TRAINING PROJECT IN PEDOLOGY

KISII KENYA

Detailed Soil Survey of the Marongo area

PRELIMINARY REPORT NO 3

AGRICULTURAL UNIVERSITY

WAGENINGEN - THE NETHERLANDS

A DETAILED SOIL SURVEY OF THE MARONGO AREA

A reconnaissance study

by

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TRAINING PROJECT IN PEDOLOGY, KISII KENYA.

Agricultural University, Wageningen - The Netherlands.

Contents

Preface

This report of the Training Project in Pedology at Kisii, Kenya, of the Section on Tropical Soil Science of the Agricultural University at Wageningen, Netherlands, is the third one of a series to be presented to Kenyan officials.

The project started in November 1973 after assent had been granted by the Office of the President of Kenya. It is meant for training of postgraduate students of the Agricultural University at Wageningen and furnishing research opportunities to the staff. The activities of students and staff are directed to obtaining a better knowledge of the soils and agricultural conditions of the project area to provide a basis for the further agricultural development of the area.

The project in Kisii is conducted by:

Ir. W.G. Wielemaker, teaching and research

Ing. H.W. Boxem, management.

Visiting specialists from the Agricultural University at Wageningen help to resolve special problems.

This report has been written by Messrs. P.N. Boerma, G.R. Hennemann, J.H. Kauffman and H.E. Verwey. They worked in the described area from November 1973 to May 1974. The compilation into this publication has been done by Mr. Boxem while drafting and map compilation was made possible to the authors through the cooperation of Messrs G. Buurman, P.G.M. Versteeg and O.D. Jeronimus. The landuse map and its legend (not included in this preparation) was prepared by H.L.M. van Wissen.

We hope to pay back with these reports a small part of the great debt we owe to Kenya in general and to many Kenyans in particular for their valuable contributions to the good functioning of the project.

The supervisor of the project

J. Bennema, Professor of Tropical Soil Science

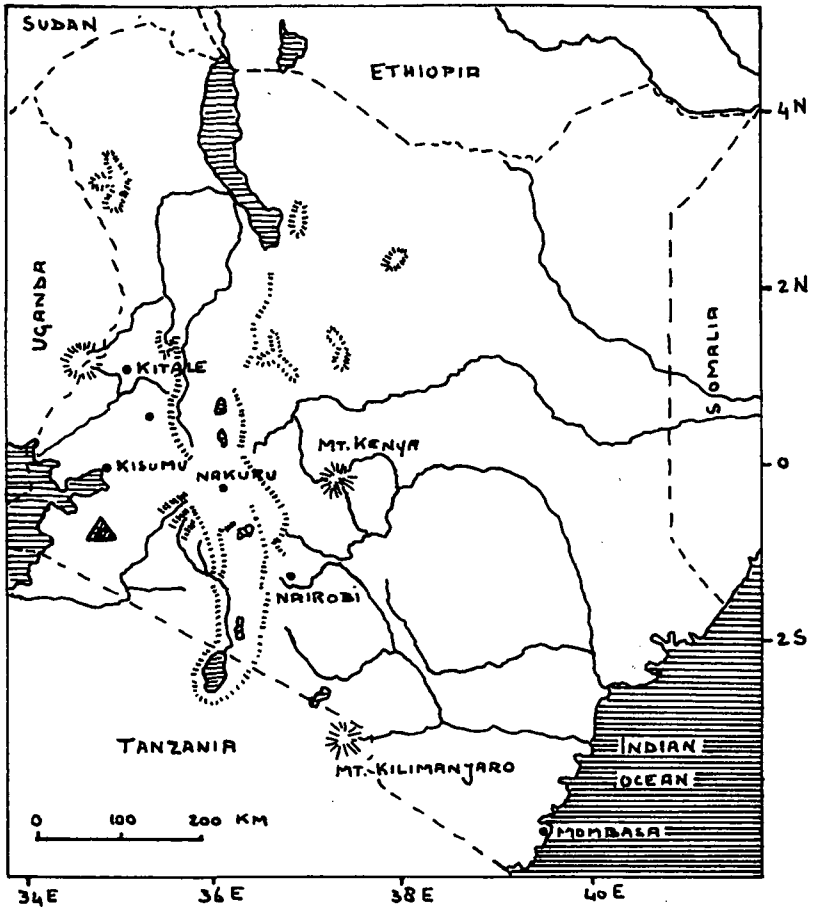
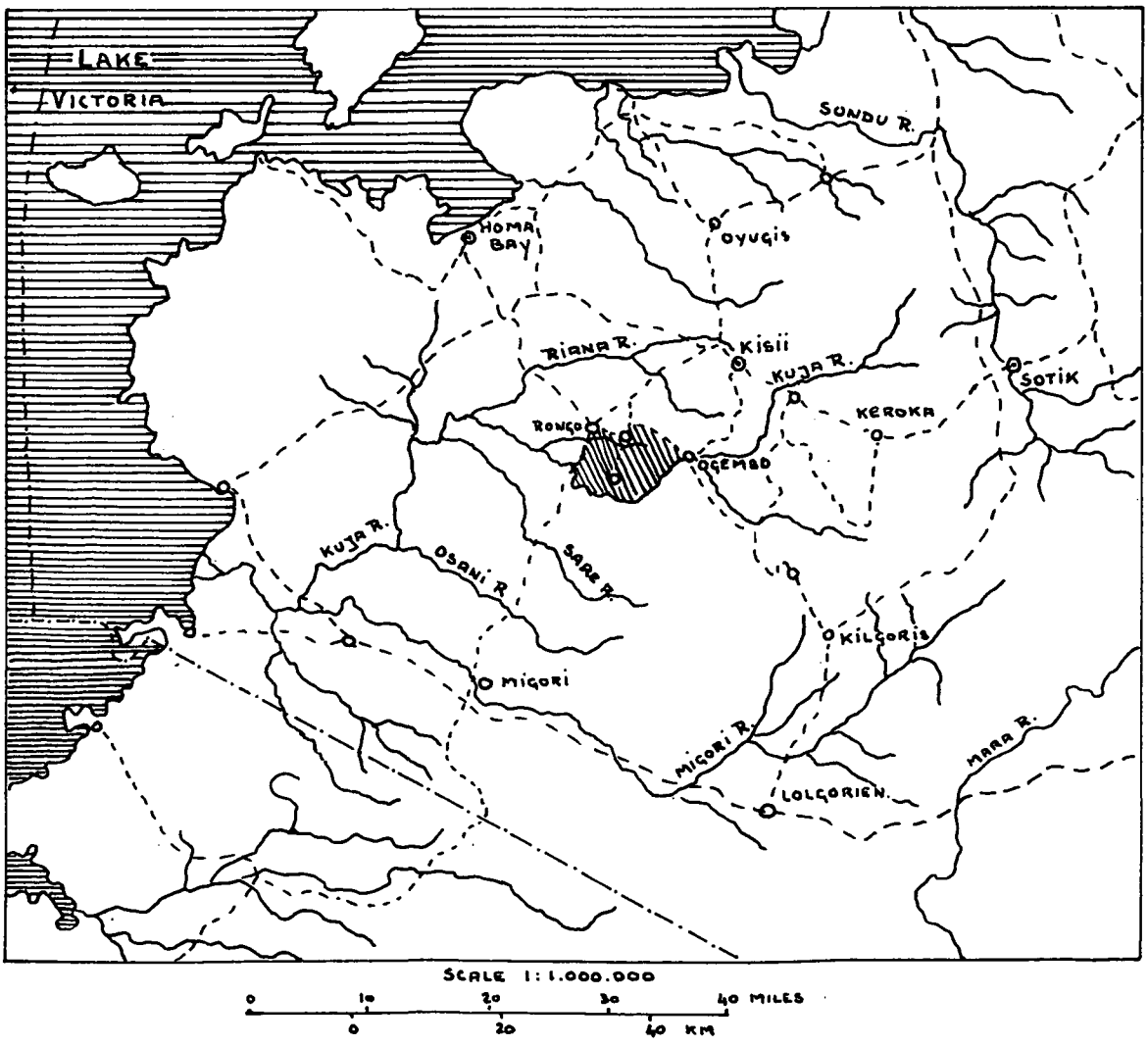


Fig.1. Location Map of the Soil Survey Area.



1. The Environment (Part I)

1.1. Location and extent

The Marongo Ridge detailed soil survey, comprising approximately 9.800 ha. is located between latitudes $0^{o}45'$ and $0^{o}51'$ South and longitudes $34^{o}35'$ and $34^{o}43'$ East in Nyanza Province, Southwest Kenya (Fig. 1).

The area covers part of East Nyokal of South Nyanza District, and of South Mugirango and Bomachoge of Kisii District. The northern boundary follows the Ogembo - Ikoba - Riosiri - Rongo road. From Rongo south to the Gucha River the boundary is formed by the main road to Tanzania. The river itself back to Ogembo forms the remainder of the boundary (Fig. 2).

Main villages are Ogembo and Rongo, both administrative centres and situated at the fringe of the survey area. Ikoba, Riosiri and Nyamarambo are important local centres and markets.

The area is reasonably accessible by roads and tracks, except for the south-eastern part where the deeply dissected steep foot-slopes of the Marongo Ridge extend all the way downwards to the Gucha River.

1.2. The physical environment

1.2.1. Physiography

The survey area with altitudes between 1325 and 1950 m. (4400-6100 ft.) is situated in the border region of two main physiographic regions; The Kisii Highlands to the east and the generally smoother and more gently undulating country to the west.

A. The Kisii Highlands are bounded on the west by prominent scarps of Quartzite (Bukoban System) which have a general elevation of about 1800 m. (6000 ft.). Within the Quartzite rim the country is deeply dissected, with steep ridges reaching to a height of 2200 m. (7200 ft.) seperated by deep, often flat bottomed valleys which are occasionally choked with swampgrass and papyrus. The main ridges show fairly evenly westward-sloping summit levels grading from about 2200 m. (7200 ft.) in the East near Keroka to 1800 m. (6000 ft.) in the West, and probably represent relics of an ancient tilted planation surface (Cretaceous ?).

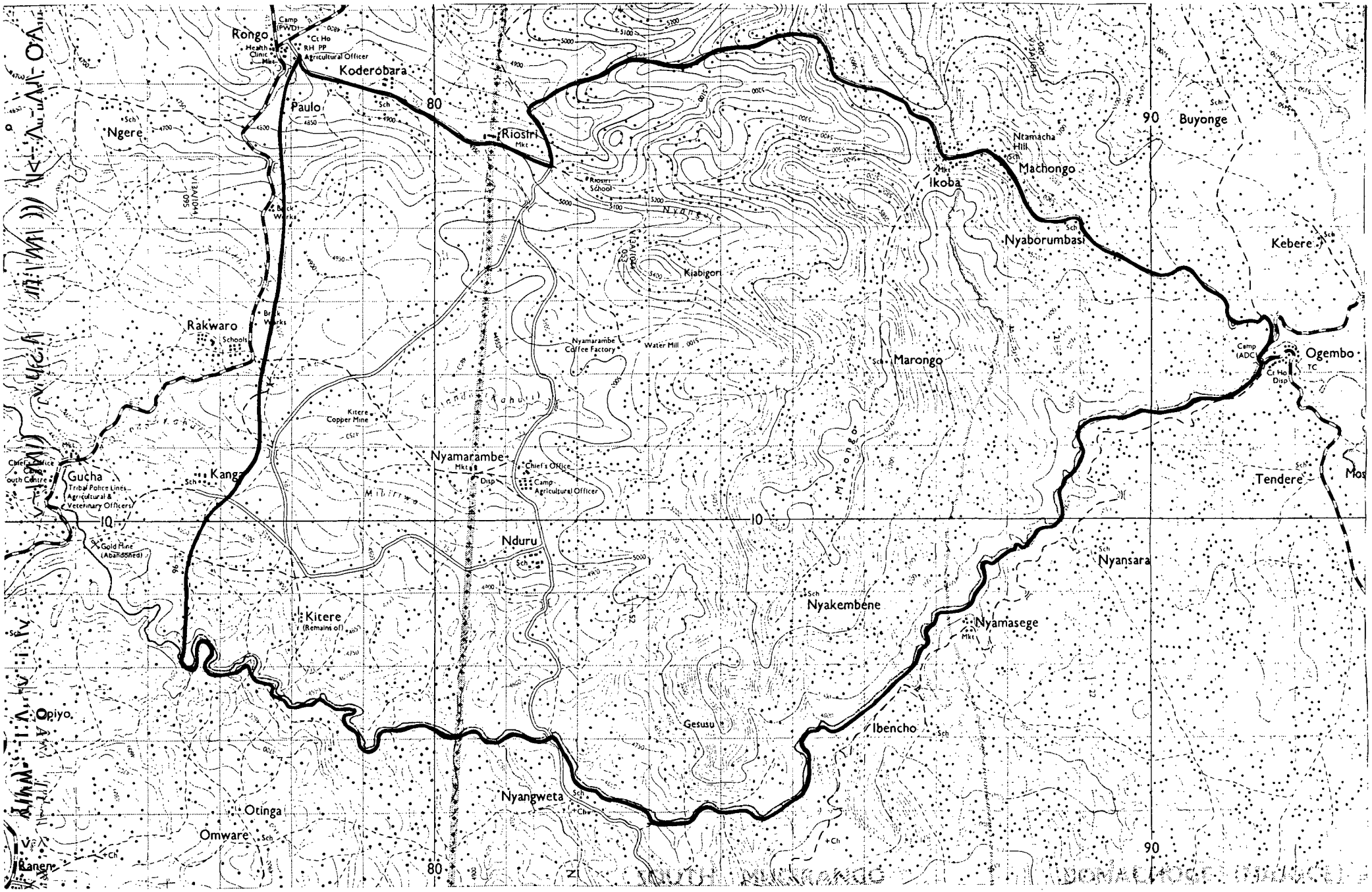


Fig. 2. Topographic map of the Survey Area showing drainage pattern and 50 ft contours. Scale approx. 1 : 70.000

B. West of the Kisii Highlands the country has a general westward decrease in height to about 1200 m. (4000 ft.) as lake Victoria is approached, in the vicinity of Homa Bay. Occasional higher and steeper ridges are formed by the Wanjare Granite and resistant Quartz-porphyric type Nyanzian Rhyolites. This main physiographic region may represent another younger planation surface (Sub-Miocene?).

Within the survey area these two main physiographic regions may be divided as follows (Fig. 3 page 8).

A. The Kisii Highlands

AM. The Marongo Quartzite ridge system is part of the prominent Quartzite scarp bounding the Kisii Highlands on the West. This conspicuous Quartzite band is up to 100 m. thick and gives rise to prominent scarp faces, obviously erosional features, up to 60 m. in height and with a general elevation of 1800 m. (6000 ft.).

AM 1. Part of the Marongo ridge is a non-dissected plateau with an undulating to rolling topography (steepest slope less than 16%) with good internal drainage and mainly deep soils, due to a thin layer of strongly weathered Felsites overlying the Quartzite formation.

AM. 2. The steep to very steep escarpment and very steep remnant hills(steepest slopes less than 70%) are somewhat excessively drained and have a low density of small gullies. Soils are very shallow and many outcrops occur.

AM 3a. Smooth concave footslopes (of less than 16%) of non-porphyritic Basalts with well drained mainly deep soils have a low density of small creeks and gullies. Slight mixing with transported Quartzite has occurred, but decreases strongly with increasing distance from the Quartzite formation.

AM 3b. The moderately steep (slopes less than 30%), dissected and irregular footslopes have a medium density of small creeks and gullies. The well drained shallow and deep soils consists of a mixture of residual material of non-porphyritic Basalts and transported Quartzite remnants.

AK. This physiographic unit in the eastern half of the survey area has been formed in non-porphyritic basalts at an altitude of 1500 to 1800 m. (5000 - 6000 ft.). Near the Gucha River the country is deeply dissected as a result of rejuvenation of the landscape and has yielded charateristic V-shaped valleys, markedly in the south-eastern part where the Gucha River flows in a steep-sided gorge and breaches the Quartzite escarpment between Marongo Ridge and Venjo Hill. West of Marongo Ridge, and between Ogembo and Ikoba the land is more rolling to hilly (slopes less than 75-30%), and less deeply dissected by small creeks and rivers. This unit may be subdivided into three landtypes.

AK 1. Rolling country (slopes less than 15%) with smooth hills and mainly uniform slopes, has a low density of small to medium gullies. The well drained deep soils support an abundance of subsistance crops and cash crops for a dense population.

AK 2. Hilly topography (slopes less than 30%), with convex valley sloped near tributary rivers and a high density of medium gullies, developed well drained, mainly (60%) deep soils but with some shallow (20%) to moderately deep soils (20%) on the steeper slopes, near gullies and on hilltops.

AK 3. Hilly to steep dissected topography (slopes less than 30 - 45%) with lower convex slopes near main tributaries and Gucha River, due to strong rejuvenation and head-ward erosion of the water courses. Drainage conditions are good to somewhat excessive. Soils are mainly shallow (60%) to moderately deep (30%).

B. More smooth and gently undulating country to the west

Within the survey area altitudes range from 1350 to 1500 m. (4500 - 5000 ft.) for this physiographic region. It may be subdivided into two landtypes, coinciding roughly with two geological formations, respectively rocks of the Nyanzian System and a granite intrusive.

BN. Undulating to almost flat broad ridges (steepest slopes 3 - 8%) with smooth convex-concave valley slopes and wide, flat valley bottoms with alluvial deposits developed in the area of the Kitere Granite formation. The drainage pattern has a medium density, and a general westerly drainage in the northwestern part of the survey area.

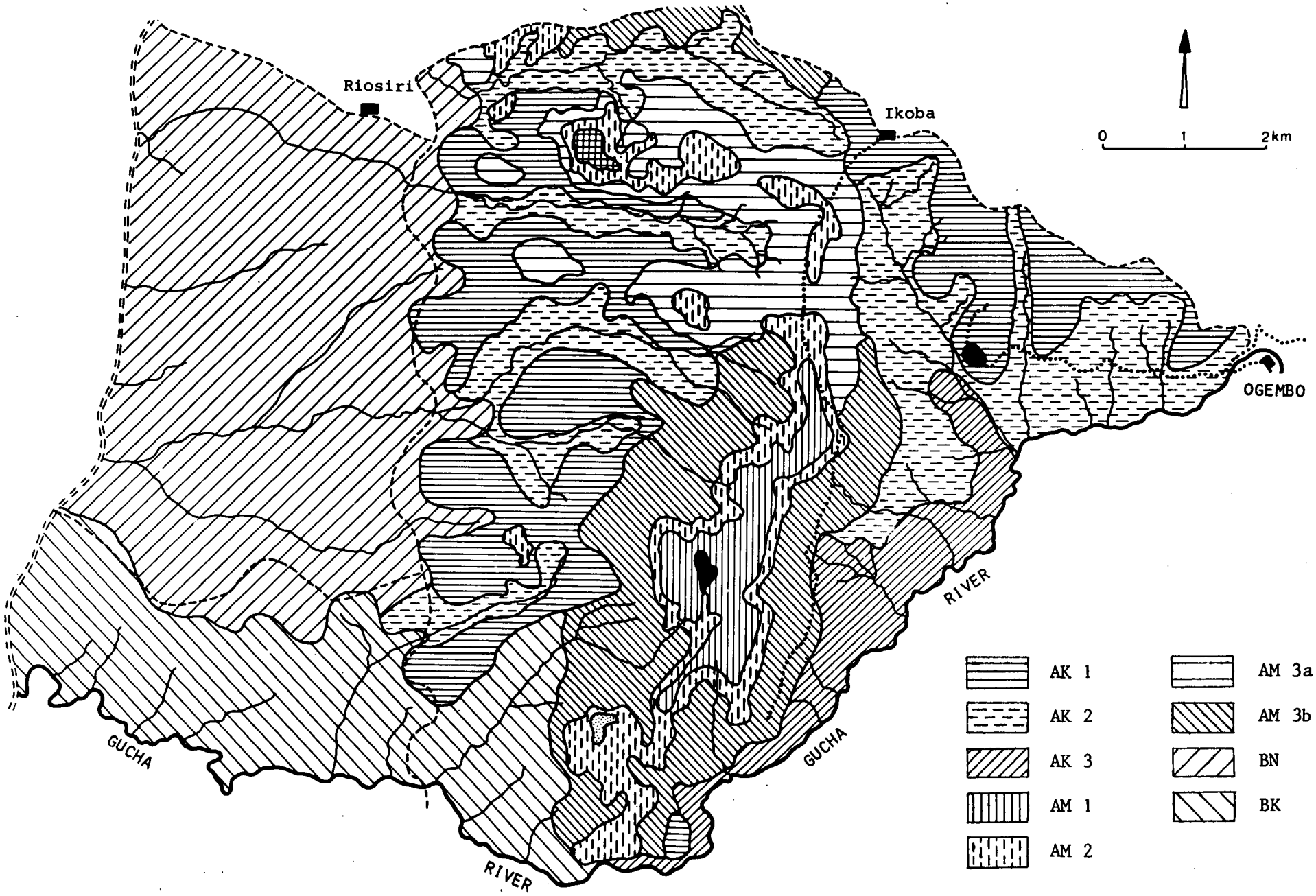


Fig. 3. Physiographic units of the survey area.

Soils are mainly shallow on the broad ridges due to plinthite formation in the Tertiary period (which has been transformed into indurated ironstone as a result of better drainage conditions). The altitude varies between 1500 m. in the East of 1420 m. in the western part of this landtype (5000 - 4700 ft.).

BK. This hilly to steeply dissected topography, with its high density of medium to large gullies and mainly well drained shallow soils, has developed along the Gucha River in the southwestern part of the survey area.

It is comparable to landtype AK 3, but has a general altitude of 1325 to 1500 m. (4400 - 5000 ft.), and the underlying rocks consist of more resistent Nyanzian Rhyolites and Rhyolitic Tuffs with small intrusions of Diorite.

1.2.2. Geology

The presumed oldest Precambrian rocks of Kenya are essentially those of Western Kenya (Fig. 4, page 10). They are to a considerable extent covered by younger rocks, notably in the Kisii and Gembe areas of Nyanzian, and the younger the Kavirondian. They are separated by an unconformity, but there is little difference in their absolute age, which is Early Precambrian.

The Nyanzian System in south-west Kenya is composed almost entirely of lavas, ranging from acid to basic in character, with minor local developments of tuffs and agglomerates. Rhyolites attain a great thickness in this area. The Nyanzian rocks are tightly folded along north-west to south-east areas and dips are usually steep.

This intense folding took place prior to the deposition of the Kavirondian Conglomerates, syntectonic Granites (G_2) being injected into the folded rocks. A long period of erosion during which the older Granites were exposed intervened, and the Kavirondian Conglomerates were laid down unconformably over the Nyanzian system.

The Kavirondian System is mainly represented by extensive developments of Conglomerates, though Grits and Mudstones are also present. These rocks do not occur within the survey area. The Kavirondian beds were laid down on the eroded edges of Nyanzian folds, and then infolded with the Nyanzian rocks during a period of fairly intense deformation. Folding of both the Kavirondian Conglomerates and the already folded

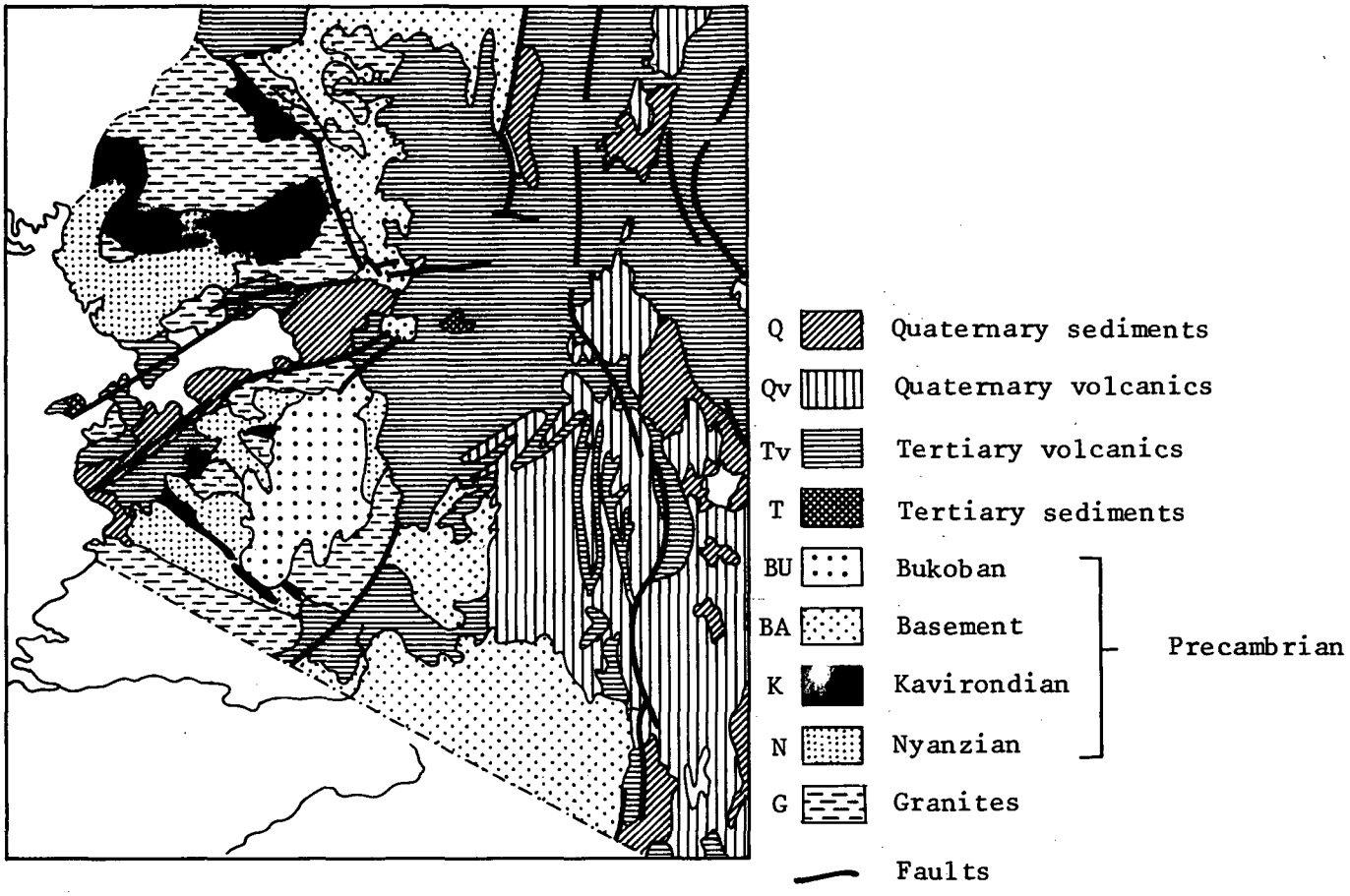


Fig. 4. Geological Map of Southwestern Kenya, Scale 1:3.000.000

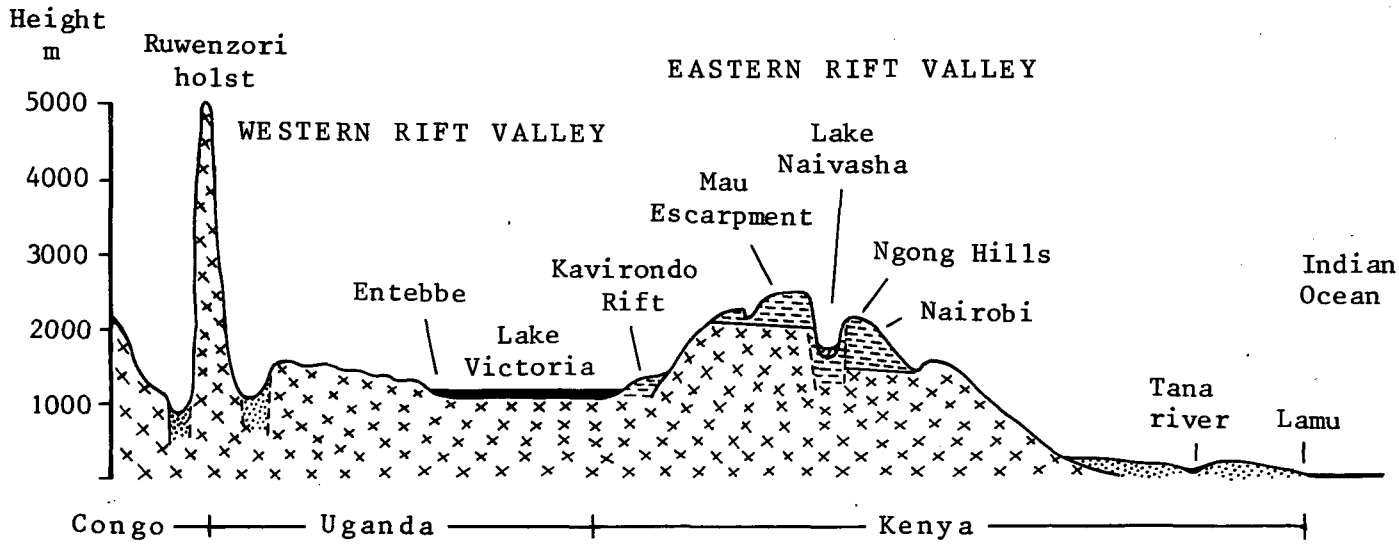


Fig. 5. Schematical geologic cross-section from West to East through Congo to the Indian Ocean.

