SOILS OF THE RANGWE SAMPLE AREA

AND THE

SOUTH NYANZA NORTH-EAST AREA

KENYA

by

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SOILS OF THE RANGWE SAMPLE AREA AND THE SOUTH NYANZA NORTH EAST AREA, KENYA

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Preface

The soil surveys presented in this report are a part of the soil mapping and research programme of the Training Project in Pedology at Kisii, Kenya, which is a project of the Agricultural University of Wageningen, the Netherlands. The surveys have been carried out by me as a post graduate student of this university, as the practical part of the MsC studies. The first part of this report deals with the soils of a small sample area, surveyed to a scale of 1 : 12,500. This area should be representative for a much bigger area around it, that has been surveyed to a scale of 1 : 50,000 and which is reviewed in the second part of this report. Because of the limited representativity of the sample area, references to other sample areas and other soil surveys have been made at the description of the soil-groups of the South Nyanza North East Area.

Acknowledgements

I am very grateful for the good guidance and the considerable help for my work, which I received from the project managers of the above mentioned project, Ir. W.G. Wielemaker and Ing. H.W. Boxem. Also I owe thanks to professor J. Bennema for his critical remarks and suggestions, during his visit to Kisii in october 1975. At last but not at least I thank my personal assistant and friend mr. James Nyambane and my co-assistant mr. Peter Mkua for their pleasant coöperation with the fieldwork.
Beside these people, I would like to thank all the other people of the project, who made it possible for me to have a nice time in Kenya.

PART I : SOILS OF THE RANGWE SAMPLE AREA

Chapter 1 : Introduction

1.a. Location and Extent

The Rangwe sample area is located in the South Nyanza (Homa Bay) district of Nyanza province in western Kenya. It is situated in two locations: East Nyokal (Kamagambo) location and Gem location. It covers a strip of land, 1 to 2 km wide and almost 13 km long, along the road from Rongo to Rangwe, an area of about 1825 hectares (4510 acres). (see fig. 1).
To be more precise, the area lies between 34°35' and 34°36' Eastern longitude and between 0°35'20" and 0°42'30" Southern latitude. The altitude of the area ranges from about 1275 m (4250 ft) in the river valleys north of Rangwe, to about 1410 m (4700 ft) above sea level, on top of Kuna hill.

1.b. People of the Area

The people who are living in the area nowadays, belong to the Luo tribe. Originally the Masai tribe inhabited the area untill about 200 years ago. Then the Kisii tribe occupied the area for about 100 years and were displaced by the Luo tribe, around 1850. The Luo tribe is a Nilotic tribe, originating from the Sudan, from where they moved along the Nile river and settled along the shores of Lake Victoria. The first Luo settlers were no farmers, but they lived by fishing and cattle raising. At the beginning of this century they started growing crops like sorghum, wimbi (finger millet) and sweet potatoes. The area is not very densely populated, the population density is 100 to 200 persons per square kilometer. The population pattern is scattered, although the hills are definitely prefered for settlement, above the plains with impeded drainage. The settlements ('villages') take the form of a large circular or rectangular dense hedge of Euphorbia, surrounding the huts of the father, his wives and children.

1.c. Land Tenure

Within the survey area there are no officially registered land proprietary rights, as we find this for instance in the Kisii district. The land is owned by the clans who first settled on the land. The settling and consequent building of houses and the cultivation of the land was predominantly on hills and ridges. This was done for protection against the raiding Masai and to escape the poorly drained areas, which are swampy during the long

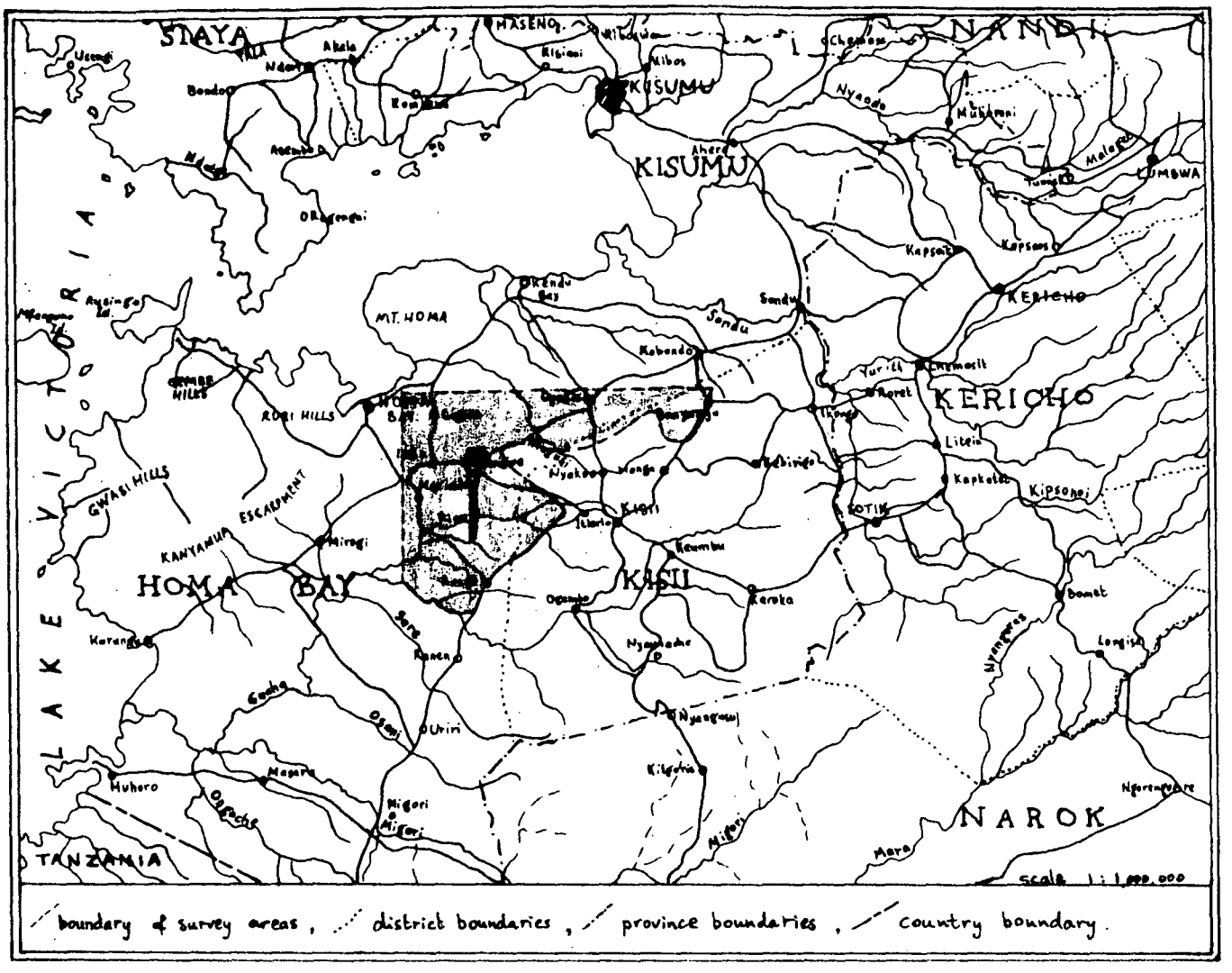


fig. 1 LOCATION MAP OF THE SURVEY AREAS

Rangwe sample area (dark coloured)

South Nyanza north - east area (light coloured)

rains. The elders of the clan divided the occupied land in long narrow strips, which were allocated to the different families of the clan. Afterwards the rights of cultivation and grazing became inherited.

Chapter 2 : Physical and Biological Environment

2.a. Climate

Meteorological data are available from three places around the area. The closest to the area is Asumbi mission, about 4 km south east of Kangwe. Further away are Marinde, about 9 km west of Kuna hill (in the middle of the area) and Kamagambo, about 5 km south east of the southern boundary of the area. From the mean monthly rainfall diagrams of these meteo stations it is clear that the mean annual rainfall in the area is about 1550 mm. The rainfall distribution throughout the year shows a clear peak in April-May, with April being the wettest month with a mean rainfall of about 250 mm. A second but minor peak occurs in September-October, with about 130 mm per month. These short rains however are rather unreliable.
The driest month is January, with often less than 50 mm. Also dry, but not so pronounced, are February and July, having about 80 mm of rainfall.
It should be noted that these figures are based on rather short records of data (not more than 15 years). Moreover these figures only indicate mean values and give no information about the reliability of the rain. Marinde records for instance show a low year of 820 mm and eight out of ten years a rainfall of less than 1200 mm.
Only little is known about the evaporation in the area. To give an idea of the magnitude of the potential evapo-transpiration, the following table is given. (from V. Mourik, 1974, (9))

Table 1. Average monthly Epo (optimal potential evapo-transpiration)

	D	J	F	M	A	M	J	J	A	S	O	N
Kisii town :	113	119	108	121	105	113	108	130	123	144	137	115
Ahero :	149	168	160	174	147	146	139	137	144	159	164	148

Temperature records of Kamagambo show mean maximum temperatures of 28°C and mean minimum temperatures of 18°C. In the dry season however, temperatures can rise to about 35°C and in cool months temperatures can drop to about 10°C.
For the rainfall and temperature diagrams see pages 42 and 43.

2.b. Geology

The first to study the geology of the survey area was mr. A. Huddleston, who made a geological map of the Kisii district in the late 1940's. According to his map almost the whole of the area is made up of Nyanzian rocks, which are of pre-Cambrian age. The Nyanzian system is composed almost entirely of rhyolites, andesites and basalts, with minor local developments of tuff and agglomerate. In the survey area we find mainly rhyolite and basalt, with only a small strip of rhyolites with intercalated tuffs and agglomerates. In the southern part of the area we find two isolated occurrences of minor intrusives, consisting of diorite porphyry, which are of post-Nyanzian age.

Apart from this geological map, I have the impression that the southern part of the area (south of Awundo's Village) has been considerably influenced by fine grained alluvium, deposited by the Riana river in the geological past. For instance in the Pleistocene. An indication for this idea was the occurrence of rounded pebbles in a pit on the plateau between the Aora Nam river and the Riana river. The plateau could thus be considered entirely or partly, as a terrace.

For more details see the 'Geological map of the Kisii District' plus report, by A. Huddleston (8). A copy of the relevant part of this map is given in the appendix, at the back of this report.

2.c. Physiography

Physiographically the area can be divided into two main landforms:

1. The hills and ridges of Rangwe in the north,
2. The Riana river plain in the south.

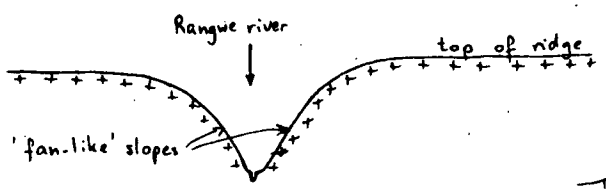
The boundary is formed by the line between Awundo's Village and the place where the Rangwe river enters the survey area. In the Riana river plain, there is one element, that belongs physiographically and pedologically to the Rangwe hills. This element is Kuna hill, a kind of 'inselberg' in the flat topography of the plain. These two distinguished landforms will be described in more detail below.

Hills and ridges of Rangwe

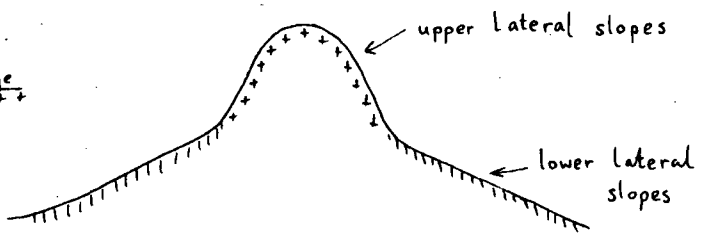
The Rangwe landscape is dominated by ridgelike hills with rounded, slightly sloping tops and not very steep (5 - 12 %), slightly convex, a bit irregular lateral or footslopes. The valleys of the streams and rivers are rather narrow and have convex slopes. There is hardly any alluvial plain,

because the rivers have cut themselves down quite rapidly and have reached the bedrock on many places. The whole of this landscape gives the impression of an eroding landscape.

Near Rangwe we find some clear ridges, with a south-east - north-west extension. They have rather steep lateral slopes (10 - 25 %) and a narrow top. However, the lateral slopes are not steep from top to bottom, but only the upper slopes are steep, while the lower slopes are rather flat. The transition between upper and lower slopes is often quite sharp. It is striking that on the places where the Rangwe river has cut his way through these ridges, they have formed steep 'fan-like' slopes (slopes of 20 - 30 %). These slopes are steeper than the upper lateral slopes. All of the steeper ridges, as they are described here, are made up of rhyolite rock, that is found very shallow under the upper lateral slopes. The top of Kuna hill also has these steep slopes and shallow rock. An illustration of these steep topped ridges is given below.



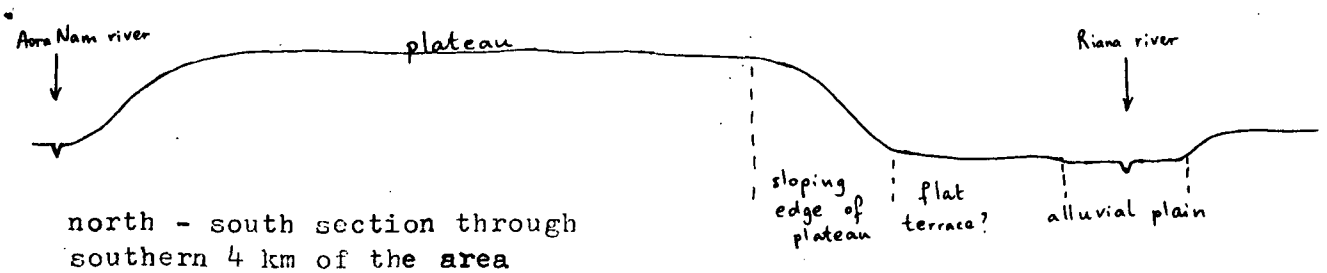
section along axis of ridges



transverse section through ridge

Riana river plain

This physiographic unit (with exception of Kuna hill) has a flat to undulatinf macrorelief. Most of the land has a slopegradient of less than 5 %. The southern part of the area, between the kilometermarks 99^{25} and 99^{22-23} (half-way between them), forms a part of a plateau, that extends further to the west. It has a flat topography (slopes less than 3 %) with steeper sloping edges (slopes of 3 to 8 %). South of the Riana river and north of this plateau we find a very flat strip of land, which perhaps is a terrace of the Riana river. Along the Riana river we find a narrow alluvial plain (about 200 m wide), which lies lower than the adjacent land. A schematic section through the described southern part of the area is given below.



north - south section through southern 4 km of the area

The rest of the Riana river plain (north of the Riana river) has an undulating macrorelief, with gentle slopes that merge with the Rangwe hills. In this physiographic unit most of the gentle slopes (less than 5 %) are affected by seepage and become semi - swampy during the long rains. In the hills of Rangwe however, the majority of the slopes are steeper and the soils are free draining. Only a small strip of land along the rivers has drainage problems in this landscape.

2.d. Vegetation

The most significant differences in vegetation can be distinguished between the vegetation of the Rangwe hills and that of the Riana plain. (with about the same boundary as the main physiographic units have)

- The Rangwe hills, including Kuna hill and the northern edge of the plateau in the southern part of the survey area (near the 99^{25} kilometer mark), have a Combretum woodland vegetation, a so called loww tree - high grass savanna. Because of the widespread cultivation however, much of the original vegetation has been removed and new species (e.g. Eucalyptus spp.) are introduced.
- The Riana river plain (excluding Kuna hill etc.) is an area with impeded drainage and has a grassland vegetation with grouped trees and bushes. Often these groups of trees and bushes are located on former termite hills, where they find a better physical environment for their roots. The dominant grass species is Pennisetum catabasis. The density of the trees-bushes clumps is variable. On the plateau in th south of the area, we find a low density of mainly bushgroups, while north of this plateau, near the Riana river a much higher density is found of mainly thorny Acacia species, together with some bush.

Beside these two main types of vegetation, there is another type, the riverine bush, which is a rather dense vegetation of trees, shrubs, herbs and grasses. The extension is limited to the riversides, which are quite small in this survey area, especially in the Rangwe hills.

For more details reference is made to the Vegetation map of Kenya, sheet 3, 1 : 250,000. The relevant part of this map has been copied and is represented in fig. 2, opposite page 6.

Legend to the Vegetation map of Kenya, 1 : 250,000 (partly):

Forest clearings and cultivation communities:

- From Moist Montane and Intermediate forests:

  Undifferentiated clearings and scrub - - - - - - - - - 35

  cultivated Triumfetta - Vernonia - - - - - - - - - - 35[c]

  cultivated Croton and Vernonia - Clerodendron - - - - - 35[d]

- From lower Moist Intermediate forest:

  cultivated Albizia - Bridelia - Vernonia - - - - - - - 25[d]

Combretum and allied broad - leaved savanna types:

- Moist Combretum and allied vegetation:

  Undifferentiated Combretum types, including cultivated areas -40

  Combretum with Euclea schimperi - - - - - - - - - - 40[c]

Broad - leaved savanna mixtures of semi - evergreen thicket origin:

- Combretum semi - evergreen thicket mixtures - - - - - - - 50[a]

Intermediate semi - evergreen thicket and associated types:

- Derived clearings, cultivation communities and bushland,

  Undifferentiated - - - - - - - - - - - - - - - - 46

  Albizia coriaria - Turraea type - - - - - - - - - - 46[a]

Open grassland types on drained soils:

- Grasslands and scrub - grasslands of forest origin:

  from moist montane and intermediate forests - - - - - - 2[a]

Vegetation of soils with impeded drainage:

- Acacia and allied vegetation on clay plains, undifferentiated - 56

  Acacia sieberiana vars. and A. polyacantha - - - - - - 56[b]

  Acacia seyal and Balanites, Kano type - - - - - - - - 56[c]

- Open grassland areas on clay plains:

  Hyparrhenia - Pennisetum catabasis - - - - - - - - - 56A

- Grasslands and clump grasslands, undifferentiated

  Vlei and drainage - line types - - - - - - - - - - 8

  Evergreen clump grassland on vlei soils - - - - - - - 8[a]

- Papyrus, swamp grass and reed swamp - - - - - - - - - 9

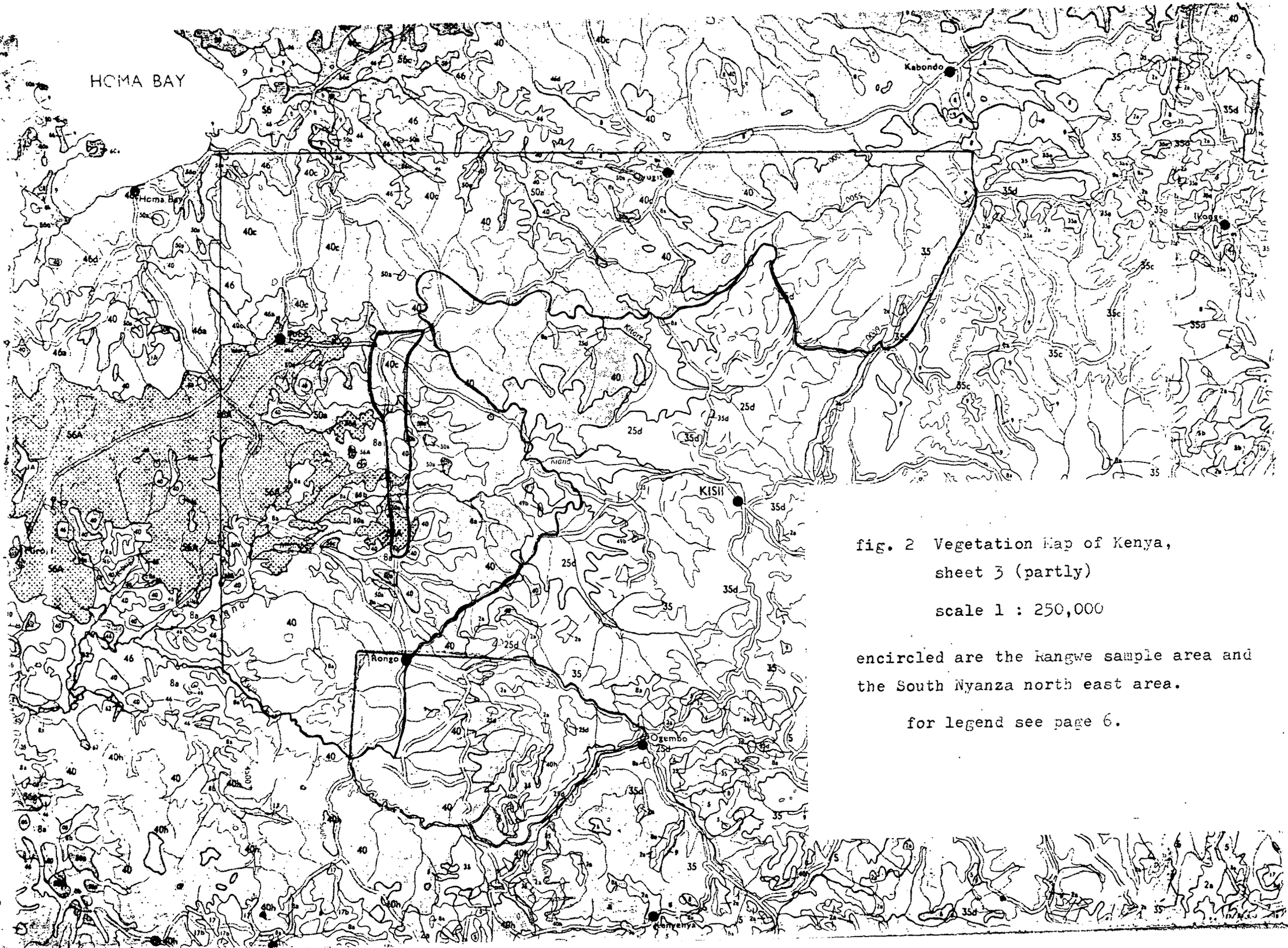


fig. 2 Vegetation Map of Kenya,
sheet 3 (partly)

scale 1 : 250,000

encircled are the Rangwe sample area and the South Nyanza north east area.

for legend see page 6.

