification	:Chromic luvisol
Geology	:Basement
Local petrography (Parent material)	:Gneiss complex
Physiography	:Upland
Macro-relief	:Undulating
Slope (length, shape and pattern)	:500 m,convex,regular
Slope gradient	:2%
Position on slope	:Upper
Meso- and micro-relief	:none
Vegetation/ Landuse	:Arable & grassland
Erosion	:Slight sheet
Rock outcrops	:Fairly rocky
Surface stoniness	:Fairly stony
Overwash	:Very slight
Surface runoff	:Rapid
Surface sealing/crusting/cracking	:Slight sealing
Drainage class	:Well drained
Flooding	:none
Groundwater level (actual)	:> 0.80 m
Presence of salts/ alkali	:none
Soil fauna	:Ants
Expected rooting depth	:80 cm

Horizons:

1Ap 0-7 cm dark reddish brown (5 YR 3/3 moist, 5 YR 3/4 dry); clay; weak coarse subangular blocky breaks into moderate fine subangular blocky; slightly hard, friable, sticky and plastic; common micro, many fine, few coarse pores; common fine, few medium, few coarse roots; pH = 5.6; clear smooth boundary to:

1Bt 7-45 cm dark reddish brown (2.5 YR 3/4) moist, dark red (2.5 YR 3/6) dry; clay; moderate medium subangular blocky; slightly hard, friable, sticky and plastic; patchy thin clay cutans; many micro, many fine,few coarse pores; many fine, few medium, few coarse roots; PH = 6.7; clear wavy boundary to:

2C 45-57 cm Gravel stone line

3Bt 57-80 cm dark reddish brown (2.5 YR 3/4) moist, dark red (2.5 YR 3/6) dry; slightly gravelly clay; weak medium subangular blocky; slightly hard, friable, sticky and plastic; patchy thin clay cutans; many micro, many fine, few coarse pores; many fine, few medium, few coarse roots; pH = 6.9; abrupt irregular boundary to:

3C 80-100+ cm Rotten rock.

PROFILE DESCRIPTION

Date/ season	:25/6/86; end of rainy season
Observation No.	:B27
Coordinates	:3682 E, 99636 N
Elevation	:795 m
Authors	:Suluvale,Magoggo,Zhu
Soil mapping unit	:LcIbp
Soil classification	:Haplic phaeozem
Geology	:Basement
Local petrography (Parent material)	:Colluvium over alluvium
Physiography	:Scarpment
Macro-relief	:Undulating
Slope (length, shape and pattern)	:-
Slope gradient	:5%
Position on slope	:Lower
Meso- and micro-relief	:none
Vegetation/ Landuse	:Arable land (millet)
Erosion	:Moderate sheet
Rock outcrops	:none
Surface stoniness	:none
Overwash	:none
Surface runoff	:Slow
Surface sealing/crusting/cracking	:-
Drainage class	:Well drained
Flooding	:none
Groundwater level (actual)	:> 0.90 m
Presence of salts/ alkali	:none
Soil fauna	:-
Expected rooting depth	:30 cm
Remarks	:Red colluvial soil over stone line over grey alluvium

Horizons:

1A 0-30 cm dark brown (7.5 YR 3/2 moist, 7.5 YR 4/2 dry); gravelly clay; moderate coarse subangular blocky; very friable, sticky and plastic; many micro, many very fine, many fine, common medium, few coarse pores; many very fine, many fine, common medium, many coarse roots; smallrounded gravels; pH = 6.2; abrupt smooth boundary to:

2Bw 30-55 cm dark reddish brown (5 YR 3/3) moist; reddish brown (5 YR 4/3) dry; gravelly, stony clay; weak medium subangular blocky and weak fine subangular blocky; sticky and plastic; many micro pores; few fine, few medium, few coarse roots; basalt stones and gravels (stone line); pH = 7.0; clear smooth boundary to:

3Bt 55-90+ cm dark brown (7.5 YR 3/2 moist, 7.5 YR 4/2 dry); gravelly clay; moderate coarse angular blocky; extra hard, very firm, very sticky and very plastic; broken thin clay (stress) cutans; few micro, few very fine, few fine, few medium pores; few fine, few medium roots; pH = 7.0 .

PROFILE DESCRIPTION

Date/ season	:25/6/86; end of rainy season
Observation No.	:B24
Coordinates	:3757 E, 99695 N
Elevation	:690 m
Authors	:Udaya,Szogi
Soil mapping unit	:UWb
Soil classification	:Chromic luvisol
Geology	:Basement
Local petrography (Parent material)	:Gneiss
Physiography	:Upland
Macro-relief	:Undulating
Slope (length, shape and pattern)	:200 m,convex,irregular
Slope gradient	:3%
Position on slope	:Upper
Meso- and micro-relief	:none
Vegetation/ Landuse	:Arable & grassland
Erosion	:Severe sheet & rill, moderate gully
Rock outcrops	:none
Surface stoniness	:Stony
Overwash	:none
Surface runoff	:Rapid
Surface sealing/crusting/cracking	:Moderate crusting & cracking
Drainage class	:Well drained
Flooding	:none
Groundwater level (actual)	:> 0.90 m
Presence of salts/ alkali	:none
Soil fauna	:-
Expected rooting depth	:75 cm

Horizons:

Btl 0-20 cm dusky red (10 R 3/4) moist, dark red (2.5 YR 3/6) dry; clay; moderate coarse subangular blocky; hard, friable, very sticky and plastic; patchy thin clay cutans; many micro, many very fine, many fine, many medium, few coarse pores; common very fine, common fine, few medium roots; pH = 6.4; gradual smooth boundary to:

Bt2 20-50 cm dark reddish brown (2.5 YR 3/4) moist, dark red (2.5 YR 3/6) dry; clay; moderate coarse subangular blocky; hard, friable, very sticky and plastic; broken thin clay cutans; common micro, many very fine, many fine, common medium pores; few very fine, few fine roots; pH = 6.8; clear smooth boundary to :

BC 50-75 cm red (2.5 YR 4/6 moist, 2.5 YR 5/6 dry); slightly gravelly clay; structureless massive; hard, friable, slightly sticky and slightly plastic; patchy thin clay cutans around gravels; common fine, few coarse pores; few fine roots; pH = 6.6; clear smooth boundary to:

C 75-90+ cm rotten rock (gneiss)

PROFILE DESCRIPTION

Date/ season	:25/6/86; end of rainy season
Observation No.	:B22
Coordinates	:3745 E, 99665 N
Elevation	:770 m
Authors	:Udaya,Szogi
Soil mapping unit	:UBc
Soil classification	:Umbric cambisol
Geology	:Nyambeni volcanics
Local petrography (Parent material)	:Basalt
Physiography	:Upland
Macro-relief	:Undulating
Slope (length, shape and pattern)	:300 m,convex,regular
Slope gradient	:3%
Position on slope	:Upper
Meso- and micro-relief	:none
Vegetation/ Landuse	:Grassland
Erosion	:Moderate sheet
Rock outcrops	:none
Surface stoniness	:Very stony
Overwash	:none
Surface runoff	:Medium
Surface sealing/crusting/cracking	:Slight crusting
Drainage class	:Well drained
Flooding	:none
Groundwater level (actual)	:> 1.60 m
Presence of salts/ alkali	:none
Soil fauna	:-
Expected rooting depth	:120 cm

Horizons:

A 0-25 cm dark reddish brown (5 YR 3/3 moist, 5 YR 3/4 dry); slightly gravelly, slightly stony clay; weak fine subangular blocky breaks into weak very fine crumbs; soft, friable, sticky and slightly plastic; many micro, many very fine, many fine, common medium, few coarse pores; many very fine, many fine, few medium roots; murram gravel; pH = 4.0; clear smooth boundary to:

BC 25-55 cm dark red (2.5 YR 3/6) moist, red (2.5 YR 4/6) dry; gravelly clay; weak very fine subangular blocky; soft, very friable, slightly sticky and slightly plastic; many micro, many very fine, common medium pores; many very fine, many fine, few medium roots; murram gravel; pH = 5.8; clear smooth boundary to:

C1 55-85 cm dark red (2.5 YR 3/6) moist, red (2.5 YR 4/8) dry; gravelly, stony, bouldery clay;structureless single grain; loose, sticky and slightly plastic; few medium pores; few very fine, common fine roots; murram gravel; pH = 5.2; clear smooth boundary to:

C2 85-160+ cm dark red (2.5 YR 3/6) moist, red (2.5 YR 4/6) dry; gravelly, stony, bouldery clay; structureless single grain; few fine roots; murram gravel; pH = 5.4 .