Quaternary sediment

Tertiary and Quaternary volcanics

Precambrian basement gneiss, granites and sediments

(After K. Bjorlykke, 1972).

Nyanzian rocks took place adopting, to a large extent the older Nyanzian trends. These movements compressed, ruptured and sheared the Nyanzian rocks, but the massive Kavirondian Conglomerates did not undergo a comparable disruption.

The Precambrian rocks are extensively invaded by Granites. The principle intrusion has been considered connected with the Post-Nyanzian Grogeny and is associated with gold mineralisation in the Kitere belt. In addition to the major igneous rocks, the Precambrian rock is invaded by innumerable small masses and dykes ranging from acid to basic in character.

The Bukoban System (Kisii Series) is restricted to a small area of south-western Kenya, where it overlies unconformably the Nyanzian and Kavirondian Systems, forming the Kisii Highlands. The series is three-fold with upper and lower divisions of lavas, and a middle division composed largely of Quartzites.

The Quartzite in places form prominent escarpments at the edges of the plateau. Frequently on the western side of the Highlands there are lenticular masses of non-magnesian Soapstone, which are metasomatic replacements of the lower lavas (Basalts).

The series lies more or less flatly, with only gentle folding, across the upturned edges of the Nyanzian and Kavirondian formations.
The Bukoban System is considered as possibly Late Precambrian.

Since a gentle orogeny in Post-Bukoban times and until Tertiary times movement has been confined mainly to general uplift and periods of long continued denudation, culminating in the planation of much of the area in the Late Jurassic, Cretaceous, and Palaeogene (sub-Miocene level) times.

Since the Miocene movement has been mainly confined to geologically moderate vertical or tilting movements.

All the visible faults connected with the Rift Valley, equatorial trough and lambwe trough are of Tertiary or later age. Lake Victoria is a gentle depression caused by sag over a wide area, probably as a result of the Rift faulting in Kenya and the Albertine rifting in Uganda. The sinking of the Nyanza basin led to tilting and rejuvenation of the planation surface, resulting in deep V-shaped valleys with swift rivers, with bars and rapids at frequent intervals.

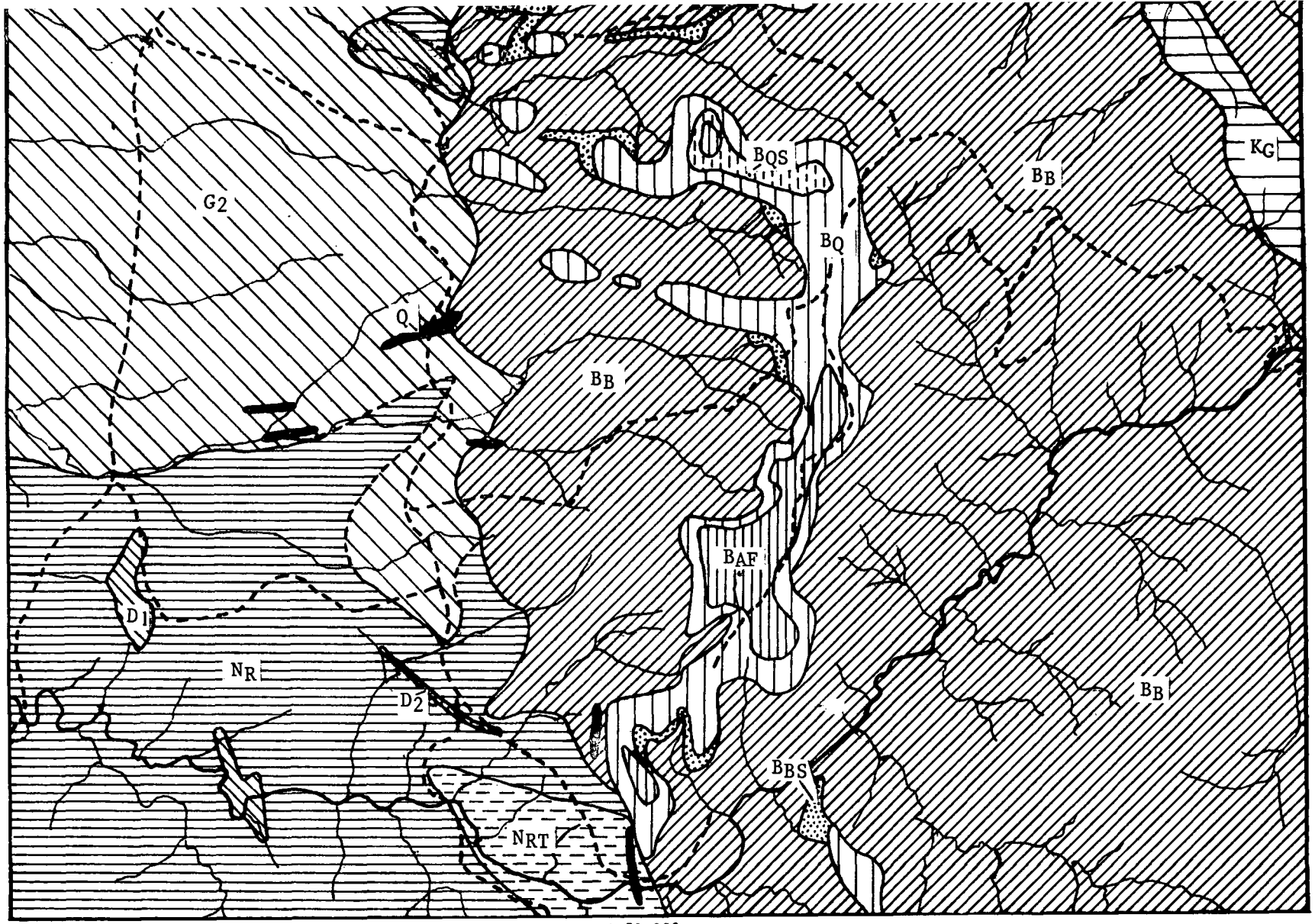


Fig. 6. Simplified Geological Map of the Soil Survey Area, scale 1:70.000

Precambrian : Bukoban
- B_{AF} Non-porphyritic Felsites
- B_{QS} Cherts
- B_Q Quartzites
- B_{BS} Kisii Soapstone locally developed
- B_B Non-porphyritic Basalts

Kavirondian
- K_G Conglomerates

Nyanzian
- N_R Rhyolites
- N_{RT} Intercallated tuffs and agglomerates

Post-Kavirondian Intrusives
- D_2 Younger Dolerites

Post-Nyanzian Intrusives
- G_2 Older granite of Kitere
- D_1 Basic minor intrusives (Dolerites)
- Q Quartz veins and Giant white quartz veins

1.2.3. Parent materials

The rocks of the survey area comprise Precambrian lavas and sediments belonging to two Systems, as well as an extensive series of intrusive rocks (Fig. 6, page 12).

The Systems and Geological succession represented, are indicated in the following table:

4.	Post-Bukoban Intrusives
4.2.	Giant white Quartz veins (Q)
4.1.	Younger Dolerites (D_2)
3.	Bukoban System (Kisii Series: approx. 600 mln. yrs. old)
3.3.	Non-porphyritic Felsites (B_{AF})
3.2.2.	Cherts ($B_Q s$)
3.2.1.	Quartzites (B_Q)
3.1.2.	Kisii soapstone, locally developed (B_{Bs})
3.1.1.	Non-porphyritic Basalts (B_B)
2.	Post-Nyanzian Intrusives
2.2.	Kitere Granite (G_2)
2.1.	Basic Minor Intrusives, mainly Dolerites (D_1)
1.	Nyanzian System (2200 + mln. yrs. old)
1.2.	Rhyolite Tuffs and Agglomerates (N_{RT})
1.1.	Rhyolites (N_R).

1. Nyanzian System: Rhyolites and Rhyolitic Tuffs occur in the south-west part of the survey area. They are fine-textured highly siliceous-looking rocks, and show great variations in colour, from dark greyish black through putty colour to shades of pink, cream and pale green. Streaky banded textures are common. It is not so weatherable as Basalts, and gives rise to shallow and poor soils.

2. Post Nyanzian Intrusives: Dolerites are sheet-like masses or sills which have no extensive occurrence within the area. They are found in three locations north-west of Kitere, near the Gucha River south-east of Kitere, and north-east of Riosiri.

   Of great importance is the extend of older Granite of Kitere, covering the northwestern part of the survey area. The Granite has low and insignificant outcrops, occasional small tors occur in the vicinity of the Tanzania Road. The Kitere Granite is normally fine-grained, and grey to pale pink in colour. It is often moderately porphyritic

with felspar phenocrysts usually pink or greenish. Indurated ironstone (fossil plinthite) covers to a large extent the interfluvial undulating ridges.

3. Bukoban System: The rest of the survey area belongs to this System. Non-porphyritic Basalts are widespread. The rock is usually fine-grained with a dark blue-grey or dark green colour, with or without vesicles, 3-4 mm. across and generally filled with finely banded chalcedonic silica. Weathering often produces spheroidal blocks and corestones.

   The Marongo Quartzite ridge overlies the non-porphyritic Basalt and extends in a NNE - SSW direction across the survey area. The Quartzite is a hard, fine to medium-grained rock with a usually creamy-white to bluish colour and locally stained by pink oxides. It is almost inert chemically, and physical weathering is dominant.

   The "Kisii Soapstone" occurs as isolated patches close to the junction of the Basalts and Quartzites. This rock is a result of metasomatic replacement of the Bukoban Basalts. The normal soapstone is off-white and often iron-stained along cracks and joint planes, and is soft, dense and extremely fine grained. The rock consists of a mixture of sericite and kaolin but may grade into more complex types. The stone has been quarried on a small scale for many years and worked as carvings.

   Overlying the Quartzite band in places is a very fine-grained siliceous cherty material which is a product of chemical deposition. This chert was deposited in small isolated basins in which normal sedimentation was either absent or weak, and outlasted the period of normal deposition which produced the Quartzites. The cherts are extremely fine-grained dense rocks of pale to dark grey colour, which often exhibit very fine layering by clear and brown iron-stained bands, or are completely iron-stained. Within the survey area cherts were found SW of Ikoba between the Misadhe River and Nyangoro River.

   Felsites form the top of the Kisii Series (Bukoban) within the survey area. They occur on the Marongo Plateau, Gesusu Hill and on a small hill SW of Ikoba. Felsites are dense microcrystalline rocks with a deep red or purple colour (only 10-40 % dark minerals). Often Felsites contain highly vesicular bands in which vesicles range from a few mm. to 3 cm. in size. The vesicles are infilled with chalcedony, chlorite and/or coarsely crystalline Quartz.

4. Post-Bukoban Intrusives include giant white Quartz veins and a dyke of younger Dolerites. This dyke of fresh Dolerite cuts through the Nyanzian Rhyolites South of Nduru and forms a well-marked feature of blocky rock outcrops. It is a bluish fresh-looking, medium-grained rock with dark augite phenocrysts.

   Large white Quartz veins have a fairly wide distribution, sometimes emplaced along a fracture zone parallel to a fault, e.g. NW and SW of Gesusu Hill in the Kisii Basalt and in Nyanzian Rhyolitic tuffs. Other Quartz veins follow no general lines, being orientated at all angle irrespective of the rock type they intersect.

1.2.4. Hydrology

The survey area is drained by one of the major rivers of the Kisii Highlands the Gucha River and many smaller tributaries, of which only the Muma, Misadhi, Nyangore, Olando and Mibiriwa rivers are worthwhile mentioning. The area East of Marongo Ridge and the south western parts drain towards the Gucha River in southern direction. The rest of the land has a westward decrease in height with a corresponding drainage system. Of the tributary rivers mentioned only the Misadhi River is a tributary of the Riana River, which drains the Kisii Highlands further North and joins the Gucha River 15 km. west of the survey area (Fig. 2).

Of the survey area only the BN landtype has poor drainage conditions, due to indurated ironstone at very shallow depth on the ridges, and flat valley bottoms with often hydromorphic conditions. On the broad ridges too, some marsh soils may be found, this are usually broad and shallow depressions surrounded by indurated ironstone.
During the rainy seasons these soils are partly flooded, but in the remaining months of the year the top soil dries out and is used for cattle grazing.

1.2.5. Climatic Condition

The climate of the Marongo detailed survey area is a transition of the monsoon-climate (Am according to Koppen's classification) of the Kisii Highlands and the tropical savannah-climate (Aw) of the lower area around Lake Victoria.
Temperatures over 30° C rarely occur due to the rather high altitude (1400-1800 m.) whereas night temperature are low (10-15°C).

The mean annual temperature is about 20°C; the annual maximum and minimum temperatures is about 27°C and 12°C respectively (Kamagambo Training School - 9034/05); these temperatures are somewhat lower for the Marongo ridge (1800 m.).

The mean annual precipitation ranges from 1700 mm. in the west to 1800 mm. in the east. A moderate dry period during January and February is followed by the "long rains" during April and May. A short dry period in August preceeds the "short rains" in October and November. Drought periods are more pronounced in the western part of the area.

Climate data are scarce and meteorological records cover only short periods (Fig. 8).
Diagrams of average monthly rainfall have been prepared with the aid of Summary of Rainfall of Kenya (1938-1971) (Fig. 9, 10 and 11).

Mean maximum and minimum temperatures are derived from the Climate and Vegetation Map of S.W. Kenya (sheet 3; 1 : 250.000).

Mean and maximum intensities of rainfall could be calculated from records made by the Project-rainfallrecorder (Casella in Kisii) (Table 1).

In Studies of Potential Evaporation (T. Woodhead) data were available for the Diagram of the average monthly evaporation (Fig. 7).

1.3. Vegetation and Landuse

On the 1 : 250.000 Climate and Vegetation Map of Southwest Kenya, the survey area is shown as belonging to 2 Western decline zonal vegetation types.

a. The Western moist forest zone (WM) with higher rainfall, lower temperatures and less hours of sunshine per day.
b. The Western combretum savannah zone (WS) with decreasing rainfall, higher temperatures and more hours of sunshine per day towards Lake Victoria.

The 5000 ft. contour (approx. 1525 m.) may be taken as an approximate boundary between the two zonal vegetation types. To draw a clear line between WM and WS on the map is of course impossible, due to an existing transition zone and the human activity in the area, which did not leave much of the original vegetation in the area.

Fig. 7

MONTHLY POTENTIAL EVAPORATION FROM OPEN WATER (PENMAN E_o) of the MARONGO ridge AREA.

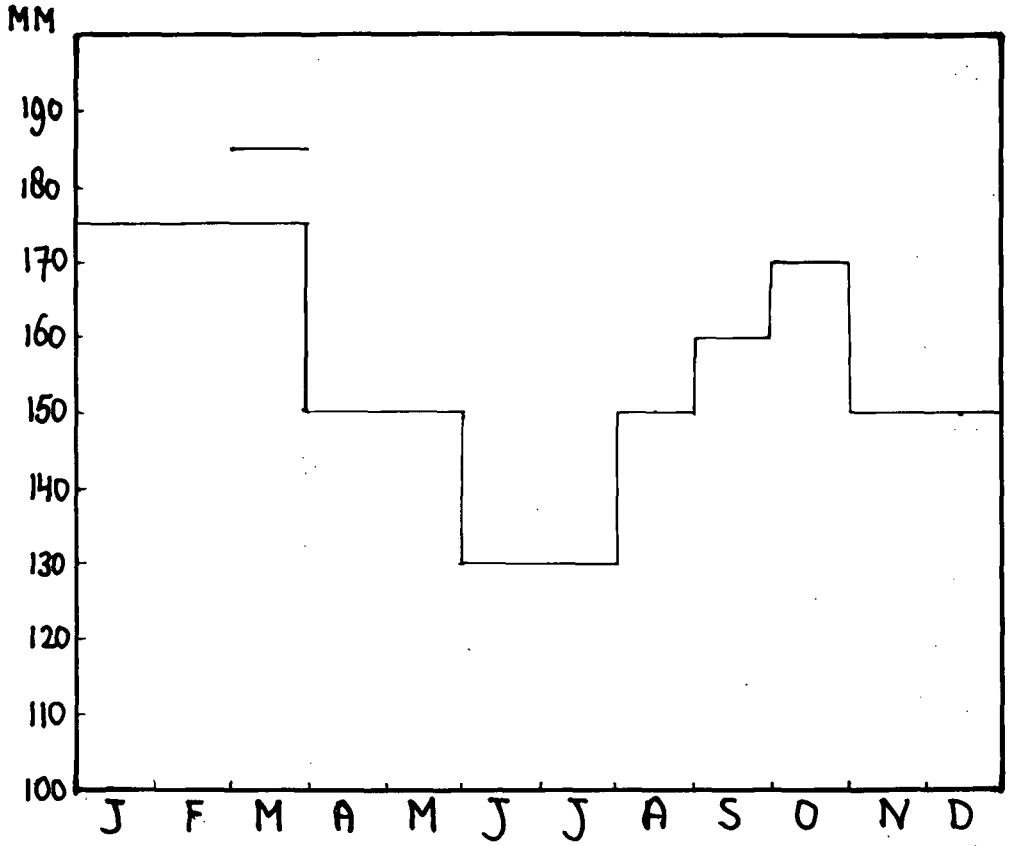
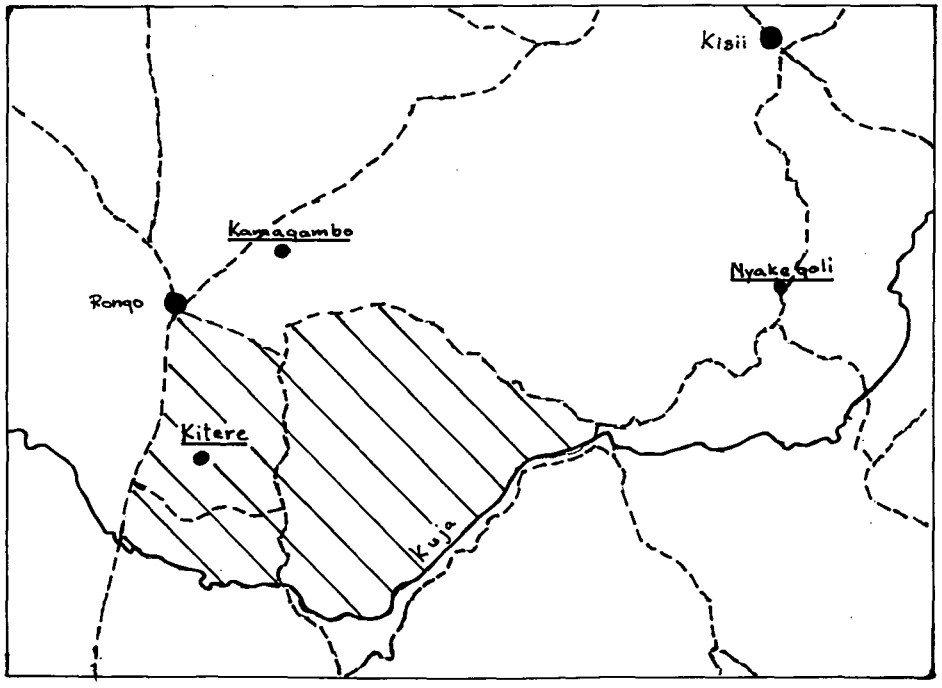


Fig. 8

LOCATION OF THE WEATHER STATIONS



Average monthly RAINFALL

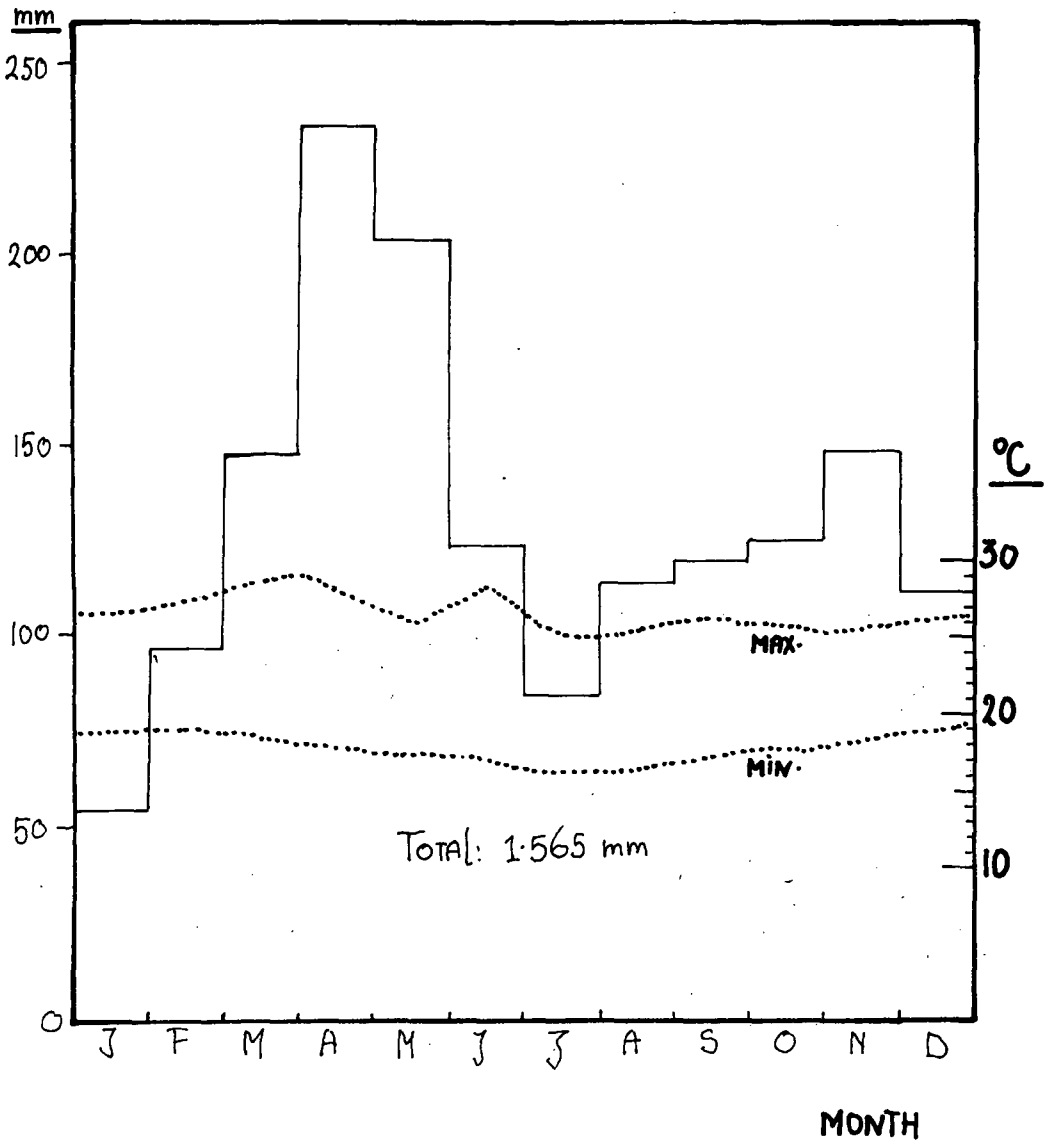
Average monthly temperature (dotted lines)

Kamagambo school. 9034-005

Coordinates 0.45S - 34.38E
Altitude: 5000 ft
Period: 1913 - 1967 (29 years)