Chapter 3 : Land Use

When we look at the arable land in the survey area, it is clear that the soils of the Rangwe hills are much more intensively cultivated than the dark cleyey soils of the plain. The main reason for this is the better physical characteristics of these soils (good permeability and consequently no waterlogging) and the fact that these soils are easier to till. (because of the loamy texture). In the plain most of the land is left under its natural clump grassland vegetation and is used as grazing land. All grazing in the area is communal.

The agricultural system in the southern part of the area is shifting cultivation. A certain plot of land is cultivated nutill it becomes exhausted and is then abandoned and a new plot is cleared from its grass vegetation. In the hills near Rangwe the agriculture has a more permanent character, although not every plot is tilled each year. People use fallow periods to let the soil regain some of its natural fertility. No manure nor fertilizers are used to improve crop yields.

Most of the tillage operations is done by 'jembe' (broad bladed hoe). Only few people have an oxen plough to do the heavy ploughing work. Weed control is poor, because the time between planting and the first weeding is too long. Weeding is done by 'jembe'. An average crop rotation system for the Rangwe hills looks as follows:

first crops : maize or finger millet
second crops: maize, sorghum, finger millet, beans or groundnuts
last crops : sweet potatoes and/or cassava,
followed by a few years of fallow usually.

The most important crops that are grown in the area, are listed below.

1. Maize Maize is the principal food crop. Most of the maize is grown for home consumption, but surpluses are sold on the local markets. (at Rangwe, Oboke, Rongo etc.) Sometimes it is used for brewing local beer. Maize is planted either alone or mixed with sorghum. It can also be intercropped with legumes, in many cases cowpeas.

2. Sorghum Sorghum is the second important food crop, but it is also used for brewing beer. It is never a cash crop, but it is always consumed by the producing family. Compared with maize, sorghum has the advantage that it is less vulnerable for conditions like drought or waterlogging. On the other hand it has a lower yield potential than maize.

3. Sweet potatoes Sweet potatoes are rather popular, but they don't have an important place in the diet of the people. They are often stored as a reserve food crop, but they are seldom sold at markets. They are grown mostly on the loamy soils of the hills.

4. Finger millet Finger millet ('wimbi') is a minor cereal crop, used at home for food and beer brewing and it is never sold. In most cases some maize is interplanted with finger millet.

5. Sugar cane Sugar cane is grown on the dark coloured, imperfectly drained soils of the area. It is used for the production of jaggery (brown unrefined sugar), which is sold on the markets. Much of this sugar is used for the illegal distillation of local spirits ('changa'). People also sell the cane in small peaces for chewing.

6. Groundnuts Groundnuts are the most important cash crop in the area. They are grown preferentially on the reddish brown loamy soils of the hills, but also other kinds of soils are used for groundnuts. They become more and more popular to the farmers and the acreage is increasing consequently.

7. Cowpeas Cowpeas are an important legume crop. Much of it is for home consumption, but a fair part of the crop is sold to Asian traders. Many farmers use tu plant cowpeas between maize, which helps to keep the weeds under control. The young green leaves are often used as a vegetable.

8. Green grams Green grams are another legume crop, however of lesser importance than cowpeas. Often green grams are grown together with maize. Most of the crop is sold to the Asians.

9. Cassava Cassava is usually raised on the shallow gravelly soils of the hills, because of its ability to do well even on poor soils. Beside this it has the advantage that it is drought resistant. However the tuber has a low nutritive value. In the survey area it isn't a popular crop and it is used merely as an emergency crop.

10. Vegetables Vegetables, an important ingredient of the African menu, are usually grown on moist plces, e.g. in small valleys, on plots just bordering a stream or small river. The most important vegetables are cabbage, onions, tomatoes and beans. Beside these kale, cauliflower and carrots can be found incidentally.

11. Coffee Coffee was found at some places in the hills of Rangwe, on rather shallow soils. Without exception the coffee trees were of very poor quality. Beside the rather unsuited soils, coffee deseases will be responsible for the cropfailure. The altitude and particularly the rainfall of the area are marginal for coffee.

12. Fruits On a small scale, only near villages and for home - use, fruits are grown. The most important one is bananas, but also paw paws (Carica papaya), pumpkins, mangoes and citrus fruits can be found.

13. Sisal Sisal has been found in the area in abandoned fields, mostly bearing the flowering stem. No sisal is produced commercially nowadays, probably due to the drop of sisal prices on the world market. It is only used in rows as fences and for the home-use production of ropes.

Beside these food and cash crops, some people grow small plots of nicotine tobacco (Nicotiana rustica) for home-use, mostly for smoking in pipes.

Chapter 4 : Survey Methods

The actual soil survey is a detailed one, with a rather large scale of 1 : 12,500. The survey methods followed, can be described as a four step method. The first step comprises a reconnaissance of the general character of the area. The second step consists of the interpretation of aerial photographs and the preliminary drawing of suspected soil boundary lines. The third step is the fieldwork to check whether the preliminary boundaries are virtual soil boundaries or not. The fourth step is the final drawing of these boundaries on the aerial photographs. A further elucidation of these different steps is given in the following sections.

4.a. Reconnaissance

A first reconnaissance of the area was obtained by studying the topographical map of Gem (Survey of Kenya, sheet 130/1, 1 : 50,000), on which the whole survey area is represented. An impression of the topography of the land in the area can be obtained for instance by comparing the different densities of the 50 feet contours on the map. Also the main drainage pattern can be studied from this map. Another map important for the reconnaissance of the area, was the geological map of the Kisii district (Huddleston, 1951 (8)). Beside this map the Vegetation map of Kenya, sheet 3 (1 : 250,000) was examined to give an impression of the local vegetation. After studying these maps, a first drive through the area was made to get a first picture of the area.

4.b. Airphoto interpretation

In order to get a first indication where differences in soils occur, aerial photoes are studied stereoscopically. By means of runs of aerial photograghs with a foreward overlap of 60 % and a mirror stereoscope, we can get a three dimansional image of the area with an exaggerated relief. By carefully studying these stereo images, paying attention to differences in landscape, slopegradient, vegetation, land use, grey-tone (often an indicatin for wetness) etc., provisional soil boundary lines can be deduced. In this way an airphoto interpretation map can be made, using the photographs as base maps.

4.c. Fieldwork

This is the most extensive and time consuming part of the soil survey. Within the units, distinguished on the interpretation map, the soil is examined at various places to check whether the soil is uniform enough

to be grouped in one soil series. The definition of a soil series is given below.(see section 5.a.) The examination of the soil was done by augering with a so called Edelman auger, to a depth of 2.20 m maximally, if the bedrock was not found sooner. All augering sites were numbered and their positions recorded on the airphotoes, and later on they were all transfered to the location map of augering sites and profile pits. (appendix map c)) Of the soil material, brought up by augering, colour, mottling, texture, consistence, gravelliness (e.g. of concretions) and the occurrence of lime was determined. Differences in these characteristics from top to bottom, enabled the subdivision of the soil into soil horizons. At each augering point information about the soil surface (e.g. slope, stoniness) and the environment (e.g. vegetation, land use) was added to the soil material description, on special augerhole observation forms.
In this way the whole of the area was covered with boring sites, which enabled the surveyor to draw the final soil series and soil phases boundaries. Often it appeared that the interpretation lines of the aerial photographs were not very accurate and often they had to be changed oe even removed. Intensive augering was needed to find the real soil boundaries.

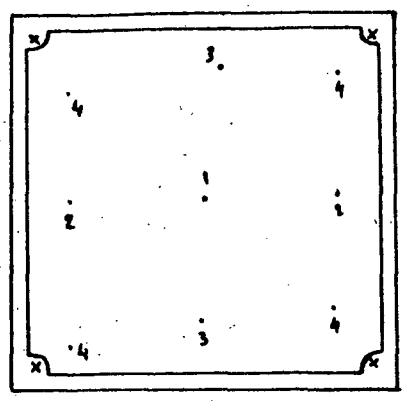
In order to make detailed descriptions of each soil series, deep pits were dug on representative places and profile descriptions were made, mentioning soil colour, colour and density of mottling, structure, texture, pore distribution, concretions and cutans of each horizon distinguished. Not only profile descriptions were made, but also each horizon was sampled for laboratory analysis, to enable a more reliable classification of the soils. These profile descriptions together with the data of the augerhole observations lists, are the basic material to distinguish and describe soil series with their range in characteristics. This was done during the progress of the fieldwork.

After a certain part of the area was checked by augering, the interpretation lines were adjusted and the final soil series and soil phase boundaries were drawn on the aerial photoes. When once the whole area was covered with photoes, showing the soil boundaries, a next phase in soil mapping began. This phase is the map compilation by composing all photo images to one soil map.

4.d. Map Compilation

In order to transfer the lines on the photographs to a base map, each photograph is marked with nine points: one principal point (1), two transfered principal points (2), two wing points (3) and four transfered wingpoints (4).

(see illustration below). The transfered points on a photo come from the two adjacent photoes in the same run (because of the 60 % foreward overlap of two successive photographs). These points are all transfered to a base map by means of the so called 'slotted template method'. The actual transfer of the lines on the photoes is done with a sketchmaster, with which the photo and the map can be seen simultaneously. When the apparatus has been adjusted in such a way that the points of the photo are coinciding with the corresponding points on the base map, the lines between these points can be traced on the base map. In this way photo by photo the map was composed.



airphoto with principal and wing points

4.e. Laboratory Work

To get more accurate data of soil characteristics, laboratory analysis were carried out. Especially for soil classification data obtained from the laboratory are indispensable. However due to the limited capacities of the small laboratory in Kisii, only some rather simple analysis were done. Data were obtained on: organic matter content, texture and base saturation. They are represented together with the soil profile descriptions in the appendix. For more data reference is made to the East Konyango soil survey, for which chapter 6 gives some correlations.

Chapter 5 : Soils of the Area

5.a. Classification

The way of classification of the soils is according to the concepts of soil series, soil types and soil phases from the Soil Survey Manual (12). In contrast with the definition of a soil series of the Soil Survey Manual, in this soil survey a soil series is not necesarily a group of soils that developed from the same parent material. This was done for the practical reason that the differences in parent rock were not clearly reflected in soil differences. Therefore the definition of a soil series, as it was used in this survey can be expressed as follows:

= A soil series is a group of soils, that have the same horizons, the same horizon sequence and the same characteristics of these horizons, within the limits given in the range of characteristics.

A subdivision of the soil series is given by the soil types and the soil phases. The soil type represents the texture of the topsoil. Three classes of texture are distinguished:

A : cleyey (more than 40 % clay)
B : loamy (less than 40 % clay, but finer than loamy sand)
C : sandy (less than 40 % clay, but coarser than loamy sand)

The soil phases are subdivisions refering to soil depth or subsoil campact clay depth (for some soil series), slope, occrrrence of ironstone under the profile, erosion of topsoil and for some special places an extra wet variant of the central concept of the soil series.
The following soil depth phases are distinguished:

0 : deeper than 150 cm
1 : depth between 100 and 150 cm
2 : depth between 50 and 100 cm
3 : depth between 20 and 50 cm
4 : shallower than 20 cm

With the term soil depth is meant the effective soil depth, which can be described as the depth of the soil that is still contributing reasonably in moisture storage, rootability, nutrient delivery etc. So a C-horizon consisting of rotten rock, where roots can only penetrate into the weathered joints, is not considered to be effective soil.
For two soil series, the Akelo and the Riana-Kuna series, the soil depth phase was replaced by a depth phase of the compact subsoil clay.

Both soil series have a medium textured topsoil and a very fine textured compact subsoil, with an abrupt (or at least a clear) boundary. For the agricultural potential evaluation it seems much more important how deep this water stagnating clay occurs than to know till how deep this clay continues. Therefore two clay depth phases are introduced:

c_1 : clay deeper than 30 cm
c_2 : clay within 30 cm depth

Note: only on a few places where ironstone or an indurated concretionary layer overlaid the compact clay, the normal depth phase was used.
Beside these depth phases, slope phases were distinguished:

A : 0 - 3 %
B : 3 - 8 %
C : 8 - 15 %
D : 15 - 30 %

Slopes were measured with a simple hand slopemeter, and of course only an average of the sometimes complex slopes can be determined in this way. But for the overall view of the area this is an acceptable measure.

Special phases were introduced for ironstone under the profile, for erosion and for more extreme wetness than is stated in the central concept of a soil series.

Ironstone phase: The occurrence of ironstone under the profile, especially in the Oboke series, was seperated from the same profile on rotten rock, because of the impervious and root growth limiting effects of this iron-rich indurated material. Often however on rotten rock a layer of loose iron - manganese concretions is found and a sharp distinction between such a soil and one on ironstone is rather difficult by means of a soil auger only.

Erosion phase: This phase is used to seperate the plain area south (and a small piece north) of Riana river, which is moderately to severely affected by erosion. Most of the medium textured topsoil of the Riana-Kuna soils has been washed off and even the clay is being eroded at some places. The small part of this eroded unit, north of the Riana river, consists of a cow path that has been eroded down to the rocks.

Wetness phase: This phase is used for soils, that are located in a low position and that are collecting and transfering the water from adjacent higher places towards streams and rivers. Most of these soils are Akelo or Riana-Kuna soils and have in addition to the normal features more and pronounced signs of wetness: pronounced mottling and even iron-manganese

concretions in topsoil and/or subsoil. The water is transported in these soils through the permeable topsoil and very soon, after even light rains these soils are in a swampy condition. And they stay like that long after surrounding soils have become practicable again.

Complexes and undifferentated soilgroups : On some places the soil is too complex to be grouped under one soil series or soils of two series were found too close together to be mapped seperately. In the latter case a soil complex has been mapped, consisting of different percentages of two soil series. In the first mentioned case, as it was found in the flood plain of the Riana river, considerable differences in the profile chracteristics on short distances were found and this made the establishment of a soil series impractical. Therefore these soils were grouped under the undifferentiated soil group of alluvial soils. Units where two or more phases of one soil series have been found, are not considered as a complex.

5.b. Description of Soil Series (including ranges of chracteristics)

The legend of the soil map of the Rangwe sample area consists of ten soil series, which are subdivided in groups according to their drainage class. Only the four well drained soil series have been further subdivided after their parent material. Beside these soil series two soil complexes have been distinguished (one on the southern plateau and one on the Kuna hill) and one undifferentiated soil group (in the Riana river flood plain).
The legend with short descriptions of the soil series, plus their classification according to the F.A.O. system of classification, is written on the soil map of Rangwe sample area.
Furtheron in this section a detailed description will be given of the soil series, including their range in characteristics, land use and the similar soils of each series. For profile description reference is made to the appendix, at the end of this report.

1. Aora Nam Series

surface in hectares: 168 (9.2 % of the area)
see profile Ra 1, appendix

Aora Nam series are poorly drained soils, with a very dark grey, light clay topsoil and a dark grey, heavy clay mottled subsoil with evidences of swelling and shrinking.
Classification: acc. to F.A.O. '74: gleyic phaeozems and gleyic luvisols
acc. to Soil Taxonomy '73: typic argiaquolls and typic tropaqualfs.

The Aora Nam soils belong to two classification units because the epipedons not always fullfill the requirements for a mollic epipedon. The major part of these soils are mollisols (phaeozems).

Range in characteristics

A. Profile characteristics:

Aora Nam soils are poorly drained, with a depth ranging from 100 to more 150 cm.

- A horizon: thickness from 10 to 50 cm, very dark grey to very dark brown (10 YR 3/1, 3/2, 2/2) in colour, a heavy clay loam to light clay texture (30 - 50 % clay), with few weak fine dark brown mottles, a fine subangular blocky structure and a gradual to clear boundary towards the B2 horizon.
- B2 horizon: thickness 70 to 140 cm, dark grey colour (hues yellower than 7.5 YR, values 4,5, chromas 0,1), a heavy clay texture (60 - 80 % clay), with common weak to clear fine brown mottles and a strong coarse angular blocky structure, breaking into strong medium and fine angular blocky peds and having many intersecting slickensides.
- B3 horizon: thickness 30 - 80 cm, grey to greyish brown (hues yellower than 7.5 YR, values 5,6, chromas 1,2) in colour, with a heavy clay texture (60 - 80 % clay) and the same mottling and structure as the B2 horizon, plus some rotten rock gravels and many intersecting slickensides.

Special features: In the B2 horizon some iron-manganese concretions may occur (less than 5 %) and in the lower B2 and in the B3 horizon lime concretions can be found locally (less than 1 % of exposed surface).

Erosion: Because of the gentle slopes, surface runoff is rather slow. But since the subsoil consists of heavy clay with a low permeability, the topsoil can be soon saturated with water, resulting in surface runoff. Therefore slight water erosion (sheet erosion) occurs.

B. Environmental characteristics:

Physiography: An soils occur in stream and river valleys in the slightly undulating to undulating landscapes of the southern plain and as a small strip along the streams and rivers in the Rangwe hills. These strips however are not composed purely of poorly drained An soils, but also some better drained dark coloured clay loam to clay soils occur locally. But their extend was not big enough to be mapped seperately or as a complex with An soils. Slope range: 0-6 % in the south, 0-8 % in the Rangwe hills.

Geology: An soils can be derived from various rocks, but generally from rhyolites, diorite porphyry and only incidentally from basalt.

Vegetation: Most An soils lie under an open grassland vegetation with

grouped trees and bushes, but sometimes, at swampy places they have a rush and grass vegetation. Along the Rangwe river only the better drained soils directly bordering the river, have a riverine bush vegetation.

Land use

About 90 % of the land is left under its natural vegetation and is only used for extensive grazing of cattle and goats. Only some places, where the drainage is somewhat better, small plots have been cleared for sugar cane, vegetables or for maize and sorghum. Often people have dug some superficial drainage ditches down the slope.

Similar soils

Aora Nam soils are related to Akelo and Awundo soils. The Akelo soils however are characterized by an abrupt textural change between topsoil and subsoil and moreover the dark topsoil is usually thicker. The Awundo soils have no medium textured topsoil, but are very fine textured from top to bottom and have no mottling in the topsoil.

2. Akelo Series

surface in hectares: 280 (15.3 % of the area)
see profile Ra 5, appendix

Akelo series are poorly drained soils, with a very dark brown to very dark grey medium textured topsoil and an abrupt boundary towards the mottled dark grey, heavy clay subsoil, which has evidences of swelling and shrinking.

Classification: acc. to F.A.O. '74: gleyic phaeozems (+ gleyic luvisols)
acc. to Soil Taxonomy '73: abruptic argiaquolls (+ abruptic tropaqualfs)

Range in characteristics:

A. Profile characteristics:

Akelo soils are poorly drained soils, with a depth ranging from 50 to more than 150 cm, depending upon gravelly-stony layers which occur locally at shallow depth.

- A horizon: thickness from 25 to 50 cm, (very) dark brown to (very) dark grey (hues 10 YR (and 7.5 YR), values 3,4, sometimes 2, chromas 1,2), with a clay loam to silty clay loam texture (sometimes loam or silt loam) and often common fine faint brown mottles, having a very fine subangular blocky structure and an abrupt boundary towards the B2 horizon.
- B2 horizon: thickness 40 to 100 cm, can be mostly divided into two parts:

B21 horizon: very dark grey (hues 10 YR (and 7.5 YR), values 3,4,5, chromas generally 1, sometimes 2), a heavy clay texture (60 - 80 % clay) and common fine distinct brownish yellow or prominent reddish mottles, with a coarse prismatic structure, composed of strong fine angular blocky peds and common slickensides.

B22 horizon: grey to greyish brown colours (hues 10 YR (+ 7.5 YR), values 5,6, chromas 1,2), a heavy clay texture, with many fine distinct brownish yellow mottles and a strong fine angular blocky structure and many intersecting slickensides.

- B3 horizon: thickness variable from 30 to 60 cm, same colours as B22, mixed with light yellow, orangeish and black rotten rock colours, texture: decreasing clay content with depth and increasing gravelliness with depth; few slickensides and slightly calcareous at profile bottom.