PROFILE DESCRIPTION

Date/ season	:7/6/86; end of rainy season
Observation No.	:B4
Coordinates	:3725 E, 99658 N
Elevation	:800 m
Authors	:Sulu,Buss,Udaya,Magoggo,Jordens
Soil mapping unit	:UV
Soil classification	:Chromic cambisol
Geology	:Basement
Local petrography (Parent material)	:Gneiss & colluvium
Physiography	:Upland
Macro-relief	:Undulating
Slope (length, shape and pattern)	:200 m, convex, regular
Slope gradient	:6%
Position on slope	:Middle slope
Meso- and micro-relief	:none
Vegetation/ Landuse	:Grassland
Erosion	:Moderate sheet and rill
Rock outcrops	:none
Surface stoniness	:Fairly stony
Overwash	:none
Surface runoff	:Medium
Surface sealing/crusting/cracking	:Moderate crusting
Drainage class	:Well drained
Flooding	:none
Groundwater level (actual)	:always deep, > 1.35 m
Presence of salts/ alkali	:none
Soil fauna	:termites
Expected rooting depth	:135 cm

Horizons:

1A 0 -14 cm dark reddish brown (5 YR 3/4) moist, reddish brown (5 YR 4/4) dry; clay; medium moderate crumbs; very hard, friable, sticky and plastic; many micro, many fine, many medium, pores; common fine roots; pH = 6.5; clear smooth boundary to:

1Bw 14-32 cm dark red (2.5 YR 3/6) moist, red (2.5 YR 4/6) dry; clay; moderate coarse subangular blocky; very hard,firm, sticky and plastic; many micro, many fine, many medium, few coarse pores; few fine roots; pH = 6.4; abrupt and wavy boundary to:

2C 32-55 cm dark red (2.5 YR 3/6) moist, red (2.5 YR 4/6) dry; very gravelly (stone line) clay; very hard, firm, sticky and plastic; many micro, many fine pores; few fine, few coarse roots; pH = 6.2; abrupt wavy boundary to:

3Btb1 55-82 cm dark red (2.5 YR 3/6) moist, red (2.5 YR 4/6) dry; clay; medium coarse angular blocky; very hard, firm, sticky and plastic; patchy thin clay cutans; many micro, many fine, common medium, few coarse pores; few fine roots; pH = 6.1; gradual smooth boundary to:

3Btb2 82-109 cm dark red (2.5 YR 3/6) moist, reddish brown (2.5 YR 4/4) dry; clay; weak fine subangular blocky; very hard, firm, sticky and plastic; patchy thin clay cutans; many micro, many fine, many medium pores; few very fine roots; pH = 7.0; abrupt wavy boundary to:

3C 109-135+ cm Rotten rock; pH = 7.0

PROFILE DESCRIPTION

Date/ season	:25/6/86; end of rainy season
Observation No.	:B25
Coordinates	:3740 E, 99700 N
Elevation	:750 m
Authors	:Buss,Mateos,Jordens
Soil mapping unit	:UWr
Soil classification	:Dystric Cambisol
Geology	:Basement
Local petrography (Parent material)	:Gneiss
Physiography	:Upland
Macro-relief	:Undulating
Slope (length, shape and pattern)	:300 m,convex,regular
Slope gradient	:1%
Position on slope	:Summit
Meso- and micro-relief	:none
Vegetation/ Landuse	:Arable land
Erosion	:none
Rock outcrops	:none
Surface stoniness	:Fairly stony
Overwash	:none
Surface runoff	:Medium
Surface sealing/crusting/cracking	:Slight sealing
Drainage class	:Well drained
Flooding	:none
Groundwater level (actual)	:> 1.25 m
Presence of salts/ alkali	:none
Soil fauna	:-
Expected rooting depth	:125 cm

Horizons:

A 0-12 cm dark reddish brown (5 YR 3/3 moist, 5 YR 3/4 dry); slightly gravelly clay; moderate fine subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; many micro, common fine pores; many very fine, many fine, common medium, few coarse roots; pH = 6.9; clear smooth boundary to:

Bw 12-27 cm dark reddish brown (5 YR 3/4) moist, reddish brown (5 YR 4/4) dry; slightly gravelly clay;moderate medium subangular blocky; slightly hard, very friable, sticky and plastic; many micro, common fine, few coarse pores; many fine, common medium, few coarse roots; pH = 6.0; clear smooth boundary to:

CB 27-57 cm reddish brown (5 YR 4/4) moist, yellowish red (5 YR 4/6) dry; very gravelly clay; structureless, single grain; soft, loose, slightly sticky and slightly plastic; many micro, few fine pores; common fine, few medium roots; pH = 5.9; clear wavy boundary to:

C1 57-78 cm yellowish red (5 YR 4/6 moist, 5 YR 5/8 dry); very gravelly, stony clay; structureless, single grain; soft, loose, slightly sticky and slightly plastic; common micro, few fine pores; common fine, few medium roots; murram gravel; pH = 5.9; clear wavy boundary to:

C2 78-125+ cm yellowish red (5 YR 4/6 moist, 5 YR 5/8 dry); very gravelly clay; structureless, single grain; soft, loose, slightly sticky and slightly plastic; common micro, few fine pores; common fine, few medium roots; murram gravel; pH = 5.8 .

PROFILE DESCRIPTION

Date/ season	:25/6/86; end of rainy season
Observation No.	:B21
Coordinates	:3624 E, 99653 N
Elevation	:940 m
Authors	:Buss,Mateos,Jordens
Soil mapping unit	:UI
Soil classification	:Umbric cambisol
Geology	:Mt Kenya volcanics
Local petrography (Parent material)	:Lahar
Physiography	:Upland
Macro-relief	:Rolling
Slope (length, shape and pattern)	:200 m,convex,irregular
Slope gradient	:10%
Position on slope	:Middle
Meso- and micro-relief	:none
Vegetation/ Landuse	:Bushes & grasses. Grassland
Erosion	:Moderate sheet and slightly sheet
Rock outcrops	:none
Surface stoniness	:Very gravelly & stony, bouldery
Overwash	:none
Surface runoff	:Medium
Surface sealing/crusting/cracking	:Slight sealing
Drainage class	:Somewhat excessively drained
Flooding	:none
Groundwater level (actual)	:> 1.10 m
Presence of salts/ alkali	:none
Soil fauna	:-
Expected rooting depth	:100 cm

Horizons:

A 0-14 cm very dark grey (10 YR 3/1) moist, very dark greyish brown (10 YR 3/2) dry; slightly gravelly, slightly stony clay; weak fine subangular blocky; slightly hard, very friable, sticky and plastic; many micro, many very fine, many fine, few medium pores; many fine, common medium roots; pH = 6.0; clear smooth boundary to:

AB 14-32 cm dark reddish brown (5 YR 3/3 moist, 5 YR 3/4 dry); slightly gravelly, slightly stony weak fine subangular blocky; slightly hard, friable, sticky and plastic; many micro, many fine, few medium, few coarse pores; many fine, common medium roots; murram gravel; pH = 6.0; clear smooth boundary to:

Bw 32-49 cm dark reddish brown (5 YR 3/4) moist, yellowish red (5 YR 4/6) dry; slightly gravelly, stony clay; moderate medium subangular blocky; slightly hard, friable, sticky and plastic; many micro, many fine, common medium pores; many fine, common medium roots; pH = 5.7; gradual wavy boundary to:

CB 49-55 cm dark brown (7.5 YR 3/4) moist, strong brown (7.5 YR 4/6) dry; slightly gravelly, stony clay; moderate fine angular and subangular blocky; very hard, friable, sticky and slightly plastic; many micro, many fine, few medium pores; common fine roots; pH = 6.1; clear wavy boundary to:

C 55-110+ cm dark brown (10 YR 3/3) moist; slightly gravelly, stony clay; structureless, single grain; very hard, very firm, sticky and slightly plastic; common micro, common medium pores; common fine roots; weathered fragments of rock (lahar); pH = 6.1 .

PROFILE DESCRIPTION

Date/ season	:21/6/86; end of rainy season
Observation No.	:B19
Coordinates	:3708 E, 99664 N
Elevation	:800 m
Authors	:Suluvale,Buss,Udaya,Jordens
Soil mapping unit	:UWbp
Soil classification	:Chromic cambisol
Geology	:Basement
Local petrography (Parent material)	:Gneiss
Physiography	:Upland
Macro-relief	:Undulating
Slope (length, shape and pattern)	:200 m,linear,single
Slope gradient	:2%
Position on slope	:Middle
Meso- and micro-relief	:none
Vegetation/ Landuse	:Grassland
Erosion	:Slight sheet
Rock outcrops	:none
Surface stoniness	:Fairly stony
Overwash	:none
Surface runoff	:Slow
Surface sealing/crusting/cracking	:Slight sealing
Drainage class	:Well drained
Flooding	:none
Groundwater level (actual)	:> 1.1 m
Presence of salts/ alkali	:none
Soil fauna	:Ants
Expected rooting depth	:80 cm

Horizons:

A 0-14 cm dark reddish brown (5 YR 3/3 moist, 5 YR 3/4 dry); slightly gravelly clay; moderate fine subangular blocky; slightly hard, very friable, sticky and plastic; many micro, few fine,few medium pores; common very fine, few medium, few coarse roots; quartz gravel; pH = 7.0; clear smooth boundary to:

Bw 14-42 cm dark reddish brown (5 YR 3/4) moist, yellowish red (5 YR 4/6); slightly gravelly clay; slightly hard, friable, sticky and plastic; many micro, few fine pores; common very fine, common fine roots; pH = 7.0; abrupt wavy boundary to:

C 42-110+ cm very gravely; massive; few fine roots; pH = 7.7

PROFILE DESCRIPTION

Date/ season	:25/6/86; end of rainy season
Observation No.	:B23
Coordinates	:3757 E, 99770 N
Elevation	:760 m
Authors	:Buss,Mateos,Jordens
Soil mapping unit	:UWrp
Soil classification	:Chromic cambisol
Geology	:Basement
Local petrography (Parent material)	:Gneiss
Physiography	:Upland
Macro-relief	:Undulating
Slope (length, shape and pattern)	:200 m,convex,irregular
Slope gradient	:3%
Position on slope	:Middle
Meso- and micro-relief	:none
Vegetation/ Landuse	:Arable & grassland
Erosion	:Slight sheet
Rock outcrops	:none
Surface stoniness	:Gravelly,stony,bouldery
Overwash	:none
Surface runoff	:Rapid
Surface sealing/crusting/cracking	:Moderate sealing
Drainage class	:Well drained
Flooding	:none
Groundwater level (actual)	:> 1.0 m
Presence of salts/ alkali	:none
Soil fauna	:-
Expected rooting depth	:100 cm

Horizons:

A 0-12 cm dark brown (5 YR 3/4 moist, 5 YR 4/4 dry); clay; weak coarse subangular blocky breaks into moderate fine subangular blocky; slightly hard, very friable, sticky and plastic; many micro, many fine, common medium,few coarse pores; common fine, few medium, few coarse roots; quartz gravel; pH = 6.8; clear smooth boundary to:

Bw 12-46 cm dark brown (5 YR 3/4) moist, strong brown (5 YR 4/6) dry; slightly gravelly clay; hard, friable, sticky and plastic; many micro, many very fine, common fine, few medium pores; common fine, few medium, few coarse roots; quartz gravel; pH = 7.1; abrupt wavy boundary to:

CR 46-100+ cm weathered rock (gneiss); few fine roots.

PROFILE DESCRIPTION

Date/ season	:7/6/86; end of rainy season
Observation No.	:B7
Coordinates	:3678 E, 99689 N
Elevation	:870 m
Authors	:Sulu,Buss,Mateos,Udaya
Soil mapping unit	:LtIbp
Soil classification	:Mollic leptosol
Geology	:Mt. Kenya volcanics
Local petrography (Parent material)	:Lahar
Physiography	:Plateau
Macro-relief	:Flat
Slope (length, shape and pattern)	:-
Slope gradient	:0%
Position on slope	:-
Meso- and micro-relief	:none
Vegetation/ Landuse	:Grassland
Erosion	:none
Rock outcrops	:Rocky
Surface stoniness	:Very stone
Overwash	:none
Surface runoff	:none
Surface sealing/crusting/cracking	:none
Drainage class	:Well drained
Flooding	:none
Groundwater level (actual)	:-
Presence of salts/ alkali	:none
Soil fauna	:-
Expected rooting depth	:25 cm

Horizons:

A 0 -16 cm very dark greyish brown (10 YR 3/2) moist, dark brown (10 YR 3/3) dry; silty clay loam; weak medium subangular blocky breaks in moderate fine crumbs; soft, very friable, slighty sticky and slighty platic; many micro,many very fine, common fine, common medium pores; many fine, few coarse roots; pH = 6.1; clear and wavy boundary to:

AC 16-30 cm very dark greyish brown (10 YR 3/2) moist, dark brown (10 YR 3/3) dry; gravelly, silty clay loam; moderate medium crumbs; loose, slightly sticky and slightly plastic; many micro, many very fine, many fine pores; common fine roots; pH = 6.8; clear and wavy boundary to:

C 30-45 cm dark brown (10 YR 3/3) moist; gravel; soft, very friable, slightly sticky and non-plastic; few fine, few coarse roots; pH = 6.9; clear and irregular boundary to:

R 45-83+ cm layer of continuous indurated rock (Lahar).