Total annual RAINFALL

Fig. 9



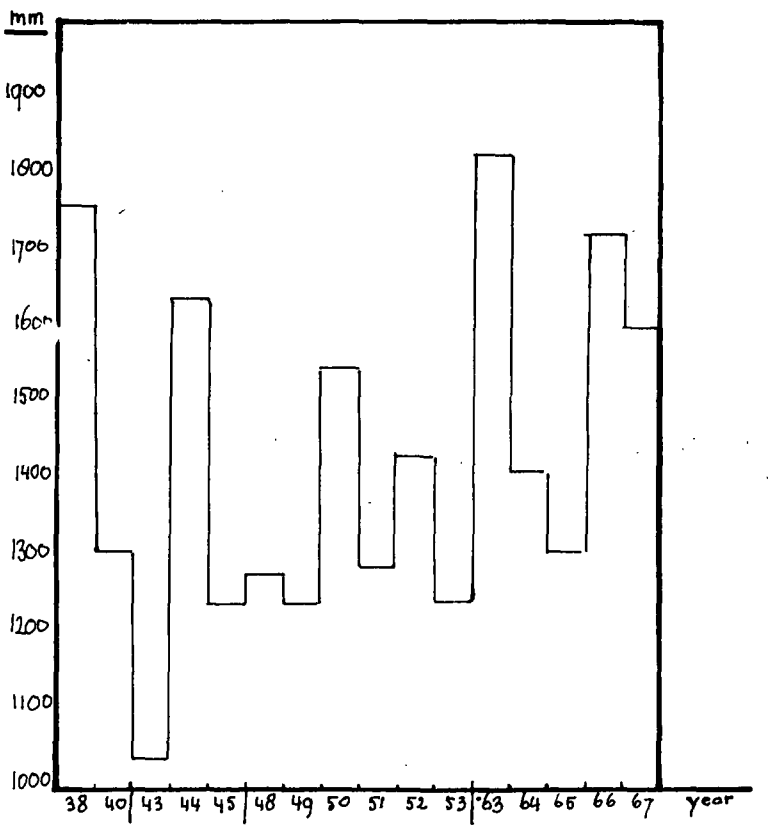
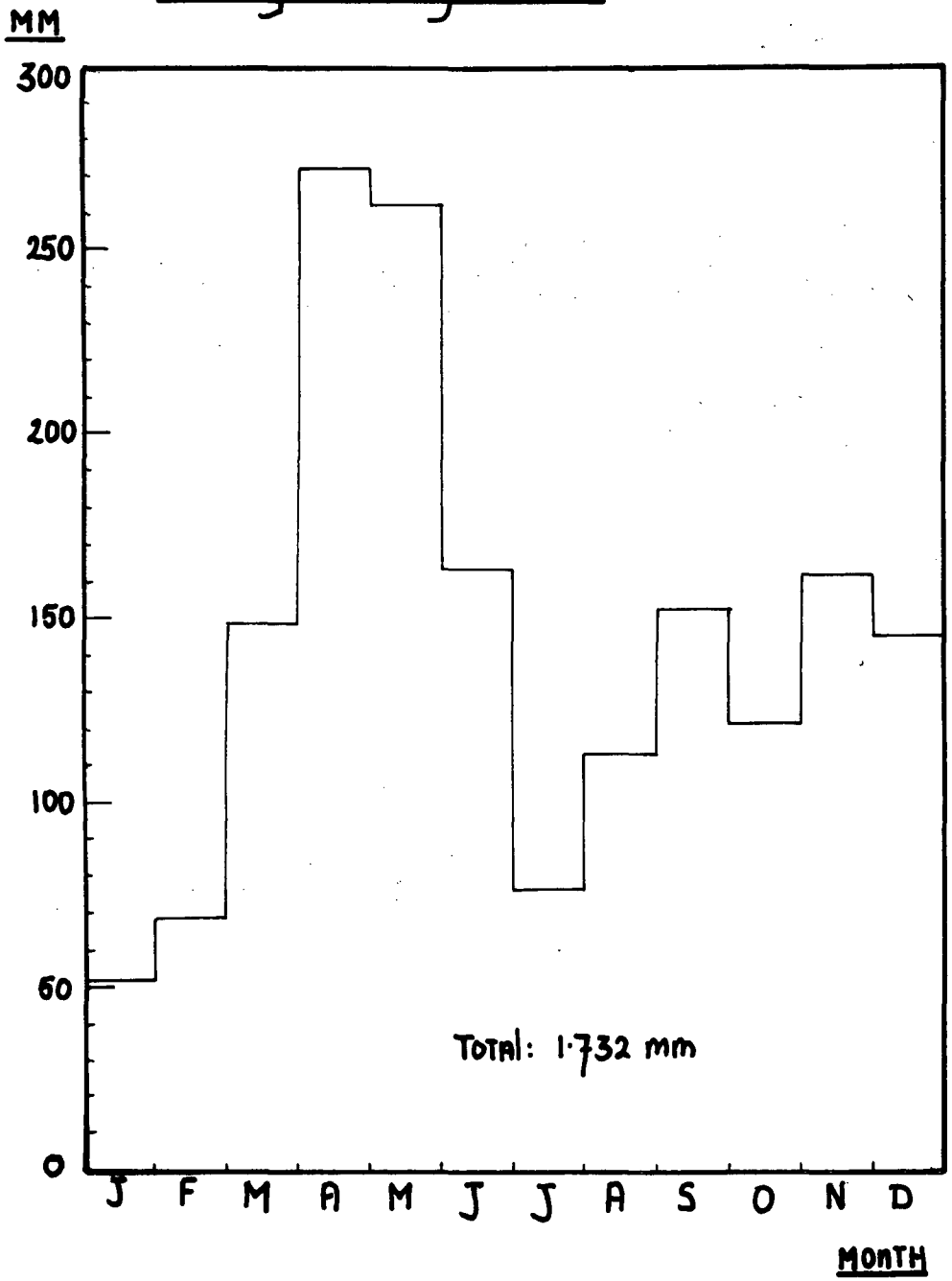


Fig. 10

KITERE goldfield, nr. 90-34-040

Coordinates: 0·48 S - 34·36 E
Altitude: 5000 ft
Period: 1942 - 1954

Average monthly rainfall



Total Annual Rainfall

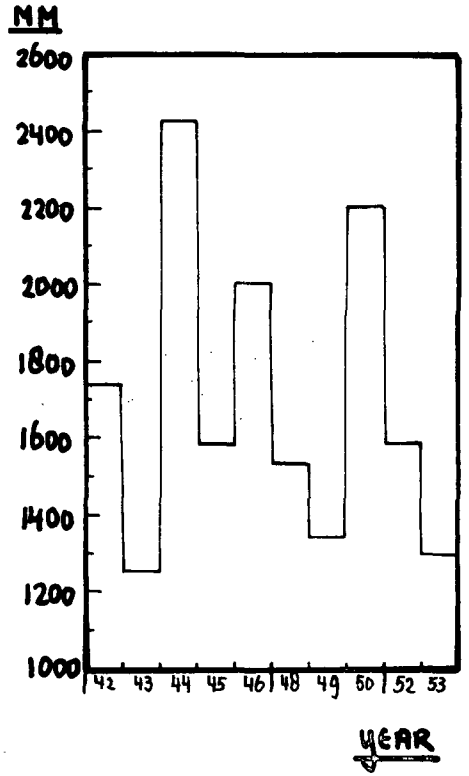
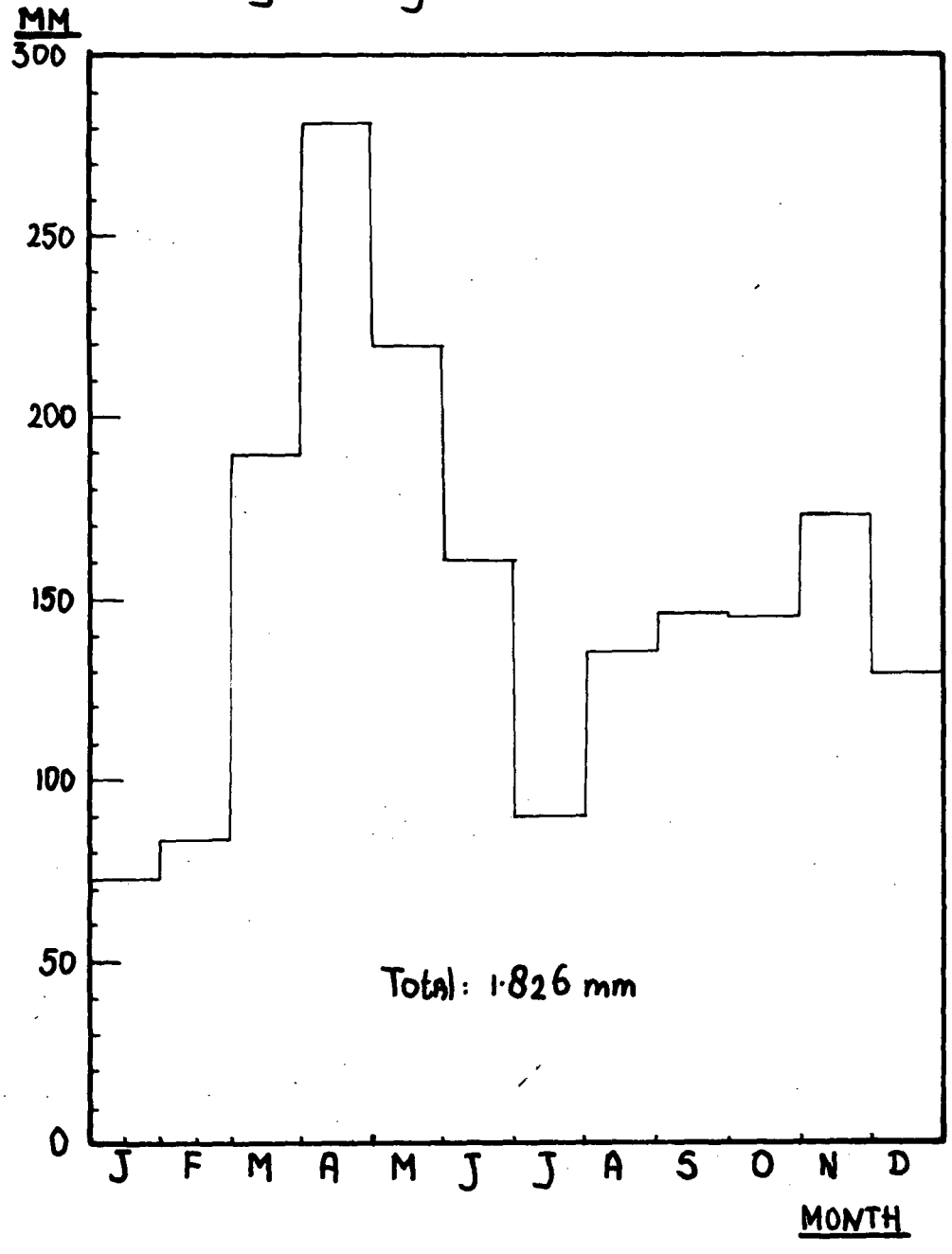


Fig. 11

Nyakegoli, nr. 90·34 - 042

Coordinates: 0·48S - 34·44 N
Altitude 5400 ft
Period 1943 - 1971 (24 years)

Average monthly rainfall



Total Annual Rainfall

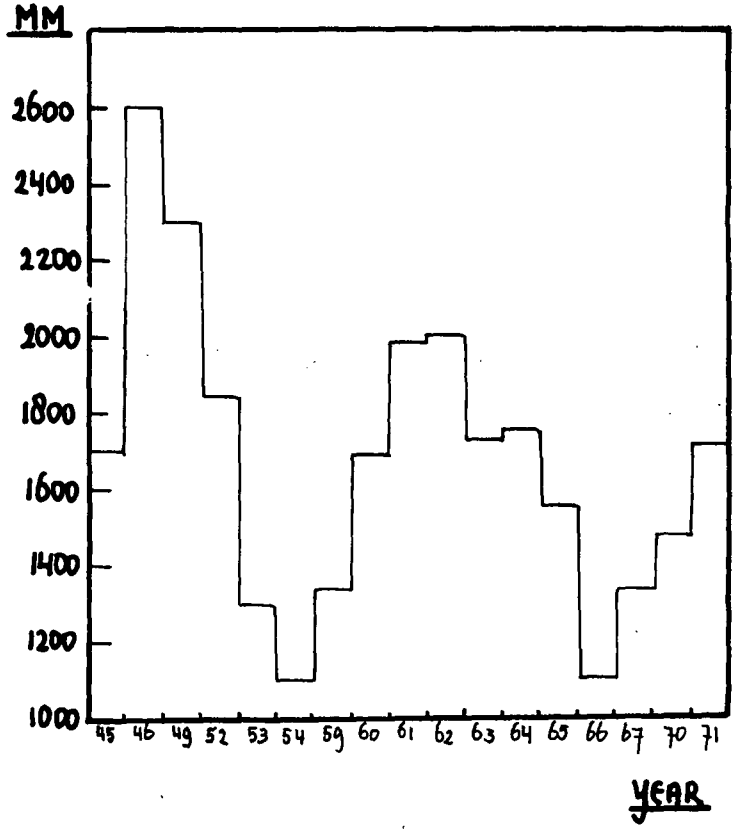


Table 1.

RAININTENSITIES IN KISII FROM 3 TO 28 APRIL (CASELLA RECORDER)

DATE	INTENSITY (mm/min)	DURATION (min)	MAX. INTENSITY	DURATION	TOTAL RAINFALL (mm)
3	0,63-0.20-0.22	35-60-14	0.89-0.32-0.22	23-30-14	37
4	0.86	18	0.86	18	15.5
5	0.005	530	0.005	530	2.5
6	0.02	60	0.02	60	1
7	0.04-0.08	35-20	0.04-0.08	35-20	3
8	0.65-0.07	26-200	1.60-0.11	5-80	39.5
9	0.01	300	0.01	300	2.5
10	0.09	195	0.90	15	17
11	0.25-0.07	53-15	0.65-0.07	20-15	15
12	0.67-0.02	18-235	0.77-0.1	15-15	19
13	0.1-0.5-0.12-0.06	10-12-25-98	0.1-0.88-1-0.27	10-8-4-30	17
14	0.43-0.13-0.06-0.04	15-15-40-25	0.6-0.14-0.08-0.04	10-15-25-40	15.5
15	0.25	20	0.38	12	6
16	0.05	110	(0.25-0.3)	(8-5)	6.5
17	-	-	-	-	-
18	-	-	-	-	-
19	0.05	90	0.31	8	4.5
20	0.56	8	0.56	8	4.5
21	- (defect)	-	-	-	-
22	0.19	18	0.19	18	3.5
23	0.57	30	0.75	20	14.5
24	-	-	-	-	-
25	0.15	48	0.23	20	12.5
26	0.20	5	0.20	5	1.5
27	-	-	-	-	-
28	-	-	-	-	-

Total rainfall: 244 mm.

The western part of the area belongs to the WS zonal vegetation type, with Combretum and allied broad-leaved savannah types, including semi-permanent cultivated areas and grazing (10-50 %) (40).

The eastern part of the region falls within the WM vegetation zone, but a few scattered areas, mainly consisting of rocky and stony ridges and slopes, maintain a Combretum vegetation: the Faurea and Parinari-Combretum mixtures (40h), including some cultivated areas, mainly used for grazing.

North-east from Riosiri and along the Gucha River the vegetation consists of 75 % forest clearing and cultivation communities from a lower moist intermediate forest, with cultivated Albizia-Bridelia-Vernonia (25d).

The rest of the eastern WM vegetation consists of 95 % forest clearings and cultivation communities from Moist montane and intermediate forest with undifferentiated clearings and scrub (35).

Subdivision of the survey area into regions with different types of landuse is based upon

a. landscape
b. altitude and its influence on climate
c. ethnic group
d. density of population.

Thre agro-ecological regions may be recognized: one of them coincides with the WS vegetation zone, the second is a transition zone, the third comprises the region with WM vegetation.

1. The western area as far as the district boundary is inhabited by the Luo (River and Lake) Nilotes, who travelled up the Nile from the southeastern corner of the present Sudan Republic in the 15th century. They are originally pastoralists, who adopted themselves to farming. Density of population 150-170 persons per km^2.

   The altitude is 1430-1500 m. (4700-4900 ft.) and covers most of the BN landscape with broad ridges, covered with indurated ironstone, and wide, flat-bottomed valleys.

   The strongly dissected BK landscape, with shallow and poor soils, along the Gucha River belongs to this agro-ecological region. Most of the land is used for extensive grazing because the very shallow soils suffer of either waterlogging or drought. Semi-permanent cultivation for subsistence agriculture is characterized by the cultivation of a mixture of crops on small farms. The products serve

mainly for local use or for near villages. Principal crop is hybrid maize, common crops are local maize, cassave, coffee, sisal, bananas and sugar cane.

2. The western part of the Kisii District, in the survey area with an altitude between 1500 and 1550 m. (4900-5100 ft.), belongs to the WS-WM transition zone. The inhabitants are the Gusii (Kisii) peoples, belonging to the Highlands and Plains Nilotes, who migrated from Ethiopia or Eastern Sudan. They are farmers, but cattle play an important part in the lower region of the Kisii Highlands. Density of population is approximately 200-300 persons per km^2.

   Included in this agro-ecological region are the remaining parts of BN and BK physiographic units and the AK3 unit along the Gucha River.

   The soils are mainly shallow, due to indurated ironstone on the flat, broad ridges (BN), or due to strongly dissected, steep valley sides (BK and AK 3).

   Semi-permanent cultivation and grazing on shallow soils to permanent cultivation on deep soils supplies a variety of crops.

   Major crops : hybrid maize
   Common crops: sugar cane, coffee and bananas
   Minor crops : local beans and vegetables.

3. The Western moist forest zone with an altitude of 1550 to 1800 m. (5100-6100 ft.). Rainfall amounts to 1600-2100 mm. with a high April/May top with continuous rainfall. Average temperatures are lower and hours of daily sunshine shorter, compared with the other two agro-ecological regions.

   The area is occupied by the Kisii tribe; density of population amounts to 350-400 persons per km^2.

   Both deep (AK 1, AK 2, AM 1), intermediate (AM 3a and AM 3b) and shallow soils (Am 2) occur. 95% of the area has been cleared and is used mainly for permanent cultivation (95%).

   Major crops : hybrid maize, coffee
   Common crops: bananas
   Minor crops : local maize, wimbi, sweet potatoes, sugar cane, black wattle and vegetables.

2. The soils (Part II)

2.1. Survey methode and materials

For this detailed soil survey an area of approximately 10.000 ha. was selected with the aid of the geological map of the Kisii district (1951) and the topographical map, sheet 130/3 Kitere (1962).
The Marongo ridge area was surveyed by 4 participants.

The procedure followed for this detailed soil survey was:
a physiographic airphoto interpretation of a small area (about 100 ha.), which was checked the day after in the field, followed by a correction of the soil boundaries and a physiographic airphoto interpretation of a new area.
This procedure - interpretation, fieldcheck, correction - was carried out daily.
The interpretation was done with airphotos and Topcon stereoscopes, the geological map (1951) on scale 1 : 125.000 and the topographical map, sheet 130/3 Kitere (1962) on scale 1 : 50.000.
The airphotos were obtained from the Survey of Kenya on scale 1 : 12.500, (1966).
The most important elements used are relief, drainage and landuse.

Fieldwork has been carried out with auger- and pit observations.

Auger observations

About 2000 soil profile augerings (see auger and pit location map) were made, to a depth (if possible) of 1.80 m., by means of a soil-auger (Edelman type).
Properties of the soil and the surroundings observed at the augering site:

- depth of the solum and the thickness of the horizons
- colour, the soil colours were measured by comparison with the Munsell soil colour charts
- texture
- stoniness and rockiness
- slopeform and slopegradient, the latter measured with the Abney level
- parent material
- land use

Pit observations

In every soil series observations were completed with at least one detailed description of a soil profile.

About 50 soil pits were dug to a depth of 0,5 - 2,00 m. (see auger and pit location map and Appendix I).
The soil profiles were described in detail according to the directives given in the Soil Survey Manual (1952) and the FAO guidelines for soil description.

Properties of the soil and the surroundings observed at the pit place:
- the properties as mentioned above
- presence of clay skins
- structure
- biopores and rootdevelopment
- consistency
- mottles and concretions
- width and topography of the soil boundaries

From every horizon one or more soil samples were taken for analyses at the laboraties of the Agricultural University at Wageningen, the Netherlands.
The following analyses will be carried out:
texture, pH, organic matter content, cation exchange capacity, base-saturation, total analysis.
Soil peels were made from selected soil profiles and undisturbed soil samples were taken for micromorphological studies in thin sections.

Map compilation:
A detailed soil map on scale 1 : 12.500 had been produced.
At first a base map was prepared, using the slotted template method.
The soil boundaries and other soil data drawn on the air photos were transferred to this base map with the aid of a Sketchmaster, used was the Vertical Sketchmaster of Keuffel and Essen.
A landuse map was produced by transferring the land use data on the airphotos to a copy of the above mentioned base map, also with the aid of the Sketchmaster.
A land suitability map was produced by using the soil map and a study, which had been made, about the suitability of all the soil series for several crops.

2.2. Description of the soils.

2.2.1. Explanatory legend of the Marongo area

A table has been made with the main characteristics of each series. See for this table Appendix II.

2.2.2. Series, types and phases

Criterions and symbols for the distinction of the series:

a. Series name

Each series has a geographical name. The first two characters of the series name have been derived from that name.

b. Parent material

Begincharacter of the parent material is the third character of the seriescode.

B = Basalt	G = Granite
Q = Quartzite	L = Laterite
R = Rhyolite	A = Alluvial
F = Felsite	

c. Thickness of the solum and genetic horizons.

The thickness of the solum has been defined from the soil surface to the upper boundary of the B3 horizon.

The auger criterions of the genetic horizons are:

- for the A horizon : chroma's and values lower than 4
- for the B2 horizon: a color of 2,5 YR 3/4 or redder
- for the B3 horizon: the B3 horizon is a transition horizon between the B2 and the rotten rocks, it has characteristics of the B2 as well as the rotten rock, e.g. weathered mottles and weathered gravels or stones.

The criterions for thickness and genetic horizons are combined and give 5 classes:

THICKNESS		GENETIC HORIZONS
shallow	: 0-20 and 0- 50 cm.	A
shallow	: 20- 50 cm.	A + B
moderately deep	: 50-120 cm.	A + B
deep	: 120-180 cm.	A + B
very deep	: more than 180 cm.	A + B

d. Thickness of the A horizon

A new series has been distincted if the A horizon (chroma's and values lower than 4) has a thickness of more than 40 cm.

e. Drainage

The criterions of hydromorphic soils are:
topsoil, dark colours 7,5 YR 3/2 and 10 YR 3/2 or darker subsoil, grey colours and/or gley features.

Criterions and symbols for distinction of the types and phases:

Type, this is the texture class of the topsoil of 15 cm.

F = fine, more than 35% clay

M = medium, 17 - 35% clay

C = coarse, 0 - 17% clay

Nearly all soil have a fine or very fine texture (more than 50% clay).

Phases:

a. Depth of the soil, i.e. the penetrability of the soil with the auger.

4 = 0 - 20 cm.

3 = 20 - 50 cm.

2 = 50 - 100 cm.

1 = 100 - 150 cm.

0 = more than 150 cm.

b. Slope

A = 0 - 3% (nearly) level

B = 3 - 8% (very) gently sloping

C = 8 - 15% (strongly) sloping

D = 15 - 30% moderate steep

E = 30 - 65% steep

F = more than 65%, very steep

c. Stoniness of the soil surface

S1 = 0 - 3%

S2 = 3 - 15%

S3 = 15 - 90%

S4 = 90 - 100%

e. Drainage

Depth of mottling, which are signs of impeded drainage:

m4 = 0 - 20 cm.

m3 = 20 - 50 cm.

m2 = 50 - 100 cm.

m1 = more than 100 cm.

Depth of completely reduced horizon:

g4 = 0 - 20 cm.

g3 = 20 - 50 cm.

g2 = 50 - 100 cm.

g1 = more than 100 cm.

Each mapping unit is indicated by formula with the symbols for the series, types and phases mentioned above:

for example: $\frac{\text{NyB - F2}}{\text{C - S2R1}}$

NyB = series symbol
F2 = type and soildepth
C = slope
S2 = stoniness
R1 = rockiness

2.2.3. Key to the soils

The series and their phases: drainage class, depth, slope, surface-stoniness and -rockiness.