Special features: Sometimes the lower part of the A horizon shows some signs of bleaching and is therefore somewhat lighter coloured than the upper A horizon. But a clearly lighter coloured A2 horizon can not be distinguished. Sometimes iron-manganese concretions or small gravels are found at the boundary of the A to the B horizon.

Erosion: Surface runoff is slow, because of the flat to gently undulating topography. But as water can rise to the surface after rains, because of the low permeability of the B horizon, slight sheet erosion occurs.

B. Environmental characteristics:

Physiography: Akelo soils are found in two parts of the area: the southern occurrence is on the flat to gently undulating plateau, which is dissected by small rivers and streams. The northern occurrence is on the gentle slopes between Kuna hill and the Rangwe hills. This landscape has a more undulating character. The slope range of Akelo soils on the southern plateau is less than 3 %, while the northern valleyslopes range from zero to about 5 %.

Geology: Akelo soils can be developed on various parent materials. On the southern plateau most soils lie on rhyolite and diorite porphyry rocks. The northern Akelo soils have been developed from basalt parent material.

Vegetation: Akelo soils are exclusively found under an open grassland vegetation with scattered Acacia trees and groups of bushes. Only the density of these trees and bush groups is variable. On the plateau for instance this density is low, while north of Kuna hill the trees are closer together.

Land use

Arable farming is rather difficult on Akelo soils, due to their excess of

water in rainy seasons. Therefore most of the land is still under its natural vegetation and people only use it as range land for their cattle. Only some small plots on better drained places have been tilled and sugar cane, maize, sorghum, finger millet and some vegetables are grown, but not always with good results.

Similar soils

Akelo soils can be considered as intergrades between Aora Nam soils and Riana-Kuna soils, because it has the dark topsoil of Aora Nam soils and the abrupt textural change of Riana-Kuna soils. Awundo soils are also similar, but they don't have an abrupt textural change and are of clayey texture throughout the profile.

3. Riana - Kuna Series

surface in hectares: 343 (18.8 % of the area)
see profile Ra 7, appendix

Riana-Kuna series are poorly drained soils, with a dark greyish brown silty topsoil, of which the lower part is grey and bleached and has an abrupt boundary with the heavy clay subsoil, which is dark grey and has yellow or red mottles and evidences of swelling and shrinking.

Classification: acc. to F.A.O. '74: solodic planosols
acc. to Soil Taxonomy '73: abruptic tropaqualfs (actually they should be called tropical albaqualfs)

Range in characteristics

A. Profile characteristics:

Riana-Kuna soils are poorly drained soils, generally deeper than 150 cm.
- Al horizon: thickness from 3 to 25 cm, with colours of dark grey to very dark greyish brown (hues 10 or 7.5 YR, values 3,4, chromas 1,2), having a silty clay loam to silt loam texture, with common weak brown mottles and a very fine subangular blocky structure.
- A2 horizon: thickness 5 to 50 cm, dark grey to light brownish grey in colour (hues 10 or 7.5 YR, values 4,5,6, chromas 1,2), with a silt loam texture and many fine distinct brown mottles, having a very fine subangular blocky structure and an abrupt boundary with the B2 horizon. This boundary may be accompanied by many yellow to reddish mottles and/or iron-manganese concretions.

- B2 horizon: thickness ranges from 50 to 100 cm, colours are dark grey in the upper part and grey to greyish brown downwards (hues 10 YR (or 7.5 YR), value 4, chromas 1,2 in top and value 5, chromas 1,2,3 downwards), a heavy clay texture, many prominent red, orange or yellow mottles in top and downwards common fine distinct yellow to brown mottles, with a moderate coarse prismatic structure, breaking into strong fine angular blocky peds and downwards many intersecting slickensides.
- B3 horizon: thickness variable from 30 to over 100 cm, colours same as B2 horizon (lower part) or some lighter and browner (e.g. pale brown 10 YR 6/3), together with various rotten rock colours (ranging from whitish, yellowish to blackish), texture is heavy clay, with decreasing clay content with depth and a strong very fine angular blocky structure and few slickensides are found. In the B3 horizon or in the C horizon few lime may be found.

Special features: Sometimes concretions occuring between A and B horizon are indurated and form a continuous ironstone layer, that limits augering till 30 to 50 cm depth. In these cases the normal soil depth phase is used instead of the heavy clay depth phase as used for Akelo and Riana-Kuna series. It should be noted that the A2 horizon should be distinguishable by colour in the central concept of the Rk series. However, this may be difficult in some soils mapped as Rk soils. In these cases the soils are quite similar to Akelo soils and are not always well separatable from them.

Erosion: Most of the time during rainy seasons the topsoil of Rk soils is saturated with water, due to the almost impervious heavy clay subsoil, and a slow surface runoff through the high grass vegetation is found. This results in a light sheet erosion, taking away the dark brown coloured A1 horizon. The thickness of this A1 horizon can be quite small therefore.

B. Environmental characteristics:

Physiography: Rk soils can be found in the slightly undulating Riana river plain, which is slightly dissected by small streams and rivers. Minor parts of these soils are found in the undulating to rolling hills of Rangwe, associated with streams and river valleys, on the poorly drained sites.

Slope range: in the plains, slopes have gradients usually less than 3 %, while in the narrow valleys between the Rangwe hills, slopegradients can be up to 5 %.

Geology: Riana-Kuna soils occur on different types of parent rock. According to the geological map of Huddleston, most of it is basalt and rhyolite, plus some diorite porphyry. But most of them might as well be developed on old fine grained sediments of the Riana river.

Vegetation: Riana-Kuna soils have been found under a grassland vegetation with scattered Acacias (often thorny Acacia species) and groups of bushes. The density od these trees and bushes can be rather high (as high as 40 %, seen on an airphoto), but everywhere the grasscover is dominant.

Land use

Almost the entire area is left under the natural vegetation and is used for extensive grazing of cattle and some goats. Only very occasionally plots have been tilled, but with poor results.

Similar soils

The most similar soils are Akelo soils, which are only darker in colour and don't have a clear A2 horizon. Aora Nam soils are also similar, having clay illuviation evidences, but less clear than Ak and Ik soils. Awundo soils don't have these evidences.

4. Awundo series

surface in hectares: 23 (1.3 % of the area)
see profile Exc 13, appendix

Awundo series are poorly drained black to dark grey, heavy clay soils without an abrupt textural change from topsoil to subsoil and that have vertic properties (cracks, slickensides etc.).

Classification: acc. to F.A.O. '74: pellic and chromic vertisols
acc. to Soil Taxonomy '73: entic and typic pelluderts and aquentic chromuderts.

Range in characteristics

A. Profile characteristics

Awundo soils are poorly drained soils, with a depth generally more than 150 cm.

- A horizon: thickness of 15 to 35 cm, black to very dark grey colours (hues 10 YR (and 7.5 YR), values 2,3, chroma 1) and a clay texture, sometimes with faint dark brown mottles and a fine to medium subangular blocky structure.
- B1 horizon: thickness 20 to 40 cm, dark brownish grey to brown colours (7.5 YR, values 3,4,5, chromas 1,2), often with brown mottles, a heavy clay texture and an angular blocky structure, plus some slickensides.

- B2 horizon: thickness of 40 to 100 cm, brown to dark grey colours (10 YR, values 4,5, chromas 1,2,3) with strong brown mottles, a heavy clay texture, an angular blocky structure and intersecting slickensides, with generally a gradual boundary towards the C horizon, but sometimes an abrupt boundary towards a R-horizon is found (boulder weathering of basalt).
- C horizon: pale brown to greyish brown colours (10 YR, values 4,5,6, chromas 2,3) and a light clay texture.

B. Environmental characteristics

Physiography: These soils are found on the southern slopes of the Rangwe hills, as a transition between Akelo soils and Nyandara I and II soils. The slopes range from 0 to 6 %.

Geology: The parent material of Aw soils is exclusively basalt.

Vegetation: The vegetation on these soils is the same open grassland, with scattered trees and bushes as in case of the Akelo series.

Land use

The soils are rather difficult to cultivate and most of the area occupied by Awundo soils is therefore used as rangeland for cattle and goats.

Erosion

Because of the rather flat topography and the rather high clay content of the topsoil, these soils are not very susceptible to erosion. In dry seasons the soils cracks and these cracks can transport the water of rains, untill they have closed by swelling.

Similar soils

An soils are most similar, also having vertic properties (evidences of swelling and shrinking), but they have also evidences of clay illuviation. Akelo and Riana-Kuna soils are also poorly drained and of heavy clay texture, but they have pronounced clay illuviation characteristics.

5. Oboke Series

surface in hectares: 90 (4.9 % of the area)
see profile Ra 10, appendix

Oboke series are imperfectly to moderately well drained soils, with a dark brown colour and which are often gravelly and have a clay loam to light clay texture. They are shallow and have at the profile bottom iron-manganese

concretions, covering the rotten rock or they have ironstone. The occurrence of ironstone is indicated on the map with a special ironstone phase.

Classification: acc. to F.A.O. '74: haplic phaeozems
acc. to Soil Taxonomy '73: aquic, lithic and typic haplúdolls.

Range in characteristics

A. Profile characteristics

Oboke soils range in drainage class from imperfectly to moderately well drained, depending upon soil depth, occurrence of impermeable ironstone and slope gradient. Most of the Oboke soils are not deeper than 50 cm, because of indurated ironstone and have low slope gradients. These soils are therefore imperfectly drained. Moderately well drained are those soils, that don't have this ironstone layer, but have gravelly rotten rock at the profile bottom, that permits a better subsoil drainage. Soil depth is more than 10 cm, but often less than 50 cm and in most cases less than 100 cm. Surface stoniness ranges from 0 - 5 %, surface gravelliness from 0 up to 30 %.

- A horizon: thickness 10 to 40 cm, colour very dark brown to dark brown (hues 7.5 or 10 YR, 2/2, 3/1, 3/2, 3/3) with a clay loam texture, often slightly gravelly to gravelly, sometimes with iron-manganese concretions, a fine subangular blocky to granular structure and a gradual boundary towards the B horizon.
- B horizon: thickness 10 - 70 cm, colour dark brown to dark greyish brown (7.5 and 10 YR, values 3,4, chromas 2,3), a clay loam to light clay texture, gravelly from rotten rock gravels and iron-manganese concretions, in many cases (imperfectly drained soils) few to common, fine distinct yellowish brown mottles and a fine subangular blocky structure.
- C horizon: thickness depending upon stoniness and softness of rotten rock (in case of no ironstone), mixed colours: brown, blackish, yellowish from rotten rock gravels. Often iron-manganese concretions are found above the rotten rock.

Special features: Sometimes ironstone is found so shallow, that the drainage class of the soil above it is imperfectly to poorly drained. These soils and also deeper imperfectly drained soils are sometimes artificially drained by the local people by means of shallow furrows along the slope.

Erosion: Because the ironstone layers often have a certain slope, subsoil drainage by lateral flow over the ironstone layer is sufficient to prevent surface runoff. However, the very shallow soils on ironstone will have surface runoff and consequently sheet erosion. Soils without ironstone don't have erosion because of the better subsoil drainage.

B. Environmental chracteristics

Physiography: Oboke soils are found on the sloping edges of the southern plateau, where ironstone was found on many places. North of Kiana river we find Oboke soils on more elevated (dome-like) places in the hydromorphic valleys and plains. Slopegradients of these soils range from 0 to 6 %.

Geology: The parent material of Oboke soils can be rhyolite, basalt or diorite porphyry.

Vegetation: Oboke soils are frequently tilled and the vegetation is mostly secondary, consisting of bushes, trees (e.g. Eucalyptus) and few grasslands.

Land use

Oboke soils are rather intensively tilled, because of their better physical properties, compared to the poorly drained soils around them. About 80 % is used as arable land and 20 % for extensive grazing of cattle. All kinds of subsistence crops are grown, like maize, sorghum, sweet potatoes, wimbi (finger millet), beans, vegetables etc. Sugar cane is grown too.

Similar soils

Similar to Oboke soils are Marando and Nyandara II soils, which are also shallow and often gravelly soils, but they are well drained and don't have ironstone layers in their profiles.

6. Alluvial Soils, undifferentiated

surface in hectares: 16 (0.9 % of the area)
see profile Ra 15, appendix

These alluvial soils are an association of imperfectly to moderately well drained dark grey to reddish brown, mottled soils, with a sandy to clayey subsoil and a clay loam to clay topsoil. The soils close to the riverbed have a permanent groundwater table, fluctuating with the riverdischarge.

Classification: acc. to F.A.O. '74: eutric fluvisols
acc. to Soil Taxonomy '73: aquic eutropepts and aeric tropaquepts and some typic haplaquolls.

Range in characteristics

A. Profile characteristics

Because this unit isn't a pure soil series but an association of soils, it is impossible to give the range of characteristics of only one profile.

Therefore it is more sense to sketch some common alluvial profiles.

profile A (imperfectly drained):
0 - 40 cm: dark grey (± 10 YR 4/1) topsoil with approx. 40 % clay.
40 - 100 cm: dark grey clay (± 60 %) with big faint reddish brown mottles.
100 - 200+cm: dark grey/brownish clay loam (± 30 % clay) with mottles.

profile B (imperfectly drained):
0 - 40 cm: dark brown (7.5 YR 4/2) silty clay loam topsoil.
40 - 80 cm: brownish grey sandy loam with blackish mottles.
80 - 200+cm: dark grey-brown, mottled with sandy texture.
Often groundwater is found at 100 to 200 cm depth.

profile C (mod. well drained):
0 - 50 cm: dark reddish brown (5 YR 3/2-3) light clay (± 40 - 50 %) topsoil.
50 - 100 cm: reddish brown (5 YR 4/3) B-horizon with a clay texture (50 - 60 %).
100 - 200+cm: dark grey (5 YR 4/1) subsoil with a silt loam to sandy loam texture downwards.

It was noted that profile A and B had a specific position compared with the riverbed. The brown sandy profile B (see also profile Ra 15, appendix) was found closest to the streambed and profile A further away of it, near the boundary with the adjacent Rk soils. Profile C occured on places with better drainage within the alluvial plain of the Riana river.

B. Environmental characteristics

Physiography: The alluvial soils as described above occur in the alluvial plain along the Riana river. This plain is only about 200 m wide and it has a real flat topography, except for the riverbed which lies about 2 m lower than the plain. To the north this plain has a distinct topographical boundary: a shoulder-like difference in altitude.
To the south it has a rather gradual transition to the plain with eroding Rk soils. Perhaps this plain has belonged to the alluvial plain formerly, being a terrace now.

Geology: Recent alluvial deposits of the Riana river are the parent material for these groups of soils.

Vegetation: The vegetation on these soils has been removed to a fair extend for agricultural practices, but in general it can be called a riverine bush vegetation.

Land use

About 70 % of the soils is tilled and most of it is used for sugar cane

production, because of the rather wet conditions of these soils. But also maize and sorghum and sweet potatoes are grown with fairly good results.

Similar soils

These soils are quite unique and there are no real similar soils. It should be stated however that in the An-unit along Rangwe river also few alluvial soils occur, but their extent is too limited to be mapped seperately or to necessitate the establishment of a soil complex.

7. Rabuor Series

surface in hectares: 235 (12.9 % of the area)
see profile Ra 14, appendix

Rabuor series are well drained, moderately shallow to deep reddish brown to red clay soils, with a clear clay illuviation horizon and a B3 horizon that starts within 150 cm depth.

Classification: acc. to F.A.O. '74: chromic luvisols and luvic phaeozems
acc. to Soil Taxonomy '73: typic tropudalfs and typic argiudolls.

Range in characteristics

A. Profile characteristics

Rabuor soils are always well drained, with a depth of 40 to more than 150 cm.
- A horizon: 15 to 30 cm thick, has colours of dark brown to weak red (7.5 YR 3/2; 5 YR values 3,4, chromas 1,2,3 ; sometimes 2.5 YR 4/2) and a heavy clay loam to light clay texture, with a fine subangular blocky and fine granular structure.
- B1 horizon: 10 to 30 cm thick, having colours of dark reddish brown to weak red (5 YR 3/2, 4/3, 4/4; 2.5 YR 4/2, 4/3) and a (heavy) clay texture, with few to common weak to moderate clay cutans and a fine subangular blocky structure.
- B2 horizon: 20 to 100 cm thick, with colours of reddish brown to weak red (2.5 YR 4/2, 4/3, 4/4), a heavy clay texture, with common to many moderate clay cutans and a fine subangular to angular blocky structure.
- B3 horizon: 10 to 80 cm, colours reddish brown to weak red (2.5 YR 4/2, 4/3, 4/4) plus some yellowish black rotten rock colours, a clay texture, slightly gravelly to gravelly (from rotten rock), an angular blocky structure.

Special features: Soils in low positions, near streams and small rivers, may have some black mottling and/or some iron-manganese concretions in the B3 horizon.

Erosion: Rabuor soils have a low erosion hazard, because of their high permeability and the resistence of the topsoil against sealing. Only on special places, like cowpathes etc. erosion can accelerate to deep gullies. Only on the steepest slopes (over 10 %), bare soil can suffer of some sheeterosion after heavy rains.

B. Environmental chracteristics

Physiography: Rabuor soils are found in the hills of Rangwe, on hillslopes and lateral ridgeslopes. Also on Kuna hill Rabuor soils are found, in a complex with Marando soils. The slopegradients of Rabuor soils vary from 3 to 10 %.

Geology: Rabuor soils are developed exclusively from rhyolitic rocks.

Vegetation: The vegetation on these soils is a secondary vegetation derived from a Combretum bushland vegetation. Most of the trees have been removed and other trees as for instance Eucalyptus have been planted. Most of the land however is cleared for agriculture.

Land use

Most of the soils are used as arable land for production of maize, sorghum, beans (cowpeas, green grams), sweet potatoes, vegetables and occasionally sugar cane and groundnuts. Only a minority of the acreage of Rabuor soils is left idle, or is only used as grazing land. Especially the deep Rabuor soils are relatively the best soils for cropland.

Similar soils

Nyandara I soils are very similar to Rabuor soils. The main difference is the parent material: Nyandara I soils are basalt-weathered soils. Minor differences are colour and texture.

8. Marando Series

surface in hectares: 475 (26.0 % of the area)
see profiles Ra 11 and Ra 17, appendix

Marando soils are generally well drained, dark brown to reddish brown, shallow, gravelly clay loam soils, without a clear clay illuviation horizon.

Classification: acc. to F.A.O. '74: haplic phaeozems and eutric and chromic cambisols
acc. to Soil Taxonomy '73: typic hapludolls and typic eutropepts.

Range in characteristics

A. Profile characteristics:

Marando soils are usually well drained, though some of the shallower soils with a low slope gradient and a rather impermeable, solid rotten rock, should be called moderately well drained. However, the central concept of Marando soils is fairly better drained than that of the Oboke soils. Soil depth (= depth of the solid rotten rock) ranges from about 30 to 130 cm. The difference between shallow and deep is mainly caused by different types and structures of rock weathering. Surface gravelliness ranges from 10 to 50 % and surface stoniness is less than 5 %.

- A horizon: thickness from 10 to 40 cm, colours are dark brown to dark reddish grey (hues 7.5 and 5 YR, values 3,4, chromas usually 2, sometimes 3), with a loam to clay loam texture, slightly gravelly to gravelly and a fine subangular blocky to granular structure; the boundary towards the B horizon is gradual.
- B horizon: 10 to 100 cm thick, colours are dark brown to reddish brown and weak red sometimes (hues 7.5 and 5, sometimes 2.5 YR, values 3,4, chromas 2,3, sometimes 4), which are often mixed with strong brown, yellow-orange and black colours of rotten rock gravels and iron-manganese concretions, with a clay loam to light clay texture, gravelly to very gravelly and a fine subangular blocky structure, mostly a gradual boundary towards the soft (massive) rotten rock.

Special features: It should be noted that in the central concept of Marando soils, they don't have an argillic (clay illuviation) B horizon, but only a cambic B horizon. It could however be that after texture analysis of many Marando soils, it would appear that a certain number of them have argillic B horizons. During the fieldwork it wasn't possible to distinguish these soils, having a weak argillic B horizon from those that don't have this. Therefore only the reddish brown soils with clear textural B horizons (Nyandara I and Rabuor soils) have been seperated from Marando and Nyandara II soils.

Often on the rotten rhyolitic rock a layer of iron-manganese concretions is found, which is not really indurated to be called ironstone. Only on the lower edge of Kuna hill, bordering Rk and Ak soils, an ironstone layer is found under the Marando soils. The same applies for Ma soils, found on the northern plateau edge (south of the Riana river), where they border Rk, Ak soils and Oboke soils.

Erosion: The erosion hazard depends upon depth of the massive rotten rock, the slopegradient and the land use. Most sensible to watererosion are those soils, that have shallow massive rotten rock, a C class slope (8 - 15 %) and which are used as arable land. No erosion occurs on soils, having deep massive rotten rock, low slopegradient and that lie under their natural vegetation.

B. Environmental characterisics:

Physiography: Marando soils can be found on the gently to strongly sloping lateral ridgeslopes and hillslopes within the hilly landscape around Rangwe. Also on Kuna hill and on the northern plateau edge (± 1 km south of the Riana river) Marando soils are found. They are mostly found on the upper and lower parts of the lateral and hillslopes. Some ridges (near Rangwe) have steeper sloping tops with Orero soils and the lower (less steep) slopes under the top often have Ma soils. On Kuna hill the same sequence is found. The slopes of the Marando soils have gradients ranging from almost flat to about 15 %.