PROFILE DESCRIPTION

Date/ season	:11/6/86; end of rainy season
Observation No.	:B8
Coordinates	:3715 E, 99618 N
Elevation	:800 m
Authors	:Sulu,Buss,Magoggo,Szogi
Soil mapping unit	:UWrp
Soil classification (FAO, soil taxonomy)	:Chromic cambisol
Geology	:Basement
Local petrography (Parent material)	:Gneiss
Physiography	.Upland
Macro-relief	:Undulating
Slope (length, shape and pattern)	:200 m,convex,regular
Slope gradient	:3%
Position on slope	:summit
Meso- and micro-relief	:none
Vegetation/ Landuse	:Grazing
Erosion	:Moderate sheet
Rock outcrops	:Rocky
Surface stoniness	:Stony
Overwash	:none
Surface runoff	:none
Surface sealing/crusting/cracking	:Slight sealing
Drainage class	:Well drained
Flooding	:none
Groundwater level (actual)	:> 0.50 m
Presence of salts/ alkali	:none
Soil fauna	:-
Expected rooting depth	:55 cm

Horizons:

A 0-10 cm dark reddish brown (2.5 YR 3/4 moist, 5 YR 3/4 dry); slightly gravelly sandy clay; weak medium subangular blocky; hard, friable, sticky and slightly plastic; common micro, common fine, few coarse pores; common fine, few medium roots; quartz gravel; pH = 6.2; clear smooth boundary to:

Bw 10-40 cm dark red (2.5 YR 3/6) moist, yellowish red (5 YR 4/6); gravelly clay; weak fine subangular blocky; hard, firm, sticky and plastic; common micro, common fine, few coarse pores; few fine, few medium roots; quartz gravel; pH = 6.4; clear smooth boundary to:

BC 40-55 cm dark red (2.5 YR 3/6) moist, yellowish red (5 YR 4/6); very gravelly clay; weak fine subangular blocky; hard, firm, sticky and plastic; few micro, few fine pores; few very fine roots; quartz gravel; pH = 6.7; abrupt irregular boundary to:

C 55-60+ cm Rotten rock (Gneiss).

PROFILE DESCRIPTION

Date/ season	:6/6/86; end of rainy season
Observation No.	:B2
Coordinates	:3648 E, 99680 N
Elevation	:1000 m
Authors	:Sulu,Buss,Magoggo,Szogi,Mateos,Udaya,Zhu
Soil mapping unit	:UIbp
Soil classification	:Dystric cambisol
Geology	:Mt. Kenya volcanics
Local petrography (Parent material)	:Lahars
Physiography	:Upland
Macro-relief	:Undulating
Slope (length, shape and pattern)	:300 m,convex,regular
Slope gradient	:2%
Position on slope	:Middle
Meso- and micro-relief	:none
Vegetation/ Landuse	:Grasses & shrubs. Grassland
Erosion	:none
Rock outcrops	:none
Surface stoniness	:Slightly stony
Overwash	:Very slight
Surface runoff	:Moderate
Surface sealing/crusting/cracking	:Slight sealing
Drainage class	:Well drained
Flooding	:none
Groundwater level (actual)	:> 0.30 m
Presence of salts/ alkali	:none
Soil fauna	:-
Expected rooting depth	:30 cm

Horizons:

A 0-10 cm dark brown (7.5 YR 3/2) moist, brown (7.5 YR 4/4) dry; very gravelly clay; medium fine crumbs; soft, loose, sticky and plastic; many micro, many very fine, few fine, few medium pores; many very fine, many fine, common medium, few coarse roots; murram gravel; pH = 6.0; abrupt smooth boundary to:

Bw1 10-23 cm dark reddish brown (5 YR 3/4) moist, reddish brown (5 YR 4/4) dry; very gravelly clay; weak medium subangular blocky; loose, sticky and plastic; many micro, many very fine, many fine, few medium pores; many fine, few medium roots; murram gravel; pH = 6.1; gradual smooth boundary to:

Bw2 23-30 cm dark reddish brown (2.5 YR 3/4) moist, dark red (2.5 YR 3/6); very gravelly clay; weak medium subangular blocky; loose, sticky and plastic; many micro, common very fine, few medium pores; many fine, common medium roots; murram gravel; pH = 5.7; diffuse broken boundary to:

C 30-120+ cm Structureless single grain; gravel, murram.

PROFILE DESCRIPTION

Date/ season	:21/6/86; end of rainy season
Observation No.	:B20
Coordinates	:3728 E, 99648 N
Elevation	:750 m
Authors	:Buss,Udaya,Zhu
Soil mapping unit	:UWbp
Soil classification	:Chromic luvisol
Geology	:Basement
Local petrography (Parent material)	:Gneiss
Physiography	:Upland
Macro-relief	:Undulating
Slope (length, shape and pattern)	:200 m,linear,single
Slope gradient	:4%
Position on slope	:Upper
Meso- and micro-relief	:none
Vegetation/ Landuse	:Grassland
Erosion	:Moderate sheet
Rock outcrops	:none
Surface stoniness	:Stony & bouldery
Overwash	:Slight
Surface runoff	:Medium
Surface sealing/crusting/cracking	:Slight sealing
Drainage class	:Well drained
Flooding	:none
Groundwater level (actual)	:always deep, > 1.1 m
Presence of salts/ alkali	:none
Soil fauna	:Termites
Expected rooting depth	:60 cm

Horizons:

A 0-15 cm dark reddish brown (5 YR 3/2 moist, 5 YR 3/4 dry); slightly gravelly clay; weak medium subangular blocky; slightly hard, friable, sticky and plastic; many micro, many very fine, few medium pores; few very fine roots; quartz gravel; pH = 7.0; clear smooth boundary to:

Bt 15-25 cm dark reddish brown (5 YR 3/4) moist, yellowish red (5 YR 4/6) dry; clay; moderate medium subangular blocky; slightly hard, friable, very sticky and plastic; patchy thin clay cutans; many micro, common fine, few medium pores; few very fine roots; quartz gravel; pH = 6.6; clear wavy boundary to:

BC 25-63 cm reddish brown (5 YR 4/4) moist, yellowish red (5 YR 4/6) dry; gravelly clay; slightly hard, very friable, sticky and slightly plastick; many micro, many fine pores; few very fine roots; quartz gravel; pH = 7.2; abrupt wavy boundary to:

C 63-105+ cm Rotten rock

PROFILE DESCRIPTION

Date/ season	:25/6/86; end of rainy season
Observation No.	:B26
Coordinates	:3726 E, 9970 N
Elevation	:760 m
Authors	:Udaya,Szogi
Soil mapping unit	:UWrd
Soil classification (FAO, soil taxonomy)	:Chromic luvisol
Geology	:Basement
Local petrography (Parent material)	:Gneiss
Physiography	:Upland
Macro-relief	:Undulating
Slope (length, shape and pattern)	:300 m,convex,regular
Slope gradient	:2%
Position on slope	:Medium
Meso- and micro-relief	:none
Vegetation/ Landuse	:Arable land
Erosion	:Moderate sheet & rill
Rock outcrops	:none
Surface stoniness	:none
Overwash	:none
Surface runoff	:Medium
Surface sealing/crusting/cracking	:Slight sealing
Drainage class	:Well drained
Flooding	:none
Groundwater level (actual)	:> 1,20 m
Presence of salts/ alkali	:none
Soil fauna	:Termites
Expected rooting depth	:120 cm

Horizons:

A 0-10 cm dark reddish brown (2.5 YR 3/4) moist, dark red (2.5 YR 3/6) dry; clay; weak medium subangular blocky breaks into strong very fine crumbs; hard, friable, sticky and slightly plastic; many micro, many fine, many medium, few coarse pores; few fine, common medium roots; pH = 6.4; gradual smooth boundary to:

Bt1 10-45 cm dark red (2.5 YR 3/6) moist, red (2.5 YR 4/6) dry; clay; moderate medium subangular blocky; slightly hard, friable, sticky and plastic; patchy thin clay cutans; many micro, common very fine, many fine, common medium pores; common very fine, common fine, few fine roots; pH = 7.1;c lear smooth boundary to:

Bt2 45-70 cm dark red (10 R 3/6 moist, 2.5 YR 4/6 dry); clay; moderate medium subangular blocky; slightly hard, friable, sticky and plastic; patchy thin clay cutans; many micro, many very fine, common medium pores; few fine, few medium roots; pH = 6.9; clear smooth boundary to:

BC 70-90 cm red (2.5 YR 4/6) moist and dry; slightly gravelly clay; structureless single grain; slightly hard, friable, sticky and slightly plastic; few very fine, few fine roots; pH = 7.4; abrupt smooth boundary to:

C 90-120 cm rotten rock muscovite gneiss.