I. Pachic Humoxic Palehumults; very deep and well drained.

a. On non-porphyritic Basalt

1. Nyaborumbasi clay, sometimes on level slopes with stoniness class 1
2. Nyaborumbasi clay, gently sloping, sometimes with stoniness class 1
3. Nyaborumbasi clay, sloping, sometimes with stoniness class 1

b. On Quartzite

1. Marongo 3, level slopes
2. Marongo 3, gently sloping
3. Marongo 3, sloping

c. On Rhyolite

1. Kitere clay, gently sloping
2. Kitere clay, sloping

d. On Felsite

1. Nyakambene, level
2. Nyakambene, gently sloping with or without a stoniness class 1
3. Nyakambene, sloping
4. Nyakambene, moderate steep

II. Humoxic Palehumults and Humic Paleudults; very deep and well drained.

a. On non-porphyritic Basalt

1. Chang'a clay level
2. Chang'a clay gently sloping
3. Chang'a clay sloping with sometimes stoniness class 1
4. Chang'a clay moderate steep with sometimes stoniness class 1

b. On Quartzite

1. Nyangori clay, level
2. Nyangori clay, gently sloping
3. Nyangori clay, sloping with or without stoniness class 1
4. Nyangori clay, moderate steep

c. On Granite with laterite in the subsoil

1. Nyasoka clay, level
2. Nyasoka clay, gently sloping

d. On Rhyolite

1. Nyokal clay, level
2. Nyokal clay, gently sloping
3. Nyokal clay, sloping
4. Nyokal clay, moderate steep

e. On Felsite

1. Skuli clay, gently sloping
2. Skuli clay, moderate steep

III. Pachic Humoxic Palehumults and Pachic Humoxic Tropohumults; deep and well drained.

a. On non-porphyritic Basalt

1. Ikoba clay, sometimes on level slopes
2. Ikoba clay, gently sloping with or without stoniness class 1
3. Ikoba clay, sloping with or without stoniness class 1 and rockiness class 1
4. Ikoba clay, moderate steep

IV. Humoxic Palehumults and Humoxic Tropohumults; deep and well drained.

a. On Rhyolite

1. Nduru clay, gently sloping
2. Nduru clay, sloping with sometimes stoniness class 1

V. Humoxic Palehumults, Humoxic Tropohumults, Humic Paleudults and Typic Rhodudults; deep and well drained.

a. On non-porphyritic Basalt

1. Muma clay, gently sloping with or without stoniness class 1
2. Muma clay, sloping with or without stoniness class 1
3. Muma clay, moderate steep with or without stoniness class 1
4. Muma clay, steep with or without stoniness class 1

VI. Humoxic Palehumults, Humoxic Tropohumults, Humic Paleudults and Typic and Flavic Rhodudults; deep and well drained.

a. On Quartzite

1. Kiabigori clay, level
2. Kiabigori clay, gently sloping
3. Kiabigori clay, sloping with or without a stoniness class 1 or stoniness 2 or sometimes stoniness- and rockiness class 1
4. Kiabigori clay, moderate steep with or without stoniness class 1

VII. Pachic Humoxic Tropohumults; moderately deep and well drained.

a. On non-porphyritic Basalt

1. Machongo clay, sometimes on sloping slopephase

VIII. Humoxic Tropohumults, Typic and Flavic Rhodudults; moderately deep and well drained.

a. On non-porphyritic Basalt

1. Gucha clay, sometimes on level slopes with stoniness class 1
2. Gucha clay, gently sloping with or without stoniness- and rockiness class 1
3. Gucha clay, sloping with or without stoniness class 1 or 2 or stoniness- and rockiness class 1
4. Gucha clay, moderate steep with or without stoniness class 1 or stoniness- and rockiness class 1 or 2

b. On Quartzite

1. Itumbi clay, gently sloping with sometimes stoniness class 2
2. Itumbi clay, sloping with sometimes stoniness class 2
3. Itumbi clay, moderate steep with or without stoniness class 1 or 2
4. Itumbi clay, very steep with stoniness- and rockiness class 1

c. On Granite with laterite in the subsoil

1. Paulo clay, level
2. Paulo clay, gently sloping
3. Paulo clay, sloping
4. Paulo clay, moderate steep

IX. Humoxic Tropohumults and Typic Rhodudults; moderately deep and well drained.

a. On Kitere Granite with laterite in the subsoil

1. Ndiwa clay, level
2. Ndiwa clay, gently sloping
3. Ndiwa clay, sloping
4. Ndiwa clay, sometimes on moderate steep slopes

X. Humoxic Tropohumults and Flavic Rhodudults; moderately deep and well drained.

a. On Rhyolite

1. Nyerega clay, level
2. Nyerega clay, gently sloping with or without stoniness class 1
3. Nyerega clay, sloping with or without stoniness class 1
4. Nyerega clay, moderate steep with or without stoniness class 1 or 3

XI. Humoxic Tropohumults, Typic and Flavic Rhodudults; shallow and well or somewhat excessively drained.

a. On non-porphyritic Basalt

1. Mugirango clay, sometimes on level slopes with stoniness class 1
2. Mugirango clay, sometimes on gently sloping positions with stoniness class 1 or 2
3. Mugirango clay, sloping with stoniness class 1 or 2 with stoniness class 1 and rockiness class 1

4. Mugirango clay, moderate steep with or without stoniness class 1 or 2 or 3 or stoniness class 1 or 2 and rockiness class 1 or 2
5. Mugirango clay, steep with stoniness class 2 or with stoniness class 1 or 2 and rockiness class 1 or 2

XII. Lithic Humitropepts, Lithic oxic entic Dystropepts with or without Lithic Troporthents; shallow and imperfectly to well drained.

a. With laterite within 20 cm.(very shallow)

1. Rongo clay, level with or without stoniness class 1 or 2
2. Rongo clay, gently sloping with or without stoniness class 1 or 2
3. Rongo clay, sloping with or without stoniness class 1 or 2
4. Rongo clay, moderate steep

b. With laterite between 20 - 50 cm.

1. Riosiri clay, level with or without stoniness class 1 or 2
2. Riosiri clay, gently sloping with or without stoniness class 1 or 2
3. Riosiri clay, sloping with or without stoniness class 1 or 2 or stoniness class 1 and rockiness class 1
4. Riosiri clay, moderate steep

XIII. Lithic oxic Humitropepts and Lithic oxic entic Dystropepts; shallow and well or somewhat excessively drained.

a. On non-porphyritic Basalt

1. Ogembo clay, sloping with or without stoniness class 1 or 2 and rockiness class 1 or 2
2. Ogembo clay, moderate steep with stoniness class 1 or 2 and rockiness class 1 or 2
3. Ogembo clay, steep with stoniness class 1 or 2 and rockiness class 1 or 2

b. On Felsite

1. Gesusu clay, gently sloping with stoniness class 2
2. Gesusu clay, steep with stoniness class and rockiness class 2

XIV. Ruptic lithic oxic Humitropeptic (or Lithic oxic entic Dystropeptic) Troporthents; shallow and well or somewhat excessively drained.

a. On Quartzite

1. Marongo I clay, sometimes on gently sloping positions with stoniness class 2
2. Marongo I clay, sloping with or without stoniness class 2 or 3 or stoniness class 1 or 2 and rockiness class 1 or 2
3. Marongo I clay, moderate steep with or without stoniness class 1 or 2 or 3 or stoniness class 1 or 2 or 3 and rockiness class 2 or 3
4. Marongo I clay, steep with stoniness class 1 or 2 and rockiness class 1 or 3 or 4
5. Marongo I clay, very steep with stoniness class 1 and rockiness class 4

XV. Ruptic lithic Troporthentic oxic Humitropepts or Ruptic lithic Troporthentic oxic Dystropepts; shallow and well or somewhat excessively drained.

a. On Rhyolite

1. Kananga clay, level with or without stoniness class 1
2. Kananga clay, gently sloping with or without stoniness class 1 or 2
3. Kananga clay, sloping with stoniness class 1 or 2 or stoniness class 1 or 2 and rockiness class 1 or 2
4. Kananga clay, moderate steep with stoniness class 2 or 3 or stoniness class 2 and rockiness class 2
5. Kananga clay, steep with stoniness class 2 or 3 and rockiness class 2 or 3

XVI. Oxic Plinthaquults; deep to very deep and imperfectly to moderately well drained.

1. Rakwaro clay, level with mottling class 4 or 3 and gley class 1
2. Rakwaro clay, gently sloping with mottling class 4

XVII. Fluventic Tropaquepts; deep and poorly to moderately well drained.

1. Olando clay, level with mottling class 4 or 3 and gley class 1 or 2
2. Olando clay, gently sloping with gley class 1 or 2
3. Olando clay, sloping with gley class 1

XVIII. Typic Tropaquepts; shallow to deep and poorly to imperfectly drained.

1. Maraba clay, deep, level with mottling class 4 or 3 and gley class 1 or 2
2. Maraba clay, moderately deep, level with gley class 1 or 2
3. Maraba clay, shallow, level, with gley class 3.

2.2.4. Short descriptions of the series, miscellaneous and complexes

S e r i e s

NbB: Nyaborumbasi series (see Appendix I, profile 5)

Surface in ha: 892 (9.1%)
The Nyaborumbasi series occur on uniform non- or slightly dissected slopes, ranging from gently sloping to moderately steep.
The stoniness class of this series is always 0. It comprises deep moderate to strong subangular to angular blocky, dark red clay soils with mostly continuous clay skins. The A-horizon dark brown to dark reddish brown and thick (often more than 60 cm.).
The soils are very suitable for all kinds of crops, especially for cashcrops as coffee and bananas.

MrQ: Marongo III series (see Appendix I, profile 51)

Surface in ha: 39 (0,4%)
The series is mainly found on gently sloping to moderately steep positions below Quartzite-escarpments. It includes deep, moderate subangular blocky, dark red clay soils with broken clay cutans in the B-horizon. The A-horizon is dark reddish brown and thick (more than 40 cm.). The series is well drained.

NkF: Nyakembene series (see Appendix I, profile 63)

Surface in ha: 157 (1,6%)
The Nyakembene series occur on the Marongo Plateau with slopes ranging from level to moderately steep. The stoniness class is 0.

The series includes deep moderate fine angular to subangular blocky dark red clay soils with patchy clay cutans. The A horizon is dark brown and thick (more than 40 cm.). The series is well drained.

Chb: Chang'a series (see Appendix I, profile 66)

Surface in ha: 1.205 (12,3%)
The Chang'a series is found on slightly dissected uniform slopes ranging form nearly level to moderately steep. The stoniness is mostly 0. This series comprises deep moderate to strong subangular to angular blocky dark red clay soils with continuous clay cutans. The A-horizon in mostly shallow and on moderately steep positions, it is somewhat eroded. The soils are well drained.

NnQ: Nyangori series (see Appendix I, profile 17)

Surface in ha: 186 (1,9%)
The Nyangori series occur mostly on plateaus and lower slopes ranging from nearly level and sloping to moderately steep and which are non- or slightly dissected. The series includes deep weak subangular blocky dark red clay soils with broken and continuous clay cutans. The A-horizon is normally reddish brown and shallow (10-20 cm.). The series is well drained.

NsG: Nyasoka series (see Appendix I, profile 69)

Surface in ha: 235 (2,4%)
The series occur on flattopped low hills with uniform slopes ranging from level to gently sloping. It has a stoniness class 0. The series includes deep weak to moderate subangular blocky dark red clay soils with broken clay cutans. The A-horizon is dark brown or dark reddish brown and rather shallow (20-30 cm.). The soils are susceptible to sealing due to their sand fraction (30%). The series is well drained.

NkR: Nyokal series (see Appendix I, profile 18)

Surface in ha: 69 (0,7%)
The series is normally found on upper convex slopes and on concave slopes around valley-heads ranging from gently sloping to moderately steep. The series has a stoniness class 0. It comprises deep moderate angular to subangular blocky dark red clay soils with broken and continuous clay cutans. The A-horizon is often shallower than 20 cm and has a dark brown colour. The soils are all well drained.

IkB: Ikoba series (see Appendix I, profile 8)

Surface in ha: 127 (1,3%)
The Ikoba series is found on uniform slightly dissected slopes ranging from level to moderately steep. The stoniness class is mostly 0. The series comprises deep moderate to strong angular and subangular blocky dark red clay soils with continuous clay cutans. The A-horizon is dark reddish brown and thick (more than 40 cm.). The soils are well drained.

NdR: Nduru series (see Appendix I, profile 71)

Surface in ha: 69 (0,7%)
The Nduru series occur on upper convex slopes and on concave lower slopes around valley-heads, ranging from gently to strongly sloping. It includes deep moderate subangular blocky red clay soils with continuous clay cutans. The A-horizon has dark brown to dark reddish brown colours and a thickness of more than 40 cm, due to supply from upper slopes. The series is well drained.

NmB: Muma series (see Appendix I, profile 7)

Surface in ha: 353 (3,6%)
The series is found on slightly dissected lower and upper slopes, ranging from gently to moderately steep. Sometimes stoniness 1 is present. The series includes deep strong angular to subangular blocky dark red clay soils with continuous clay cutans.
On moderately steep valley-slopes the A-horizon has become shallow (less than 20 cm.)due to erosion. The soils of this series are well drained.

KbQ: Kiabigori series (see Appendix I, profile 52)

Surface in ha: 127 (1,3%)
The Kiabigori series mostly occur on plateaus and on upper and lower slopes, ranging from level to moderately steep. Stoniness class 1 and 2 are sometimes present. The series comprises deep weak to moderate subangular blocky dark red clay soils with broken clay cutans. The dark reddish brown A-horizon normally has a thickness of 20 cm. Due to the sand-fraction in this series (20%) there is somewhat more susceptibility to sealing. The soils of this series are well drained.

ItQ: Itumbe series (see Appendix I, profile 16)

Surface in ha: 78 (0,8%)
The series occur on small plateaus and below escarpments, slopes ranging from level to steep. You may find a surface stoniness of 0 - 15% and a surface-rockiness of 0 - 10%. It is a moderate deep, dark red, clay soil, having a weak subangular blocky structure. The clay cutans in the B-horizon are broken. The series is well drained.

GcB: Gucha series (see Appendix I, profile 58)

Surface in ha: 515 (5,3%)
The series occur on slightly or moderate dissected slopes, ranging from gently sloping to moderate steep slopes. It has a surface stoniness of 0 - 90% and a surface rockiness of 0 - 2%. It is a moderate deep, dark red, clay soil, having a moderate to strong subangular blocky structure. The clay cutans in the B-horizon are continuous or broken. The series is well drained.

PeQ: Paulo series (see Appendix 1, profile 11)

Surface in ha: 294 (3,0%)
The series occur on the plain of the East Nyokal subdistrict on undulating to rolling slope positions.
It is a moderate deep, yellowish red, clay soil, having a weak subangular blocky structure. The clay cutans in the B-horizon are broken. The series is well drained and is susceptible to sealing.

NdG: Ndiwa series (see Appendix I, profile 13)

Surface in ha: 284 (2,9%)
The series occur on flat topped low hills with uniform slopes, ranging from nearly level to sloping. It is a moderate deep to deep, yellowish red, clay soil, having a weak subangular blocky structure. The clay cutans in the B-horizon are broken. The series is well drained and is susceptible to sealing.

NrR: Nyerega series (see Appendix I, profile 24)

Surface in ha: 274 (2,8%)
The series occur on upper and lower convex and concave slopes of low hills with slopes ranging from nearly level to (strongly) sloping.

It is a moderate, deep dark red, clay soil, having a moderate (sub) angular blocky structure. The clay cutans in the B-horizon are broken or continuous. The series is well drained.

MgB: Mugirango series (see Appendix I, profile 55)

Surface in ha: 451 (4,6%)
The series occur on slightly or moderate dissected slopes and on the knickpoints of slopes, ranging from sloping to steep slopes. Usually the series has a surface-stoniness between 0- 90% and a surface rockiness of 0 - 10%. It is a shallow, dark red, clay soil, having a moderate subangular blocky structure. The clay cutans in the B-horizon are broken. The series is well or somewhat excessively drained.

RnL: Rongo series (see Appendix I, profile 74)

Surface in ha: 402 (4,1%)
The series occur on flat summits and lower valley slopes of low and smooth hills with slopes ranging from nearly level to moderate steep. Usually the series has a surface stoniness between 0 - 90%. It is a shallow, dark brown, clay soil, having a moderate subangular blocky structure. The series is imperfectly or well drained and is susceptible to sealing.

MnQ: Marongo I series (see Appendix I, profile 57)

Surface in ha: 1089 (11,1%)
The series occur on edges of plateaus, on escarpments and just below escarpments, slopes ranging from level to very steep. Usually the series has a surface stoniness between 0 - 90% and a surface rockiness of 0 - 50%. It is a shallow, dark reddish brown, clay soil, having a moderately weak subangular blocky structure. The series is well or somewhat excessively drained and is susceptible to sealing.

KnR: Kananga series (see Appendix I, profile 65)

Surface in ha: 1372 (14,0%)
The series is strongly influenced by the Gucha- and the relatively small branches of the Gucha river. The soils have been developed on ridges, which have slopes of about 10 - 15% towards the Gucha river.

The slopes on which this series occur range from gently sloping to steep, usually you find a surface stoniness between 0 - 90% and a surface rockiness of 0 - 10%. It is a shallow, dark brown, clay soil, having a moderate subangular blocky structure. The series is well or somewhat excessively drained.

RkR: Rakwaro series (see Appendix I, profile 19)

Surface in ha: 39 (0,4%)
The series occur on gently sloping slightly concave lower slopes, near broad hydromorfic valley bottoms (Hv1). It is a deep, brown to dark brown, clay soil with plinthite in the sub soil.
The B-horizon has broken clay cutans and a moderately to strong structure. The series is imperfectly to moderately well drained, but only the lower positions have some water logging during the wet season.

MrA: Maraba series (see Appendix I, profile 10)

Surface in ha: 69 (0,7%)
The series occur mainly in depressions of a nearly level to undulating plain.
It is a shallow to deep, dark brown and/or dark grey, clay soil with gley mottles and a moderate to strong structure. The series is poorly drained and is a part of the year waterlogged.

M i s c e l l a n e o u s

Miscellaneous of soapstone (see Appendix I)

Soapstone areas with more than 90% surface rockiness occur on moderate steep to very steep positions at the contact zones of Quartzite and Basalt.
There are many small areas, only a few are mappable.

C o m p l e x

Valley complex (see Appendix I)

Surface in ha: 314 (3,2%)
Occur on the lower convex valley slopes and in the valleys of relatively small valleys.
Slopes are ranging from level to very steep phases.

On the level or gently sloping positions (about 30%) occur the hydromorphic Olando series on sloping to very steep phases, (about 70%) you will find the Ogembo, Mugirango and Gucha series or the Kananga series or the Marongo I series.
You often find a stoniness class 1, 2 or 3 and/or a rockiness class 1 or 2.

Complex on Basalt

1. Occur on the summit of a low ridge West of the Marongo series. Slopes are ranging from gently sloping to steep. The complex has a stoniness class 3 and a rockiness class 1 or 2 with about 30% of the Ogembo series and about 70% of the Mugirango series.
2. On sloping and moderate steep positions of an irregular slope below the Quartzite escarpment West of the Marongo ridge, with 30% of the Mugirango series and 70% of the Gucha series. You will find a stoniness class 1 or 2 and a rockiness class 1.
3. This complex occurs on the irregular slopes below the Quartzite escarpment East of the Marongo ridge with slopes ranging from sloping to very steep. There are series in this complex: 20% of the Ogembo-, 40% of the Mugirango-, and 40% of the Gucha series.
4. On moderate steep positions of lower valley slopes of low Quartzite ridges, West of the Marongo ridge.
   There are two series in this complex: 40% of the Gucha series and 60% of the Muma series.
5. This small complex occur on a sloping positions of an irregular lower slope East of the Marongo ridge, with about 30% of the Gucha series and about 70% of the Nyaborumbasi series.

Complex on Quartzite

1. On sloping and very steep positions of the irregular slopes below the Quartzite escarpment West of the Marongo ridge, with 50% of the Marongo I series and 50% of the Itumbi series.
   You find a stoniness class 1 or 2 and a rockiness class 1 or 2.
2. On gently sloping of a lower Quartzite hill West of the Marongo ridge, with 50% of the Kiabigori series and 50% of the Nyangori series.

2.2.5. Simple description of the map legend

I. Soils without waterlogging

A. Soils with a low nutrient content and with a subsoil which has a higher clay content than the topsoil

1) Very deep (soil depth more than 1,80 m.), dark red, clay soil

		series symbol
1.1. with a thick humusrich topsoil		
developed on:	1.11 Basalt rocks	NbB
	1.12 Quartzite rocks	MrQ
	1.13 Rhyolite rocks	KtR
	1.14 Felsite rocks	NkF
1.2. without a thick humusrich topsoil		
developed on:	1.21 Basalt rocks	ChB
	1.22 Quartzite rocks	NnQ
	1.23 Rhyolite rocks	NkR
	1.24 Felsite rocks	SkF
	1.25 Granite rocks	NsG

2) Deep soil (soil depth between 1,20 and 1,80 m.), dark red and/or yellowish red, clay soil

2.1. dark red soil with a thick humusrich topsoil		
developed on:	2.11 Basalt rocks	IkB
2.2. dark red soils without a thick humusrich topsoil		
developed on:	2.21 Basalt rocks	MmB
	2.22 Rhyolite rocks	NdR
2.3. dark red and yellowish red soils without a thick humusrich topsoil		
developed on:	2.31 Quartzite rocks	KbQ

3) Moderately deep (soil depth between 0,50 and 1,20 m.), dark red and/or yellowish red, clay soil

3.1. dark red soil with a thick humusrich topsoil		
developed on:	3.11 Basalt rocks	McB
3.2. dark red soil with a thick humusrich topsoil		
developed on:	3.21 Granite	NdG

3.3. dark red and yellowish red soils without a humusrich topsoil

developed on:	3.31 Granite	PlG
	3.32 Basalt	GcB
	3.33 Quartzite	ItQ
	3.34 Rhyolite	NrR

4) Shallow (soil depth less than 0,50 m.) dark red to yellowish red clay soil

developed on:	4.11 Basalt rocks	MgB

B. Soils with a low nutrient content and without a subsoil which has a higher clay content than the topsoil

1) Shallow (soil depth less than 0,50 m.), clay soil, with or without a humic topsoil or a color B-horizon

1.1. soil depth less than 0,20 m.

developed on:	1.11 Laterite	RnL

1.2. soil depth between 0,20 - 0,50 m.

developed on:	1.21 Laterite	RsL
(depth less than 0,20 m.)	1.22 Basalt rocks	OgB
(depth less than 0,50 m.)	1.23 Felsite rocks	GsF

1.3. soil depth less than 0,50 m.

developed on:	1.30 Quartzite	MnQ

1.4. soil depth less than 0,50 m.

developed on:	1.41 Rhyolite	KnR

II. Temporarily waterlogged soils

A. Soils with a low nutrient content and with a subsoil which has a higher clay content than the topsoil

1) Moderately deep to very deep (soil depth more than 0,50 m.) clay soil RkR

B. Soils with a low nutrient content without a subsoil which has a higher clay content than the subsoil

1) Moderately deep to deep (soil depth between 0,50 and 1,80 m.) clay soil

1.1. soil depth between 1,20 and 1,80 m. OlA

1.2. soil depth between 0,50 and 1,80 m. MrA

3. Interpretation of the survey data (Part III)

3.1. Actual land utilisation types

First the term 'utilisation type' has to be explained.
Under land utilisation type is understood the use possibilities of land. It may be used for the present situation in a certain area, or the future after certain improvements have been established.

In the Marongo area two land utilisation types can be distinguished:

A. Mixed farming - grazing
- cultivation of subsistence crops

B. Mixed farming - grazing
- cultivation of subsistence and cash crops

Each land utilisation type can be characterised by the following key attributes:

a. Nature of produce
b. Land tenure system
c. Size of the farms
d. Labour intensity
e. Level of technical know-how

By means of these attributes an effort will be made to describe the actual land utilisation types.

3.1.1. Nature of produce

A n i m a l h u s b a n d r y

The animals kept in the area are donkeys, cattle, sheep and goats. Most of the area is used for arable farming, but there are places where grassland is found.
The grasslands may be divided into:
- natural grassland
- permanent grassland
- temporary grassland

Natural grassland is found, where the soils are unsuitable for the cultivation of crops, e.g. very shallow and stony soils on steep slopes, or not yet cultivated land.
The permanent grassland around the homesteads is mainly used to collect cow dung and to reduce the risk of theft of cattle.

Temporary grassland is created at places where farmers use a fallow period, when the soils need rest for some years to restore fertility.

Animal husbandry is not well developed in this area, when we think in terms of milk and meat production. The production per cow of the local cattle is only a few litres a day.

Besides improvement of cattle, attention has to be given to improvement of grasslands, as these are often covered with shrubs and other vegetation of low nutritive value. Clearing of these shrubs does not take place regularly. Often cattle grazes along roads and tracks if the pasture near the farm is not enough to feed all of them. Quite a great deal of the grassland is common property. A important factor is that raising cattle is not primarily for the production of milk and meat; reasons such as capital investment and ox-traction are more important.

S u b s i s t e n c e c r o p s

In order of importance the subsistence crops grown in the area are listed below:

a. Maize
b. Beans
c. Cassava
d. Sweet potatoes
e. Wimbi
f. Bananas
g. Cabbage, spinach and millet

a. Maize

Like everywhere in East Africa maize is the main staple food. In areas where soils are unsuitable for growing cash crops, maize may be used for trading.

The seed used is not always Hybrid, also the farmers often use harvested Hybrid again. They probably think that they have to buy a bag of Hybrid once to get advantage of higher yields forever. Because of its importance as a subsistence crop and due to population pressure maize is often planted on soils which are less suitable (e.g. soils on very steep slopes: danger of erosion).

The planting date varies from year to year, depending on the onset of the rains. Most farmers start planting the maize after the rains have started, due to the unreliability of the beginning of the rains.

However the best time of planting is 14 days before this start.
Very often you notice maize that has been planted much later and sometimes even too late so that there will not be any harvest at all.
Most farmers, especially when they farm on less fertile soils, grow only one crop of maize a year during the long rains.
They prepare the land in January up to February and start planting in February up to March.
After removal of the cobs they often leave the stems on the fields and do not start preparing the land again after the short rains. In the meantime the cattle can enjoy what is left of the crop. The weeding of maize is most important when the plants are young. For cleaning the field farmers use the jembe, a small hoe. The frequency of weeding varies from 2 to 4 times during one growing season.
The use of fertilizers is restricted to a small group of more 'progressive' farmers. In the field many places can be found where the maize shows a considerable deficiency of phosphate and sometimes magnesium as well.
Application of cow dung to maize is rare.
The table underneath shows the influence of various factors on the yield of maize.
Maize districts husbandry trials, Kisii S966 (A.Y. Allan, Kenya farmers weekly news)

Factor	Treatment	Costs/acre Ksh	Difference in yield	Yield Bags/acre
1. Time of planting	early	little	9.9	20.1
	4 weeks later			10.2
2. Plants per acre	14.520	4/-	1.5	15.9
	7.260			14.4
3. Type of maize	Hybrid 613A	12/-	6.3	18.3
	local maize			12.0
4. Weeding	clean weeding	20/-	1.8	16.1
	1 late weeding			14.3
5. Phosphate	250 lb.super-P	32/-	1.7	16.0
fertilizers	none			14.3
6. Nitrogen	270 lb. ASN	80/-	1.0	15.2
fertilizers	none			15.1

The table above shows that the factors, which affect the yield of maize most are the time of planting and the type of seed used.

It does not say anything about the soil, which is as important as the above mentioned factors.

b. Beans

Beans are often intercropped with maize. This crop must be considered as a very good crop, because of its protein content. In the area children, especially the very young ones, often show a certain degree of protein shortage, because the food they get is not diversificated enough (too much maize in the daily diet). At the local markets one can see that beans are also an important cash crop.
As a crop it can be very attractive because of its short growing season.

c. Sweet potatoes

It is an easy crop because it does not require a special climate of planting conditions. Also a large variety of soils can be used. For planting, pieces of vine can be taken and no special moisture status of the soil is necessary.
Next to cassava, sweet potatoes is the most important root crop, but the total acreage grown is not very much. Because of the high rainfall in the area sweet potatoes are often kept as a perennial crop.
Sometimes they are grown after a crop that is more exhaustive to the soil.

d. Cassava

Cassava is a very drought resistent crop and it is grown in areas below 1500 m., because the crop needs a warm climate.
That may explain that we find cassava only in South Mugirango and South Nyanza, but not in Majoge Chache.
Because of its low nutrient requirements cassava is very suitable on less fertile soils.

e. Wimbi (Eleusine)

Formerly this crop has been grown much more intensively. The same can be said of millet. The introduction of maize has reduced the acreage of these two crops remarkably.
Wimbi is still grown both as a food crop and as a cash crop and is used for making porridge and local beer.

But it is clear that maize became popular because of its higher yield per acre, less diseases, less pests and the weeding is more easy.

f. Cabbage and spinach

These crops are grown on a very small scale to the homesteads. They are mainly used for own consumption, but sometimes part of the harvest is sold at the local markets.