Geology: Marando soils are developed on the rhyolites and dellenites of the Nyanzian system.

Vegetation: Most of the vegetation on Ma soils has been cleared away for agriculture or is secondary, derived from Combretum woodland. There are some old Ficus trees left, but most of the trees (e.g. Eucalyptus) have been planted. The rest consists of high grasses mixed with herbs.

Land use

Most of the area with Marando soils is cultivated to be used as arable land (about 60 %). Main crops grown on these soils are: maize, sorghum, sweet potatoes, groundnuts and beans. Cassava is grown on the shallower soils, while only near villages we find very small plots of domestic tobacco and trees of bananas, papaya and occasionally mango. The rest of the land is used as a natural pasture for cattle and goat grazing.

Similar soils

Marando soils are very similar to Nyandara II soils, which are found on basaltic rocks. In general Nyandara II soils are more clayey and better drained, because of the better subsoil drainage of basaltic rotten rock. Less similar are the Orero soils, that are more shallow and don't have a B horizon.

9. Nyandara I series

surface in hectares: 59 (3.2 % of the area)
see profile Ra 12, appendix

Nyandara I series are well drained moderately shallow to deep reddish brown to red clay soils, with a clear clay illuviation B horizon and that have B3 horizons starting within 150 cm depth.

Classification: acc. to F.A.O. '74: chromic luvisols and luvic phaeozems
acc. to Soil Taxonomy '73: typic tropudalfs and typic argiudolls.

Range in chracteristics

A. Profile characteristics:

Nyandara I soils are well drained; only near streams and rivers there might be some groundwater influence, giving rise to mottling and a somewhat worse drainage (moderately well drained). Soil depth can be from 40 to over 150 cm.

- A horizon: 15 - 35 cm thick, colours are dark reddish brown to weak red (hues 5 and 2.5 YR, values 3,4, chromas 2,3), a heavy clay loam to light clay texture and a fine subangular blocky and fine granular structure.
- B1 horizon: 5 to 30 cm thick, with colours of dark reddish brown to red (hues 5 and 2.5 YR,3/2, 4/2, 4/3, 4/4), a heavy clay texture, with a fine subangular blocky structure and few to common moderate clay cutans.
- B2 horizon: 20 to 100 cm thick, with colours varying between weak red and reddish brown (2.5 YR 4/2, 4/3, 4/4; sometimes 4/5), a heavy clay texture and a strong fine subangular to angular blocky structure, with abundant strong clay cutans.
- B3 horizon: 10 to more than 60 cm thick, same colours as B2 plus some rotten rock colours (yellowish) and occasionally mottles (near groundwater table), a clay texture with a fine to medium angular blocky structure and possibly some rotten rock gravels or stones.

Erosion: Nyandara I soils have a low erosion hazard because they are very permeable and also have a good resistence against surface sealing. The slopes on which they occur are not very steep as well.

B. Environmental characteristics:

Physiography: Nyandara I soils are found on two places in the hilly landscape of Rangwe: In the southern part near Awundo's Village and along the Nyandara river. These are the places where basalt is found in the hills of

Rangwe. The soils occur on tops and slopes of hills and ridges. The slope-gradient therefore varies from 0 to 12 %.

Geology: Nyandara I soils are formed entirely out of basaltic parent material.

Vegetation: The flora on the Nyandara I soils is the same as that on Rabuor soils, but along the Nyandara river it is more or less a riverine bush vegetation.

Land use:

Most of the Ny I soils, especially the deeper ones are used for cropland. Only along the Nyandara river relatively few soil is used for cultivation, probably because of the slope. Main crops grown are maize, sorghum, sweet potatoes, beans. Beside these crops one can find a few groundnuts, some vegetables and some fruit trees near villages.

Similar soils

Rabuor soils are very similar to Nyandara I soils. The differences are just few (colour, texture), because the influence of parent material on soil formation is quite limited in the survey area. Often therefore, the presented boundaries between Ra and Ny I soils are very vague and their position isn't very certain. They shouldn't be given too much value.

10. Nyandara II Series

surface in hectares: 50 (2.8 % of the area)
see profile Ra 16, appendix

Nyandara II soils are well drained dark brown to reddish brown, shallow, often slightly gravelly clay loam to clay soils, without a clear clay illuviation B horizon.

Classification: acc. to F.A.O. '74: haplic phaeozems and eutric and chromic cambisols
acc. to Soil Taxonomy '73: typic hapludolls and typic eutropepts.

Range in characteristics

A. Profile characteristics:

Nyandara II soils are well drained soils, sometimes even somewhat excessively drained, having a depth of 30 to 100 cm. The surface gravelliness is less than 30 % and the surface stoniness isn't more than 2 %.

- A horizon: 10 to 40 cm thick and colours of dark brown to dark reddish grey (hues 7.5 and 5 YR, values 3,4, chroma 2), with a silty clay loam texture, often slightly gravelly and with a fine subangular blocky to granular structure.
- B horizon: thickness from 10 to 70 cm and colours varying between dark brown and reddish brown (hues 7.5 and 5 YR, values 3,4, chromas 2,3), a (silty) clay loam to light clay texture, gravelly and/or slightly stony and a fine subangular structure. The boundary towards the C horizon is often irregular or broken, due to the tuber-like weathering of basaltic rock.

Special features: The same as was stated about a possibly present weak argillic B horizon in Marando soils, counts for the Nyandara II soils. Here could also an argillic B horizon be present, which however is not distinguishable with fieldwork methods.

Erosion: In contrast with the Marando soils with the rather massive rotten rock, Nyandara II soils have a fairly permeable rotten rock. This results in a better subsoil drainage, through which the soil won't be saturated soon. Therefore surface runoff is not likely to happen very often. So the erosion hazard of these soils, unless they are very shallow, is not high.

B. Environmental characteristics:

Physiography: Nyandara II soils are found near Awundo's Village in the southern part of the hills and ridges of Rangwe, together with the Ny I soils. Another place where Ny II soils occur, are the higher parts of the slopes (northern slopes especially) of the Nyandara river valley, So on both sites they occur on hillslopes. The slopes of these soils range from 3 to 15 %.

Geology: Nyandara II soils are derived exclusively from basaltic rock.

Vegetation: The vegetation on Ny II soils is the same secondary vegetation derived from Combretum woodland as on the Marando soils. Much of the original vegetation has been removed for agricultural use of the land.

Land use:
Most of the Nyandara II soils (50 to 60 %) is used as cropland for producing crops like maize, sorghum, groundnuts, sweet potatoes, beans and sometimes cassava and some fruit trees near villages. The other part of the land is left idle or is used for cattle (and goat) grazing.

Similar soils

Marando soils are very similar to Nyandara II soils. The main differences are the parent material and the gravelliness. The same as stated under the section of Nyandara I soils, about the uncertainty of the boundary between Ra and Ny I soils, counts for the boundary between Ny II and Ma soils.

11. Orero Series

surface in hectares: 86 (4.7 % of the area)
see profile Ra 18, appendix

Orero series are excessively drained, dark brown to brown, very shallow, gravelly and stony soils.

Classification: acc. to F.A.O. '74: eutric regosols (lithic phase)
acc. to Soil Taxonomy '73: lithic ustorthents.

Range in characteristics

A. Profile characteristics:

Orero soils are excessively drained soils, with a depth ranging from 5 to 30 cm, depending upon the weathering of the rocks. The surface stoniness is generally high: about 50 % of the surface is covered with gravels and stones, but stoniness can range from about 10 % to about 80 % and at some places solid rotten rock is cropping out.

- A horizon: 5 to 30 cm thick, with a colour ranging from dark brown to brown (7.5 YR, values 3,4, chromas 2,3), texture is loam to silty clay loam, gravelly to very gravelly, slightly stony, with a very fine granular to subangular blocky structure and a clear wavy to irregular or broken boundary with the C or R horizon.
- C/R horizon: solid hard rock with very little dark brown soil material in the joints.

Erosion: As Orero soils occur on moderately steep and steep slopes and as the soils are shallow, surface runoff can happen and could be rather rapid. However, these soils still have their dense vegetation of bushes and low trees with grasses and herbs on the surface, so water erosion can't be severe.

B. Environmental characteristics:

Physiography: Orero soils are found on strongly sloping to moderately

steep ridges and hills, as they occur near Rangwe. These ridges and hills are clearly visible in the landscape because of their slopes and undisturbed vegetation. The most shallow Orero soils occur mainly on the steep lateral slopes of the ridges. The slopes range in gragient from nearly level on top of the ridges to 25 % on the steep slopes.

Geology: Orero soils occur exclusively on rhyolitic rocks, especially the most acid ones (with many quartz veins and big quartz phenocrists).

Vegetation: The vegetation on Orero soils is probably still original and is composed out of many trees and bushes, with grasses and herbs beneath them. It could be called a bushed woodland vegetation.

Land use:

Only about 3 % of these soils are tilled, but with poor results, due to drought mainly. The rest of the land is left under natural vegetation and is not used or perhaps to a limited extend for grazing of goats.

Similar soils

The most similar soils are Ma and Ny II soils. They have, however, a cambic B horizon and not, as the Orero series, an AC or AR profile. Sometimes the boundaries between Orero and very gravelly Ma soils are hard to determine by means of only a soil auger. Generally a physiographical boundary is drawn in these cases.

Chapter 6 : Correlation with the East Konyango Soil Survey

In behalf of the comparability between the Rangwe soil survey and the soil survey of the East Konyango Area, which covers most of the Rangwe sample area, a correlation table is given of the soil series distinguished in both soil surveys.

Soil series of this report:	Correspondent soil series of East Konyango:
Aora Nam series	Oboke sandy loam, Nyamauro loam and for a small part Nyokal sandy loam
Akelo series	Nyokal sandy loam and Nyamauro loam
Riana - Kuna series	Nyamauro loam
Awundo series	Nyamauro loam
Oboke series	Rangwe sandy loam (smaller parts not seperated, fall under Nyamauro loam and Nyokal sandy loam).
Rabuor series	Rangwe sandy loam
Marando series	Rangwe sandy loam
Nyandara I series	Rangwe sandy loam
Nyandara II series	Rangwe sandy loam
Orero series	Stony land on silicious rocks
Alluvial soils, undifferentiated	Not seperated, they fall under Nyamauro loam

It should be emphasized that the East Konyango soil survey has been made to a scale of 1 : 50,000 and can be less detailed of course than the present survey, made to a scale of 1 : 12,500. This fact limits the comparability of both soil maps.

Chapter 7 : Suitability Evaluation

7.a. Introduction

By no means it is the intension to make a complete land evaluation, taking into consideration the different land utilization types, the improvement capacities of the land, the land qualities before and after these improvements, the derived land suitability classes etc., as this is the work of a whole team of agricultural, economical and sociological experts.
Moreover, the suitability evaluation in this report isn't a part of a land use planning project, where it is the base for an economical land classification, but it has only the function of making the soil characteristics practical for agricultural use. It tries to translate the soil attributes, presented in the preceding chapters, into suitability classes for the production of different crops and for cattle grazing.
So the evaluation will be based mainly on the soil possibilities (including slope, surface stoniness etc.) and the crop requirements. Also some data of the present-day agricultural practices in the area, like crop rotations, use of manure or fertilizer, kind of tillage implements used etc. are given to provide a rough framework for the suitability classes.

7.b. Suitability classification system

In order to give a good picture of the feasibilities of the soils in the area, a number of crops have been selected, which are grown in the area and that can be placed in an order of decreasing demands from their physical and pedological environment. These crops are: coffee, maize, sweet potatoes and sorghum, in this order of decreasing demands. An explanation of these crops and why they were choosen for this suitability classification is given below.

Coffee (Coffea arabica) is a perennial crop, that needs a rather high, fairly well distributed rainfall (about 1500 mm is considered ideal) and a free draining, rather deep soil with a good moisture retension capacity. The altitudes where coffee can be grown range from 1200 to 2000 m above sea level. So for coffee the survey area is rather marginal, especially concerning the rainfall. But because it is a crop with high demands and because it occurs in the area, it is very useful for the suitability classification purpose.

Maize (Zea mays) is an annual cereal crop, which has specific water requirements. In the first five weeks the young maize plant is moderately drought resistant and is susceptible to unfavourable soil/air relati-

onships (lack of oxygen). But after these five weeks the maize plant is less drought resistant and needs fairly high amounts of water for optimal growth. It needs a well drained soil and cannot tolerate the slightest degree of waterlogging. So this crop is less demanding than coffee, but still it needs quite a lot.

Sweet potatoes (Ipomea batatus) is a perennial vine, but it is mostly treated as an annual crop. It is a very drought resistant crop and it can grow in areas which have an average annual rainfall of 750 mm or more. Sweet potatoes can be grown from sea level up to 2100 m. They don't have specific soil requirements, but they need fertile soils for optimal yields. So this crop demands less than maize and can be planted on rather shallow soils, because of the drought resistence.

Sorghum (Sorghum vulgare) is an annual cereal crop, which is very drought resistant, because of its very efficient, well-branched rootsystem and because its ability to reduce transpiration by rolling its leaves. It needs a rainfall of 300 to 380 mm, during its growing period. Beside its drought resistence, sorghum withstands short periods of waterlogging, which makes it not always unsuited to the poorly drained soils of the Riana plain. So this crop has the widest range of soils where it can do well.

The suitability classes, that are distinguished for the area, range from class 1, which is well suited for all four crops to class 7, which is unsuited for all crops. To the last classes, from 5.5 to 7, an addition has been given about the suitability for the use of the land as a pasture for extensive grazing of cattle and goats. The classes are given below in the suitability classification table.

Suitability Classification Table

suitability class	coffee	maize	sw. potatoes	sorghum
1	++	++	++	++
1.5	+	++	++	++
2	+-	++	++	++
2.5	-	++	++	++
3	--	++	++	++
3.5	--	+	++	++
4	--	+-	++	++
4.5	--	-	+	+
5	--	--	+-	+-

.5

suitability class	coffee	maize	sw. potatoes	sorghum	grazing
5.5	--	--	-	+-	+
6	--	--	--	+-	+
6.5	--	--	--	-	+
7^a	--	--	--	--	+
7^b	--	--	--	--	-

explanation of symbols: ++ = well suited
+ = moderately well suited
+- = moderately suited
- = rather unsuited
-- = unsuited

7.c. Framework and suitability evaluation of soil units

Before making the actual suitability evaluation, a framework, although a rough one will be sketched of the average kind of farm, that this suitability counts for. The modal farm, that we aim at is the traditional farm as it is found in the area, with an average size of about 3 hectares, with a rotation system with finger millet or maize as first crops, maize, sorghum, finger millet, beans or groundnuts as secondary crops and cassava and sweet potatoes as last crop, whereby usually a few years of fallow follow. Tilling operations are usually done by 'jembe' (broad-bladed hoe), like seedbed preparation, weeding etc. Only a minority of the people possess an oxen plough. The use of manure is negligible and commercial fertilizers are too expensive for the modal Luo farmer in the area. The kind of maize that is grown is for two-third local varieties and only one-third is hybrid maize.

The actual classification of the different soil phases is given below, whereby the slope phases have not been classified seperately, because they are of minor importance for the traditional way of cropgrowing (mechanisation has been left out of consideration). Only the steepest slopes have been taken into consideration: the landunits with a C class slope are given half a suitability unit more than the same soils on a A or B class slope.(except for the Orero series). The other phases, especially the depth phase have been evaluated seperately for each soil series. Generally can be stated that the deeper the soil,the more it is suited to the more demanding crops. The poorly drained soils have been given low suitability marks, because the water excess that is found in these soils during the rainy season has a very limiting effect on cropgrowth. (due to a lack of oxygen for rootgrowth).

Soil Suitability Evaluation table

soil series	soil phase	suitability class	soil series	soil phase	suitability class
Aora Nam	depth 0	5.5	Rabuor	depth 1	2
Aora Nam	depth 1	5.5	Rabuor	depth 2	3
Aora Nam	depth 2	5.5	Rabuor	depth 3	4
Aora Nam	extra wet	7^b	Marando	depth 1	2.5
Akelo	clay depth c_1	6	Marando	depth 2	3.5
Akelo	clay depth c_2	7^a	Marando	depth 3	4.5
Akelo	extra wet	7^a	Marando	extra wet	4
Riana - Kuna	clay depth c_1	6	Nyandara I	depth 0	1
Riana - Kuna	clay depth c_2	7^a	Nyandara I	depth 1	2
Riana - Kuna	extra wet	7^a	Nyandara I	depth 2	3
Riana - Kuna	eroded	7^b	Nyandara I	depth 3	4
Awundo	depth 1	5.5	Nyandara II	depth 1	2.5
Awundo	depth 2	5.5	Nyandara II	depth 2	3.5
Oboke	depth 2	3.5	Nyandara II	depth 3	4.5
Oboke	depth 3	5	Orero	depth 3	7^b
Alluvial	depth 0	3	Orero	depth 4	7^b
Rabuor	depth 0	1			

Note: The ironstone phase has not been taken into consideration at the suitability evaluation, because often it doesn't occur as a continuous indurated layer of big extend. In most cases it are just locally indurated layers, so for the utilization possibilities it is not of great importance. Beside this the distinction between real indurated ironstone and a slightly indurated layer of iron-manganese concretions was quite difficult in the field. Therefore the ironstone phase is not more than an indication that the bottom of the profile is rather indurated locally.

For the distribution of the different suitability classes over the area, one should take a look at the suitability map of the Rangwe sample area, belonging to this report.

PART II : SOILS OF THE SOUTH NYANZA NORTH EAST AREA

Chapter 1 : Introduction

1.a. Location and extent

The South Nyanza north east area is located in two districts. Most of it lies in the South Nyanza district (Homa Bay district) and some parts, the north east and the south east near Riana and Gasero, are located in the Kisii district. Both districts belong to Nyanza province, western Kenya. Within the districts mentioned, the area occupies parts of several locations: In South Nyanza district: East Nyokal, East Konyango, Gem, Kanyada, North Nyokal, Kasipul and a very small piece of Kabondo location; In Kisii district: Wanjare, plus a small piece of South Mugirango location and in the north east Kitutu and a small part of North Mugirango location.
The northern boundary of the area is formed by the 0°30' southern latitude parallel and the western boundary runs along the 34°30' eastern longitude meridian. The east-south boundary is an irregular line, starting in the north east near Bonyaiguba school and is going south almost parallel to the Bonyunyu - Manga road (east of the northern extension of the Manga ridge) till Mwabogonko school. From there the boundary follows the road to Rioma, untill it crosses the Isanta river (or its main tributary actually), from where it follows the swampy area of this river untill Mosocho. From Mosocho the boundary has a wavy course going west, along the southern part of the Kodara forest towards Aora Kogonda river, where it makes a bend south eastwards. It follows the tributaries of the Nyandara river and continues its wavy course somewhat east of the road Odingo - Itierio. Before it reaches Itierio however the survey boundary bends southwards, with some waves to Gasero. From Gasero to Kanga the boundary is formed by the 'Tanzania road', a major tarmac road from Kisii to the Tanzanian border near Isebania. From Kanga it follows the Olando river and furtheron the Kuja river.
The area has a surface of about 72,300 hectares (about 178,700 acres).
The altitude in the area has a rather big range. The highest partis the north eastern part, on top of the Manga ridge extension, where the altitude is up to 1950 m (about 6500 ft) above sea level. As the area is tilted from the Kisii highlands towards Lake Victoria, the lowest part of the area is the north western part, where the altitude is as low as 1125 m (3750 ft). The southern part of the area (south west of Rongo) has an altitude of

1250 to 1400 m (4200 to 4700 ft) above sea level.(see fig. 1 for location)

For more topographical details see the topographical maps 1 : 50,000 of Gem (sheet 130/1), Kisii (sheet 130/11) and Kitere (sheet 130/111).

1.b. People of the Area

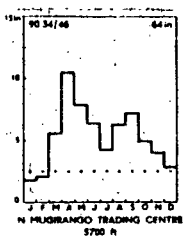
The district boundary between Kisii and South Nyanza districts is also an ethnic boundary. It is the boundary between the Luo tribe (in South Nyanza) and the Kisii (Gusii) tribe (in Kisii). There are a lot of differences between these two tribes. First of all they are of different origin. The Luo tribe is a Nilotic tribe, originating from the Sudan, while the Kisiis are belonging to a bantu tribe. The Kisii district is very densely populated: 300 to over 500 persons per square kilometers. It has a scattered population pattern of 'villages', consisting of a group of huts, belonging to one family. The average number of children per family is eight to ten.
The South Nyanza district, at least the part covered by this soil survey, is much less densely populated (100 to 200 persons per square kilometer as average). Especially the poorly drained areas and the north western part, where many steep and stony soils are found, are thinly populated. Here we find a scattered population pattern too, at least in the areas with imperfectly to well drained soils. In the poorly drained areas the population is concentrated on the somewhat better drained places (often sloping). The average family size is lower than in the Kisii district (about 5 children per family as an average).
Both tribes practisa a peasant type of agriculture, but for the Kisii it is a more permanent cultivation. The Luo may shift his cropland when he thinks it is necessary. Also there is a difference in crops that are grown.
Both tribes keep cattle beside their cropgrowing and they regard the number of it as a measure for their status.
For more details about the history of the Luo tribe, see part I, section 1.b. of this report.