PROFILE DESCRIPTION

Date/ season	:25/6/86; end of rainy season
Observation No.	:B14
Coordinates	:3738 E, 99628 N
Elevation	:690 m
Authors	:Buss,Mateos,Jordens
Soil mapping unit	:UWr
Soil classification	:Chromic luvisol
Geology	:Basement
Local petrography (Parent material)	:Gneiss
Physiography	:Upland
Macro-relief	:Undulating
Slope (length, shape and pattern)	:200 m,convex,complex
Slope gradient	:5%
Position on slope	:Middle
Meso- and micro-relief	:none
Vegetation/ Landuse	:Arable land
Erosion	:Slight sheet
Rock outcrops	:none
Surface stoniness	:Fairly stony
Overwash	:none
Surface runoff	:Rapid
Surface sealing/crusting/cracking	:Moderate sealing
Drainage class	:Well drained
Flooding	:none
Groundwater level (actual)	:> 1.50 m
Presence of salts/ alkali	:none
Soil fauna	:-
Expected rooting depth	:75 cm

Horizons:

A 0-16 cm reddih brown (2.5 YR 4/4) moist, red (2.5 YR 4/6) dry; clay; moderate medium subangular blocky; slightly hard, very friable, sticky and plastic; many micro, many fine, few medium pores; common fine roots; pH = 6.5; clear smooth boundary to:

Bt 16-26 cm red (2.5 YR 4/6 moist, 2.5 YR 4/8 dry); clay; weak coarse compound prisms breaks into moderate medium subangular blocky; slightly hard, very friable, sticky and plastic; patchy thin clay cutans; many micro, many very fine, many fine, few medium pores; few fine roots; pH = 7.0; clear smooth boundary to:

BC 26-75 cm red (2.5 YR 4/6 moist, 2.5 YR 4/8 dry); clay; weak fine subangular blocky; very hard, friable, sticky and slightly plastic; few fine roots; pH = 7.0; abrupt wavy boundary to:

CR 75-150+ cm weathered gneiss.

PROFILE DESCRIPTION

Date/ season	:6/6/86; end of rainy season
Observation No.	: B3
Coordinates	:3675 E, 99668 N
Elevation	: 900 m
Authors	:Sulu,Buss,Magoggo,Szogi,Mateos,Udaya,Zhu
Soil mapping unit	:UV
Soil classification	:Haplic alisol
Geology	:Mt. Kenya volcanics
Localpetrography (Parent material)	:Unconsolidated sediments
Physiography	:River plain colluvium at upland
Macro-relief	:Undulating
Slope (length, shape and pattern)	:100 m,convex,regular
Slope gradient	:2%
Position on slope	:Lower slope
Meso- and micro-relief	:none
Vegetation/ Landuse	: Arable land Erosion :Slight sheet and rill
Rock outcrops	:none
Surface stoniness	:none
Overwash	:Slight
Surface runoff	:Medium
Surface sealing/crusting/cracking	:Moderate sealing
Drainage class	:Well drained
Flooding	:none
Groundwater level (actual)	:> 1.50 m
Presence of salts/ alkali	:none
Soil fauna	:-
Expected rooting depth	:150 cm

Horizons:

Ap 0 -20 cm reddish brown (5 YR 4/3) moist, yellowish red (5 YR 5/6) dry; clay; weak medium crumbs; soft, very friable, sticky and plastic; many micro, many fine, many medium pores many fine, few medium roots; pH = 6.6; clear smooth boundary to:

Bt1 20-40 cm dark reddish brown (5 YR 3/3 moist, 5 YR 3/4 dry); clay; moderate coarse angular blocky breaks into strong fine crumbs; slightly hard, friable, sticky and plastic; patchy thin cutans; many micro, many fine, common medium, common coarse pores; many fine roots; pH = 6.6; clear smooth boundary to:

Bt2 40-90 cm dark reddish brown (5 YR 3/3 moist, 5 YR 3/4 dry); slightly gravelly clay; moderate coarse angular blocky; very hard, firm, sticky and plastic; broken thin clay cutans; many micro, many fine, common medium pores; few fine roots; pH = 6.1; gradual smooth boundary to:

BC 90-150+ cm reddish brown (5 YR 4/4) moist, yellowish red (5 YR 5/8) dry; slightly gravelly clay; slightly hard, friable, sticky and plastic; many micro, many fine few medium pores; few coarse roots; pH = 6.3.

PROFILE DESCRIPTION

Date/ season	:11/6/86; end of rainy season
Observation No.	: B6
Coordinates	:3668 E, 99644 N
Elevation	: 825 m
Authors	:Mateos,Udaya,Zhu,Szogi,Jordens
Soil mapping unit	:LtIbp
Soil classification	:Mollic leptosol
Geology	:Mt. Kenya volcanics
Localpetrography (Parent material)	:Lahars
Physiography	:Plateau
Macro-relief	:Flat
Slope (length, shape and pattern)	:700 m,convex,single
Slope gradient	:0-2%
Position on slope	:middle slope
Meso- and micro-relief	:none
Vegetation/ Landuse	: Herbs and grasses. Grazing Erosion :slight sheet and gully
Rock outcrops	:Rocky
Surface stoniness	:Stony
Overwash	:none
Surface runoff	:Medium
Surface sealing/crusting/cracking	:Moderate sealing
Drainage class	:Well drained
Flooding	:none
Groundwater level (actual)	:> 0.70 m
Presence of salts/ alkali	:none
Soil fauna	:-
Expected rooting depth	:0.64 m

Horizons:

A 0 -31 cm very dark greyish brown (10 YR 3/2) moist, dark brown (10 YR 3/3) dry; clay; weak medium subangular blocky breaks into weak fine crumbs; slightly hard, friable, slightly sticky and slightly plastic; many micro, many fine, common medium pores; few fine, few medium, few coarse roots; pH = 6.4; clear smooth boundary to:

Bw 31-50 cm very dark greyish brown (10 YR 3/2) moist, dark yellowish brown (10 YR 4/4); slightly gravelly, clay; weak coarse subangular blocky breaks into weak fine crumbs; slightly hard, friable, sticky and plastic; many micro, common medium pores; common fine, few medium roots; pH = 6.2; clear smooth boundary to:

BC 50-64 cm dark brown (7.5 YR 3/4) moist, strong brown (7.5 YR 4/6) dry; very gravelly clay; weak fine subangular blocky; slightly hard, friable, sticky and plastic; few micro, few very fine pores; few fine roots; pH = 6.6; clear smooth boundary to:

R 64-70 cm layer of continuous indurated rock (lahar).