C a s h c r o p s

Also for the cash crops grown in the area a list can be made in order of importance.

a. Coffee
b. Bananas
c. Maize
d. Sugar cane
e. Groundnuts
f. Beans
g. Tea
h. Pyrethrum

a. Coffee

Up till now coffee is the most important cash crop in this area, but it has not got the highest gross margins, what may be due to some problems in the recent past, when the societies stopped the free supply of fertilizers and when in 1969 an extremely heavy thunderstorm damaged many plantations very badly.
The result of these events was that prices, yield and quality went down and people lost interest in the crop.
This also explains that only occasionally young coffee plantations can be found in the field and that on many plantations pruning systems are absent. Application of cow dung is the only fertilization of the coffee trees in most cases.
By improving management it must be possible to increase yields and quality of the coffee beans, resulting in a higher gross margin, that is even higher than tea and pyrethrum in this area.
The crop is grown in both South Mugirango and Majoge Chache on the deeper soils with a thick dark coloured topsoil.

In South Nyanza remarkable less coffee is grown, because of the lower altitude and the generally less fertile soils.

b. Bananas

The importance of this crop as a cash crop depends on whether lorries are able to come up the roads in the different parts of the area. These lorries take the bananas to the markets in the urban centres. The prices paid by these traders do not seem to be very high in comparison to what the traders receive at the markets.
Also part of the bananas grown is sold at the local markets.
The bananas is a shallow rooting plant with most of the roots in the upper 15 cm.of the soil. This means that the crop can be grown on a larger variety of soils than for instance coffee, supposing that enough moisture is available. The banana plants need plenty of water and that explains why the crop is often grown in the wetter valley bottoms.
The varieties grown are cooking and sweet bananas.
Fertilization is mostly restricted to some supply of cow dung at planting time, but most farmers mulch their bananas.

c. Sugar cane

Especially in South Nyanza this is very important as a cash crop. At many places jaggeries are used, which are simple handtools made by the farmers themselves, but sometimes donkey-traction is practised.
The crop is often grown along the edges of the broad and flat valley bottoms, where more moisture is available for the plants.

d. Groundnuts

Groundnuts are grown in the lower western part of the area and only during the long rains, because the crop needs plenty of water in a period of at least three months to get a reasonable yield.

e. Tea and pyrethrum

For the area as a whole these crops are not very important. Probably the altitude of the area is too low for growing tea and pyrethrum.
The lower altitude of the area implicates a higher temperature which causes tea to grow faster resulting in a inferior quality of the leaves.
Only in Majoge Chache subdistrict a few fields of tea and pyrethrum have been established recently.

3.1.2. Land tenure

C o m m u n a l l a n d

At some places natural grassland where farmers from the area can graze their cattle.

P r i v a t e o w n e d l a n d

Majority of the smallholders.

R e n t e d l a n d

Occassionally farmers rent land temporarily.

3.1.3. Size of the farms

L e s s t h a n 10 a c r e s

Farms with cash crops.

O v e r 10 a c r e s

More extensively farmed.
Few cash crops.

The Marongo Ridge area is a small scale farming area. The average size of the holdings is in the Majoge subdistrict (the most eastern part of the area) 5.45 acres and in South Mugirango (the central part of the area) 6.89.
For South Nyanza (western part) no figures are known. The size of the farms depends partly on the soils. There where the soils are more fertile and less shallow the area is more densily populated and so the farms are smaller.
The population density in South Mugirango and in Majoge is resp. 268 and 339 persons per square km.

3.1.4. Labour intensity

The amount of required labour depends merely on the fact whether or not cash crops are grown. Especially tea and pyrethrum ask a lot of labour inputs (tea - 250-320 mandays/acre/year; pyrethrum - 270-520 mandays/acre/year).
Because most farmers are not able to pay 'foreign labour' (from outside

the farm) it follows the acreage of cash crops grown, is restricted by the amount of labour the family can deliver.
In the area three levels of labour intensity are distinguishable, mainly depending on the acreage of cash crops grown.

Labour intensity levels:

V e r y l o w

Labour mainly delivered by wife(s) and children, seldom labour of husband

L o w

As very low plus labour of man

M e d i u m

Labour periodically delivered from outside the farm, rest as low.

3.1.5. Level of technical know-how

This level mainly depends on the difficulty of the cultivation of crops, used farm power and management practices.
The following three levels of technical know-how are distinguishable:

L o w

Handtools used for the preparation and weeding of the field.
Occasionally ox-ploughing.
Only small acreage of cash crops, mainly food crops.
No Hybrid maize or fertilizers are used.

M e d i u m

Ox-ploughing for land preparation.
Cash crops more important.
Fertilizers and Hybrid maize are used.

H i g h

As medium, but also:
Improved cattle and pasture.
Cash crops most important crops.

3.1.6. Capital intensity

As has been said under labour intensity, capital intensity depends very much on the establishment of cash crops, and also on soil conservation works, the size of the farm and the kind of farm power used.
Three capital intensity levels have been distinguished:

T r a d i t i o n a l (very low)

Non-recurring input requirements or development costs

- simple hand tools
- maize stores (small buildings near homesteads)
- contours for soil conservation (not in all cases)

Recurring production costs

- own produced seed
- cow dung manuring
- mulching
- only 'family' labour

L o w

Non-recurring development costs

- simple hand tools
- maize stores
- contours for soil conservation
- donkey(s) for transportation
- plough (ox-traction)

Recurring production costs

- occassional fertilizers
- planting material - Hybrid maize and seedlings
- cow dung manuring
- mulching
- more labour input than under "Traditional".

M e d i u m

Non-recurring development costs

- very occasional tractor
- donkeys for transportation
- improved pasture and grade cattle
- sheds and stores
- hand tools, plough
- contours for soil conservation

Recurring production costs

- fertilizers and cow dung manuring
- seeds and seedlings
- mulching
- more labour and sometimes even 'foreign' labour (when cash crops are grown)

3.2. Relevant land qualities

The value of land is measured by certain properties of this land, concerning chemical, physical, and environmental phenomena. For this area we have selected a number of land qualities, which are most important for the use possibilities of land.

The distinguished land qualities are:

Major land qualities related with requirements of plant growth

availability of water
availability of nutrients
availability of oxygen (for root growth)

Major land qualities related with requirements of management practices

resistance against erosion
trafficability of the area

Besides above mentioned land qualities, which accomplish most directly important differences between the distinguished land units, other land qualities can be important for the area as a whole but not for a seperate land unit, for instance absence of wind and storm as affecting plant growth and the climate (temperature, radiation and air humidity).

3.2.1. Rating and specification of the relevant land qualities

Each land quality can be subdivided into land quality factors and by means of quantification of these factors a rating for the concerned land quality can be made. But in this case the rating will be more qualitative, because of lack of laboratory results.

We have distinguished the following grades of rating:

- Very high grade of availability / absence of risk
- High grade " " " "
- Medium grade " " " "
- Low grade " " " "
- Very low grade " " " "

Availability of water

land quality factors:

- texture of the soils
- amount of organic matter
- amount of rainfall
- evapotranspiration
- depth of solum
- susceptibility of sealing
- steepness of the slope

For the rating not all above mentioned factors have to be taken into account, because rainfall and evapotranspiration data do not vary for the area as a whole.

Thus we have only taken the depth of the solum, amount of organic matter, slope and sealing for the rating.
The amount of sealing can be noticed in the field but has to be considered as slight in the worst case.

Rating - availability of water

a. Very high grade:
- depth of solum over 120 cm.
- pachic epipedon (dark topsoil over 40 cm. thick)
- no sealing
- slope 0-8%

b. High grade:
- depth of solum between 50 and 120 cm.
- pachic epipedon
- no sealing
- slope 0-8%

c. Medium grade:
- depth of solum between 50 and 120 cm.
- no pachic epipedon
- no sealing
- slope 8-30%

d. Low grade:
- depth of solum less than 50 cm.
- no pachic epipedon
- slight sealing
- slope 8-30%

e. Very low grade: - depth of solum less than 50 cm.
- no pachic epipedon, B-horizon on surface
- slight sealing
- slope over 30%

Availability of nutrients
land quality factors:

- organic matter content
- CEC and base-saturation
- amount of weatherable minerals

In tropical soils the organic matter is functioning as a storage for nutrients. Under cultivation mineralization will take place, followed by severe losses of nutrients due to leaching by rainwater.
In the Marongo Ridge area the forest has been cleared away about 30-40 years ago, which resulted in a decrease of the amount of organic matter and in a complete stripping off of the humus layer by erosion on the dissected landtypes.
That is the reason that the nutrient level has become critical and phosphorus is at a minimum because of fixation by iron and aluminium oxides.
The amount of weatherable minerals supplying potassium, calcium and magnesium is low because most of the soils are intensively weathered.
The CEC is low since the dominant clay mineral is kaolinite. The leaching effect of the rainfall is high causing a low basesaturation except for soils consisting of freshly weathered rock.
The pH is rather low (about 5), which enables the iron and aluminium oxides to fixate phosphorus.
Because of lack of laboratory results the only factors used for the rating of this land quality are the thickness and darkness of the topsoil (measure for the organic matter content) and the depth of the solum (presence of weatherable minerals).

Rating - availability of nutrients:

a. Very high grade: - pachic epipedon: dark topsoil over 40 cm.
- depth of solum less than 50 cm.

b. High grade: - pachic epipedon (thickness about 40 cm).
- depth of solum less than 50 cm.

c. Medium grade:
- no pachic epipedon
- depth of solum between 50 and 120 cm.

d. Low grade:
- dark topsoil of about 15 cm.
- depth of solum between 50 and 120 cm.

e. Very low grade:
- no dark topsoil at all (eroded)
- depth of solum over 120 cm.

Availability of oxygen

land qualty factors:

- depth of groundwater table or seasonal waterlogging (hydromorphy)
- occurrence of horizon which is impermeable to water (e.g. indurated ironstone)

The rating is based on the depth where the indurated ironstone layer occurs and the presence of permanent or seasononal waterlogging.

Rating - availability of oxygen

a. Very high grade:
- depth occurrence ironstone pan over 150 cm. deep
- no mottles or soft concretions within 150 cm. below the surface

b. High grade:
- depth of occurrence ironstone pan between 100 and 150 cm.
- no mottles, concretions or reduction colours

c. Medium grade:
- depth occurrence pan between 50 and 100 cm.
- no mottles, soft concretions or reduction colours

d. Low grade:
- depth occurrence pan between 10 and 50 cm.
- mottles, concretions or reduction colours visible in profile

e. Very low grade:
- depth occurrence pan less than 10 cm.
- mottles, soft concretions and reduction colours present in profile

Resistance against erosion

land quality factors:

- steepness of the slope (+ length of this slope)
- susceptibility of sealing, mainly depending on structure stability, which depends on:

- parent material, soils derived from Granite and Quartizitic rock show light to moderate sealing while soils on Basaltic and probably also Rhyolite rock show only very slight sealing or non at all
- organic matter content
- porosity of the topsoil
- cover and rooting intensity of vegetation
- texture of soil

The rating is based on the susceptibility to sealing (structure stability), thickness topsoil (presence pachic epipedon) and on the soil slope.

Rating-resistance against erosion

a. Very high grade:
- slope 0-8%
- pachic epipedon, dark topsoil over 40 cm.
- no sealing

b. High grade:
- slope 8-12%
- pachic epipedon
- no sealing

c. Medium grade:
- slope 12-20%
- no pachic epipedon
- no sealing

d. Low grade:
- slope 20-35%
- no pachic epipedon
- slight sealing

e. Very low grade:
- slope over 35%
- no pachic epipedon
- slight to moderate sealing

The erosion we have to deal with in this area is mainly sheet erosion, gully erosion does not occur.
Length and steepness of the slope are important factors, as they strongly control the amount of run-off. The longer and steeper the slope, the larger the amount of run-off.

Trafficability of the area

For the area as a whole this is an important factor because the presence of roads, which can be used by lorries is most important when cash crops have to be transported to markets.

Already it is mentioned that the cultivation of bananas is restricted by the presence or absence of roads.
Some parts of the area have a good road system, while in areas with more unsuitable soils, like around the Marongo Ridge, roads and tracks cannot be used by cars.
It is of no use to make a rating for this land quality, because the absence or presence of the roads is not correlated with certain mapped land units.

3.2.2. Other land qualities which have not been rated

Wind and hail affecting plant growth

The damage caused by wind and hail primarily depends on the following factors:

- intensity and frequency of wind- and hailstorms
- cropping system

Especially in the wet season (April-May and October-November) heavy rain- and hailstorm occur, causing a lot of damage to crops. Maize, coffee and tea are susceptible to hail damage, causing brown and light spots on the leaves. In the case of tea this leads to a bad quality and immediately influences the price.
Bananas and also maize and coffee trees are often damaged by storms, when not well protected.

Possibilities of mechanisation

By improving and developing agriculture, one would almost automatically think about the introduction of machinery and implements, to reduce the labour inputs and to be able to manage a larger area of cash crops, so the income of the farmer could be increased considerably.

However in this area labour costs are still remarkably low so that the introduction of machinery is not preferable, economically seen. Because of the kind of cash crops grown, a lot of hand work will still be necessary and the use of machinery will only be restricted to prepare the land.
The possibilities of mechanisation are the further introduction of ox-traction ploughs and small two-wheel tractors. The use of the 4-wheel tractors is not preferable because the operation costs are much higher, and the use of it is restricted by slope and other soil conditions (stoniness).

The climate

Also this is a factor that does not change much over the area, but an important factor still is the altitude. It is known for instance that tea does best at a altitude of over 1500 m., and pyrethrum prefers an altitude of about 2000 m.

Underneath a list of crops is given with their altitude and rainfall requirements:

crop	altitude (m.)	rainfall (mm.)
bananas	0 - 1800	
beans	900 - 2100	
cassava	0 - 1500	500 - 2000
coffee	1400 - 2100	900 - 1800
groundnuts	0 - 1500	1000 -
maize	0 - 2400	
mango	0 - 1500	
paw paw	0 - 2100	
pine apple	1370 - 1750	1000 -
pyrethrum	2000 - 2400	1250 -
sisal	0 - 1800	625 - 1250
soja	0 - 2400	
sugar cane	0 - 1600	1500 -
sweet potatoes	0 - 2100	750 -
Irish potatoes	1800 -	
tea	1500 - 2200	1500 -
tobacco	900 - 1500	
wattle	1800 - 2400	
finger millet	0 - 2400	1150 -
sorghum	900 - 1500	650 -
passion fruits	purple - high	
	yellow - low	

The Marongo Ridge area can be divided in three main ecological zones according to the altitude, influencing the cropping pattern in these areas.

I	II	III
Western part	Central part	Eastern part
South Mugirango + South Nyanza partly 1350 - 1500 m.	Marongo Ridge plateau 1800 - 1900 m.	Mahoge Chache 1500 - 1800 m.

Crops that can be grown in all different areas:

- beans
- maize
- paw paw
- soja beans
- sweet potatoes
- finger millet
- passion fruits

Crops that can be grown in the different areas because of altitude restrictions

I	II	III
Western part	Central part	Eastern part
- bananas	- coffee	- coffee
- cassava	- potatoes	- bananas
- groundnuts	- tea	- pine apple
- mango	- wattle	- sisal
- pine apple	- pine apple	- tea
- sisal	- tomatoes	- tomatoes
- sugar cane	- irish potatoes	- Irish potatoes
- tobacco		
- sorghum		
- tomatoes		

3.3. Relevant current land utilisation alternatives

In a developing country like Kenya is, it is most important to pay attention to the agricultural sector, that serves as a buffer for people, because employment in other sectors does not grow fast enough. In future even more people will have to live of incomes derived from agriculture.

So it is clear that we have to intensify agriculture as much as possible and make an optimal use of the available land.
One of the things that have to be done is to formulate land utilisation types which result in optimal results (in yields and money income).
To be able to fullfill this task it is necessary to enable relevant figures about soils, climate, actual land use, crops that can be introduced, labour requirements of agaricultural practises, gross margins of crops and many other things.
For this area we have tried to formulate two utilisation types, that together with certain improvements will result in a more optimal use of both land and labour that is available in the area.
One of the assumptions made, was that it is thought that farmers will not give up growing food crops, because they do not want to be dependent on other people. Another point is that some agricultural practises, e.g. keeping cattle is done, because of cultural reasons in stead of economical reasons.

The proposed current land utilisation types are:

1. Mixed farming: subsistence crops
   cash crops
   grazing
2. Arable farming: subsistence crops
   cash crops (more important as under 1)

Underneath follows a more detailed description of the current land utilisation types characterised by their key attributes (like is done under 1).

3.3.1. Mixed farming with subsistence and cash crops and grazing

a. Produce

Subsistence crops are mainly grown for own consumption, but the acreage has to be so large that even in years with less favourable weather conditions, still enough can be harvested.
But this implies that in years with optimal circumstances part of the harvested crop can be sold.
Maize will be the most important staple food, but attention has to be paid to the cultivation of fruits, vegetables and beans, so that the overall diet is sufficient in nutritive value.

The cash crops grown depend on the altitude of the area, availability of labour (size of the family), price of the crop and of course on the soil.
The grassland used for the cattle grazing can be cultivated pasture, improved grassland or temporary grassland (when soils need fallow to restore fertility).
For establishing cultivated and temporary grassland, high quality seeds will have to be used and especially in the first year after sowing the grass seeds it will be necessary to take away less favourable grasses and herbs.
Natural grassland can be improved simply by cutting shrubs and other plants which are useless as food for cattle.
Besides improvement of the grassland attention has to be paid to improve cattle, so that the milk and meat production will be increased.
Not all the cattle has to be improved because the farmers will still need cows for traction. In this case we might as well think about donkeys for transportation of the products to the markets.
It will also be interesting to study the introduction of garded pigs, sheep, goats and chickens, because these animals can be kept at small fields near the homesteads and can be fed with all sorts of food.
In this case the cultivation of cash crops is of minor importance, because it will not be easy to manage so many different products as maize, cows and for instance passion fruits.
The sale of milk, meat and in the last place the cash crops must result in a reasonable cash income.

b. Capital intensity

b.1. Non-recurring development costs

- soil conservation works (establishment of forest and grassland on the steeper slopes)
- improvement of grassland (clearing bush or new seeds)
- plough for ox-traction and other small farm implements
- small 2-wheel wagon for transportation of products
- fencing of grassland
- small hand tools
- sheds and stores
- establishment of cash crops (seedlings etc.)

b.2. Recurring production costs

- Hybrid maize
- fertilizers for cash crops
- some foreign labour in periods of top labour requirement

c. Farm power

It has already been said that ox-traction is used for ploughing and that weeding and harvesting is done by hand.
The ox-traction however is not used optimally, namely the yokes used for the oxen to pull the plough do not fit properly to the neck of the ox. They have to be kept in the right position by a rope that is tied around the neck of the cattle. When the oxen start pulling the plough they can hardly breathe. By changing this construction it should be possible that only two oxen pull the plough instead of four like it is done often at the moment. This would make ploughing with cattle much easier.
Also the plough itself can be improved so that it is easier to keep it on the right and demanded depth. It is thought that this is something for the extension service and farming training centres to improve.

d. Labour

For this utilisation type the amount of required labour is reasonable high and the quality of this labour is as important as the amount. Especially keeping cattle is not an easy job, because they ask for constant attention of the farmer. Milking is a careful job that has to be done at regular moments, otherwise the production will decline severely.

e. Farm size

A farm like proposed here has to be quite large, existing of about 5 acres of grassland, 1 or more acres of cash crops and 5 or more acres of subsistence crops (which depends on the size of the family). The total size of the farm will have to be between 10 and 15 acres at least. The total acreage depends very much upon the quality of the soils, suitability of the land to create plantations of cash crops and the population pressure in a certain area.

f. Technical know-how level

As mentioned under labour it should be clear that keeping cattle can only be successful when the farmers are trained in taking care of cattle (milking, feeding, animal diseases, pasture management etc.). At the moment only seldom 'well looked after' cattle and pasture can be found. Also the cultivation of cash crops asks some knowledge.
In both cases training and extension service can improve quite a lot with reasonable less investments to make.

3.3.2. Arable farming with subsistence and cash crops

a. Produce

In respect to the subsistence crops the same can be said as is done before (see 3.3.1.a.).
In future less land will be used for grazing cattle because of the increasing pressure on the land, caused by the growth of the population. This means that the land will have to be used more intensively and that the cattle has to produce more to supply all these people. The kind of cash crops grown depends on the soil and on the altitude (see 3.3.1.).

b. Capital intensity

Most of the development costs will be the establishment of the cash crops, like buying seedlings and soil conservation works. Also in the beginning the yields of the cash crops will be low and the farmers will need credit to come through this period. The production costs are mainly labour costs, fertilizers, spraying and other management practises.

c. Farm power

The cultivation of subsistence crops can be done partly by using ox-traction. It is thought that it is more effective for the farmers to cooperate in such a way that a few farmers together buy one plough and keep a few oxen for traction. That decreases the total amount of oxen in the area and also of the required grassland and food these oxen need.

d. The total amount of required labour will be about as high as under 3.3.1. In this case it also may be possible that in certain periods foreign labour is needed.

e. Farm size

It is proposed that in this case the farms can be smaller than in the case of mixed farming. It must be possible to create a reasonable income with farms of 8 - 10 acres. The total size will depend on the soil, the cash crop grown, the ability of the farmer to grow a certain cash crop and the prices paid to the farmer.

3.3.3. Current land utilisation types - summary

attributes	mixed farming	arable farming
produce		
- subsistence crops	x	x
- cash crops	(x)	x
- grazing	x	
Capital		
- non recurring costs		
low		
medium	x	x
high		
- recurring costs		
low		
medium	x	x
high		
farm power		
- hand	x	x
- animal	x	x
labour		
- low		
- medium		
- high	x	x
farm size		
- 10-15 acres	x	
- 8-10 acres		x
Techn. know-how level		
- low		
- medium	x	x
- high		

3.4. Conversion tables for the determination of suitability classes

Because of the fact that a certain use of the land ask for certain properties of this land, we can make a table in which is shown when a certain land unit is suitable or unsuitabele for such a use.

3.4.1. Mixed farming

suitability classes		major land quality: available water	available nutrients	available oxygen	resistance erosion
I	High	2	2A	1	1B
II	Medium	3	2A	2	2B
III	Restricted	3-4	2A	3	2B
IV	Low	Any grade of the qualities lower than for restricted or any grade of improvement inputs higher than for restricted.			

The numbers in this table are the same as given under 3.2.1 (rating and specification of relevant land qualities). A and B are improvements that will be discussed in the next part of the chapter.

3.4.2. Arable farming

suitability classes		major land quality: available water	available nutrients	available oxygen	resistance erosion
I	High	1-2	1A	1	1B
II	Medium	2	1A	1-2	1-2B
III	Restricted	2-3	2A	2	2B
IV	Low	Any grade of the qualities lower than for restricted or any grade of improvement inputs higher than for restricted.			

3.4.3. Improvements

For this area we propose 4 kinds of improvements:

1. Soil conservation works
2. Maintenance and improvement of soil fertility
3. Increasing the quantity and quality of the extension service
4. Road construction works.

The main problem is erosion. It is not easy to restrict, since soil conservation works do not affect yields and incomes on short term. However these works may prevent a reduction in yields due to erosion.

It may influence soil fertility too in such a way that the topsoil, which contains a lot of nutrients will not be washed away.
The works that have to be established depend on slope mainly.
The proposed works are:

a. terracing of slopes
b. establishment of pasture or forest on slopes that are too steep to be used for growing crops
c. preventing the occurrence of uncovered soil
d. contour ploughing

Soil fertility may be improved by applications of fertilizers, and cow dung. The use of fertilizers is a difficult point, because prices went up dramatically since the oil crisis. This means that special attention must be given to the use of cow dung and practices like mulching, incorporating crop residues with the soil and cultivation of green manuring crops.
Both improvements will be more successful if the extension service in the area is more accurate than it is at the moment. Most of the required work can be done by hand, but the farmers have to know how to do it. Especially in the case of soil conservation works there must be a good cooperation between farmers and extension officers, because this is a problem dealing with the area as a whole, and all activities have to be coordinated by the extension service.

Road construction works are necessary to improve transport of goods. This kind of work can be done by the people themselves under supervision of roadbuilding specialists. The advantage of all this labour is, to give work to a lot of people.

One of the important questions to answer is: Are we going to use machinery or manpower? Another question will be: What is more expensive, manpower or machinepower?

3.5. The land qualities of the different land units and the suitability classification of these land units for the defined utilisation types.