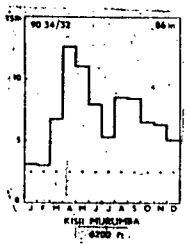
Chapter 2 : Physical and Biological Environment

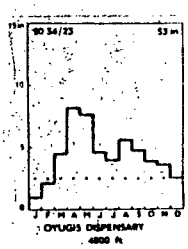
2.a. Climate

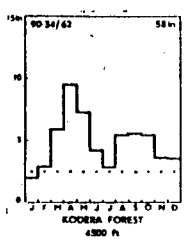
Climatic data are available from several places in and around the survey area. For the north east records have been made at N. Mugirango trading centre and at Kisii Murumba, for the northern part at Oyugis, Kodera forest and at Asumbi mission and for the central and southern parts at Marinde, Kamagambo and Kitere. For the location of these places, see the location map of meteo stations (fig. 3).

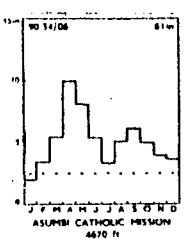
Avarage monthly rainfall diagrams:

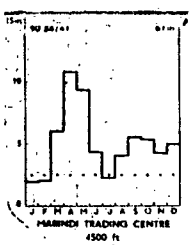


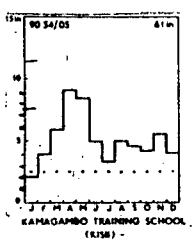


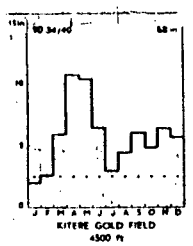












From the above given rainfall diagrams, including the average annual rainfall (printed in the right upper corner), it is clear that the north eastern part of the survey area receives most rainfall, varying from 1500 to 2200 mm per year. The driest part is the north east, with an average annual rainfall of 1200 - 1300 mm. The central and southern partsc of the area have about 1400 - 1700 mm of rain per year.

When we look at the rainfall distribution throughout the year, it is clear that everywhere the April-May rainfall reaches peak values. These values are 33 mm per month in the north east to 20 mm per month in the north west. In the north east the drier spell in January-February is not very pronounced, while in the north west this dry spell is clearer.

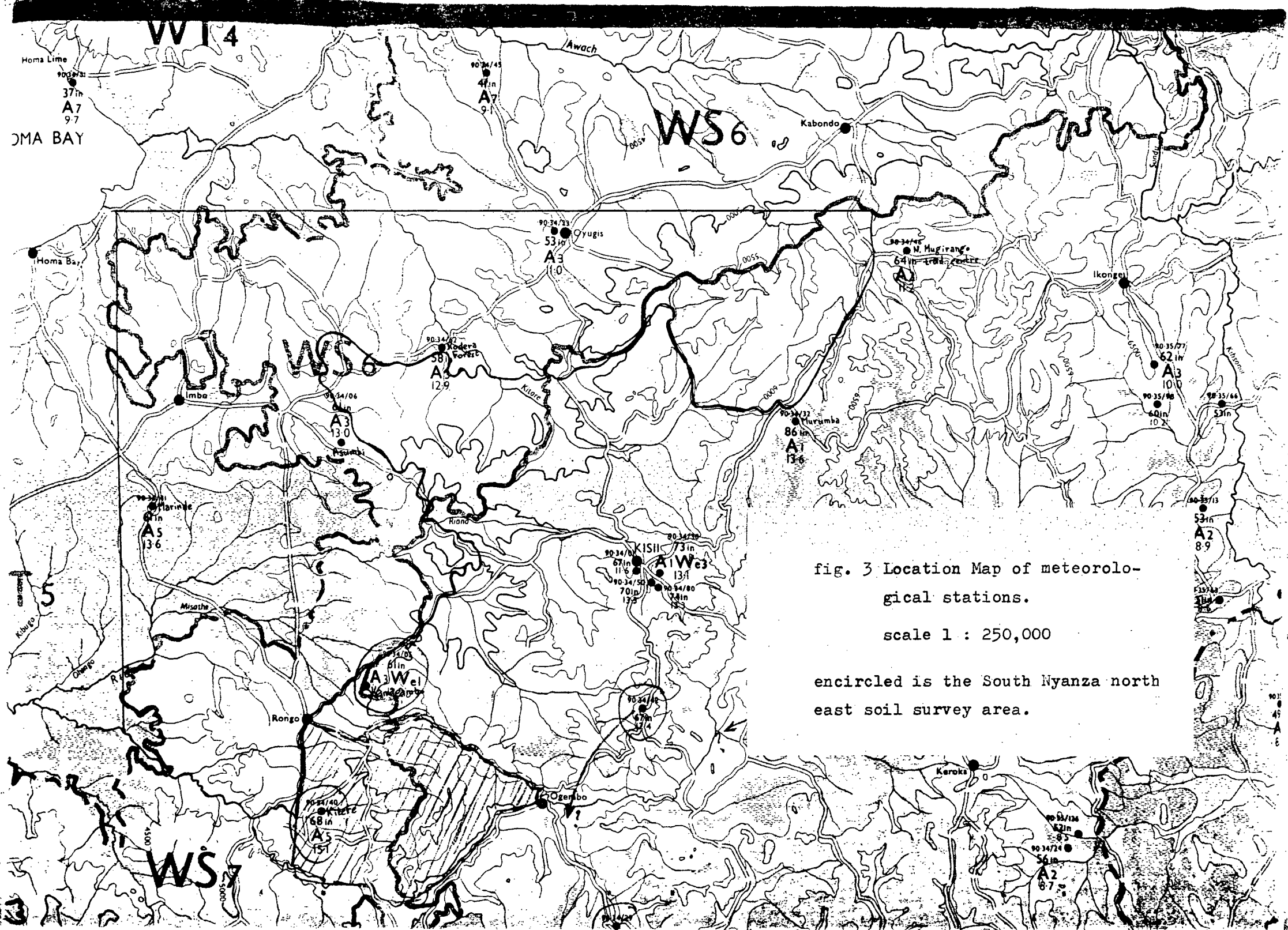
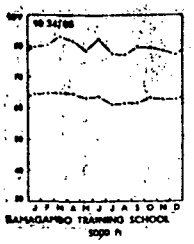


fig. 3 Location Map of meteorological stations.

scale 1 : 250,000

encircled is the South Nyanza north east soil survey area.

Temperature data are only available from Kamagambo, indicating mean maximum temperatures of 26 °C and mean minimum temperatures of 18 °C. For comparison also the temperature diagram of Kisii has been given here. The mean maximum is here 28 °C and the mean minimum temperature is 13 °C. In the lower north western part of the area however, temperatures are higher and in the higher north east temperatures are like in Kisii or even lower, especially east of the Manga escarpment.



mean minimum and mean maximum temperature diagrams.

The winds that are blowing in the area are usually west to north west, carying the watervapour from Lake Victoria up the country and producing rain-clouds when they have to ascend for the Kisii highlands, east of the Manga ridge.

About the evaporation some figures are given in part I, section 2.a. Figures about the optimal potential evapo-transpiration averages per month at Kisii town and at Ahero, which lies east of Kisumu. At Kisii the figures range from 105 to 144 mm per month, while those of Ahero range between 137 and 174 mm per month. The evapo-transpiration of the north eastern part of the survey area, will be of the same magnitude as that of Kisii town. For the north western part the figures will be more comparible to those of Ahero market. So roughly the evapo-transpiration (optimal potential) in the area will range from about 100 mm in the coolest month in the north east of the area, to about 170 mm in the hotest month in the north west of the area.

2.b. Geology

When we look at the geological map of the Kisii district, made by A. Huddleston and of which a partial copy has been given in the appendix, we can distinguish several formations in the survey area, forming the basement system rocks. The youngest formation is the Tertiary one, represented by basic lavas (nephelinites) and pyroclastics. These are found in the north west of the area, between Nagena and Imbo and as some small isolated spots, between Imbo, Kagan and Achego. Older than these Tertiary volcanics is the Bukoban formation, which is to be found in the north east of the area and also a very small part around Nyachenge. Porphyritic basalts are the earliest types exposed (along the western boundary of the Bukoban formation). Going east we reach the broad belt of non-porphyritic basalts. Overlying the

basalt is a conspicuous quartzite band up to 400 m thick, which forms a pronounced cuesta in the land scape (Manga ridge). This quartzite is followed (exposed to the east of it) by andesites, but they occur almost entirely east of the survey area.

In the chronological order the Kavirondian formation follows the Bukoban rocks. It is of pre-Cambrian age and it occurs as rather coarse boulder conglomerates with minor intercalations of grits, sandstones, mudstones or shales. They are found at four different places in the area: one west of Magena, one west of Imbo, one south of Imbo and one extending from the Kodera forest to Mosocho.

Elder than the Kavirondian conglomerates is the Nyanzian formation, also of pre-Cambrian age. It covers the rest of the area, with the exception of the intrusives. It is composed almost entirely of rhyolites, andesites and basalts, with minor developments of tuff and agglomerate. Rhyolites are most important, followed by basalt and then by andesite.

Through the above mentioned basement system rocks, several intrusives have broken. The most important ones being the granite intrusives of Kitere (from Kitere extending to Magena and Kamagambo) and of Oyugis (between Oyugis and Achego). Both are post-Nyanzian intrusives. A smaller occurrence of granites lies near Nyakongo. The whole of the Wanjare granite intrusive is supposed to be outside the survey area. However, between Sunaka (Wanjare) and Riana some soils on Wanjare granite lie inside the survey area.

Beside these major intrusives, some minor intrusives are found: dolerites, epidiorites, diorite porphyries, quartz porphyries etc.

Resuming we can say that the most important types of rock in the area, in order of importance, are: rhyolite, basalt, granite, conglomerate, tertiary basic volcanics, andesite and quartzite.

For more details see map and report of Huddleston (8).

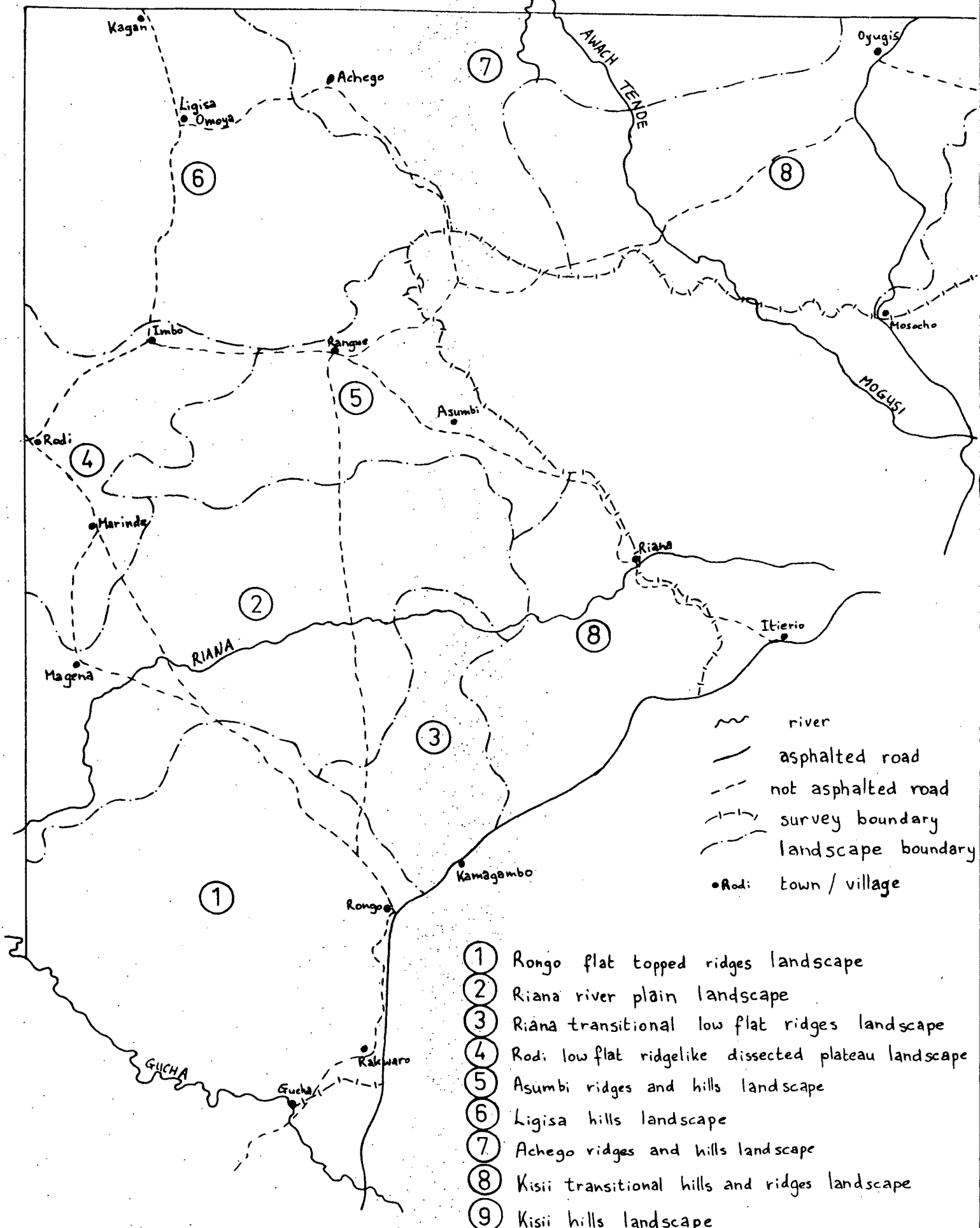
2.c. Physiography

Physiographically the area is rather alternately and to give a proper description, a subdivision of the area has been made into ten landscapes.

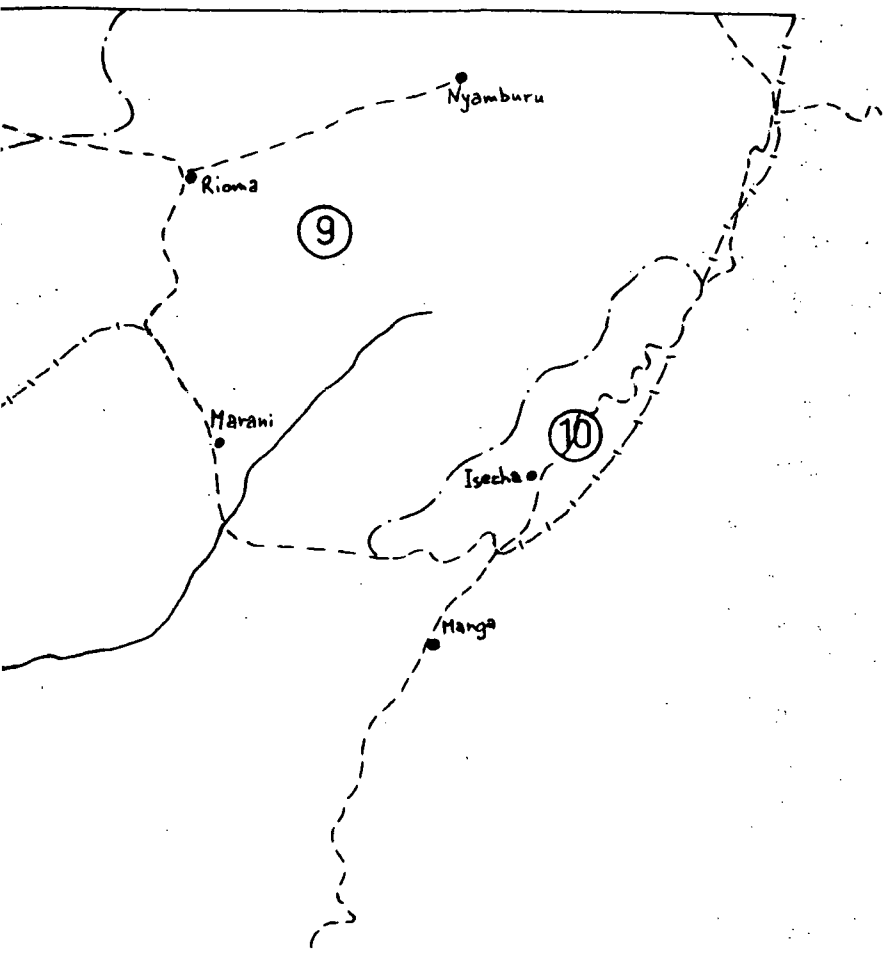
These landscapes are the following:

1. Rongo flat topped ridge landscape
2. Riana river plain landscape
3. Riana transitional low flat ridges landscape
4. Rodi low flat ridgelike dissected plateau landscape
5. Asumbi ridges and hills landscape

fig. 4 LANDSCAPES OF THE SURVEY AREA



1. Rongo flat topped ridges landscape
2. Riana river plain landscape
3. Riana transitional low flat ridges landscape
4. Rodi low flat ridgelike dissected plateau landscape
5. Asumbi ridges and hills landscape
6. Ligisa hills landscape
7. Achego ridges and hills landscape
8. Kisii transitional hills and ridges landscape
9. Kisii hills landscape
10. Manga escarpment landscape


Nyamburu
Riona
9
Marani
10
Iseche
Manga

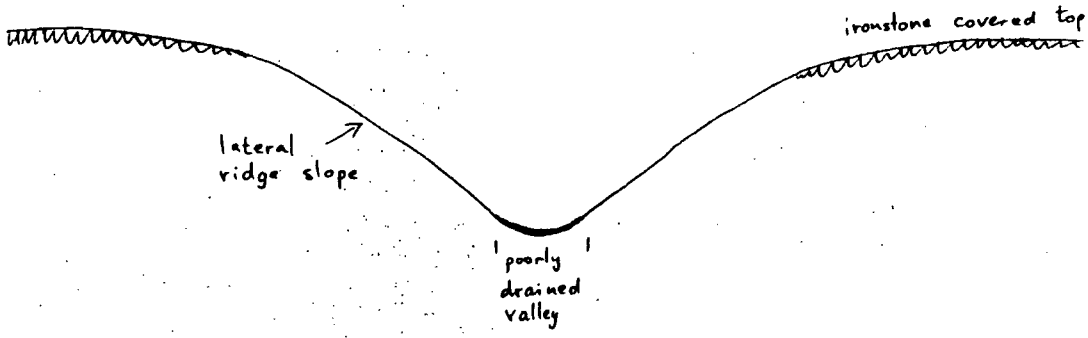
6. Ligisa hills landscape
7. Achego ridges and hills landscape
8. Kisii transitional hills and ridges landscape
9. Kisii hills landscape
10. Manga escarpment landscape

For location and extent of the different landscapes, see fig. 4 (landscapes of the area).
Below a description is given of the above mentioned landscapes.

1. Rongo flat topped ridge landscape

This landscape is found in the south of the survey area, west of Rongo. It has an undulating macrorelief (lateral slopes between 5 and 10 %). The ridges are rather high and have flat tops, which are covered with an ironstone layer, that can be indurated or is a loose concentration of iron-manganese concretions. The valleys between the ridges are narrow and have poorly drained soils (planosolic soils). All the ridgetops have about the same altitude, so probably they have been a part of a peneplain, which was covered with ironstone (in literature described as a submiocene bevel). The whole of this landscape is formed on the Kitere granites.

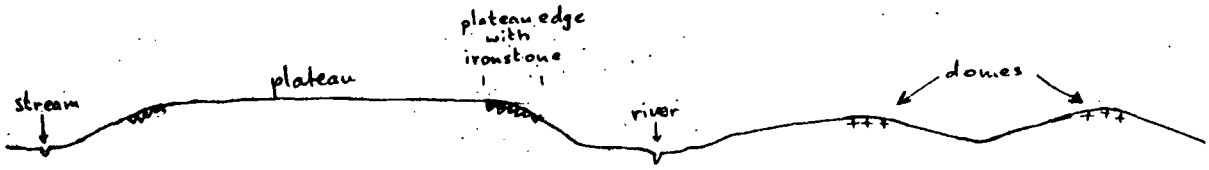
sketch of this landscape:



2. Riana river plain landscape

This landscape is found along the Riana river, from Magena to south of Asumbi. It has a flat to gently undulating macrorelief (slopes of 0 - 5 %). We can distinguish some clear plateaus, which are dissected by the Riana river and its tributaries, that cross the plain. The edges of these plateaus often have better drained soils, mostly with ironstone (Msg2 and Msm), while the plateaus and stream valleys have poorly drained soils (Ppg and Ppm). The rest of the landscape is gently undulating with low flat domes (small hills) and broad streamvalleys. The mesorelief is generally slight, only along rivers and streams some small flat terrace-like plains are found, probably formed by erosion.