PROFILE DESCRIPTION

Date/ season	:26/6/86; end of rainy season
Observation No.	: B10
Coordinates	:3616 E, 99655 N
Elevation	: 975 m
Authors	:Buss,Mateos,Jordens
Soil mapping unit	:UI
Soil classification	:Chromic luvisol
Geology	:Mt Kenya volcanics
Localpetrography (Parent material)	:Lahar
Physiography	:Upland
Macro-relief	:Undulating
Slope (length, shape and pattern)	:300 m,linear,regular
Slope gradient	:5%
Position on slope	:Middle
Meso- and micro-relief	:none
Vegetation/ Landuse	: Grassland
Erosion	:Moderate sheet
Rock outcrops	:none
Surface stoniness	:Stony & bouldery
Overwash	:none
Surface runoff	:none
Surface sealing/crusting/cracking	:Moderate sealing
Drainage class	:Well drained
Flooding	:none
Groundwater level (actual)	:> 1.20 m
Presence of salts/ alkali	:none
Soil fauna	:-
Expected rooting depth	:120 cm

Horizons:

A 0-25 cm dark brown (7.5 YR 3/2 moist, 7.5 YR 3/4 dry); clay; weak corse subangular blocky breaks into moderate fine subangular blocky; slightly hard, very friable, sticky and plastic; many micro, many fine, common medium pores; many fine, common medium, few corse roots; pH = 5.5; clear smooth boundary to:

Bt 25-65 cm yellowish red (5 YR 4/6 moist, 5 YR 5/6 dry); clay; weak coarse compound rough prisms breaks into moderate medium subangular blocky; hard, very friable, very sticky and plastic; patchy thin clay cutans; many micro, many very fine, many fine, common medium pores; common fine, few medium roots; pH = 6.5; clear smooth boundary to:

C 65-120+ cm yellowish red (5 YR 4/6 moist, 5 YR 5/8 dry); very gravelly clay; structureless single grain; many micro, few fine, few medium pores; loose, very friable, slightly sticky and slightly plastic; common fine roots; murram gravel.

PROFILE DESCRIPTION

Date/ season	:25/6/86; end of rainy season
Observation No.	: B12
Coordinates	:3610 E, 99662 N
Elevation	: 1020 m
Authors	:Udaya,Szogi
Soil mapping unit	:UI
Soil classification	:Chromic cambisol
Geology	:Mt Kenya volcanics
Localpetrography (Parent material)	:Lahar
Physiography	:Footridge slope
Macro-relief	:Undulating
Slope (length, shape and pattern)	:500 m,linear,regular
Slope gradient	:4%
Position on slope	:Middle
Meso- and micro-relief	:none
Vegetation/ Landuse	: Arable & grassland Erosion :none
Rock outcrops	:none
Surface stoniness	:none
Overwash	:none
Surface runoff	:Medium
Surface sealing/crusting/cracking	:Slight sealing
Drainage class	:Well drained
Flooding	:none
Groundwater level (actual)	:> 1.00 m
Presence of salts/ alkali	:none
Soil fauna	:-
Expected rooting depth	:85 cm

Horizons:

A 0-20 cm dark reddish brown (5 YR 3/3) moist, dark brown (7.5 YR 3/2) dry; clay; moderate medium subangular blocky breaks into moderate very fine crumbs; hard, friable, slightly sticky and plastic; many micro, many very fine, common fine, common medium, few coarse pores; many very fine, many fine, common medium, few coarse roots; audible HCl reaction; pH = 6.8; clear smooth boundary to:

Bw 20-30 cm dark red (2.5 YR 3/6) moist, yellowish red (5 YR 4/6) dry; slightly gravelly clay; weak medium subangular blocky; slightly hard, very friable, slightly sticky and plastic; many micro, common very fine, many fine, common medium, few coarse; many very fine, many fine, common medium roots; murram gravel; pH = 6.5; clear smooth boundary to:

BC 30-70 cm dark red (2.5 YR 3/6) moist, yellowish red (5 YR 5/8) dry; gravelly clay; weak fine subangular blocky; softt, very friable, slightly sticky and slightly plastic; many micro, many very fine, many fine, common medium pores; common very fine, common fine, few medium roots; murram gravel; pH = 6.1; clear wavy boundary to:

C 70-85 cm rotten rock; murram gravel; abrupt smooth boundary to:

R 85-100+ cm consolidated rock (lahar).

PROFILE DESCRIPTION

Date/ season	:11/6/86; end of rainy season
Observation No.	:C4
Coordinates	:3773 E, 99607 N
Elevation	:700 m
Authors	:Sulu,Buss,Magoggo,Szogi
Soil mapping unit	:UGb
Soil classification	:Chromic cambisol
Geology	:Basement
Local petrography (Parent material)	:Granitoid gneiss
Physiography	:Upland
Macro-relief	:Rolling
Slope (length, shape and pattern)	:100 m,convex,single
Slope gradient	:10%
Position on slope	:Upper
Meso- and micro-relief	:none
Vegetation/ Landuse	:Arable land
Erosion	:Moderate sheet & rill, slight gully
Rock outcrops	:none
Surface stoniness	:none
Overwash	:none
Surface runoff	:Medium
Surface sealing/crusting/cracking	:Moderate sealing
Drainage class	:well drained
Flooding	:none
Groundwater level (actual)	:> 1.1 m
Presence of salts/ alkali	:none
Soil fauna	:-
Expected rooting depth	:100 cm

Horizons:

Ap 0-12 cm dark reddish brown (5 YR 3/4) moist, yellowish red (5 YR 4/6) dry; sandy loam; moderate medium subangular blocky; slightly hard, very friable, slightly sticky and slightly plastic; many micro, many very fine, common fine , common medium, few coarse pores; many very fine, many fine, common medium roots; pH = 5.9; clear smooth boundary to:

Bw 12-33 cm dark red (2.5 YR 3/6) moist, yellowish red (5 YR 4/6) dry; sandy clay; medium coarse subangular blocky; hard, very friable, slightly sticky and slightly plastic; many micro, many very fine, many fine, many medium pores; common very fine, common fine, few medium roots; pH = 6.2; clear smooth boundary to:

BC 33-100 cm dark red (2.5 YR 3/6) moist; clay; moderate coarse subangular blocky; hard, very friable, sticky and plastic; many micro, many very fine, few medium pores; few fine, few coarse roots; pH = 5.7; abrupt and wavy boundary to:

C 100-105+ cm weathered rock (granitoid gneiss)

PROFILE DESCRIPTION

Date/ season	:7/6/86; end of rainy season
Observation No.	:C1
Coordinates	:3786 E, 99675 N
Elevation	:800 m
Authors	:Suluvle,Szogi,Mateos
Soil mapping unit	:UGb
Soil classification	:Chromic luvisol
Geology	:Basement
Local petrography (Parent material)	:Granite
Physiography	:Upland
Macro-relief	:Undulating
Slope (length, shape and pattern)	:200 m,convex,single
Slope gradient	:2%
Position on slope	:Middle
Meso- and micro-relief	:none
Vegetation/ Landuse	:Arable and grassland
Erosion	:Slight sheet & gully
Rock outcrops	:none
Surface stoniness	:Fairly stony
Overwash	:Very slight
Surface runoff	:Slow
Surface sealing/crusting/cracking	:Moderate sealing
Drainage class	:Well drained
Flooding	:none
Groundwater level (actual)	:> 1.20 m
Presence of salts/ alkali	:none
Soil fauna	:Ants
Expected rooting depth	:65 cm

Horizons:

1A 0-5 cm reddish brown (5 YR 4/4) moist, strong brown (7.5 YR 4/6) dry; sandy clay; weak coarse subangular blocky breaks into strong very fine crumbs; slightly hard, friable, non-sticky and slightly plastic; many micro, many very fine, many fine, common medium, few coarse pores; many very fine, common fine, few medium roots; presence of mica; pH = 6.7; abrupt smooth boundary to:

1Bt1 5-20 cm dark reddish brown (2.5 YR 2.5/4 moist, 2.5 YR 3/4 dry); clay; moderate coarse subangular blocky; very hard, firm, sticky and plastic; patchy thin clay cutans; many micro, many very fine, common fine, common medium pores; common fine, few medium, few coarse roots; pH = 6.6; clear smooth boundar

1Bt2 20-65 cm dark red (2.5 YR 3/6) moist, red (2.5 YR 4/6) dry; clay; moderate coarse angular blocky; hard, firm, sticky and plastic; broken thin clay cutans; many micro, many very fine, many fine, few coarse pores; common very fine, few fine, few medium, few coarse roots; pH = 6.7; abrupt wavy boundary to:

2C 65-75 cm quartz gravel, stone line with rounded and sharp edged fragments; abrupt and wavy boundary to:

3Btb 75-105 cm dark reddish brown (2.5 YR 3/4) moist, red (2.5 YR 4/6) dry; slightly gravelly clay; moderate medium rough prisms; hard, firm, sticky and plastic; patchy thin clay cutans; many micro, many very fine, many medium pores; few medium roots; presence of black micas; pH = 6.0; clear wavy boundary to:

3C 105-120+ cm rotten rock (gneiss).

PROFILE DESCRIPTION

Date/ season	:19/6/86; end of rainy season
Observation No.	:C6
Coordinates	:3777 E, 9966 N
Elevation	:720 m
Authors	:Szogi,Zhu
Soil mapping unit	:UGb
Soil classification	:Umbric acrisol
Geology	:Basement
Local petrography (Parent material)	:Granite (complex of shallow soils)
Physiography	:Upland
Macro-relief	:Rolling
Slope (length, shape and pattern)	:300 m, convex, irregular
Slope gradient	:10%
Position on slope	:Summit
Meso- and micro-relief	:none
Vegetation/ Landuse	:Grazing
Erosion	:Slight sheet
Rock outcrops	:Very rocky
Surface stoniness	:Excesivelly stony and bouldery
Overwash	:none
Surface runoff	:Rapid
Surface sealing/crusting/cracking	:-
Drainage class	:Well drained
Flooding	:none
Groundwater level (actual)	:> 1.50 m
Presence of salts/ alkali	:none
Soil fauna	:Termites
Expected rooting depth	:120 cm

Horizons:

A 0-30 cm dark reddish brown (5 YR 2.5/2 moist, 2.5 YR 2.5/4); stony and bouldery sandy clay loam; weak fine crumbs; hard, firm, sticky and slightly plastic; many micro, many very fine, common fine, few medium pores; few fine, few medium, few coarse roots; quartz gravel; clear broken boundary to:

Bt1 30-70 cm dark reddish brown (2.5 YR 3/4) moist; dark red (2.5 YR 3/6) dry; gravelly, stony and bouldery sandy clay; weak fine subangular blocky breaks into weak very fine crumbs; hard, firm, sticky and slightly plastic; patchy thin clay cutans; many micro, common very fine, common fine, few medium pores; clear wavy boundary to:

Bt2 70-120 cm dark red (2.5 YR 3/6) moist, red (2.5 YR 4/6); gravelly stony sandy clay; moderate medium angular blocky breaks into weak fine subangular blocky; hard, firm, sticky and plastic; patchy thin clay cutans; many micro, many very fine, many fine pores; few very fine, few fine, few medium roots; abrupt wavy boundary to:

C 120-150+ cm rotten rock

PROFILE DESCRIPTION

Date/ season	:20/6/86; end of rainy season
Observation No.	:C7
Coordinates	:3782 E, 99662 N
Elevation	:760 m
Authors	:Sulu,Buss,Szogi,Zhu,Jordens
Soil mapping unit	:UGr
Soil classification	:Chromic luvisol
Geology	:Basement
Local petrography (Parent material)	:Granitoid gneiss
Physiography	:Upland
Macro-relief	:Undulating
Slope (length, shape and pattern)	:300 m,linear,single
Slope gradient	:5%
Position on slope	:Lower
Meso- and micro-relief	:none
Vegetation/ Landuse	:Grassland
Erosion	:Slight sheet
Rock outcrops	:none
Surface stoniness	:Fairly stony
Overwash	:none
Surface runoff	:Rapid
Surface sealing/crusting/cracking	:Moderate sealing
Drainage class	:Well drained
Flooding	:none
Groundwater level (actual)	:> 0,80 m
Presence of salts/ alkali	:none
Soil fauna	:Termites
Expected rooting depth	:80 cm

Horizons:

A 0-20 cm dark reddish brown (2.5 YR 2.5/4 moist, 2.5 YR 3/4 dry); slightly gravelly clay; weak medium subangular blocky breaks into moderate very fine crumbs; hard friable, sticky and plastic;many micro, many very fine, many fine, many medium, few coarse pores; few very fine, few fine, common medium, few coarse roots; presence of charcoal; pH = 7.1; clear wavy boundary to:

Bt 20-52 cm dark red (2.5 YR 3/6) moist, red (2.5 YR 4/6) dry; slightly gravelly clay; weak coarse angular blocky breaks into moderate fine subangular blocky; slightly hard, friable, sticky and plastic; patchy thin clay cutans; many micro, many very fine, many fine, many medium, few coarse pores; few fine, few medium, few coarse roots; pH = 6.9; abrupt broken boundary to:

BC/R 52-80+ cm dark reddish brown (2.5 YR 2.5/4) moist, dark red (2.5 YR 3/6) dry; clay; weak coarse angular blocky breaks into moderate fine subangular blocky; slightly hard, friable, sticky and plastic; patchy thin clay cutans; many micro, many very fine, many fine, few medium, few coarse pores; few fine, few medium, few coarse roots; quartz gravel; intermingled bedrock; pH = 7.2

PROFILE DESCRIPTION

Date/ season	:11/6/86; end of rainy season
Observation No.	:C5
Coordinates	:3779 E, 99644 N
Elevation	:760 m
Authors	:Sulu,Buss,Magoggo,Szogi
Soil mapping unit	:LtBr
Soil classification	:Dystric cambisol
Geology	:Nyambeni volcanics
Local petrography (Parent material)	:Basalt
Physiography	:Plateau
Macro-relief	:Flat
Slope (length, shape and pattern)	:-
Slope gradient	:0%
Position on slope	:-
Meso- and micro-relief	:none
Vegetation/ Landuse	:Woodland
Erosion	:none
Rock outcrops	:none
Surface stoniness	:none
Overwash	:none
Surface runoff	:none
Surface sealing/crusting/cracking	:Slight sealing
Drainage class	:well drained
Flooding	:none
Groundwater level (actual)	:always deep, > 120 m
Presence of salts/ alkali	:none
Soil fauna	:termites
Expected rooting depth	:120

Horizons:

A 0-20 cm dark reddish brown (5YR 3/3 moist, 5YR4/4 dry); clay; moderate medium subangular blocky breaking into moderate fine crumbs; soft, friable, sticky and plastic; many micro, many very fine, common fine, many medium, common coarse pores; many very fine, many fine,few medium roots; pH = 6.5; clear and smooth boundary to:

Bw1 20-50 cm reddish brown (2.5YR 4/4) moist,yellowish red (5YR4/6) dry; gravelly sandy clay loam; moderate medium subangular blocky breaking into moderate fine crumbs; soft, firm, slightly sticky and slightly plastic; many micro, many fine, common medium pores; many fine and few medium roots; basalt gravels; pH = 5.9; gradual smooth boundary to:

Bw2 50-85 cm yellowish red (5YR 5/6 moist, 5YR 5/8 dry); very gravelly sandy clay loam; weak fine crumbs; soft,loose, slightly sticky and slightly plastic; many micro, many very fine, common fine, few medium, few coarse pores; many fine and very fine, few coarse roots; basalt gravels; pH = 5.3; gradual smooth boundary to:

C 85-120+ cm very gravelly (murram) sandy loam; structureless, single grain; pH = 5.7.