Land unit			Land quality				Land utilisation type	
soil series	depth class	slope class	W	N	O	E	mixed farming	arable farming
NdB	0	A	1	2-3	1	1	I	IA
		B	2	2-3	1	2	IB	IAB
		C	2	2-3	1	3	IB	IAB
		D	2	2-3	1	3	IB	IAB
ChB	0	A	2	3	1	2	IAB	IAB
		B	2	3	1	2-3	IAB	IAB
		C	2	3	1	3-4	IAB	IAB
		D	2	3	1	4	IAB	IIAB
IkB	1	A	1	2	1	1	I	IA
		B	2	2	1	2	IB	IAB
		C	3	2	1	3	IB	IAB
		D	3	2	1	3-4	IB	IAB
MnB	1	B	2	2-3	1	2	IAB	IAB
		C	3	2-3	1	3-4	IIB	IIAB
		D	3	2-3	1	4	IIB	IIAB
		E	3	2-3	1	4	IIB	IIAB
McB	2	C	2-3	2	1	3	IB	IAB
GcB	2	B	3	3	1	2	IAB	IIAB
		C	3	3	1	3-4	IIAB	IIAB
		D	3	3	1	4	IIAB	IIIAB
		E	4	3	1	4	IIAB	IIIAB
MgB	3	C	4	2	1	3-4	IIIB	IV
		D	4	2	1	4	IIIB	IV
		E	4	2	1	5	IV	IV
OgB	4	C	4-5	3	1	4	IV	IV
		D	4-5	3	1	4-5	IV	IV
		E	5	3	1	5	IV	IV
NkF	0	A	1	2-3	1	1	I	IA
		B	2	2-3	1	2	IB	IAB
		C	2	2-3	1	3	IB	IAB
		D	2	2-3	1	3	IB	IAB

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Land unit			Land quality				Land utilisation type	
soil series	depth class	slope class	W	N	O	E	mixed farming	arable farming
IkF	0	B	2	3	1	2-3	IAB	IAB
		D	2	3	1	4	IAB	IAB
GeF	3/4	E	4	3	1	5	IV	IV
MrQ	0	B	2	3	1	2	IAB	IAB
		C	2	3	1	3	IAB	IAB
		D	2	3	1	3	IAB	IIAB
NnQ	0	A	2	3-4	1	2	IAB	IAB
		C	2	3-4	1	3-4	IAB	IIAB
		D	2	3-4	1	4	IAB	IIAB
KbQ	1	A	2	3	1	2	IAB	IAB
		B	2	3	1	2	IAB	IAB
		C	3	3	1	3-4	IIAB	IIAB
		D	3	3	1	4	IIAB	IIIAB
ItQ	2	C	3	3-4	1	3-4	IIAB	IIAB
		D	3	3-4	1	4	IIAB	IIIAB
		E	4	3-4	1	5	IV	IV
MaQ1	3/4	A	4	3-4	1	2	IIIAB	IV
		B	4-5	3-4	1	3	IIIAB	IV
		C	4-5	3-4	1	4	IV	IV
		D	4-5	3-4	1	4-5	IV	IV
		E	5	4-3	1	5	IV	IV
		F	5	4	1	5	IV	IV
KtR	0	B	2	3	1	2-3	IAB	IAB
		C	2	3	1	3	IAB	IAB
NkR	0	B	2	3-4	1	3	IAB	IAB
		C	2	3-4	1	4	IAB	IIAB
		D	2	3-4	1	4-5	IIAB	IIIAB
NdR	1	B	2	3	1	2-3	IAB	IAB
		C	2	3	1	4	IAB	IIAB

Continuation of page 70

Land unit			Land quality				Land utilisation type	
soil series	depth class	slope class	W	N	O	E	mixed farming	arable farming
NrR	2	A	3	3-4	1	2	IAB	IIAB
		B	3	3-4	1	3	IIAB	IIAB
		C	3	3-4	1	4	IIAB	IIIAB
KaR	3/4	A	4-5	3-4	1	2	IIIAB	IV
		B	4-5	3-4	1	3	IIIAB	IV
		C	4-5	3-4	1	4	IV	IV
		D	5	3-4	1	5	IV	IV
NsG	0	A	2-3	3-4	1	3	IAB	IIAB
		B	2-3	3-4	1	3-4	IAB	IIAB
NdG	1	A	2-3	4	2	3	IIAB	IIIAB
		B	2-3	4	2	3-4	IIAB	IIIAB
		C	3	4	2	4	IIIAB	IIIAB
PlG	2	B	3-4	4	2	3-4	IIAB	IIIAB
		D	4	4	2	4	IIIAB	IIIAB
RlL	3	A	4-5	4	3	3	IIIAB	IV
		B	4-5	4	3	3-4	IIIAB	IV
		C	4-5	4	3	4	IIIAB	IV
RoL	4	A	4-5	4	3-4	3	IIIAB	IV
		B	4-5	4	3-4	3-4	IIIAB	IV
		C	5	4	3-4	4	IV	IV
		D	5	4	3-4	4-5	IV	IV

Explanation of table at page 68, 69 and 70:

- depth class:
  - 0 - over 150 cm. deep
  - 1 - 100 - 150 cm.
  - 2 - 50 - 100 cm.
  - 3 - 20 - 50 cm.
  - 4 - 0 - 20 cm.

- slope class:
  - A - 0 - 3%
  - B - 3 - 8%
  - C - 8 - 15%
  - D - 15 - 30%
  - E - 30 - 65%
  - F - over 65%

- land quality:
  - W - availability of water
  - N - availability of nutrients
  - O - availability of oxygen
  - E - resistance against erosion

- rating of land qualities (see 3.2.1.)

- suitability classification for the different utilization types: see conversion tables (3.4.).

  I high suitable
  II medium suitable
  III restricted suitable
  IV low suitable

  A - improvement of soil fertility
  B - refers to soil conservation works.

Example:

At page 68 the first land unit that is classificated is NdB. When this unit is situated on slopes of less than 3% (slope class A), its land qualities are qualified as follows:
available water - very high grade (1) of availability
available nutrients - high to medium grade of availability
available oxygen - very high grade
resistance against erosion - very high grade of absence of erosion.

It is clear that this land unit is high suitable to both arable and mixed farming. The only precaution that has to be made is, that for the cultivation of cash crops attention will have to be paid to the nutrient status (that explains the A behind I in the table).

3.6. Land units which have the same suitability classification for the different land utilisation types.

A. Land units which are highly suitable to be used for mixed and arable farming: the only improvement necessary is the soil fertility in case of growing cash crops.

land units	slope class	suitability - utilisation types	
		mixed farming	arable farming
NdB	A	I	IA
IkB	A		
NkF	A		

B. Land units which are highly suitable to be used for mixed and arable farming. Improvements: in case of arable farming - soil fertility and in both cases - soil conservation works

land units	slope class	suitability - utilisation types	
		mixed farming	arable farming
NdB	B-C-D	IB	IAB
IkB	B-C-D		
McB	C-D		
NkF	B-C-D		

C. Land units which are highly suitable to be used for mixed and arable farming. Improvements: in both cases improvement of soil fertility and establishment of soil conservation works.

land units	slope class	suitability - land utilisation types	
		mixed farming	arable farming
ChB	A-B-C-D	IAB	IAB
MmB	A-B		
SkF	B-D		
MrQ	B-C-D		
NnQ	A		
KbQ	A-B		
KtR	B-C		
NkR	B		
NdR	B		
IkB	C-D		

D. Land units which are highly suitable to be used for mixed farming, and medium suitable for arable farming. Improvements as under C.

land units	slope class	suitability - land utilisation types	
		mixed farming	arable farming
NnQ	C-D	IAB	IIAB
NkR	C		
NdR	C		
NrR	A		

E. Land units which are medium suitable to be used for mixed and arable farming. Improvements as under C.

land units	slope class	suitability - land utilisation types	
		mixed farming	arable farming
MmB	C-D-E	IIAB	IIAB
GcB	C-D		
KbQ	C		
ItQ	C		
NrR	B		
NsG	A-B		
NdG	A-B-C		

F. Land units which are medium suitable to be used for mixed farming and restricted suitable for arable farming. Improvements in both cases - soil conservation works.

land units	slope class	suitability - land utilisation types	
		mixed farming	arable farming
PlG	B	IIB	IIIB
MgB	C-D-E		

G. Land units which are medium suitable to be used for mixed farming and restricted suitable for arable farming. Improvements as under C.

land units	slope class	suitability - land utilisation types	
		mixed farming	arable farming
GcB	E	IIAB	IIIAB
KbQ	D		
ItQ	D		
NkR	D		
NrR	C		
MaQ	A		

H. Land units which are restricted suitable for mixed farming, and low suitable for arable farming. Improvements as under C.

land units	slope class	suitability - land utilisation types	
		mixed farming	arable farming
KaR	A-B	IIIAB	IV

I. Land units which are low suitable to be used for mixed farming and arable farming

land units	slope class	suitability - land utilisation types	
		mixed farming	arable farming
OgB	C-D-E	IV	IV
MaQ	B-C-D-E-F		
GeF	E		
KaR	C-D		
ItQ	E		
PlG	D		
RlL	A-B-C		
RoL	A-B-C-D		

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Appendix I

Profile 5	:	Nyaborumbasi series (NbB)
Classification	:	Soil Taxonomy 1970 : Pachic Humoxic Palehumult
		FAO 1970 : Humic Nitosol
Location	:	Majoge, near Ikoba-Ogembo road about 3 km eastly of Ikoba
Coordinates	:	9913.75 N, 689.10 E.
Elevation	:	5200 ft.
Described by	:	Hennemann and Kauffman on 8-12-1973
Geomorphology	:	hilly, uniform slope of 12%
Parent material	:	non-porphyritic Basalt of the lower Bukoban system
Relief and slope	:	normal relief and slope class 3 (sloping)
Stoniness	:	class 0 (no stones)
Drainage	:	well drained
Moistness	:	topsoil and subsoil moist
Biology	:	few krotovinas, depth of the undisturbed soil deeper than 1,80 m., common roots mainly at a depth of 0-30 cm.
Land use	:	coffee

Soil Profile:

A1 0 - 20 cm.	:	Dark brown (7.5 YR 3/2), moist; very fine clay; moderate fine subangular blocky; common fine and few fine and medium biopores; slightly sticky and slightly plastic; gradual and smooth boundary.
A3 20 - 60 cm.	:	Dark reddish brown (5 YR 3/3), moist; very fine clay; moderate fine subangular blocky; common very fine and few fine and medium biopores; slightly sticky and slightly plastic; gradual and wavy boundary.
B1 60 - 85 cm.	:	Dark reddish brown (5 YR 3/3), moist; very fine clay; strong fine angular blocky; common very fine, few fine and medium biopores; slightly sticky and slightly plastic, friable; broken clay cutans; gradual boundary.
B2 85 - 150 cm.	:	Dark red (2,5 YR 3/6), moist; very fine clay; strong very fine angular blocky; few very fine biopores; firm, slightly sticky and slightly plastic; continuous clay cutans.

Range in characteristics:

Profile characteristics : The Nyaborumbasi very fine clay series is always well drained.
The A1 horizon has a colour of 7,5 YR 3/2 or 5 YR 3/2 and a thickness from 30 - 60 cm.
The transition horizon A3 or B1 if present has a colour of 5 YR 3/3 or 2,5 YR 3/4 and a thickness of 20 - 40 cm.
The B2 horizon has always a colour of 2,5 YR 3/6 and has a moderate to strong structure, clay cutans are mostly continuous.
The porosity of all these horizons is high.

Environmental characteristics : The Nyaborumbasi series occur on uniform non- or slightly dissected slopes, ranging from very gently sloping to strongly sloping, sometimes on moderate steep slopes.
Stoniness and rockiness of these series is always class 0 (no stones).

Profile no. 7	:	Muma series (MmB)
Classification	:	Soil Taxonomy 1970 : Humoxic Palehumult
		FAO 1970 : Humic Nitosol
Location	:	Bomachoge, along road Maraba-Ogembo
Coordinates	:	9912.05 N, 690.40 E
Elevation	:	5150 ft.
Described by	:	Kauffman and Hennemann on 4-12-19-1973
Geomorphology	:	convex lower slope, rolling area
Relief and slope	:	normal - strongly sloping (single)
Parent material	:	non-porphyritic Basalt (Bukoban)
Stoniness	:	class 0
Drainage	:	well drained, watertable not present
Moistness	:	topsoil and subsoil moist
Biology	:	depth of undisturbed soil 1.50 m.
		rootdevelopment mainly in upper 30 cm.
Land use	:	bananas

Soil Profile:

A1 0 - 23 cm. : Dark brown (7.5 YR 3/2), moist; very fine clay; weak very fine subangular blocky; many fine to very fine continuous biopores; friable, slightly sticky and slightly plastic; common krotovinas (Ø ± 2 cm.); clear and smooth boundary.

A3 23 - 50 cm. : Dark reddish brown (5 YR 3/4), moist; very fine clay; moderate fine angular to subangular blocky; common fine and many very fine continuous biopores; friable, slightly sticky and slightly plastic; thin broken humus and clay cutans; clear and smooth boundary.

B2 50 - 170 cm. : Dark red (2.5 YR 3/6), moist; very fine clay; strong very fine angular blocky; many very fine and few fine continuous biopores; friable, slightly sticky and slightly plastic; moderately thick broken clay cutans; clear and smooth boundary.

B3/C 170 - 250 cm. : Yellowish red (5 YR 4/8), moist; few, small, soft, sferical black concretions; common, fine and medium distinct red (2.5 YR 4/6) mottles, increasing downwards.

Range in characteristics:

Profile characteristics : The Muma series is always well drained.
The A1 has a colour of 7.5 YR 3/2 or 5 YR 3/3 and a thickness of 20 - 30 cm.
The transition zone A3 or B1 has a colour of 5 YR 3/4 or 2.5 YR 3/4 and a thickness of about 30 cm.
The B2 horizon always a colour of 2.5 YR 3/6 and a strong to moderate structure and broken to continuous clay skins.
The B3 horizon has weathering colours 5 YR 4/6 and 5 YR 4/8 and often black soft manganese concretions.

Environmental characteristics : The Muma series occur on non- or slightly dissected lower and upper slopes, ranging from gently sloping to moderately steep, sometimes with a class 1 stoniness (0 - 3%).

Profile no. 8	:	Ikoba series (IkB)
Classification	:	Soil Taxonomy 1970 : Pachic Humoxic Tropohumult
		FAO 1970 : Humic Nitosol
Location	:	Majoge, near the track Maraba - Ogembo
Coordinates	:	9912.10 N, 690.10 E
Elevation	:	5150 ft .
Described by	:	Hennemann and Kauffman on 4-12-1973
Geomorphology	:	convex slope
Parent material	:	non-pophyritic Basalt of the Bukoban system Precambrium
Relief and slope	:	normal relief and slope class 3 (sloping)
Stoniness	:	class 0 (no stones)
Moistness	:	topsoil and subsoil moist
Drainage	:	well drained
Biology	:	depth of the undisturbed soil more than 1,25 m.
Land use	:	grassland

Soil Profile:

A1 0 - 30 cm. : Dark reddish brown (5 YR 3/2) dry and dark brown (7.5 3/2), moist; very fine clay; weak to moderate very fine subangular blocky; many fine and very fine biopores; friable, slightly sticky and slightly plastic; common termite holes (Ø 2,5 cm.); clear and smooth boundary.

A3 30 - 52 cm. : Dark reddish brown (5 YR 3/3) moist; very fine clay; strong to moderate very fine angular and subangular blocky; many fine and very fine biopores; friable, slightly sticky and slightly plastic; broken humus-clay cutans; common termite holes (Ø 2,5 cm.); few krotovinas (Ø 4,5 cm.), spherical; clear and smooth boundary.

B2 52 - 125 cm. : Dark reddish brown (2.5 YR 3/4),moist; very fine clay; strong to moderate very fine and fine angular and subangular blocky; many fine biopores, firm, sticky and plastic; continuous clay-humus cutans; gradual and smooth boundary.

B3 125 - 160 cm. : Red (2.5 YR 4/8),moist; very fine clay; weathered gravels, weathering colours.

Range in characteristics:

Profile characteristics : The Ikoba series is always well drained. The A1 horizon has a colour of 7.5 YR 3/2 or 5 YR 3/2 or 5 YR 3/3 and a thickness of 30 - 50 cm. The transition horizon A3 has a colour of 5 YR 3/3 and a thickness of about 30 cm. The B2 horizon has always a colour of 2.5 YR 3/6 and has a moderate to strong structure, clay cutans are mostly continuous.

Environmental characteristics : The Ikoba series occur on uniform non- or slightly dissected slopes, ranging from nearly level to moderately steep slopes. Stoniness and rockiness is nearly always class 0 (no stones), sometimes class 1 (0 - 3%).

Profile no. 10 : Maraba series (MrA)
Classification : Soil Taxonomy 1970 : Typic Tropaquept
FAO 1970 : Humic Gleysol
Location : near Riosiri
Coordinates : 9915.05° N, 680.80° E
Elevation : 4950 ft.
Described by : Hennemann and Kauffman on 4-1-1974
Geomorphology : depression in a plain
Parent material : from different origin, with underlying the Kitere Granite
Relief and slope : flat relief and slopeless 1 (level)
Stoniness : class 0 (no stones)
Drainage : poorly drained, watertable at a depth of 80 cm.
Moistness : topsoil moist, subsoil wet
Biology : depth of undisturbed soil 95 cm., few krotovinas, rootdevelopment up to 40 cm., mainly at a depth of 0 - 20 cm.
Land use : grassland

Soil Profile:

A0 0 - 4 cm. : mainly fresh and partly decomposed organic material above the mineral soil.

A1 4 - 10 cm. : Very dark brown (10 YR 2/2), moist; very fine clay, weak very fine subangular blocky; many fine biopores; very friable, slightly sticky and slightly plastic; common, medium, distinct and clear dark reddish brown (2,5 YR 3/4) mottles; clear and smooth boundary.

A3 19 - 42 cm. : Very dark brown (10 YR 2/2), moist; very fine clay; moderately weak very fine subangular blocky; many fine biopores; very friable, slightly sticky and slightly plastic; many medium, distinct, clear, dark red (2.5 YR 3/6) mottles; clear and smooth boundary.

Cg1 42 - 56 cm. : Dark grey (5 YR 4/1), wet; very fine clay *); moderate very fine to fine angular blocky; many fine biopores; friable, slightly sticky to sticky and slightly plastic to plastic; many medium prominent sharp strong brown (7.5 YR 5/8) and red (2.5 YR 4/8) mottles; very few, fresh and rounded chert and quartzite gravels; clear and smooth boundary.

Cg2 56 - 100 cm. : Dark grey (5 YR 4/1), wet; very fine clay *); strong very fine to fine angular blocky; common fine biopores; friable, sticky and slightly plastic to plastic; many medium, prominent, sharp and red (2.5 YR 4/8) mottles; few, fresh, rounded chert and quartzite stones.

*) Remarkable is the difference between the A1+A3 and the Cg1+Cg2 horizons, both have a very fine clay texture, yet the C-horizons feel much heavier, probably due to a difference in clay mineralogy.

Range in characteristics:

Profile characteristics : The Maraba series is poorly drained and is a part of the year waterlogged. The A1 horizon of approximately 10 cm. with a very dark brown colour is overlain by a thin A0 horizon. The A3 horizon has a very dark brown colour and dark red mottles. The thickness of the Cg1 is approximately 15 cm. and the colour of the matrix is dark grey, predominant mottles have strong brown and red colours. The Cg2 is also dark grey with prominent red mottles. The permanently reduced horizon is present about 1 meter.

Environmental characteristics : The Maraba series occur in depressions of a nearly level to undulating plain in the East Nyokal subdistrict.

Profile no. 11	:	Paulo series (PlG)
Classification	:	Soil Taxonomy 1970 : Plintic Umbriorthox
		FAO 1970 : Plintic Ferralsol
Location	:	Riosiri - Rongo
Coordinates	:	9915.00° N, 680.50° E
Elevation	:	4925 ft.
Described by	:	Hennemann and Kauffman on 4-1-1974
Geomorphology	:	convex slope of a rolling plain
Relief and slope	:	subnormal and nearly level
Parent material	:	Kitere Granite intrusive in the Nyanzian system, Precambrium
Stoniness	:	class 0 (no stones)
Drainage	:	moderately well drained
Moistness	:	topsoil dry, subsoil moist
Biology	:	few krotovinas, rootdevelopment up to a depth of 140 cm., mainly at a depth of 0 - 30 cm.
Land use	:	natural grassland

Soil Profile:

A1 0 - 25 cm. : Dark reddish brown (5 YR 3/3), dry; fine clay; weak very fine subangular blocky; many very fine and common biopores; slightly hard, slightly sticky and slightly plastic; clear and smooth boundaries.

B1 25 - 50 cm. : Dark reddish brown (5 YR 3/4), to yellowish red (5 YR 4/8) dry; fine clay; weak very fine subangular blocky; many very fine and common fine biopores; slightly hard, sticky and slightly plastic; broken clay cutans; clear and smooth boundary.

B2 50 - 90 cm. : Yellowish red (5 YR 4/8), moist; fine clay; weak very fine subangular to angular blocky; many very fine and common fine biopores; very friable, slightly sticky and slightly plastic; broken clay cutans; clear and smooth boundary.

B3 90 cm. + : Dark red (2.5 YR 3/6) moist; partly cemented and oxidised plinthite gravels; moderate very fine and fine biopores; very friable, non sticky and non plastic; common medium prominent sharp black concretions; very many (70 - 80%) colourless and sharp quartz gravels; few rounded quartz and granite stones.

Range in characteristics:

Profile characteristics : The Paulo fine clay is moderately well drained, the topsoil has a dark reddish colour; the B-horizon has mostly a yellowish red colour. Throughout the whole profile you find very few to few coarse sandgrains. Within 50-100 cm. a soft or hard plinthite layer occurs. The surface often has a stoniness class of 1 or 2.

Environmental characteristics : These soils occur on the plain of the East Nyokal subdistrict on undulating to rolling slope positions.

Profile no. 13 : Ndiwa series (NdG)
Classification : Soil Taxonomy : Humoxic Tropohumult
FAO 1970 : Humic Acrisol
Location : South Nyanza East Nyokal, along the Rongo-Riosiri road
Coordinates : 9915.30 N, 680.15 E
Elevation : 4950 ft.
Described by : Hennemann and Kauffman on 4-1-1974
Geomorphology : summit of convex slope
Relief and slope : normal - nearly level
Parent material : Kitere Granite (Intrusive in Nyanzian system)
Stoniness : class 0
Drainage : well drained, watertable deeper than 2.00 m.
Moistness : topsoil dry, subsoil moist
Biology : few krotovinas to a depth of 0.80 m., rootdevelopment mainly at a depth of 0 - 30 cm.
Land use : grassland

Soil Profile:

A1 0 - 30 cm. : Dark reddish brown (5 YR 3/4), dry; fine clay; weak very fine subangular blocky; very many fine biopores; slightly hard, slightly sticky and slightly plastic; common distinct coarse channels filled with humic material; very few quartz gravels to a depth of 50 cm; gradual and smooth boundary.

A3 30 - 80 cm. : Dark reddish brown (5 YR 3.5/4), moist; fine clay; weak very fine subangular blocky; many very fine and common fine biopores; very friable, non sticky to slightly sticky and slightly plastic; common distinct coarse channels filled with humic material; few krotovinas (Ø 5 cm., sferical); diffuse and smooth boundary.

B 80 - 150 cm. : Yellowish red (5 YR 4/6), moist; fine clay; weak very fine subangular blocky; many very fine and common fine biopores; very friable, non sticky to slightly sticky and slightly plastic; common distinct coarse channels filled with humic material; clear to gradual and wavy boundary.

B3 150 cm. + : Yellowish red (5 YR 4/6), moist; strongly weathered laterite; many very fine and few fine biopores; friable, non sticky and non plastic; common medium sferical soft knobbly black concretions.

Range in characteristics:

Profile characteristics : The Ndiwa series is always well drained and are susceptible for sealing. The A1 horizon has a colour of 5 YR 3/4 or 5 YR 3/3 and a thickness of about 20 cm. The transition horizon A3 or B1 has a colour of 5 YR 3.5/4 and a thickness of about 20 cm. The B2 horizon has a colour of 5 YR 4/6, a weak structure and broken clay cutans.

Environmental characteristics : The Ndiwa series occur on flat-topped low hills with uniform slopes, ranging from nearly level to sloping. These series has always a stoniness class 0 (no stones).

Profile no. 15 : Itumbi series (ItQ)
Classification : Soil Taxonomy 1970 : Humoxic Tropohumult
FAO 1970 : Humic Acrisol
Location : South Mugirango, Ruora, Gotichaki school
Coordinates : 9914.60° N, 683.80° E
Elevation : 1650 m.
Described by : Kauffman on 31-1-1974
Geomorphology : plateau
Parent material : Quartzite
Relief and slope : normal relief and slope class 1 (level)
Stoniness : class 0 (no stones)
Drainage : well drained
Moistness : topsoil dry, subsoil moist
Biology : depth of the undisturbed soil more than 80 cm., many roots from 0 - 30 cm.,common roots from 30 - 80 cm.
Land use : grassland

Soil Profile:

A1 0 - 25 cm. : Dark brown (7.5 YR 4/4),dry dark brown (7.5 YR 3/4) moist, very fine clay; moderate medium subangular blocky breaking into very fine subangular blocky; many very fine biopores; consistency; hard; friable, slightly sticky and slightly plastic; gradual and smooth boundary.

B2 25 - 65 cm. : Brown (7.5 YR 5/4),dry and dark reddish brown (5 YR 3/4), moist; very fine clay; weak medium subangular blocky breaking into moderately weak very fine blocky; many very fine biopores; hard, friable, slightly sticky and slightly plastic; patchy, thin clay cutans; clear and smooth boundary.

B3 65 - 80 cm. : Dark brown (7.5 YR 4/4),moist; very fine clay; very many, small and large soft, spherical, black manganese concretions; many angular, fresh and weathered quartzites stones.

Range in characteristics:

Profile characteristics : The Itumbi series is always well drained and are susceptible for sealing. The A1 horizon has a colour of 5 YR 3/3, 5 YR 3/4 or 7.5 YR 3/4 and a thickness of about 20 cm.

The B1 if present has a colour of 2.5 YR 3/6 or 5 YR 3/4 and a thickness of about 20 cm. The B2 horizon has a colour of 2.5 YR 3/6, a weak to moderately weak structure and patchy or broken clay cutans.

Environmental characteristics : The Itumbi series occur on small plateaus and below the escarpment, slope classes ranging from level to steep.
The stoniness classes are 1 and 2 (0-3% and 3-15%) and the rockiness classes 1 and 2 (0-2% and 2-10%).

Profile no. 16	:	Itumbi series (ItQ)
Classification	:	Soil Taxonomy : Typic Rhodudult
		FAO 1970 : Orthic Acrisol
Location	:	South Mugirango, near Gotichaki school
Coordinates	:	9914.6 N, 683.7 E
Elevation	:	5450 ft.
Described by	:	Kauffman on 31-3-1974
Geomorphology	:	low plateau
Relief and slope	:	normal - nearly level
Parent material	:	Quartzite (Bukoban)
Stoniness	:	class 0
Drainage	:	well drained, watertable absent
Moistness	:	topsoil dry, subsoil moist
Biology	:	depth of undisturbed soil 1,15 m., rootdevelopment mainly in upper 30 cm.
Land use	:	grassland

Soil Profile:

A1 0 - 25 cm. : Dark reddish brown (5 YR 3/3),dry and moist; very fine clay; weak fine to very fine subangular blocky; many very fine continuous biopores; hard, slightly sticky and slightly plastic; gradual and smooth boundary.

B2 25 - 115 cm. : Reddish brown to dark reddish brown (5 YR 3.5/4), dry; dark red (2.5 YR 3/6), moist; very fine clay; weak medium subangular blocky, breaking into moderately weak subangular blocky;many very fine and common fine continuous biopores;

hard, slightly sticky and slightly plastic; clay cutans, broken; few spherical termiteholes (Ø 3 cm).; clear and smooth boundary.

B3 115 - 125 cm. : Dark red (2.5 YR 3/6) moist; very many angular fresh and weathered stones of quartzite.

Range in characteristics: (see profile no. 15).