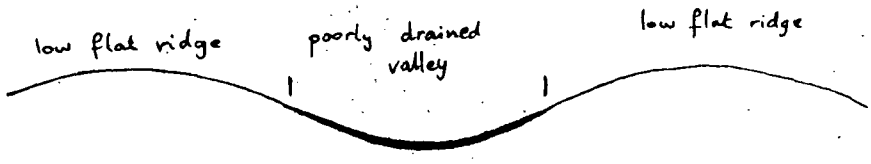
sketch of this landscape:



3. Riana transitional low flat ridges landscape

This landscape occurs as a transition between the Riana river plain and the hilly Kisii landscape near Kamagambo (outside the survey area) and the Kisii transitional landscape near Riana. It has a gently undulating macrorelief (slopes of 2 - 8 %). Half of the area is occupied by the well drained flat ridges and the other half by broad gently sloping stream valleys. From east to west the ridges decline in importance and the poorly drained land gains importance. The low flat ridges and the broad valleys are interlobing like a puzzle.

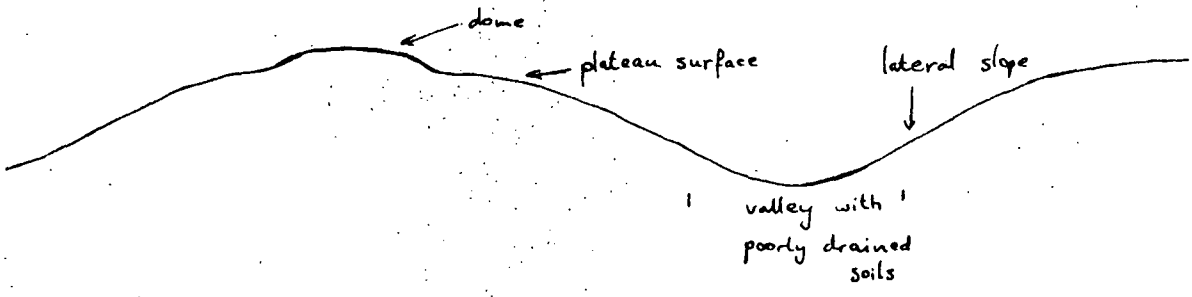
sketch of this landscape:



4. Rodi low flat ridgelike dissected plateau landscape

This landscape can be found extending from Nagena to Imbo. It has a gently undulating macrorelief (slopes 2 - 5 %) and it consists of a kind of plateau, that is dissected from many sides by rivers and streams and at some places it has more the appearance of low flat ridges with broad valleys. However in contrast with the Riana transitional ridges, they are covered with poorly drained soils (Pvr). The plateau surface is rather flat, but at some places low flat domes (small hills) rise above this surface (e.g. around Marinde). Almost the entire landscape is formed on Tertiary volcanic rocks.

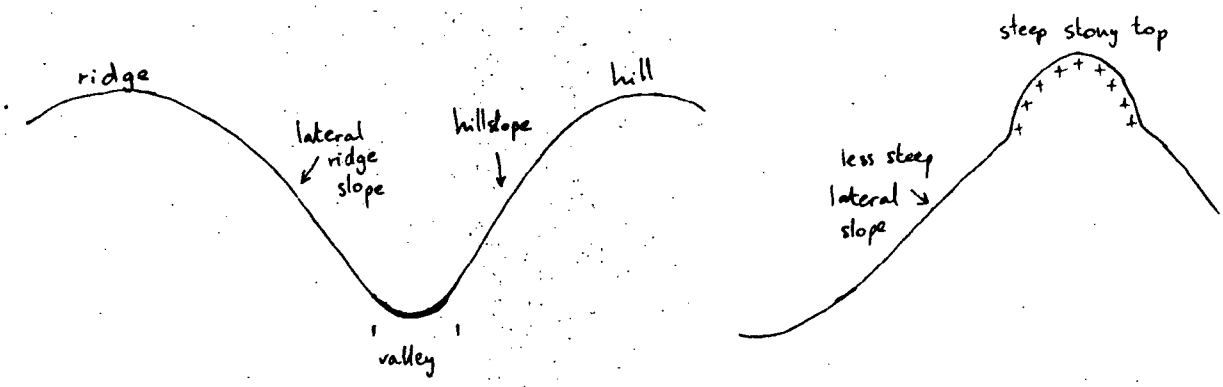
sketch of this landscape:



5. Asumbi ridges and hills landscape

We find this landscape around Asumbi and Rangwe. It has an undulating to rolling macrorelief (2 - 10 % slopes), with some steep tops of ridges with a rolling to hilly topography (slopes of 16 - 30 %). These ridges and hills have about the same altitude and relative hight (compared with the valleys) as the Rongo ridges. These ridges and hills don't have ironstone covers however, only often a layer of iron-manganese concretions over the rotten rock. The average slope has a convex top, a linear to slightly convex middle section and a small concave bottom. Many slopes however are rather irregular, due to dissection by streams from many sides. Some ridges have clearly steeper tops than the lateral slopes. On these tops we find shallow rock (examples can be found near Rangwe). The valleys between the ridges and hills are rather narrow.

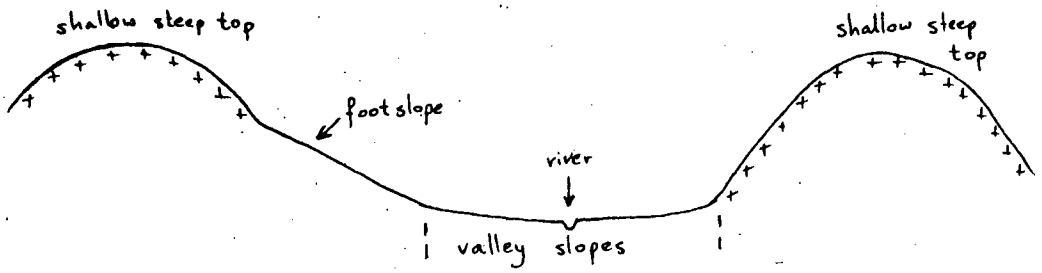
sketch of this landscape:



6. Ligisa hills landscape

This landform is found in the north western part of the survey area between Rangwe, Imbo and Kagan. It has an undulating to rolling macrorelief (slopes of 5 - 16 %), with some tops having a hilly topography (16 - 30 % slopes). This landscape is formed by rather steep tops, with less steep, straight footslopes and some less steep valleyslopes. The tops are steep, with convex, irregular slopes (5 - 16 %, sometimes even up to 30 %). The footslopes are rather straight to slightly concave, regular and with gradients of 5 to 10 %. The valleyslopes are straight to slightly convex, due to incision of the rivers (with gradients of 2 - 5 %). Another result of this incision is the sheet and gully erosion that happens on these lower slopes. Often the footslopes (upper hillslopes, having Lmm soils) are not present and the top with the steep slopes and shallow rock is very big and at its foot it has the gently sloping valleyslopes, with the imperfectly drained, eroding planosols. The Ligisa landscape is formed on Nyanzian rhyolites mainly.

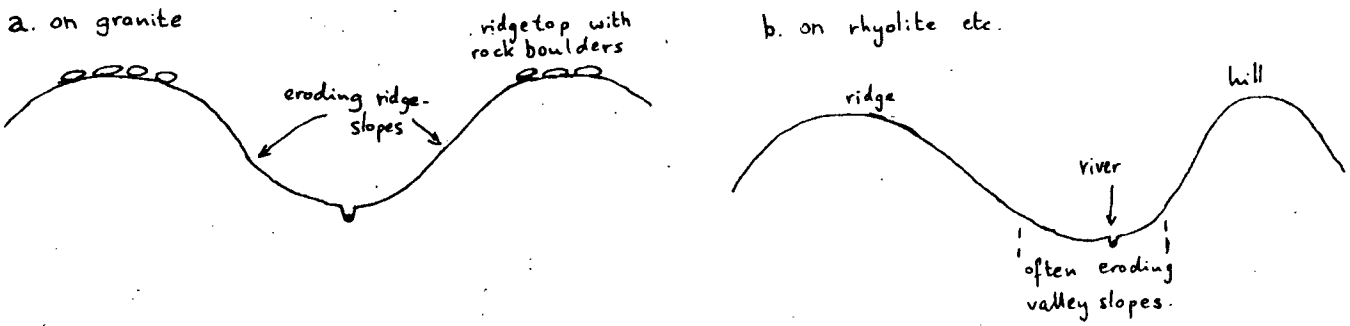
sketch of this landscape:



7. Achego ridges and hills landscape

This landscape we find east of Achego with a lobe towards Oyugis. It has an undulating macrorelief (2 - 8 % slopegradients) with locally some steep tops with rolling to hilly topography (16 - 30 % slopes). It has the same kind ofridges and hills as the Asumbi landscape. Only the valleys are broader and often have eroding soils. Hills often have steep tops and less steep, less stony footslopes. The ridges formed on Oyugis granite often have big rock boulders scattered on their tops with sandy soils. The lateral slopes of these ridges are covered with planosols (or solodized solonetzes). Beside Oyugis granite, this landscape is formed on Nyanzian rhyolites and andesites and on dolerites, epidiorites and some other minor intrusives.

sketch of this landscape:

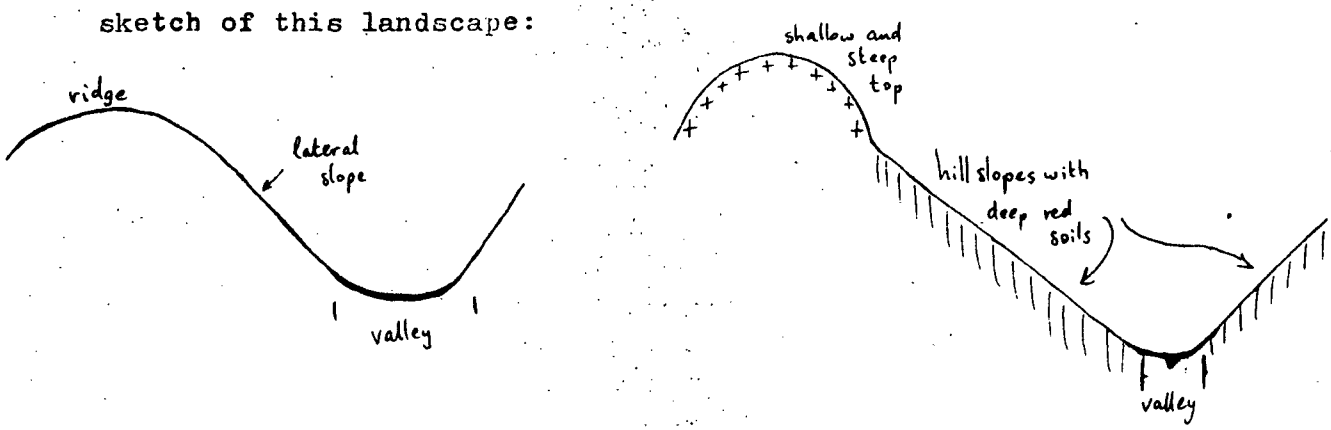


8. Kisii transitional hills and ridges landscape

We find this landscape west of Riana and Itierio and also between Oyugis and Mosocho. It has a rolling macrorelief (5 - 16 % slopes), with some steeper tops. It should be considered as a transitional landscape between the Kisii hills landscape (in the north west of the survey area but also east of Riana, Itierio) and the ridges and hills landscapes of Achego, Asumbi and the Riana plain and Riana transitional landscapes. The hills are dominant, often with smaller or bigger shallow stony tops with steep slopes (up to 25 %), but also the flat topped ridges are found. In general they are higher (in altitude as well as in relative hight) than the ridges

and hills of Achego and Asumbi landscapes. Also these hills and ridges have more deep red soils than those of the Achego and Asumbi landscapes.

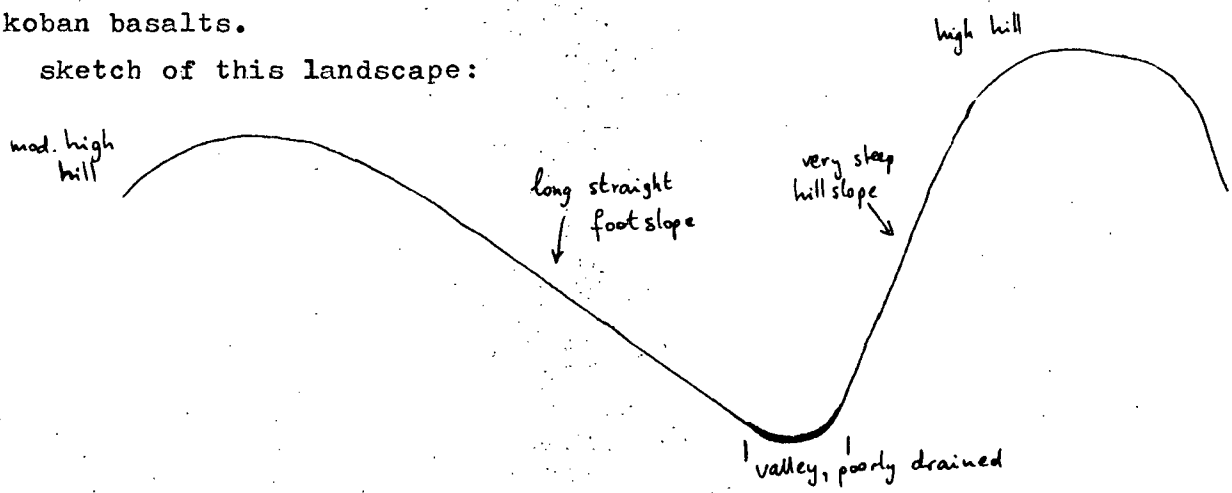
sketch of this landscape:



9. Kisii hills landscape

This landscape is found in the north east of the area, around Rioma, Nyamburu and Marani. It has a rolling to hilly macrorelief (5 - 30 % slopes), with some slopes even steeper than 30 %. It is a landscape of high and moderately high hills. These high hills often have very steep slopes (even over 30 %), but the moderately high hills have long straight footslopes (up to 20 % slopegradient), with deep red soils. The valleys are rather narrow and have poorly drained soils. The whole of this landscape is formed on Bukoban basalts.

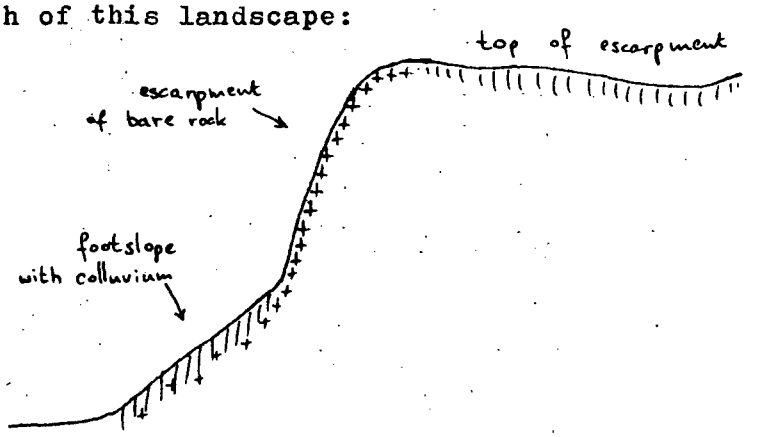
sketch of this landscape:



10. Manga escarpment landscape

This landscape we find north of Manga, around Isecha. It consists of an escarpment of bare quartzite rock with a steep footslope (up to 30 % slopegradient) underneath it. On top of the escarpment the relief is undulating (slopes of 2 - 8 %) and moderately deep and deep reddish brown soils are found. The footslopes have colluvial material from the escarpment and shallow brown to deep reddish soils. The landscape is formed on the Bukoban quartzites (and cherts locally).

sketch of this landscape:



2.d. Vegetation

For studying the vegetation in the area, it is useful to take a look at the Vegetation Map of Kenya, sheet 3 (1 : 250,000) of which the relevant part has been copied and this copy is given in part I, section 2.d., opposite page 6. It is clear when we look at this map, that the north eastern part of the area together with a small part between Riana and Gasero, has a vegetation which is different from the rest of the area. It is a forest clearing vegetation, derived from moist montane and intermediate forests. The biggest part of the area (except for the Riana river plain and the Rodi landscapes and a great part of the valleys in the north) has a Combretum and allied broad-leaved savanna vegetation. The Riana river plain and Rodi landscapes are dominated by grasslands and clumpgrasslands, because of their poorly drained soils.

In the north west are some areas with intermediate semi-evergreen thicket vegetations, while some valleys in the central-northern part of the area have a Combretum semi-evergreen thicket vegetation. So the vegetation in the area has a rather great range, from a moist montane forest clearing vegetation in the north east to a semi-evergreen thicket vegetation in the north west and grassland vegetations in the central west of the area.

Chapter 3 : Land Use

To give a clear picture of the land use, especially the arable farming, it is necessary to subdivide the area. The best subdivision for this purpose is the physiographic one, as it was introduced in the preceding chapter. So now each landscape will be reviewed for its specific land use.

1. Rongo flat topped ridges:
Here we find a rather intensive cultivation of the land, especially on the lateral ridgeslopes, where the soils are generally deeper than on the ridgetops. But also on these tops arable land is found. About 60 - 70 % of the land is used for growing crops. Most important are the subsistence crops maize, sorghum, sweet potatoes, beans and cabbages and beside these one can find sugar cane, groundnuts. The rest of the land is used for cattle grazing or is left idle.

2. Riana river plain:
Only a small part of the area is tilled, about 20 to 30 %, for subsistence crops like maize, sorghum, finger millet, sweet potatoes, beans and also for sugar cane and incidentally groundnuts. This arable land is concentrated on the edges of the plateaus and on the domes, where soils with better drainage are found. The rest of the area, having poorly drained soils, has a natural grassland vegetation and is used for cattle grazing.

3. Riana transitional low flat ridges:
This landscape consists for about half of well drained soils on the ridges and the other half are poorly drained soils in the broad valleys. These well drained ridges are cultivated intensively (about 70 % is tilled) and many crops are grown: from maize, sorghum, sweet potatoes to groundnuts , some sugar cane, cassava, beans etc. The poorly drained soils are left under their natural vegetation of grasses and they are used as grazing land for cattle or incidentally as cropland for sugar cane.

4. Rodi low flat ridgelike dissected plateau:
Although this area consists for a great part of poorly drained soils, the cultivation of the land is more intensive then in the Riana river plain. About 40 % of the land is tilled for cropgrowing. Usually people till the more sloping land and construct some drainage furrows along the slope to improve the water household of the soil. Crops grown are maize, sorghum, sugar cane, some finger millet, beans, some cabbages and other vegetables. The rest of the land is used for cattle grazing, because it has a natural grassland or clumpgrassland vegetation.

5. Asumbi ridges and hills:
Most of this area is under rather intensive cultivation, about 60 to 70 %, for crops like maize, sorghum, sweet potatoes, sugar cane, groundnuts, beans, cassava etc. The not-tilled area is either used for cattle grazing or is left fallow. The steep tops of ridges with their stony soils, are unused for any agricultural activity.

6. Ligisa hills:
Since a considerable part of this landform consists of steep, stony land and another not unimportant part comprises eroded planosolic soils, which are hard to till, the cultivated acreage is low. The cropland is limited to the footslopes of the stony tops of the hills, mostly having Umm soils, but also Ss soils. Here one can find maize, sorghum, cassava and cotton (a small variety). Especially the Iv soils near Kagan are used for cotton and foodcrops. The few grasslands or bushed grasslands are used for grazing cattle and goats.

7. Achego ridges and hills:
In the western and southern part of this area the tilled acreage is moderately high. Most of the Umm and Wmm soils are tilled and also a part of the Ss soils. The valleys with the planosolic soils are usually not tilled. The crops are the same as on the Asumbi ridges and hills, with the addition of cotton. In the north eastern part however, on the Oyugis granite parent material, the tilled acreage is low. The cultivation is limited to the sandy soils on top of the ridges, because the slopes often have planosollike soils, which are often eroding. But even the sandy soils give poor yields of the crops like sorghum, some maize, cassava, groundnuts and some beans. So of the whole of the Achego landscape 40 to 50 % of the land is tilled and the rest is left idle or is used for cattle and goat grazing.

8. Kisii transitional hills and ridges:
This landscape has more deep red soils than the previously reviewed landforms, but the tillage is not much more intensive as far as the Luo people are concerned. The area that lies in the Kisii district is more intensively cultivated, due to the high population density. Here about 70 % of the land which is tillable (excluding the shallow Evs soils), is used as cropland for maize mainly, plus few sorghum, some finger millet, sweet potatoes, beans, sugar cane etc. (some coffee on the higher places). Within the Luo area, approximately 50 % of the land is cultivated for maize, sorghum, sweet potatoes, sugar cane, some groundnuts, beans etc. The rest is grazing land for cattle or is unused (bushy land on Evs or Ss soils).

9. Kisii hills:

Most of this landscape comprises deep red soils, very well suited for agriculture. Within the South Nyanza district the area is moderately intensively tilled, about 50 to 60 % of the land, for the usual crops. The Kisii part of this landscape is most intensively tilled for crops like maize, sweet potatoes, sorghum and finger millet, bananas, sugar cane locally and coffee and pyrethrum on the highest places of the area (on the high hill south of Nyamburu). Cattle is grazed on the few grasslands, in rivervalleys or some plots in the croprotation.