PROFILE DESCRIPTION

Date/ season	:20/6/86; end of rainy season
Observation No.	:C8
Coordinates	:3792 E, 99692 N
Elevation	:720 m
Authors	:Sulu,Buss,Szogi,Jordens
Soil mapping unit	:UGb
Soil classification	:Chromic luvisol
Geology	:Basement
Local petrography (Parent material)	:Granitoid gneiss
Physiography	:Upland
Macro-relief	:Undulating
Slope (length, shape and pattern)	:500 m,linear,single
Slope gradient	:3%
Position on slope	:Middle
Meso- and micro-relief	:none
Vegetation/ Landuse	:Grass & woodland
Erosion	:Slight sheet
Rock outcrops	:none
Surface stoniness	:Fairly stony
Overwash	:none
Surface runoff	:Medium
Surface sealing/crusting/cracking	:Slight sealing
Drainage class	:Moderatelly well drained
Flooding	:none
Groundwater level (actual)	:> 1.20 m
Presence of salts/ alkali	:none
Soil fauna	:Ants & termites
Expected rooting depth	:105 cm

Horizons:

A 0-10 cm dark brown (7.5 YR 3/4) moist, yellowish brown (10 YR 5/4) dry; few fine faint red (2.5 YR 4/8) mottles; slightly gravelly sandy clay; moderate fine subangular blocky; hard, friable, slightly sticky and slightly plastic; many micro, many very fine, many fine, common medium, few coarse pores; many very fine, many fine, common medium, few coarse roots; pH = 6.1; clear smooth boundary to:

Bt1 10-35 cm dark red (2.5 YR 3/6) moist, reddish brown (5 YR 4/4) dry; clay; moderate medium subangular blocky; hard friable, sticky and plastic; patchy thin clay cutans; many micro, many very fine, many fine, few medium pores; few fine, few medium, few coarse roots; pH = 5.7; clear smooth boundary to:

Bt2 35-77 cm dark red (2.5 YR 3/6) moist, yellowish red (5 YR 5/8) dry; clay; weak medium subangular blocky; slightly hard, friable, sticky and slightly plastic; patchy thin clay cutans; many micro, many very fine, many fine, few medium pores; few fine, few medium, few coarse roots; pH = 5.9; clear smooth boundary to:

BC 77-105 cm yellowish red (5 YR 5/8) moist, strong brown (7.5 YR 5/8); broken fine faint red (2.5 YR 4/8) mottles; clay; slightly hard, friable, slightly sticky and slightly plastic; many micro, many very fine, many fine, few medium pores; few fine, few medium, few coarse roots; pH = 6.2; clear wavy boundary to:

C 105-120+ cm weathered rock, murram gravel.

PROFILE DESCRIPTION

Date/ season	:7/6/86; end of rainy season
Observation No.	:C2
Coordinates	:3783 E, 99713 N
Elevation	:800 m
Authors	:Mateos, Szogi, Zhu
Soil mapping unit	:F
Soil classification	:Mollic leptosol
Geology	:Basement
Local petrography (Parent material)	:Hornblende gneiss
Physiography	:Footslope
Macro-relief	:Undulating
Slope (length, shape and pattern)	:300m, irregular, convex
Slope gradient	:6%
Position on slope	:Upper slope
Meso- and micro-relief	:none
Vegetation/ Landuse	:Shrubs and grasses.Grazing.
Erosion	:Slight
Rock outcrops	:Rocky
Surface stoniness	:Very stony
Overwash	:none
Surface runoff	:Medium
Surface sealing/crusting/cracking	:Slight sealing
Drainage class	:Well drained
Flooding	:none
Groundwater level (actual)	:> 45 cm
Presence of salts/ alkali	:none
Soil fauna	:none
Expected rooting depth	:45 cm

Horizons:

A 0-28 cm dark brown (7.5 YR 3/2) moist, brown (7.5 YR 4/4) dry; slightly gravelly, sandy clay; weak mediumsubangular blocky; slightly hard, very friable, non-sticky and slightly plastic; many micro, many very fine, few medium pores; few fine, common medium, few coarse roots; pH = 6.9; clear and smooth boundary to:

Bw 28-45 cm dark reddish brown (5 YR 3/3) moist, reddish brown (5 YR 4/4); slightly gravelly, sandy clay; moderate coarse subangular blocky; slightly hard, very friable, slightly sticky and slightly plastic; many micro, many very fine,many fine, many medium pores; few fine, coarse medium, few coarse roots; pH = 6.8; abrupt and wavy boundary to:

R 45-50+ cm rotten rock, hornblende gneiss.

PROFILE DESCRIPTION

Date/ season	:20/6/86; end of rainy season
Observation No.	: C9
Coordinates	:3785 E, 9970 N
Elevation	: 750 m
Authors	:Sulu,Buss,Szogi,Zhu,Jordens
Soil mapping unit	:Uwb
Soil classification	:Chromic luvisol
Geology	:Basement
Localpetrography (Parent material)	:Hornblende gneiss
Physiography	:Upland
Macro-relief	:Undulating
Slope (length, shape and pattern)	:200 m,linear,single
Slope gradient	:5%
Position on slope	:Upper
Meso- and micro-relief	:none
Vegetation/ Landuse	: Grassland
Erosion	:Moderate sheet and rill
Rock outcrops	:none
Surface stoniness	:Fairly stony
Overwash	:none
Surface runoff	:Rapid
Surface sealing/crusting/cracking	:Moderate sealing
Drainage class	:Well drained
Flooding	:none
Groundwater level (actual)	:> 1.20 m
Presence of salts/ alkali	:none
Soil fauna	:Termites
Expected rooting depth	:90 cm

Horizons:

A 0-10 cm dark reddish brown (2.5 YR 3/4) moist and dry; clay; weak moderate subangular blocky; slightly hard, friable, sticky and plastic; many micro, many very fine, many fine, many medium, common coarse pores; many very fine, many fine, few medium, few coarse roots; pH = 6.7; clear smooth boundary to:

BA 10-50 cm dark reddish brown (2.5 YR 3/4) moist, dark red (2.5 YR 3/6) dry; clay; moderate medium subangular blocky; slightly hard, friable, sticky and plastic; broken thin clay cutans; many micro, many very fine, common fine, few medium, few coarse pores; few small soft black nodules;many fine, many medium, few coarse roots; pH = 7.0; gradual smooth boundary to:

Bt 50-90 cm dark reddish brown (2.5 YR 3/4) moist, dark red (2.5 YR 3/6) dry; clay; moderate coarse angular blocky breaks into weak fine angular blocky; hard, firm, sticky and plastic; continuous thin clay cutans; many micro, many very fine, common fine, few medium pores; frequent small soft black nodules; many fine, few coarse roots; pH = 6.9; abrupt broken boundary to:

C 90-120+ cm rotten rock (gneiss)