Profile no. 17	:	Nyangori series (NnQ)
Classification	:	Soil Taxonomy : Humic Paleudult
		FAO 1970 : Humic Nitosol
Location	:	South Mugirango, near Gotichaki School
Coordinates	:	9914.9 N, 683.5 E
Elevation	:	5450 ft.
Described by	:	Kauffman on 31-1-1974
Geomorfology	:	low plateau
Relief and slope	:	normal - nearly level
Parent material	:	Quartzite (Bukoban)
Stoniness	:	class 0
Drainage	:	well drained, watertable deeper than 1,65 m.
Moistness	:	topsoil dry, subsoil moist
Biology	:	depth of undisturbed soil 1,65+ m., rootdevelopment mainly in upper 25 cm.
Land use	:	grassland

Soil Profile:

A 0 - 25 cm.: Reddish brown (5 YR 4/3), dry, dark reddish brown (5 YR 3/3), moist; very fine clay; weak very fine subangular blocky; many, very fine continuous biopores; hard, slightly sticky and slightly plastic; gradual and smooth boundary.

B21 25 - 85 cm.: Dark red (2.5 YR 3/6), moist; very fine clay; many very fine continuous biopores; weak very fine subangular blocky; hard, slightly sticky and slightly plastic; thin broken and continuous clay cutans, diffuse and smooth boundary.

B22 85 - 165+ cm.: Dark red (2.5 YR 3/6), moist; very fine clay; many fine and very fine biopores; weak very fine subangular blocky; hard, slightly sticky and slightly plastic; thin broken and continuous clay cutans.

Range in characteristics:

Profile characteristics : The Nyagori series is always well drained, and is susceptible for sealing.
The A1 horizon has a colour of 5 YR 3/3 or 5 YR 3/4 and a thickness of 20 - 30 cm.
The B1 if present has a colour of 5 YR 3/4 or 2.5 YR 3/4 and a thickness of about 20 cm.
The B2 horizon has a colour of 2.5 YR 3/6, a weak structure and broken or continuous clay cutans.

Environmental characteristics : The Nyagori series occur mostly on a plateau or on lower slopes, ranging from level and sloping to moderate steep slopes, which are non- or slightly dissected.

Profile no. 18 : Nyokal series (NkR)
Classification : Soil Taxonomy 1970 : Humoxic Palehumult
FAO 1970 : Humic Nitosol
Location : South Nyanza, East Nyokal, near Kitere goldmine
Coordinates : 9909.60 N, 679.15 E
Elevation : 4900 ft.
Described by : Hennemann on 31-1-1974
Geomorphology : hilly, convex slope
Relief and slope : normal relief and gently sloping
Parent material : Rhyolite (Nyanzian)
Stoniness : class 0 (no stones)
Drainage : well drained
Moistness : topsoil dry and subsoil moist
Biology : depth of the undisturbed soil 1.40 m., rootdevelopment mainly in the upper 20 cm.
Land use : natural grassland

Soil Profile:

A 0 - 20 cm.: Dark reddish grey (5 YR 4/2), dry and moist; very fine clay; weak fine to medium crumbs; common fine and many very fine, continuous biopores; hard to very hard, slightly sticky and slightly plastic; few krotovinas; clear and smooth boundary.

B1 20 - 70 cm.: Dusky red (2.5 YR 3/2), dry, dark reddish brown (2.5 YR 3/4), moist; very fine clay; fine to very fine subangular blocky; many very fine, continuous biopores; very hard, slightly sticky and slightly plastic; moderately thick and broken clay cutans on horizontal and vertical ped surfaces; few krotovinas; gradual and smooth boundary.

B21 70 - 100 cm.: Dark reddish brown (2.5 YR 3/4), moist; very fine clay; very fine to moderate fine angular to subangular blocky; many very fine biopores; very firm, slightly sticky and slightly plastic; moderately thick, broken clay cutans on horizontal and vertical ped surfaces; clear and smooth boundary.

B22 100 - 140 cm.: Dark red (2.5 YR 3/6), moist; very fine clay; weak to moderate fine to very fine subangular blocky; many very fine continuous biopores; firm, slightly sticky and slightly plastic; moderately thick broken clay cutans on horizontal and vertical ped surfaces.

Remarks on substrata: depth of the pit 150 cm.

Range in characteristics:

Profile characteristics : The Nyokal series are always well drained. The A1 horizon has a colour of 5 YR 4/2 or 7.5 YR 3/2 and a thickness of about 20 cm. The transition horizon has a colour of 2.5 YR 3/4 and a thickness of about 50 cm. The B2 horizon has a colour of 2.5 YR 3/6, a moderate structure and broken or continuous clay cutans.

Environmental characteristics : The Nyokal series occur on upper convex slopes and on concave near the head of gullies, ranging from gently sloping to moderate steep slopes. These series has always stoniness class 0 (no stones).

Profile no. 19 : Rakwaro series (RkR)
Classification : Soil Taxonomy 1970 : Oxic Plinthaquult
FAO 1970 : Plinthic Acrisol
Location : East Nyokal, near the Tanzania road (Rakwaro)
Coordinates : 9911.450 N., 677.350 N.
Elevation : 4700 ft.
Described by : Hennemann on 31-
Geomorphology : uniform slope
Parent Material : Rhyolite (Nyanzian)
Relief and slope : subnormal and gently sloping
Drainage : moderately well to imperfectly drained
Stoniness : class 0
Moistness : topsoil dry, subsoil moist
Biology : depth of undisturbed soil 1,30., rootdevelopment mainly at a depth of 30 cm.
Land use : natural pasture with hedges

Soil Profile:

A1 0 - 38 cm.: Dark brown to dark greyish brown (10 YR 4/2.5), dry; very fine clay; moderate fine to very fine subangular blocky; very many very fine, continuous biopores; hard, slightly plastic and slightly sticky; gradual and smooth boundary.

A3 38 - 68 cm.: Brown to dark brown (7.5 YR 4/2), dry; very fine clay; moderate fine to very fine subangular blocky; very many very fine continuous biopores; hard, slightly sticky and slightly plastic; few fine distinct red and yellow mottles, few small hard spherical black nodules; clear and smooth boundary.

Bg1 68 - 125 cm.: Brown to dark brown (7.5 YR 4/2), moist; very fine clay; moderate to strong fine angular blocky; many very fine continuous biopores; firm, slightly sticky and slightly plastic; many distinct spherical black nodules; moderately thick broken clay cutans; clear and smooth boundary.

Bg2 125 - 145 cm.: Brown 7.5 YR 5/2), moist; very fine clay; strong fine angular blocky; many very fine continuous biopores; firm, slightly sticky and slightly plastic; many distinct spherical black nodules; moderately thick broken clay cutans.

Remarks on substrata: depth of pit 1,50 m.

Range in characteristics:

Profile characteristics : The Rakwaro series is imperfectly to moderately well drained. The A1 horizon has dark greyish brown colours (10 YR 4/2) and a thickness of 30 - 40 cm. The B-horizon starting at a depth of 70 cm. has a argillic horizon and contains a plinthite-layer with red (2.5 YR 5/8) and yellow (7.5 YR 6/8) mottles.

Environmental characteristics : The series occur on gently sloping slightly concave slopes near broad hydromorfic valley-systems.

Profile no. 24	:	Nyerega series (NrR)
Classification	:	Soil Taxonomy 1970 : Typic Rhodudult
		FAO 1970 : Orthic Acrisol
Location	:	South Nyanza, near Kitere Goldmine
Coordinates	:	9909.35 N, 676.95 E
Elevation	:	4760 ft.
Described by	:	Hennemann on 2-2-1974
Geomorphology	:	summit of convex hill, hilly area
Relief and slope	:	gently sloping (single)
Parent material	:	Rhyolite (Nyanzian)
Stoniness	:	class 0
Drainage	:	well drained
Moistness	:	topsoil dry, subsoil moist
Biology	:	depth of undisturbed soil 130 cm., rootdevelopment mainly in upper 25 cm.
Land use	:	natural grassland

Soil Profile:

A 0 - 25 cm.: Dark reddish brown (5 YR 3/2), dry; very fine clay; weak fine to very fine subangular blocky; many fine and very fine continuous biopores; very hard, slightly sticky and slightly plastic; many small and few large krotovinas; clear and smooth boundary.

B1 25 - 26 cm.: Dark reddish brown (2.5 YR 3/4), moist; very fine clay; weak fine subangular blocky; common fine and many very fine biopores; very firm, slightly sticky and slightly plastic; moderately thick broken clay cutans; many small krotovinas; gradual and smooth boundary.

B2 36 - 93 cm.: Dark red (2.5 YR 3/6), moist; very fine clay; moderate fine to very fine angular blocky; common fine and many very fine continuous biopores; very few small soft spherical manganese concretions; moderately thick broken clay cutans; many small krotovinas; abrupt and smooth boundary.

B31 93 - 100 cm.: Dark red (2.5 YR 3/6), moist; very fine clay; strong fine, very fine angular blocky; common fine and many very fine continuous biopores; many to very many small soft spherical black manganese concretions; no clay cutans; clear and smooth boundary.

B32 100 - 130 cm.: Brownish yellow (10 YR 6/6) rotten rock, moist; dominant angular weathered gravels of Rhyolite.

Remarks on substrata: depth of pit 130 cm.

Range in characteristics:

Profile characteristics : The Nyerega series is always well drained. The A1 horizon has a colour of 5 YR 3/2 or 7.5 YR 3/2 and a thickness of about 20 cm. The transition horizon A3 or B1 has a colour of 2.5 YR 3/4 and a thickness of about 20 cm. The B2 horizon has a colour of 2.5 YR 3/6, a moderate structure and broken or continuous clay cutans.
The B3 horizon has a colour of 2.5 YR 3/6, has black soft manganese concretions and/or rotten rock.

Environmental characteristics : The Nyerega series occur on upper and lower convex and concave slopes of low hills, slopes ranging from nearly level to strongly sloping. Sometimes you may find a stoniness class 1 (0-3%).

Profile no. 51 : Marongo series 3 (MrQ)
Classification : Soil Taxonomy 1970 : Humoxic Palehumult
FAO 1970 : Humic Nitosol
Location : South Mugirango, Ikoba-Marongo ridge road 100 m east of primary school
Coordinates : 9914.00 N, 686.50 E
Elevation : 5810 ft.
Described by : Boerma and Verweij on 28-11-1973
Geomorphology : uniform slope
Parent material : Quartzite and some soapstone (pseudo)
Relief and slope : normal and moderately steep
Stoniness : class 0 (no stones)
Drainage : well drained
Moistness : topsoil moist, subsoil moist
Biology : depth of undisturbed soil 2.30 m., rootdevelopment mainly at a depth of 0,25 m.
Land use : natural grassland

Soil profile:

A1 0 - 25 cm.: Dark reddish brown (5 YR 3/3), moist; very fine clay; very fine moderate subangular blocky; common fine and very fine inped, tubular biopores; friable, slightly sticky and slightly plastic; smooth and clear boundary.

A3 25 - 75 cm.: Dark reddish brown (5 YR 3/3), moist; very fine clay; moderate fine subangular blocky; common fine and very fine inped tubular biopores; very friable, slightly sticky and slightly plastic; thin to moderately thick broken humus-cutans; smooth and clear boundary.

B21 75 - 180 cm.: Dark red (2.5 YR 3/6), moist; very fine clay; strong very fine subangular blocky; few very fine random inped tubular biopores; friable, slightly sticky and slightly plastic; broken clay cutans; smooth and clear boundary.

B22 180 - 230 cm.: Dark red (2.5 YR 3/6), moist; very fine clay; moderate fine angular blocky; few fine to very fine random inped tubular biopores; friable, slightly sticky and slightly plastic; many sandgravels and very few gravels of soapstone; broken clay cutans, smooth and clear boundary.

B3 230 - 250 cm.: Dark red (2.5 YR 3/6), moist; very fine clay; very many soapstone gravels.

Remarks on substrata: depth of pit 1,90 m.,bedrock at 2,50 m.

Range in characteristics:

Profile characteristics : The Marongo series is always well drained. The A horzion has a colour of 5 YR 3/2 and a thickness of more than 40 cm. The A3 horizon, if present, is normally 20-30 cm. The colour of the B2 is 2.5 YR 3/4 or 2.5 YR 3/6; the structure is normally moderate and only broken clay cutans are present.

Environmental characteristics : The Marongo series occur on gently sloping to moderately steep positions below quartzite-escarpments. Sometimes it has a stoniness class 1 (0-30%).

Profile no. 52 : Kiabigori series (KbQ)
Classification : Soil Taxonomy 1970 : Humic Paleudult
FAO 1970 : Humic Acrisol
Location : North of the school along the road from Ikoba to the Marongo ridge
Coordinates : 9914.18° N, 686.55° E
Elevation : 5800 ft.
Described by : Boerma and Verwey on 28-11-1973
Geomorphology : hilly, concave slope of 19%
Parent material : Quartzite
Relief and slope : normal relief and slope class 4 (moderate steep)
Stoniness : class 0 (no stones)
Drainage : well drained
Moistness : topsoil and subsoil moist
Biology : depth of the undisturbed soil 150 cm.,common roots within 40 cm.,few roots deeper than 40 cm.,mainly at a depth of 0-25 cm.
Land use : cropland (wimbi)

Soil Profile:

A11 0 - 24 cm.: Dark reddish brown (5 YR 3/3), very fine clay; moderate very fine and fine subangular blocky; many very fine and common fine biopores; friable, slightly sticky and slightly plastic; quartzgrains; clear and wavy boundary.

A12 24 - 40 cm.: Dark reddish brown (2.5 YR 3/4), moist; very fine clay; weak to moderate very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; common very fine biopores; few fine black mottles; black gravels, quartzgrains; gradual and wavy boundary.

B2 40 - 132 cm.: Dark red (2.5 YR 3/5), moist; very fine clay; moderate very fine angular blocky; very few and very fine biopores; very friable, slightly broken clay cutans; few fine, common very fine, random, inped, tubular biopores, gradual and wavy boundary.

B3 132 -150 cm.: Dark red (2.5 YR 3/5), moist; very fine clay; moderate very fine angular blocky; very few very fine biopores; very friable, slightly sticky and slightly plastic; black and red gravels, charcoalpieces, blue and red weathering, quartzitelines.

Range in characteristics:

Profile characteristics : The Kiabigori series is always well drained and is susceptible for cealing. The A1 horizon has a colour of 5 YR 3/3 or 5 YR 3/4 and has a thickness of about 20 cm. The transition horizon A3 or B1 has a colour of 5 YR 3/4 and has a thickness of about 20 cm.
The B2 horizon has a colour of 2.5 YR 3/6, a moderate to weak structure and broken clay cutans.

Environmental characteristics : The Kiabigori series occur on upper and lower slopes and on plateau, slope classes ranging from level to moderate steep.
You may find a stoniness class of 1 or 2 (0-3% or 3-15%).

Profile no. 55	:	Mugirango series (MgB)
Classification	:	Soil Taxonomy 1970 : Humoxic Tropohumult
		FAO 1970 : Humic Acrisol
Location	:	Bomachoge, Ogembo-Ikoba road
Coordinates	:	9912.71 N, 691.55 E
Elevation	:	5210 ft.
Described by	:	Boerma and Verweij on 30-11-1973
Geomorphology	:	convex slope near summit of a small hill
Relief and slope	:	normal and very gently sloping
Parent material	:	non-porphyritic Basalts (Bukoban)
Stoniness	:	class 1 (interferes tillage)
Drainage	:	well drained, watertable deeper than 120 cm.
Moistness	:	topsoil moist, subsoil moist
Biology	:	depth of undisturbed soil 45 cm, few krotovinas, rootdevelopment up to a depth of 50 cm., but mainly at a depth of 0 - 22 cm.
Land use	:	sweet potatoes

Soil Profile:

A1 0 - 22 cm. : Dark brown (7.5 YR 3/2), moist; very fine clay; moderate very fine subangular blocky; common very fine and few fine continuous, inped and exped, random biopores; friable, slightly sticky and slightly plastic; common fine and medium distinct yellowish brown (10 YR 5/8) and (2.5 YR 4/8) mottles; no cutans; few rounded, weathered stones and boulders; clear and wavy boundary.

B3 22 - 50 cm. : Dark brown (7.5 YR 3/2), moist; very fine clay; moderate very fine angular blocky; very fine continuous random, inped, tubular biopores; friable, slightly sticky and slightly plastic; many coarse prominent clear yellowish brown (10 YR 5/8) and red (2.5 YR 4/8) mottles; thin and broken clay cutans; very many weathered basalt knobs (boulders and stones); clear and broken boundary.

C 50 + cm. : Red (2.5 YR 4/8), moist; very fine clay; no biopores; very friable, slightly sticky and slightly plastic; many coarse and prominent clear yellowish brown (10 YR 5/8) and dark brown (5 YR 3/3) mottles; in volume 70-90% consist of rotten rock and loose weathered material with strong colouring.

Range in characteristics:

Profile characteristics : The Mugirango series is well or somewhat excessively drained.
The A1 horizon has a colour of 10 YR 3/3, 7.5 YR 3/2 or 5 YR 3/2 and a thickness of about 20 cm. The B2, if present, has a colour of 2.5 YR 3/6 or 2.5 YR 3/4 and has broken clay cutans. The B3 horizon has weathering colours of 5 YR 4/4 or 7.5 YR 5/6.
The C horizon consists of rotten rock, colours 5 YR 4/8 and 2.5 YR 4/8.

Environmental characteristics : The Mugirango series occur on slightly or moderate dissected slopes and on the knickpoints of slopes, ranging from sloping to steep slopes. You may find the next stoniness classes: class 1, 2, 3 or 4 (0-3%, 3-15%, 15-90% or more) and a rockiness class 1 or 2 (0-2% or 2-10%).

Profile no. 57 : Marongo I series (MnQ)
Classification : Soil Taxonomy 1970 : Lithic Oxic Dystropeptic Troporthent
FAO 1970 : Dystric Regosol
Location : Ikoba - Marongo ridge road
Coordinates : 9914.10° N, 686.42° E
Elevation : 5840 ft.
Described by : Boerma and Verwey on 30-11-1973
Geomorphology : convex slope of 22% under summit with Quartzite outcrops
Parent material : Quartzite of the middle Bukoban system, Precambrium
Relief and slope : excessive relief and moderately steep slope
Drainage : excessively drained, watertable deeper than 5 m.
Moistness : topsoil dry, subsoil moist
Biology : depth of the undisturbed soil 15 cm., few krotovinas, rootdevelopment mainly at a depth of 15 cm.
Land use : grassland

Soil Profile:

A1 0 - 15 cm.: Dark reddish brown (5 YR 3/4), dry; fine clay; moderate fine and very fine subangular blocky; biopores not visible; consistency; very friable, slightly sticky and slightly plastic; soil contains 60% quartzite gravels, stones and boulders; clear and wavy boundary.

C 15 - 60 cm.: Dark reddish brown (5 YR 3/3) moist; fine clay; moderate fine and very fine subangular blocky; few, continuous, random, inped, tubular biopores; friable, slightly sticky and slightly plastic; red (10 YR 5/4) mottles in layers of broken angular quartzites between layers of more weathered material with a weak red (10 YR 5/4) colour; boundary material with a weak red (10 YR 5/4) colour; boundary clear and wavy.

IR 60 - 10 cm.: Reddish brown (2.5 YR 4/4), reddish brown (5 YR 4/4), red (2.5 YR 4/6), moist; fine clay; moderate fine angular blocky; few, fine continuous, inped, random, tubular biopores; friable, slightly sticky and slightly plastic; layers of a reddish yellow colour (7.5 YR 6/8), three layers in this horizon of which the one in the middle contains quartzite blocks (size 8 cm).

IIRI 105 - 160 cm.: Reddish brown (2.5 YR 4/4), weak red C 10 YR 4/3), moist; fine clay; massive; common fine and very fine, inped, continuous, random, tubular biopores; two layers (105-140 and 140-160 cm of kaolinitic material; parallel joints, clear and smooth boundary.

IIR2 165 - 220 cm.: Weak red (10 YR 4/3), reddish yellow (7.5 YR 6/8), dusky red (10 YR 3/4) moist; fine clay; massive structure; few fine and very fine, inped, tubular, random, continuous biopores.

Remarks on substrata: depth of measuring 3,50 m. Colours 10 YR 3/4, 10 YR 5/4 in layers. Unweathered kaolinitic material, that changes colour when exposed to the sun within one day and becomes white.

Range in characteristics:

Profile characteristics : The Marongo series is well or somewhat excessive drained and is susceptible for sealing. The A-horizon has a colour of 5 YR 3/4 and a thickness of 0 - 50 cm.

Environmental characteristics : The Marongo series occur on the edge of plateaus, on escarpments and just below the escarpments, slope classes ranging from level to very steep. These series have mostly a stoniness and/or rockiness classes, stoniness classes ranging from 1 to 3 (0 to 90%) and rockiness classes from 0 to 4 (0 to 50%).

Profile no. 58 : Gucha series (GcB)
Classification : Soil Taxonomy 1970 : Humoxic Tropohumult
FAO 1970 : Humic Acrisol
Location : Majoge, near Ogembo
Coordinates : 9912.00° N, 691.00° E
Elevation : 5150 ft.
Described by : Boerma and Verwey on 4-11-1973
Geomorphology : hilly, convex slope of 10%
Parent material : non-porphorytic Basalts of lower Bukoban system, Precambrium
Relief and slope : normal relief and slope class 3 (sloping)
Stoniness : class 1 (interferes tillage)
Drainage : well drained
Moistness : topsoil and subsoil moist
Biology : krotovinas few, rootdevelopment common
Land use : fallow.

Soil Profile:

A1 0 - 16 cm. : Dark brown (7.5 YR 3/2), moist; very fine clay; moderate very fine subangular blocky; friable, slightly sticky and slightly plastic; small, black, few, distinct, sharp mottles; quartz vesicles, few rounded basalt gravels, few stones and boulders, weathered and fresh; clear and wavy boundary.

B1 16 - 40 cm. : Dark reddish brown (5 YR 3/4), moist; very fine clay; moderate very fine to fine subangular blocky; consistency see A1; biopores see A1; many, medium, and coarse, prominent, clear, reddish yellow (5 YR 6/8), reddish brown (2.5 YR 5/4), reddish yellow (7.5 YR 7/8) mottles; few krotovinas, quartz vesicles; common gravels; humus clay cutans; gradual and smooth boundary.

B2 40 - 78 cm. : Yellowish red (5 YR 4/6),moist; very fine clay; weak very fine subangular blocky; biopores see A1; very friable, slightly sticky and slightly plastic; mottles see B1; iron concretions; common gravels, quartz vesicles; clay-humus cutans; gradual and wavy boundary.

B3 78 - 125 cm. : Red (2.5 YR 4/6),moist; very fine clay; platy; common very fine and fine, few medium, random, inped, tubular biopores; friable, slightly sticky and slightly plastic; many coarse, prominent, reddish yellow (5 YR 6/8), red (2.5 YR 5/8), dark red (2.5 YR 3/6) mottles; common quartz vesicles, few gravels; continuous and moderately thick clay cutans; gradual and wavy boundary.

C 125 - 178 cm. : Yellowish red (5 YR 5/8), moist; very fine clay; many, medium, clear, red (2.5 YR 5/8) mottles; rotten rock; clear and wavy boundary.

Remarks on substrata: depth of the pit 128 cm., depth of the augurhole 190 cm.

Range in characteristics:

Profile characteristics : The Gucha series is always well drained. The A1 horizon has a colour of 7.5 YR 3/2, 5 YR 3/2 or 5 YR 3/3 and a thickness of about 20 cm. The transition horizon A3 or B1 has a colour of 5 YR 3/4 or 2.5 YR 3/4 and a thickness of 20 - 40 cm. The B2 horizon has always a colour of 2.5 YR 3/6, a moderate to strong structure and continuous or broken clay cutans.

Environmental characteristics : The Gucha series occur on slightly or moderate dissected slopes, ranging from gently sloping to moderate steep slopes, you may find a stoniness class 1, 2 or 3 (0 - 3%, 3 - 15% or 15 - 90%) and a rockiness class 1 (0 - 2%).

Profile no. 63	:	Nyakambene series (NkF)
Classification	:	Soil Taxonomy 1970 : Pachic Humoxic Palehumult
		FAO 1970 : Humic Nitosol
Location	:	South Mugirango, 1 km NE of Nyakambene school
Coordinates	:	9909.45° N, 685.35° E
Elevation	:	5950 ft.
Described by	:	Boerma and Verwey on 4-1-1974
Geomorphology	:	plateau
Relief and slope	:	normal - rolling (complex), very gently sloping (single)
Parent material	:	porphyritic Felsite (Bukoban)
Stoniness	:	class 0
Drainage	:	well drained, watertable deeper than 2,40 m.
Moistness	:	topsoil moist, subsoil moist
Biology	:	rootdevelopment mainly in the upper 70 cm.
		depth of undisturbed soil more than 2,40 m.
Land use	:	maize fallow

Soil Profile:

A11 0 - 10 cm.: Dark reddish brown (5 YR 3/3), moist; very fine clay; moderate fine and very fine subangular blocky; many fine and very fine continuous, random, inped, tubular biopores; friable, slightly sticky and slightly plastic; abundant medium and common fine and very fine roots; moderately thick and continuous humus cutans; gradual and smooth boundary.

A12 10 - 29 cm.: Dark brown (7.5 YR 3/2), moist; very fine clay; moderate fine subangular blocky; many very fine and fine continuous, random, inped, tubular biopores; friable, slightly sticky and slightly plastic; few very fine distinct red (10 YR 5/6) mottles; moderately thick and continuous humus cutans; frequent fine and very fine, few medium roots; gradual and smooth boundary.

A3 29 - 48 cm.: Dark reddish brown (5 YR 3/3), moist; very fine clay; weak to moderate fine and very fine subangular blocky; abundant fine and very fine continuous, random, inped, tubular biopores; very friable to friable, non sticky and slightly plastic; few very fine distinct red (10 YR 5/6) mottles; patchy thin humus cutans, no clay cutans, common fine and few medium roots; clear and wavy boundary.

B1 48 - 70 cm.: Dark reddish brown (5 YR 3/4), moist; very fine clay; moderate to strong fine to very fine subangular to angular blocky; common fine and very fine continuous, random, inped, tubular biopores; friable to firm, slightly sticky and slightly plastic; common fine and very fine roots; thin and patchy clay cutans; gradual and smooth boundary.

B21 70 - 103 cm.: Red to dark red (2.5 YR 3/6 - 4/6), moist; very fine clay; very fine and fine angular blocky; few fine continuous, random, inped, tubular, biopores; firm, slightly sticky and slightly plastic; few fine and medium roots; moderately thick and broken clay cutans, few krotovinas and termite holes; gradual and smooth boundary.

B22 130 - 240 cm.: Dark red (2.5 YR 3/6), moist; very fine clay; moderate fine and very fine angular to subangular blocky; few to common very, fine continuous, random, inped, tubular biopores; very friable, slightly sticky and slightly plastic; few medium, few fine and very fine roots; thin and continuous clay cutans on macro-structure elements broken; moderately thick clay cutans on micro-structure elements.