10. Manga escarpment:

Agriculture is found on the steep footslope and on top of the escarpment where soils are deeper. On the footslope we find the same crops as in the lower Kisii hills landscape. But the land here is not intensively tilled, due to the rather steep slope. On top of the escarpment we find the crops of the higher Kisii hills landscape, including pyrethrum.

Chapter 4 : Survey Methods

The soil survey that we made, the soil survey of the South Nyanza north east area, is a semi-detailed soil survey to a scale of 1 : 50,000. The methods followed, were in main lines the same as those followed at the Rangwe sample area. The same stages of reconnaissance, airphote interpretation, fieldwork, map compilation and additional laboratory work were worked through.

The reconnaissance was carried out with the aid of topographical maps (those of Gem, Kitere and Kisii), the geological map of the Kisii district by Huddleston and the climate and vegetation map of Kenya, sheet 3 (1:250, 000). The airphoto interpretation in this survey eas much more important than in the Rangwe soil survey, because the fieldwork in this survey was considerably less than in the detailed survey and only meant to check the interpretation units. The steps of interpretation and fieldwork followed eachother closely, to keep the interpretation in line with the field results. The interpretation was carried out on photoes to a scale of about 1 : 50,000, by means of the mirror stereoscope. For more technical details see part I, chapter 4. The fieldwork, as was stated above, was of limited extend in this soil survey. After having interpreted a certain area, a number of augering sites were selected, along roads or motorable tracks, to check the interpretation units. A rather detailed description of each augering was made. Not only the soil characteristics, but also environmental data were noted down. After such a day of fieldwork the interpretation was adjusted, if necessary. In total about twelve days of fieldwork were used to make the map. This is rather low for such a big area, but the main reason for it was a lack of time. The result hereof is that the northern and north eastern part of the area hasn't been mapped very accurately.

The map compilation was done by means of a sketchmaster, which enables a kind of optical projection of the photo with the soil boundary lines, on the topographical maps 1 : 50,000. These maps were used as base maps for the actual soil map. In this way all lines were transfered to the base maps and a transparant copy of these topographical maps was made. This formed the soil map as you can see it now.

The laboratory work after the preparation of the maps could not be carried out, also because of a lack of time and also of manpower.

Chapter 5 : Soils Of The Area

5.a. Classification

The way of classification of the soils is different from that in the Rangwe detailed soil survey. The concept of soil series has not been followed, because the smaller scale made this impractical. The units of the soil map have more the character of soil groups, including similar soil series of the Rangwe sample area or other sample areas. The groups are uniform in the main soil characteristics and often in their physiographic positions too. The soil units are only subdivided into slope phases, whereby the following slope classes have been used:

A = 0 - 2 %
B = 2 - 5 %
C = 5 - 8 %
D = 8 - 16 %
E = 16 - 30 %
F = over 30 %

5.b. Legend

The soilgroups have been subdivided after their drainage class and on lower levels after profile characteristics, parent material, soil depth and occasionally after physiographic position. The legend of the soil map looks as follows:

1. Poorly drained soils

Ppm : Dark grey heavy compact clay soils, with a leached, often light grey silt loam to clay loam topsoil, on mixed parent material. (70 % planosols + 30 % gleyic phaeozems and gleyic luvisols).

Ppg : Greyish brown sandy loam soils, with a grey, heavy compact clay subsoil (or on ironstone), on granite parent material. (80 % planosols + 20 % gleysols).

Pvr : Grey heavy clay soils, with a dark grey brown light clay topsoil, on basic tertiary volcanic rocks. (mainly pellic vertisols, some gleyic and luvic phaeozems).

Pvv : Black to dark grey heavy cracking clay soils, on basic volcanic rocks. (pellic vertisols).

2. Imperfectly drained soils

Ipm : Grey heavy compact clay soils, with a bleached silty topsoil, often eroding, on mixed parent material. (planosols, eroding).

Ipg : Heavy clay soils, with or without sandy bleached topsoil, due to erosion, on granite parent material. (solodic planosols, eroding).

Iv : Dark grey to dark greyish brown heavy cracking clay soils, on basic volcanic rocks. (chromic vertisols).

Ia : Grey and brown sandy to clayey alluvial soils. (eutric fluvisols).

3. Moderately well drained soils

Msm : Dark grey to dark brown shallow to moderately deep clay loam to light clay soils, often on ironstone, on mixed parent material. (eutric cambisols + haplic phaeozems).

Msgl : Dark brown to brown, mainly shallow, sandy loam to sandy clay loam soils, on ironstone or rotten rock of Oyugis granite. (eutric cambisols and haplic phaeozems).

Msg2 : Dark brown to reddish brown, mainly shallow, sandy clay loam to clay loam soils, mainly on ironstone, covering Kitere granite rock. (mainly phaeozems + cambisols, some luvisols).

Mmb : Dark brown, mainly moderately deep clay soils on basic volcanic rocks. (luvic phaeozems).

Mmm : Reddish brown, mainly moderately deep clay loam to clay soils, with a mottled subsoil and sometimes dark grey heavy clay or ironstone at the profile bottom, on mixed parent material. (chromic + gleyic luvisols).

4. Well drained soils

Wmm : Mainly moderately deep, brown gravelly clay loam to light clay soils and reddish brown clay soils with a clear textural B horizon, on mixed parent material. (eutric cambisols, haplic + luvic phaeozems and chromic luvisols).

Wmg : Mainly moderately deep, dark brown to reddish brown, sandy clay loam to light clay soils, often having a concretionary layer on the granite parent material. (chromic luvisols and luvic phaeozems).

Wd : Moderately deep and deep, reddish brown to red clay soils, with a clear textural B horizon, on mixed parent material. (chromic luvisols and luvic phaeozems).

Wv : Very deep reddish brown to red clay soils, with clear textural B horizons, on mixed parent material. (eutric nitosols, luvic phaeozems).

5. Somewhat excessively drained soils

Ss : Mainly shallow, gravelly brown clay loam soils, on mixed parent material. (eutric cambisols, haplic phaeozems)

6. Excessively drained soils

Evs : Very shallow gravelly and rocky soils, on mixed parent material. (lithosols and regesols).

5.c. Description of soil units (including classification acc. to F.A.O.)

1. Ppm (Poorly drained, planosolic soils, on mixed parent material)

Parent material:
Probably mainly alluvial material and/or rhyolite, basalt, conglomerate (plus some diorite porphyry and dolerite).

Physiography:
The main occurrence of Ppm soils is in the Riana river plain landscape and in the Riana transitional low flat ridges landscape. Also we find Ppm soils in the valleys of the Asumbi, Achego, Kisii transitional and the Kisii hills landscapes.

Soil characteristics:
Ppm soils are poorly drained soils, having a very dark grey to dark greyish brown (10 YR 2-4/1-2, 7.5 YR 3/1-2) silt loam to clay loam topsoil, with dark brown mottling and a fine subangular blocky structure. Most of the soils have a more or less clear grey to light grey eluviation horizon, underneath the dark topsoil, with a silt loam texture and brown mottling. Under this medium textured topsoil, a heavy compact montmorillonitic clay is found, having yellowish to reddish prominent mottling and a prismatic to columnar structure. Many of these soils have an abrupt boundary between topsoil and heavy textured subsoil. On slopes of dissecting rivers, this textural change can be vague and these soils are more vertisol-like. (Aora Nam and Awundo series of the Rangwe detailed survey).

Classification:
70 % eutric and solodic planosols, probably also gleyic solonetzes;
30 % gleyic phaeozems and gleyic luvisols.

References:
Rangwe detailed survey: 70 % Riana-Kuna series, 20 % Akelo series, 10 % Aora Nam series.
East Konyango soil survey: Nyokal series, Nyamauro series, Marinde series, plus few of the Misathe series.
For profile descriptions see appendix, profiles Ra 7 and Ra 5.

Land use:
Most of these soils is left under their natural grassland and is only used extensively for cattle grazing. Just few parts have been cultivated for crop-growing (less than 10 %).

2. Ppg (Poorly drained, planosolic soils, on granite parent material)

Parent material:
The parent material is mainly Kitere granite, but also few Oyugis granite.

Physiography:
Ppg soils are found mainly in the Riana river plain landscape (on plateaus and in river valleys) and in the Rongo flat topped ridges landscape. In the latter landscape they occur in the stream valleys and on small spots on top of the ridges (so called 'damboes', small depressions surrounded by iron-stone). In the Riana transitional landscape they occur only in the valleys of the southern part, where granite is found.

Soil characteristics:
Ppg soils are poorly drained soils, with a very dark grey to dark brown top-soil of sandy loam to sandy clay loam texture. Under this dark topsoil a bleached, grey to light grey eluviation horizon with sandy loam texture is found. At 30 to 60 cm depth an abrupt change of texture, structure and co-lour is found towards the heavy grey montmorillonitic clay of the subsoil, which has prominent brown to reddish mottles. Where these soils occur on flat plateaus of the Riana river plain, a transition is found from Ppg soils to Msg2 soils, which are found on the plateau edges. These transitonal soils are dark grey to grey, mottled and have a sandy loam texture. Under these soils we find ironstone, at a depth of 50 - 100 cm. These poorly to imperfectly drained soils have been grouped under the Ppg unit, as an inclu-sion of about 20 %.

In the valleys of dissecting rivers, the sandy topsoil might have been removed by erosion, so they don't look like a proper planosol anymore. But the surface occupied by these soils isn't very large (about 5 - 10 %).

Classification:
80 % dystric and solodic planosols; 20 % dystric gleysols (petric or petroferric phase)

References:
Marongo detailed soil survey: Olando series and Maraba series.
East Konyango soil survey: Misathe series mainly, plus Nyangu series and Nyamauro series.
For profile description see appendix profile EK 1.

Land use:
Like the Ppm soils, most of the Ppg soils are under their natural grassland or clumpgrassland vegetation and are used extensively for cattle grazing. In the narrow rivervalleys, some of these soils may be tilled for sugar cane growing (less than 10 % of all Ppg soils).

3. Pvr (Poorly drained, vertisolic soils on low flat ridges)

Parent material:
Pvr soils have as parent material Tertiary volcanic rocks (nephelinites, nepheline-basalts and pyroclastics).

Physiography:
Pvr soils cover the low flat ridgetops and lateral slopes of the Rodi landscape. They are found exclusively in this part of the survey area.

Soil characteristics:
Pvr soils have a very dark grey to very dark brown topsoil of clay loam to light clay texture, having a fine granular to subangular blocky structure. The subsoil consists of dark grey heavy clay with vertic properties, slickensides and a prismatic to angular blocky structure. Soil depth can be about 50 cm on top of the ridge to more than 150 cm downslope. Because of the lateral slopegradient and the drainage furrows made by farmers, soils on the lateral slopes of the ridges tend to be imperfectly drained, rather than poorly drained.

Classification:
70 - 80 % pellic and chromic vertisols, 20 - 30 % haplic phaeozems.

References:
East Konyango soil survey: Rodi series, Kibugo series and some parts of Ongeng series.
For profile description see appendix, profile EXC 14.

Land use:
Farmers prefer the soils on the slopes to cultivate, because of the better drainage (external drainage). Usual crops to be found are: maize, sorghum, finger millet, beans, vegetables. The majority of the land however has a grassy vegetation and is used for extensive cattle grazing.

4. Pvv (Poorly drained, vertisolic soils of the valleys)

Parent material:
The rocks on which Pvv soils are developed, are Tertiary volcanic ones (nephelinites etc.) and probably also alluvial deposits in the valleys.

Physiography:
Pvv soils are found in the broad very gently sloping valleys of the Rodi low flat ridgelike dissected plateau landscape. And a small percentage together with the Ppm soils in the valleys of Asumbi and Ligisa landscapes.

Soil characteristics:
Pvv soils are poorly drained to somewhat imperfectly drained, deep to very deep heavy clay soils. The A horizon is black to very dark grey (10 YR 2/1-2), with a clay texture and a fine subangular blocky structure. The B horizon is very dark to dark grey, has a heavy clay texture and a strong angular blocky and/or a prismatic structure, with many shining pressure cutans and many slickensides. The lower B horizon or the C horizon is often calcareous.

Classification:
pellic vertisols.

References:
East Konyango soil survey: Kibigori series and some of the Ongeng series.
For profile description see appendix, profile EK2.

Land use:
Most of the Pvv soils lie under a natural pasture and is used for cattle grazing. Only minor parts of the area covered by these soils is tilled, mainly for sugar cane, but also for maize and sorghum.

5. Ipm (Imperfectly drained, planosolic soils, on mixed parent material)

Parent material:
Mainly Nyanzian rhyolites, perhaps some small parts of basalt and andesite.

Physiography:
Ipm soils are found in the valleys of the Ligisa hills and the Achego ridges and hills landscapes. They cover the gently sloping valley slopes (2-5 % slopegradient).

Soil characteristics:
These imperfectly drained soils have a silt loam to silty clay loam topsoil with (if not eroded off) a dark grey A1 horizon and a grey to light grey (when dry) eluviation horizon, which has brown mottling. The B horizon consists of grey heavy compact clay, with a prismatic structure and some weak vertic properties (swelling and shrinking). In most cases we find a transitional soil type towards the Mmm soils, that occur often upslope of the Ipm soils. This soil type has a dark brown A horizon, with a less clear eluviation horizon. These 'browned planosols', as they might be called, have been incorporated in the Ipm unit. The boundary with the Mmm soilunit is not very sharp however. Often the Ipm soils are eroded, because they occur on a sloping landsurface, that gives rise to surface runoff in the rainy season. At several places deep gullies have been formed, even taking away the clay B horizon.

Classification:
eutric or dystric planosols and probably solodic planosols. If the A horizon has been eroded off, they should probably be classified as vertisols.

References:
No reference can be made to any detailed or semi-detailed soil survey.
For profile description see appendix, profile EXC 16.

Land use:
In general these soils are not used for cropland, only for extensive grazing of cattle and goats. Only rarely crops like maize, sorghum, cotton etc. are found on these soils.

6. Ipg (Imperfectly drained, planosolic soils on granite rock)

Parent material:
The parent rock of Ipg soils is the Oyugis granite.

Physiography:
These Ipg soils are found in the northern and north eastern part of the Achego ridges and hills landscape, where we find these typical undulating rounded ridges, with a sparse grass and few trees and shrubs vegetation. Ipg soils occupy the lateral slopes of these ridges, down to the valleys. The slopegradients lie between 4 and 8 %.

Soil characteristics:
These imperfectly drained soils have planosolic properties: a dark greyish brown, sandy loam topsoil, underlain by a light (brownish) grey (when dry) eluviation horizon of loamy sand to sandy loam texture. The B1 horizon is often degraded: it has the same colours as the A2 horizon, but has darker coloured clay skins on the peds, a sandy clay loam texture and a course columnar structure, with rounded columntops. The B2 horizon consists of dark grey, heavy clay, with some red mottles in it. Also these soils are subject to heavy water erosion. Not only sheet erosion, but also deep gullies are formed. Since no analytical data are available, it is not certain whether these soils are solodized solonetzes or even solonetzes, but the morphology of these soils favoures this opinion.

Classification:
solodic planosols and probably orthic solonetzes too. (including eroded soils that don't fall in these groups).

References:
No reference is available to any other soil survey.
For profile description see appendix, profile EXC 20.

Land use:
Hardly any use is or can be made of these soils. Grazing for cows is marginal, due to the sparse grassvegetation. Goats can find a reasonable living, however with the great danger of overgrazing and subsequent heavy erosion. (which happens already actually). Some people try to grow sorghum or cassava, but with poor results.

7. Iv (Imperfectly drained, vertisolic soils)

Parent material:
The parent rocks of this soil unit are various: Tertiary volcanic rocks (nephelinites etc.), Nyanzian basalts and some alluvium.

Physiography:
Iv soils are found in some valleys along the northern edge of the Ligisa hills and the Achego ridges and hills landscape. They are broad, flat valleys between hills and ridges.

Soil characteristics:
Iv soils are imperfectly drained soils, having very dark grey to dark brown colours (10 YR 2/1 - 3/3 + 7.5 YR 3/2) in the A horizon and a heavy clay texture, together with a fine subangular to angular blocky structure. The B horizon has a dark grey to dark brown colour and a course angular blocky structure and a heavy clay texture, together with many intersecting slickensides. Soil depth can range from 100 to over 200 cm. These soils have been seperated from the Pvv soils, because they have a drier moisture regime (ustic in the Soil Taxonomy nomenclature) and are more brownish grey than the Pvv soils.

Classification:
chromic and pellic vertisols.

References:
No reference can be made to any soil survey, nor has a profile description been made of this soil unit. But the profile characteristics are, as above mentioned, not very different from those given in profile EK2, appendix.

Land use:
These soils are used for the production of cotton, sorghum, maize, sweet potatoes and vegetables. More than half of the area of Iv soils is cultivated.

8. Ia (Imperfectly drained, alluvial soils)

Parent material:
Recent alluvium of the Riana and the Misadhi rivers is the parent material of these soils.

Physiography:
These Ia soils occur within the Riana river plain landscape. They are found in a rather narrow strip of land, less than 500 m wide, along the streambeds of the Riana and the Misadhi rivers.

Soil characteristics:
The range in characteristics of these imperfectly drained alluvial soils is

rather high. The colour ranges from reddish brown (5 YR 4/2-3) to dark grey (10 YR 3-4/1-2) and the texture ranges from sandy near the river bed to clayey further away from the river. Mottling is commoc in all these soils, indicating a temporary high groundwater table.
Remark: Because of the rather small area of alluvial soils, these soils have been indicated on the map in association with planosols (Ppm) which are in almost the same physiographic position.

Classification:
eutric fluvisols.

References:
Rangwe detailed survey: Alluvial soils, undifferentiated.
East Konyango soil survey: Alluvial soils, undifferentiated.
For a profile description see profile Ra 15, appendix.

Land use:
Where these soils occur between planosols, which have a poor drainage, people prefer to cultivate the alluvial soils near the river. You can find sugar cane, maize, sorghum etc. If there are well drained soils nearby, people only use these soils as a pasture.

9. Msm (Moderately well drained, shallow to mod. deep soils on mixed par. mat.)

Parent material:
Nyanzian rhyolite, basalt, Kavirondian conglomerate and acid and intermediate intrusive rocks are the parent materials of Msm soils.

Physiography:
These Msm soils occur in the Riana river plain landscape, and are found especially on edges of the plateaus in this area and on the small domes (small flat hills) with shallow rock between the Ppm soils.

Soil characteristics:
Msm soils are moderately well drained soils with a very dark brown to dark brown topsoil, with a clay loam texture, often gravelly and a fine subangular blocky structure. The (cambic) B horizon, if present, has a dark brown to dark greyish brown colour and a texture of clay loam to light clay, is often gravelly from rotten rock and/or iron-manganese concretions and has a fine subangular blocky structure. The soil depth is generally less than 100 cm, often even between 20 and 50 cm.

Classification:
haplic phaeozems mainly plus some eutric cambisols.

References:
Rangwe detailed survey: Oboke series.
East Konyango soil survey: Rangwe series.
For profile description see appendix, profile Ra 10.

Land use:
Most of the land is used as cropland (50 to 60 %) for crops like maize, sorghum, sweet potatoes, some sugar cane, vegetables and groundnuts.

10. Msgl (Moderately well drained, mainly shallow soils on granite par. mat.)
(1 stands for Oyugis granite)

Parent material:

Exclusively Oyugis granite.

Physiography:
Msgl soils can be found in the northern and north eastern part of the Achego ridges and hills landscape. In the same landscape as the Ipg soils are found, we find these soils. The Msgl soils however aren't found on the lateral ridge slopes, but merely on the ridge tops. (having slopes between 0 and 4 %).

Soil characteristics:
The soils of this unit are moderately well drained and generally of rather coarse texture, ranging from loamy sand to sandy loam, sometimes sandy clay loam. These Msgl soils are shallow in general, having colours of dark brown (7.5 YR 3/2, moist) and brown (7.5 YR 5/2, dry). Most of the soils don't have a textural B horizon, but some may have it, with a sandy clay loam texture. The bottom of the soils can be either composed of ironstone or of a concretionary layer on top of the rotten rock or just rotten rock. The surface stoniness of these soils is comparatively high: about 5 - 10 % of the area is covered with big rounded granite boulders.

Classification:
eutric cambisols and haplic phaeozems, few orthic luvisols.

References:
No reference to any soil survey can be made.
For profile description see appendix, profile EXC 19.

11. Msg2 (Moderately well drained, mainly shallow soils on granite par. mat.)
(2 stnds for Kitere granite)

Parent material:
Exclusively Kitere granite.

Physiography:
Msg2 soils are found in the south western part of the Riana river plain landscape. In the first mentioned landscape they form the edges of the plateaus and in the Rongo landscape they occur on the tops of the ridges, where ironstone is often covering the granite rotten rock.

Soil characteristics:
Msg2 soils are moderately well drained and most of them are shallow and have ironstone or a non-indurated concretionary layer above the rotten rock. They have colours of dark brown to reddish brown (7.5 YR 3/2 - 5 YR 4/3) and sandy loam to clay loam textures, with a fine subangular blocky structure. The shallow soils don't have a textural B horizon, but the moderately deep ones may have an argillic B horizon of clay loam to light clay texture.