Remarks on substrata: depth of pit 1,60 m.,augerhole to 2,40 m.

Range in characteristics:

Profile characteristics : The Nyakambene series is always well drained.
The A1 horizon has a colour of 7.5 YR 3/2 or 5 YR 3/3 and a thickness of about 50 cm.
The transition horizon has a colour of 5 YR 3/4 and a thickness of about 20 cm.
The B2 horizon has a colour of 2.5 YR 3/6 or 2.5 YR 4/6, a moderate structure and broken or continuous clay cutans.

Environmental characteristics : The Nyakambene series occur on plateau with slopes ranging from level to moderate steep. These series have a stoniness class 0 (no stones).

Profile no. 65 : Kananga series (KnR)

Classification : Soil Taxonomy 1970 : Ruptic Lithic Troporthentic Oxic Humutropepts or Ruptic Lithic Troporthentic Oxic Dystropepts

FAO 1970 : Ferralic Cambisol or Dystric Cambisol

Location : West of Gesusu near the Gucha river

Coordinates : 9907.075 N, 683.150 E

Elevation : 4840 ft.

Described by : Boerma and Verwey on 4-1-1974

Geomorphology : summit of small ridge coming down from Marongo Ridge

Relief and slope : convex slope of 8%, normal relief

Parent material : weathered rock of Nyanzian Rhyolite tuffs, Precambrium

Stoniness : class 2 (tillage impractible)

Drainage : somewhat excessively drained

Moistness : topsoil dry, subsoil moist

Biology : few krotovinas, depth of the undisturbed soil 15 cm., rootdevelopment mainly at a depth of 15 cm., deeper roots following joints

Land use : poor range

Soil Profile:

A1 0 - 17 cm. : Reddish brown (5 YR 5/2), dry, dark brown to brown (7.5 YR 4/2) wet; very fine clay; moderate fine and very fine angular to subangular blocky; common fine and very fine continuous, random, inped, tubular biopores; hard, slightly sticky and slightly plastic; some different weathering colours (see B3 horizon); common krotovinas, very many gravels, which are angular weathered, some quartz gravels; clear and broken boundary.

B3 17 - 110 cm. : Weathering colours: strong brown (7.5 YR 5/8), reddish yellow (7.5 YR 8/6), yellow (10 YR 8/6), red (2.5 YR 5/6) moist; very fine clay; weak very fine subangular to angular

blocky; common fine and very fine continuous, random, inped, tubular biopores; hard, slightly sticky and slightly plastic; common krotovinas; colour of soil material reddish brown (5 YR 4/4) and dark brown (7.5 YR 4/4); termite holes; very many weathered gravels and stones; clear and broken boundary.

R 110 cm.+ Weathering colours; very few fine continuous biopores following the joints; between the many joints roots; vertical parallel joints crossing other joints under an angle of 75°. In the joints weathered material.

Remarks on substrata: depth of the pit 130 cm.in joi ted and partly weathered rock. Weathered rock is sandy and contains much iron (black and red colours). Fragment angular rockfragments up to 2,5 cm across are abundant. They weather into creamy white rocks.

Range in characteristics:

Profile characteristics : The soils of the Kananga series are always very stony, class 2 (tillage impractible). The colour of the A1 horizon is mostly dark brown (7.5 YR 3/2), but also more reddish colours may occur. The thickness of the A1 horizon is between 10 and 30 cm. in most cases, but may be sometimes 50 cm., at most. The soils are always somewhat excessively drained and they have a very low water holding capacity. In periods of less rainfall they dry out very quickly.

Environmental characteristics : The profiles of the Kananga series occur on slopes of 5 - 25%.
Sometimes the slopes are more of less convex, but you may also find more uniform slopes. Often the soils have been developed on the summits of ridges, which have slopes of about 10 - 15% towards the Gucha river.

Profile no. 66	:	Chang'aa series (ChB)
Classification	:	Soil Taxonomy 1970 : Humoxic Palehumult
		FAO 1970 : Humic Nitosol
Location	:	South Mugirango, nearby Chief's Camp along Gucha road
Coordinates	:	9909.6 N, 681.6 E
Elevation	:	4950 ft.
Described by	:	Boxem and Verwey on 5-1-1974
Geomorphology	:	uniform slope of 7%
Relief and slope	:	single slope, very gently sloping
Parent material	:	olivine Basalt (Bukoban)
Stoniness	:	class 0 (no stones)
Drainage	:	well drained, watertable deeper than 3,20 m.
Moistness	:	topsoil dry, subsoil moist
Biology	:	depth of undisturbed soil 2,40 m., rootdevelopment mainly in topsoil
Land use	:	coffee

Soil Profile:

Ap 0 - 15 cm.: Reddish brown (5 YR 4/3), dry; reddish brown (5 YR 4/4), moist; moderate fine subangular blocky; few large, abundant fine and very fine biopores; very firm, slightly sticky and slightly plastic; very few black clear distinct mottles; some quartz gravels; few krotovinas; clear and smooth boundary.

A3 15 - 48 cm.: Reddish brown (5 YR 4/3), dry; reddish brown (5 YR 4/4), wet; very fine clay; strong fine and very fine angular blocky; few large, common fine and very fine biopores; firm, slightly sticky and slightly plastic; very few black clear distinct mottles; clay cutans and humus cutans, few krotovinas; gradual and smooth boundary.

B21 48 - 70 cm.: Reddish brown (5 YR 4/4), moist; very fine clay; moderate fine and very fine angular blocky; few large common fine and very fine biopores, inped and exped; friable slightly sticky and slightly plastic; very few black clear distinct mottles; clay cutans; few krotovinas; gradual and smooth boundary.

B22 70 - 100 cm.: Dark red (2.5 YR 3/6), moist; very fine clay; moderate to weak fine and very fine subangular blocky few large, common fine and very fine biopores (less than in B21); friable, slightly sticky and slightly plastic; very few clear distinct black mottles; clay cutans; quartz stones; some krotovinas and termite holes; gradual and smooth boundary.

B23 100 - 130 cm.: Dark red (2.5 YR 3/6), moist; very fine clay; weak fine and very fine subangular blocky, partly angular blocky; few fine biopores; friable, slightly sticky and slightly plastic; very few clear distinct black mottles; few krotovinas; gradual and smooth boundary.

B24 120 - 160 cm.: Red (2.5 YR 4/6), moist; very fine clay; very weak fine and very fine subangular blocky, partly angular blocky; few fine biopores; friable, slightly sticky and slightly plastic; very few clear distinct black mottles; gradual and smooth boundary.

Remarks on substrata: depth of put: 1,60 m. Between 160 and 230 cm. the B2 horizon continues. Deeper than 230 cm the plinthization becomes visible in black and yellow-green mottles. At a depth of 270 cm the texture tends to become lighter. Plinthization is increasing up to 300 cm. Deeper than 300 cm plinthization decreases and at 320 cm. quartz gravels and stones are present.

Range in characteristics:

Profile characteristics : The Chang'aa series is always well drained. The A1 horizon has a colour of 7.5 YR 3/2, 5 YR 3/2 or 5 YR 3/3 and a thickness of about 20 cm. The transition horizon A3 or B1 has a colour of 5 YR 3/4, 2.5 YR 3/4 and a thickness of 20 - 40 cm.
The B2 horizon has always a colour of 2.5 YR 3/6, a moderate to strong structure and continuous clay cutans.
All the horizons have a high porosity.

Environmental characteristics : The Chang'aa series occur on non- or slightly dissected uniform slopes, ranging from nearly level to moderate steep slopes. Stoniness and rockiness of these series is always class 0 (no stones).

Profile no. 69 : Nyasoka series (NsG)
Classification : Soil Taxonomy 1970 : Humoxic Palehumult
FAO 1970 : Humic Nitosol
Location : East Nyokal, about 2 km NE of Rakwaro
Coordinates : 9914.20 N, 678.40 E
Elevation : 4900 ft.
Described by : Verwey on 1-2-1974
Geomorphology : rolling plain, on a flat topped low hill
Parent material : Kitere Granite
Relief and slope : normal and slope class 1 (nearly level)
Stoniness : class 0 (no stones)
Drainage : well drained
Moistness : topsoil dry and subsoil moist
Biology : depth of the undisturbed soil more than 150 cm., few krotovinas, rootdevelopment up to 150 cm., mainly at a depth of 0 - 28 cm.
Land use : fallow

Soil Profile:

A1 0 - 27 cm. : Dark brown (7.5 YR 3/2), dry and moist; fine clay; moderate very fine subangular blocky; common fine and very fine, common medium and coarse, tubular, inped, continuous biopores; hard, slightly sticky and slightly plastic; humus cutans; many very fine, fine and medium, common coarse roots; clear and smooth boundary.

B1 27 - 45 cm. : Dark reddish brown (5 YR 3/4), dry and moist; fine clay; moderate very fine and fine subangular blocky; common very fine and fine, common medium, few coarse, tubular, inped, continuous, random, biopores; hard, slightly sticky and slightly plastic; broken clay and humus cutans; many small quartz gravels; few krotovinas, common medium, few coarse roots; gradual and smooth boundary.

B21 45 - 63 cm. : Dark red (2.5 YR 3/6),dry and dark reddish brown (2.5 YR 3/4), moist; fine clay; moderate very fine and fine subangular blocky; common very fine and fine, few medium and coarse; tubular, inped, continuous, random biopores; hard, slightly sticky and slightly plastic; broken, moderately thick clay and humus cutans; coarse roots; few quartz gravels; gradual and smooth boundary.

B22 63 - 96 cm. : Dark red (2.5 YR 3/6),moist; fine clay; weak very fine subangular blocky; biopores as in the B21; friable, slightly sticky and slightly plastic; broken, moderately thick clay cutans; few to common very fine and fine; few to very few medium and coarse roots; few krotovinas; few quartz gravels; clear and smooth boundary.

B23 96 - 150 cm.: Red (2.5 YR 4/6) moist, fine clay; weak very fine subangular blocky; biopores as in the B21; very friable, slightly sticky and slightly plastic; broken clay cutans; roots as in the B22; few quartz gravels.

Range in characteristics:

Profile characteristics : The Nyasoka series is always well drained, and is susceptible for sealing.
The A1 horizon has a colour of 5 YR 3/4, 5 YR 3/3, 5 YR 3/2 or 7.5 YR 3/2 and a thickness of 20 - 30 cm.
The transition horizon A3 or B1 has a colour of 2.5 YR 3/4 or 5 YR 3/4 and a thickness of 20 - 40 cm.
The B2 horizon has a colour of 2.5 YR 4/6 or 2.5 YR 3/4 or 5 YR 3/4 and a thickness of 20 - 40 cm. The B2 horizon has a colour of 2.5 YR 4/6 or 2.5 YR 3/6, a weak to moderate structure and broken clay cutans.

Environmental characteristics : The Nyasoka series occur on flat topped low hills with uniform slopes, ranging from level to gently sloping. These series have always a stoniness class 0 (no stones).

Profile no. 71	:	Nduru series (NdR)
Classification	:	Soil Taxonomy 1970 : Humoxic Palehumult
		FAO 1970 : Humic Nitosol
Location	:	South Mugirango, near Nduru Secondary School
Coordinates	:	9909.00 N, 681.15 E
Elevation	:	4800 ft.
Described by	:	Verwey on 2-2-1974
Geomorphology	:	uniform slope of 5%
Relief and slope	:	single, gently sloping
Parent material	:	Rhyolite (Nyanzian)
Stoniness	:	class 0 (no stones)
Drainage	:	well drained
Moistness	:	topsoil dry, subsoil moist
Biology	:	depth of undisturbed soil 155 cm.rootdevelopment mainly in the upper 20 cm.
Land use	:	maize and coffee

Soil Profile:

A1 0 - 26 cm. : Dark brown (7.5 YR 3/2), dry; dark brown (7.5 YR 3/2),moist; very fine clay; moderate fine subangular blocky; many very fine and few coarse and medium tubular random inped continuous biopores; hard, slightly sticky and slightly plastic; continuous humus-cutans; few krotovinas; clear and smooth boundary.

A3 26 - 48 cm. : Dark reddish brown (5 YR 3/3), dry and moist; very fine clay; moderate fine and very fine subangular blocky; many very fine and fine medium and coarse tubular random inped continuous biopores; very hard, slightly sticky and slightly plastic; broken humus and clay cutans; gradual and smooth boundary.

B21 48 - 59 cm.: Dark reddish brown (2.5 YR 3/4), moist; very fine clay; moderate fine and very fine subangular blocky; common very fine, fine, medium and coarse tubular, inped, continuous biopores; friable, slightly sticky and slightly plastic; continuous, moderately thick clay cutans; few krotovinas; gradual and smooth boundary.

B22 59 - 77 cm.: Reddish brown (2.5 YR 3.5/4), moist; very fine clay; moderate fine and very fine subangular blocky; common very fine, fine medium and coarse tubular, inped, continuous biopores; firm to very firm, slightly sticky and slightly plastic; continuous moderately thick clay cutans; few krotovinas; gradual and smooth boundary.

B23 77 - 110 cm.: Reddish brown (2.5 YR 4/4), moist; very fine clay; moderate very fine subangular blocky; few very fine and fine, common medium, few coarse tubular, random inped, continuous biopores; firm, slightly sticky and slightly plastic; continuous moderately thick clay cutans; few krotovinas; gradual and smooth boundary.

B24 100 - 155 cm.: Reddish brown to red (2.5 YR 4/4 - 4/6); very fine clay; weak to moderate very fine subangular blocky; common very fine and fine, medium and few coarse tubular, random, inped, continuous biopores; friable, slightly sticky and slightly plastic; broken, moderately thick clay cutans; gradual and smooth boundary.

B3 150 + cm.: Reddish brown to red (2.5 YR 4/4 - 4/6); cemented, very few biopores; many black small concretions of manganese; many small quartzite and quartz gravels, cemented by indurated ironstone.

Remarks on substrata: depth of pit 155 cm.

Range in characteristics:

Profile characteristics : The Nduru series is always well drained. The A1 horizon has a colour of 5 YR 4/2 or 7.5 YR 3/2 and a thickness of about 20 cm. The transition horizon A3 or B1 has a colour of 2.5 YR 3/4 and a thickness of about 20 cm. The B2 horizon has a colour of 2.6 YR 4/4 - 4/6, a moderate structure and broken or continuous clay cutans.

Environmental characteristics : The Nduru series occur on upper convex slopes, ranging from gently sloping to strongly sloping, sometimes with a stoniness class 1 (0 - 3%).

Profile no. 74	:	Rongo series (RnL)
Classification	:	Soil Taxonomy 1970 : Oxic Dystropept.
		FAO 1970 : Ferrallic Cambisol
Location	:	South Mugirango, 2 km. from Nyamaramba near main N-s road
Coordinates	:	9912.35 N, 681.50 E
Elevation	:	5000 ft.
Described by	:	Boerma on 2-2-1974
Geomorphology	:	uniform slope
Parent material	:	Kitere Granite (Intrusive in Nyanzian system)
Relief and slope	:	normal - gently sloping
Stoniness	:	class 1 (interferes tillage)
Drainage	:	well drained
Moistness	:	topsoil dry, subsoil dry
Biology	:	depth of undisturbed soil 15 cm. rootdevelopment mainly at a depth of 15 cm.
Land use	:	natural grassland

Soil Profile:

A1 0 - 15 cm. : Brown to dark brown (7.5 YR 4/4), dry; fine clay; moderate fine and very fine subangular blocky; common very fine and fine, continuous, inped, tubular biopores; soft to slightly hard; non-sticky and slightly plastic; few, small, hard, irregular and rounded Fe-nodules; many fine and very fine roots; few weathered, rounded quartz, quartzite and stones; boundary abrupt and wavy.

B3 15 - cm. : Brown to dark brown (7.5 YR 4/4), dry; strongly cemented concretions and gravels; few, fine continuous random inped tubular biopores; slightly hard, non-sticky and slightly plastic; very many small and large hard irregular concretions of Fe- and (pisolithic and nodular); common fine and very fine roots; very many gravels and indurated plinthite with earthy material between many weathered and rounded gravels and stones of Quartz and Quartzite.

Remarks on substrata: depth of pit 50 cm, + 50 cm. large Quartzite boulders; weathered and rounded.

Range in characteristics:

Profile characteristics : The Rongo series is imperfectly to well drained depending on the steepness of the slope. The A horizon has a dry colour of 7.5 YR 4/4 and a thickness of 10 - 20 cm. The B3 horizon has a large amount of strongly cemented concretions and gravels.

Environmental characteristics : The Rongo series occurs on flat summits and lower valley slopes of low and smooth hills with slopes ranging from nearly level to moderately steep. The stoniness-class varies from 1 to 3 (0-3%, 3-15% and 15-90%).

FINAL AND PRELIMINARY SERIESNAMES.

FINAL SERIESNAME AND SYMBOL	PRELIMINARY (FIELD) SERIES SYMBOL
Nyaborumbasi - NbB	BDh
Marongo 3 - MrQ	QDh
Kitere - KtR	RDh
Nyakambene - NkF	FDh
Chang'aa - ChB	BD
Nyangori - NnQ	QD
Nyasoka - NsG	GD
Nyokal - NkR	RD
Skuli - SkF	FD
Ikoba - IkB	BCh
Nduru - NdR	RC
Muma - MmB	BC
Kibigori - KbQ	QC
Machongo - McB	BBh
Gucha - GcB	BB
Itumbi - ItQ	QB
Paulo - PlG	GL - F2
Ndiwa - NdG	GL - F1
Nyerega - NrR	RB
Mugirango - MgB	BA
Rongo - RnL	L en L - F4
Riosiri - RsL	L - F3
Ogembo - OgB	B
Gesusu - GsF	F
Marongo 1 - MnQ	Q
Kananga - KnR	RA
Rakwaro - RkR	Hp
Olando - OlA	Hv
Maraba - MrA	Hm

	TAXONOMIC UNIT	SERIESNAME + SYMBOL		DRAINAGE CLASS	GENETIC HORIZONS	DEPTH OF SOLUM	THICKNESS OF A-HORIZON	PARENT MATERIAL	TEXTURE	B-HORIZON COLOUR	STRUCTURE	PHYSIOGRAPHIC POSITION	TOPOGRAPHY	LAND-USE
I	PACHIC HUMOXIC PALEHUMULT	Nyaborumbasi	NbB	well	A - B2	1.80+ m	0.40+ m	Non-porphyr.Basalt	V.F.CL	2.5YR3/6	moder.-strong	uniform slopes (non- or slightly diss.)	gently sloping-mod.steep	coffee-maize
		Marongo 3	MrQ	well	A - B2	1.80+ m	0.40+ m	Quartzite	V.F.CL	2.5YR3/6	moderate	footslopes of quartzite-escarpments	gently sloping-mod.steep	coffee-maize
		Kitere	KtR	well	A - B2	1.80+ m	0.40+ m	Rhyolite	V.F.CL	2.5YR3/6	moderate	concave slopes near valley-heads	gently sloping-mod.steep	coffee-maize
		Nyakembene	NkF	well	A - B2	1.80+ m	0.40+ m	Felsite	V.F.CL	2.5YR3/6	moderate	high plateaus	level-mod.steep	coffee-maize
II	HUMOXIC PALEHUMULT HUMIC PALEUDULT	Ghang'aa	ChB	well	A - B2	1.80+ m	0.40- m	Non-Porphyr.Basalt	V.F.CL	2.5YR3/6	moderate	uniform slopes (non- or slightly diss.)	gently sloping-mod.steep	maize-coffee
		Nyangori	NnQ	well	A - B2	1.80+ m	0.40- m	Quartzite	V.F.CL	2.5YR3/6	weak-moderate	footslopes and low plateaus	nearly level-mod.steep	maize-pasture
		Nyasoka	NsG	well	A - B2	1.80+ m	0.40- m	Granite (Kitere)	F.CL	2.5YR3/6	weak-moderate	flat hilltops and uniform slopes	gently sloping-mod.steep	maize-pasture
		Nyokal	NkR	well	A - B2	1.80+ m	0.40- m	Rhyolite	V.F.CL	2.5YR3/6	moderate	concave slopes near valley-heads	gently sloping-mod.steep	maize-coffee
		Skuli	SkF	well	A - B2	1.80+ m	0.40- m	Felsite	V.F.CL	2.5YR3/6	moderate	high plateaus	level-mod.steep	maize-coffee
III	PACHIC HUMOXIC PALEHUMULT PACHIC HUMOXIC TROPOHUMULT	Ikoba	Ikb	well	A - B2 - B3	1.20 - 1.80 m	0.40- m	Non-porphyr.Basalt	V.F.CL	2.5YR3/6	moder.-strong	uniform slopes (slightly dissected)	level-mod.steep	coffee-maize
IV	HUMOXIC PALEHUMULT HUMOXIC TROPOHUMULT	Nduru	NdR	well	A - B2 - B3	1.20 - 1.80 m	0.40- m	Rhyolite	V.F.CL	2.5YR4/6	moderate	upper convex and lower concave slopes near valley-heads	gently sloping-mod.steep	maize-coffee
V	HUMOXIC PALEHUMULT HUMOXIC TROPOHUMULT HUMIC PALEUDULT TYPIC RHODUDULT	Muma	MmB	well	A - B2 - B3	1.20 - 1.80 m	0.40- m	Non-porphyr.Basalt	V.F.CL	2.5YR3/6	moder.-strong	lower and upper slopes (slightly dissected)	gently sloping-mod.steep	maize-coffee
VI	HUMOXIC PALEHUMULT HUMOXIC TROPOHUMULT HUMIC PALEUDULT TYPIC + FLAVIC RHODUDULT	Kiabigori	KbQ	well	A - B2 - B3	1.20 - 1.80 m	0.40- m	Quartzite	V.F.CL	2.5YR3/6	weak-moderate	footslopes and low plateaus	level-mod.steep	maize-pasture
VII	PACHIC HUMOXIC TROPOHUMULT	Machongo	McB	well	A - B2 - B3	0.50 - 1.20 m	0.40+ m	Non-porphyr.Basalt	V.F.CL	2.5YR3/6	moderate	slopes, slightly to moderately diss.	gently sloping-mod.steep	maize-coffee
VIII	HUMOXIC TROPOHUMULT	Itumbe	ItQ	well	A - B2 - B3	0.50 - 1.20 m	0.40- m	Non-porphyr.Basalt	V.F.CL	2.5YR3/6	moderate	slopes, slightly to moderately diss.	gently sloping-mod.steep	maize-pasture
	TYPIC + FLAVIC RHODUDULT	Gucha	GcB	well	A - B2 - B3	0.50 - 1.20 m	0.40- m	Quartzite	V.F.CL	2.5YR3/6	moderate	upper footslopes and low plateaus	level-steep	pasture-maize
		Paulo	PlG	well	A - B2 - Rm	0.50 - 1.00 m	0.40- m	Granite (Kitere)	F.CL	5YR5/8	weak-moderate	flat hilltops and uniform slopes	nearly level-sloping	maize-pasture
IX	HUMOXIC TROPOHUMULT TYPIC RHODUDULT	Ndiwa	NdG	well	A - B2 - Rm	1.00 - 1.50 m	0.40- m	Granite (Kitere)	F.CL	5YR5/8	weak-moderate	flat hilltops and uniform slopes	nearly level-sloping	maize-pasture
X	HUMOXIC TROPOHUMULT FLAVIC RHODUDULT	Nyerega	NrR	well	A - B2 - B3	0.50 - 1.20 m	0.40- m	Rhyolite	V.F.CL	2.5YR3/6	moderate	flat hilltops and slopes	level-sloping	maize-pasture
XI	HUMOXIC TROPOHUMULT TYPIC + FLAVIC RHODUDULT	Mugirango	MgB	well	A - B2 - B3	0.20 - 0.50 m	0.40- m	Non-porphyr.Basalt	V.F.CL	2.5YR3/6	moderate	slopes (slightly to moderately dissected) and knickpoints	sloping-steep	pasture-maize
XII	LITHIC TROPORTHENT LITHIC OXIC HUMITROPEPT LITHIC OXIC ENTIC	Rongo	RnL	imperfectly -somewhat excessively	A - B2 - Rm	0 - 0.20 m	-	Indurated Ironstone	V.F.CL			flat hilltops and lower valley-slopes	nearly level to moderately steep	pasture-shrubland
	DYSTROPEPT	Riosiri	RsL	imperfectly -somewhat excessively	A - B - Rm	0.20 - 0.50 m	0.40- m	Indurated Ironstone	F.CL	5YR3/4 5YR4/8	weak	flat hilltops and uniform slopes	nearly level to moderately steep	pasture-maize
XIII	LITHIC OXIC HUMITROPEPT	Ogembo	OgB	well-somewh. excessively	A - B3	0 - 0.20 m	-	Non-porphyr.Basalt				knickpoints and upper-footslopes below quartzite-escarpments	mod.steep-steep	pasture-shrubland
	LITHIC OXIC ENTIC DYSTROPEPT					0 - 0.20 m	-	Felsite						
		Gesusu	GsF	well-somewh. excessively	A - B3	0 - 0.20 m	-	Felsite				upper slopes	mod.steep-steep	shrubland-pasture
XIV	RUPTIC LITHIC OXIC HUMITROPEPTIC + RUPTIC LITHIC OXIC DYSTROPEPTIC TROPORTHENT	Marongo 1	MnQ	well-somewh. excessively	A - B3	0 - 0.50 m	0.40- m	Quartzite				escarpments and edges of plateaus	level-very steep	shrubland-pasture
XV	RUPTIC LITHIC TROPORTHENTIC OXIC HUMITROPEPT AND RUPTIC LITHIC TROPORTHENTIC OXIC DYSTROPEPT	Kananga	KnR	well-somewh. excessively	A - B2 - B3	0.20 - 0.50 m	0.40- m	Rhyolite	V.F.CL	7.5YR5/8	moderate	slopes and ridges (strongly diss.) near the Gucha river	gently sloping-steep	maize-pasture
XVI	OXIC PLINTHAQUULT	Rakwaro	RkR	imperfectly -mod. well	A - g - B2g	1.80+ m	0.40- m	Rhyolite	V.F.CL	7.5YR4/2	moder.-strong	lower concave slopes near broad hydromorfic valleys	gently sloping	pasture with shrubs and sedges
XVII	FLUVENTIC TROPAQUEPT	Olando	OlA	poorly - imperfectly	A - Cg	0.50+ m	0.40- m	Alluvium				broad valleys	level	sugarcane-marshes
XIX	TYPIC TROPAQUEPT	Maraba	MrA	poorly - imperfectly	A - Cg	1.80+ m	0.40- m	Alluvium				flat depressions, normally on flat hilltops	nearly level to level	pasture