Classification:
eutric cambisols, haplic phaeozems (petric or petroferric phase), plus few orthic luvisols.

References:
Marongo detailed survey: Rongo and Riosiri series, plus a part of the Paulo series.
East Konyango soil survey: Magina series and partly Nyangu series.
For profile description see appendix, profile EK 3.

Land use:
Not more than 40 % of this land is used for cropgrowing, due to the shallowness of the soils. The rest of the land is left idle or is used for grazing of cattle.

12. Mmb (Moderatelywell drained, mainly mod. deep soils on basic volc. rocks)

Parent material:
Tertiary volcanics (nephelinites, nepheline-basalts, pyroclastics) and Nyanzian basalts.

Physiography:
Mmb soils are found in the Rodi landscape, as the small domes above the pla-

teau and in the Ligisa hills landscape in the south western part, where basalts occur.

Soil characteristics:
These moderately well drained soils are mainly moderately deep, but can also be shallow at some places. Their colour is very dark grey to dark brown (10 YR 3-4/1-2, 7.5 YR 3-4/2) and textures are clayey. The A horizon has a granular to subangular blocky structure and a silty clay loam to clay texture. The textural B horizon has angular blocky structures and a clay texture (mainly montmorillonitic clay). The B horizon can have some vertic properties, as slickensides for instance.

Classification:
orthic luvisols and luvic phaeozems.

References:
East Konyango soil survey: Bhanji series (Bhanji clay loam), and partly Ongeng series.
For profile description see appendix, profile SN 1.

Land use:
Fairly good shambas can be found on the deeper soils, with crops like maize, sorghum, bananas, sweet potatoes, beans, vegetables etc. The shallower soils are often unused or are only used as grazing land. Erosion may occur on these shallow soils.

13. Mmm (Moderately well drained, mainly mod. deep soils on mixed parent mat.)

Parent material:
Mainly Nyanzian rhyolite, some basalt and perhaps andesite.

Physiography:
Mmm soils are found in the Ligisa hills and in the Achego ridges and hills landscapes. In the Ligisa area, they occupy the footslopes of the hills, above the valley slopes. In the Achego landscape they form also higher slopes above the gently sloping valleys.

Soil chracteristics:
These moderately well drained soils are generally moderately deep, but they may be shallow near the boundary with the steep stony hilltops. Their topsoil is dark reddish brown to dark reddish grey (5 YR 3-4/2) and has a clay loam to light clay texture with a subangular blocky structure. The

subsoil is generally mottled, having mixed colours of reddish brown (2.5 - 5 YR 4/3-4) and dark grey (5 YR 4/1) and a clay texture with a subangular blocky structure. On some places ironstone underlies the profile. Sometimes, heavy dark clay can be found at the profile bottom, which could indicate that these soils once have been planosols, like the neighbouring soils downslope.

Classification:
gleyic luvisols, chromic luvisols and luvic phaeozems.

References:
No reference is available to any other soil survey.
For profile description see appendix, profile EXC 17.

Land use:
These soils may be used for cotton, but also for growing of subsistence crops like maize, sorghum, sweet potatoes, cassava, groundnuts, vegetables etc.

14. Wmm (Well drained, mainly moderately deep soils on mixed parent material)

Parent material:
Mostly Nyanzian rhyolite, but also some basalt, andesite and conglomerate.

Physiography:
These soils are found in many landscapes of the survey area. Most of the soils are found in the Asumbi ridges and hills, the Achego ridges and hills and in the Kisii transitional hills and ridges landscapes. They are also found in the Riana transitional and Ligisa hills landscapes. They generally form the tops and lateral or footslopes of the ridges and hills.

Soil characteristics:
These well drained soils have a topsoil of dark brown to dark reddish grey colour and a clay loam to light clay texture, sometimes gravelly, with a fine subangular blocky to granular structure. The subsoil can have a colour ranging from dark brown (7.5 YR - 5 YR 3/2) to reddish brown/weak red (5 YR - 2.5 YR 4/2 - 4/4) and a texture of heavy clay loam to heavy clay, with or without claycutans and having a subangular to angular blocky structure. The transitional zone towards the rock is usually gravelly and may have some weak developed ironstone or a concretionary layer rich in iron and manganese. Actually this unit is composed of two soil groups: the brown

to reddish brown gravelly clay loam to light clay soils and the reddish brown to red clay soils with a clear textural B horizon. They cannot be seperated on this map scale and therefore they have been grouped under this soil unit, actually a soil association.

Classification:
eutric cambisols and haplic phaeozems (group 1) and chromic luvisols and luvic phaeozems (group 2).

References:
Rangwe detailed survey: Marando and Nyandara II series (group 1) and Rabuor and Nyandara I series (group 2).
East Konyango soil survey: Rangwe series.
For profile descriptions see appendix, profiles Ra 11, Ra 12, Ra 14 and Ra 16.

Land use:
The grester part of these soils is used as cropland for production of maize, sorghum, sweet potatoes, cassava, bananas (on the deeper soils), groundnuts, beans, vegetables, sometimes sugar cane. The rest of the land lies fallow or is used as grazing land for cattle and goats.

15. Wmg (Well drained, mainly moderately deep soils on granite parent mat.)

Parent material:
Wmg soils are developed exclusively on granite (of Kitere and of Oyugis).

Physiography:
We find these soils in the Rongo flat topped ridges landscape, where they occur on the lateral ridge slopes (3 - 8 % slopegradient) and on ridgetops, which are not covered with shallow ironstone. Some small parts of the Achego hills and ridges landscape (near Oyugis) also have these soils.

Soil characteristics:
The topsoil of these well drained soils, has colours of very dark grey to dark reddish brown (5 YR 3/1 - 3/2), a subangular blocky to crumby structure and a sandy loam to clay loam texture, sometimes gravelly. The textural B horizon has dark reddish grey to reddish brown colours (5 YR 4/2 - 4/4, 5/4), a clay loam to clay texture, with a subangular blocky structure and common clay cutans. Soil depth is generally between 50 and 100 cm, but sometimes if the soft rotten rock is considered as soil, the depth can be up to 170 cm. Often we find above the rotten rock a concretionary layer of iron- manganese concretions.

Classification:
chromic luvisols and luvic phaeozems.

References:
Marongo detailed survey: Paulo and Ndiwa series.
East Konyango soil survey: Magina series.
For profile description see appendix, profile MA 1.

Land use:
A fairly big part of the Wmg soils are used as arable land for growing maize, sorghum, plus some sweet potatoes, cassava, grountnuts, beans, vegetables etcetera. The rest is left idle or is used as grazing land.

16. Wd (Well drained, moderately deep soils)

Parent material:
The parent materials of Wd soils are various: rhyolite, basalt, some andesite, conglomerate and quarzite.

Physiography:
We fine Wd soils mainly in the Kisii hills, the Kisii transitional hills and ridges landscape and in the Manga escarpment landscape. Small parts are also found in the Riana transitional landscape. They form footslopes or lateral slopes of hills and ridges, or occur in small depressions on slopes with Wmm soils.

Soil characteristics:
These well drained soils have an A horizon with dark reddish brown to dark reddish grey colours (5 - 2.5 YR 3/2 - 4/2), a clay loam to clay texture and a subangular blocky to crumb structure. The B horizon has weak red to red colours (2.5 YR 4/2 - 4/6), a heavy clay texture, many clay cutans and a subangular to angular blocky structure. The soil depth is more than 150 cm, but the B3 horizon starts within 150 cm depth.

Classification:
chromic luvisols and luvic phaeozems.

References:
Rangwe detailed survey: Rabuor and Nyandara I series, the deeper soils.
Marongo detailed survey: Machongo, Nyarega, Gucha and Itumbi series and transitional to Wv soils: Ikoba, Nduru, Muma and Kiabigori series.
For profile descriptions see appendix, profiles Ra 12 and Ra 14.

Land use:
Many crops are grown on these soils. Not only maize, sorghum, sweet potatoes and finger millet, but also coffee, bananas, beans, vegetables and even pyrethrum (on the hill south of Nyamburu) is found. Together with the Wv soils the Wd soils belong to the best soils for agriculture in the area.

17. Wv (Well drained, very deep soils)

Parent material:
Nyanzian rhyolite, Bukoban basalt and some quarzite.

Physiography:
These very deep soils are characteristic for the Kisii hills landscape, with the long straight rather steep slopes. But we find the Wv soils also in the Kisii transitional hills and ridges landscape, where they cover the footslopes of hills with steep, shallow tops.

Soil characteristics:
The A horizon of these soils (well drained) has a colour of weak red to reddish brown (2.5 YR - 5 YR 4/2-3), sometimes dark reddish brown to dusky red (2.5 - 5 YR 3/2-3), a light clay texture and a fine subangular blocky to crumb structure. The B horizon has colours of reddish brown to red (2.5 YR 4/3 - 4/6), a fine subangular blocky structure and a heavy clay texture and many thick clay cutans. The B3 horizon, having reddish brown to yellowish red colours (2.5 YR 4/4 - 5 YR 5/6) and some rotten rock gravels, starts deeper than 150 cm.

Classification:
eutric nitosols, luvic phaeozems.

References:
Marongo detailed survey: Nyamborumbasi, Kitere, Shang'aa, Nyokal, Marongo and Nyangori series.
For profile description see appendix, rpofile EXC 1.

Land use:
The majority od these Wv soils are used as cropland (about 70 %) and a great variety of crops can be found on them. Subsistence crops like maize, sweet potatoes, sorghum, finger millet ('wimbi'), beans, cabbage and other vegetables, but also cash crops like coffee, bananas and pyrethrum (on the soils with a higher altitude).

18. Ss (Somewhat excessively drained, mainly shallow soils)

Parent material:
Mainly Nyanzian rhyolite, plus some andesite, basalt and Bukoban basalt.

Physiography:
Ss soils can be found in almost every landscape, but they occur most frequent in the Ligisa, Achego, Kisii and Kisii transitional landscapes. Mostly they form the rather flat tops of hills and ridges, with rock at shallow depth, but also steep valley slopes can have these soils (e.g. the valley of the Sare river, north west of the area). In the Kisii landscape Ss soils are found on steep to very steep hillslopes and on hilltops.

Soil characteristics:
The soils of this unit are somewhat excessively drained, due to their shallowness. The soils have dark brown colours (5 YR - 7.5 YR 3/2 - 4/2) and have sandy loam to clay loam texture and are gravelly to very gravelly. Soil depth is generally less than 50 cm, but locally soft rotten rock can be found deeper than 50 cm. For practical reasons however, soil depth should eb considered shallow. Agricultural potentials are low therefore.

Classification:
haplic phaeozems and eutric cambisols.

References:
Marongo detailed survey: Ogembo and Kananga series (+ some of Marongo series).
For profile description see appendix, profile EXC 18.

Land use:
Not more than 30 % of these soils are cultivated, with cassava, sorghum, few maize, sweet potatoes and groundnuts. The rest of the land is left idle.

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19. Evs (Excessively drained, very shallow soils)

Parent material:
Nyanzian rhyolite (plus perhaps some basalt and andesite) and Bukoban basalt.

Physiography:
Most of the Evs soils are found in the Ligisa hills landcsape, where they form the steep hilltops. A smaller quantity of these soils can be found in the Kisii, Kisii transitional and in the Achego landscapes, where they

usually are found on the hilltops, but also occasionally on very steep hillslopes. In the Asumbi ridges landscape we find them on ridgetops or hilltops too.

Soil characteristics:

Evs soils are excessively drained soils with a dark brown to dark reddish brown colour and a very gravelly, slightly stony silt loam to clay loam texture. Structure is fine subangular blocky to granular. The soil depth is usually less than 20 cm. The surface stoniness is 40 - 60 % and the rockiness (rock outcrops) 0 - 5 %.

Classification:

eutric regosols (lithic phase), plus few lithosols.

References:

Rangwe detailed survey: Orero series.
East Konyango soil survey: Stony land on siliceous rocks.
For profile description see appendix, profile Ra 18.

Land use:

No use can be made of these soils actually, because they are too shallow and rocky and/or too steep.

Chapter 6 : Correlation with the East Konyango Soil Survey and with the Overall Kisii Mapsheet Legend.

In order to enable a comparison of the data of this report with those of the East Konyango soil survey, carried out on a scale of 1 : 50,000 in the late 1950's, a correlation table is given below.

Correlation Table

Soilgroups of this survey:		Soil series of the East Konyango survey:
Ppm	-	Nyokal, Nyamauro and Marinde series (plus some of the Misathe series).
Ppg	-	Misathe, Nyangu and some of the Nyamauro series.
Pvr	-	Rodi and Kibugo series (plus minor parts of the Ongeng and Obeiro series).
Pvv	-	Kibigori series (+ few Ongeng series).
Ia	-	Alluvial soils, undifferentiated.
Msm	-	Rangwe (sandy loam) series (plus some of the Magina series).
Msg2	-	Magina series plus minor parts of the Nyangu series.
Mmb	-	Bhanji (clay loam) series.
Wmm	-	Rangwe (sandy loam) series.
Wmg	-	Magina series.
Evs	-	Stony land on siliceous rocks.

Note: The soil groups that are not listed in the correlation table are either not found in the area covered by the East Konyango survey or they don't have an equivalent soil series.in that soil survey.

As the legend symbols used for the South Nyanza north east soil map, differ from those of the provisional legend of the complete Kisii mapsheet (covering the topographical mapsheets 130/I, II, III and IV), a conversion table is given below.

Conversion Table

Symbols of South Nyanza n.e. survey:		Symbols of prov. legend of Kisii mapsheet:
Ppm	-	PeM_1 (+ RwC + KwC_2)
Ppg	-	PeG (+ RwC)
Pvr	-	PvV_3
Pvv	-	PvV_1
Ipm	-	RwC (B and C slopes)
Ipg	-	RwC (B and C slopes)
Iv	-	PvV_2
Ia	-	-
Msm	-	PiM
Msg1	-	$RsmG_1$
Msg2	-	$RsmG_2$ (+ PiM)
Mmb	-	RmV
Mmm	-	RmM_3
Wmm	-	RmM_1 + RmM_2
Wmg	-	RmG
Wd	-	RmM_2, KmM_1 (+ KmQ)
Wv	-	KdM_1, KdG (+ KdQ)
Ss	-	RssM, Kss
Evs	-	Rsp, Ksp

References (Bibliography) :

(1) Acland, J.D. (1971), East African Crops, An introduction to the production of field and plantation crops in Kenya, Tanzania and Uganda, FAO / Longman.

(2) Anonymous (1970), Climate and Vegetation map of Kenya, sheet 3 (1 : 250,000).

(3) Beek, K.J. and Bennema, J. (1972), Land Evaluation for Agricultural Land Use Planning, an ecological methodology, LH Wageningen.

(4) Boerma, P.N., Hennemann, G.R., Fauffman, J.H. and Verwey, H. (1974), Detailed Survey of the Marongo Area, preliminary report no. 3, Training Project in Pedology, Kisii, Kenya.

(5) Directorate of Overseas Surveys (1961), Soil Survey of the East Konyango Area, Kenya, Department of Agriculture, Kenya.

(6) FAO - UNESCO (1974), Soil Map of the World, volume I, Legend.

(7) FAO (1967), Guidelines for Soil Profile Description, Rome.

(8) Huddleston, A. (1951), Geology of the Kisii District, Geological Survey of Kenya, report no. 18 - Nairobi.

(9) Mourik, D. van (1974), The Landquality Wateravailability for some soils in the Kisii and South - Nyanza Districts in Kenya.

(10) Munsell, Soil Color Charts.

(11) Soil Survey Staff (1973), Soil Taxonomy, A basic system of Soil Classification for Making and Interpreting Soil Surveys, U.S. Department of Agriculture, Soil Conservation Service.

(12) Soil Survey Staff (1951, with suppl. 1962), Soil Survey Manual, U.S. Department of Agriculture handbook no. 18.

(13) Topographical Maps (1962): series Y 731, sheets 130/I till 130/III (called Gem, Kisii and Kitere), scale 1 : 50,000, Survey of Kenya.

(14) Webster, C.C. and Wilson, P.N. (1966), Agriculture in the Tropics, Longman Group.

(15) Wissen, H. van (1974), Agriculture in the Kisii and the South Nyanza district,(report of the Training Project in Pedology).

APPENDIX

The following profile descriptions are found in this appendix:

Behind these profile descriptions you can find a copy of the geological map of the Kisii district (partly) made by A. Huddleston.

Profile Ra 1

Representative for: Aora Nam series.
Classification: acc. to Soil Taxonomy 1973: typic tropudalf.
acc. to F.A.O. 1974: gleyic luvisol.
Location: In valley of Aora Nam river, near crossing with road Rongo-Rangwe.
coordinates: 34°35'31" E, 0°42'09" S ; altitude: 1347 m (4490 ft)
described by R.F. Breimer on 25-6-1975.

Physiography: dissected plateau, land unit: lower part of dissection slope.
petrography: Nyanzian rhyolites (and dellenites).
vegetation: 60 % grasses, 20 % trees and shrubs, 15 % herbs and 5 % bare ground.
land use: extensive grazing.
drainage class: poorly drained.
soil fauna: high activity of ants, worms, termites etc. in upper 50-70 cm.
root distribution: 0 - 30 cm: few fine, abundant very fine
30 - 120 cm: frequent very fine, few fine
120 - 170 cm: few very fine

Profile characteristics:

A_1 0 - 20 cm — Very dark greyish brown to very dark brown (10 YR 3/2 - 2/2) when moist, light clay; yellowish brown mottling (10 YR 5/4), common, fine faint; moderate fine and very fine subangular blocky and very fine granular; many fine and very fine, few medium biopores; hard, very friable, slightly sticky, slightly plastic; clear and wavy boundary.

B21t 20 - 55 cm — Dark grey (10 YR 4/1) when moist, heavy clay; common, fine, distinct yellowish brown (10 YR 5/6) mottling; strong coarse angular blocky, consisting of medium and fine strong angular blocky peds; abundant, strong clay-humus cutans and many intersecting slickensides; many very fine and common fine biopores; extremely hard, friable, sticky and sl. plastic; gradual, wavy boundary.

B22t 55 - 110 cm — Dark grey (10 YR 4/1) when moist, heavy clay; few, fine, faint yellowish brown (10 YR 5/6) mottling; strong coarse and medium angular blocky, consisting of fine angular blocky peds; abundant strong clay-humus cutans and intersecting slickensides (darker coloured than the matrix); few fine and very fine biopores; same consistence as B21t; gradual and wavy boundary.

B3 110 - over 170 cm Grey (5Y 5/1) when moist, heavy clay; olive (5Y 5/6) and greenish mottling, common, medium, distinct; strong very coarse angular blocky, consisting of medium and fine angular blocky peds; abundant strong clay cutans and intersecting slickensides; few very fine biopores; extr. hard, friable, sticky, slightly plastic consistence.

Note: pit depth was 170 cm; the A_1 horizon was at one place tonging into the B21t.

Analytic data:

depth:	sand	silt	clay	org. C	CEC	Na	K	Ca	Mg
0 - 20	14	33	53	2.4	30.1	2.2	0.3	15.4	8.3
30 - 40	23	14	63	1.3	39.9	3.0	0.3	19.6	14.1
60 - 70	10	30	60	0.6	53.6	2.9	0.3	29.3	21.7
90 - 100	6	7	87	0.3	56.8	3.2	0.3	30.5	22.6
120 - 130	20	4	76	0.2	54.7	6.3	0.5	28.0	21.7
160 - 170	18	20	62	0.1	48.2	4.2	0.4	27.6	20.8

Profile Ra 5

Representative for: Akelo series.
Classification: acc. to Soil Taxonomy 1973: abruptic argiaquoll.
acc. to F.A.O. 1974: gleyic phaeozem.
Location: On plateau south of Riana river, next to the Rongo-Rangwe road.
coordinates: 34°35' 30" E, 0°41'13" S ; altitude: 1365 m (4550 ft)
described by R.F. Breimer on 4-7-1975.

Physiography: dissected plateau, land unit: top of plateau.
petrography: Nyanzian rhyolites (and dellenites).
vegetation: 55 % grasses, 20 % trees and shrubs, 20 % herbs, 5 % bare ground.
land use: extensive grazing.
drainage class: poorly drained.
soil fauna: moderate activity of ants, worms, termites etc. in upper 30 cm.
root distribution: 0 - 30 cm: abundant very fine, frequent fine, few medium
30 - 60 cm: abundant very fine, common fine
60 - 100 cm: common very fine
over 100 cm: few very fine

Profile characteristics:

A1 0 - 25 cm Very dark brown (10 YR 2/2) when moist, dark grey (10 YR 4/1) when dry, silt loam, with light brown soft bricklike pieces; moderate very fine subangular blocky ; many very fine, common fine and medium biopores ; hard, friable, slightly sticky and slightly plastic ; abrupt, wavy boundary.

B21t 25 - 60 cm Very dark brown (10 YR 2/2) when moist, very dark greyish brown (10 YR 3/2) when dry, heavy clay, with common fine distinct brownish yellow (10 YR 6/6) mottles ; strong fine and very fine angular blocky peds inside weak coarse prismatic structure elements ; abundant strong clay-humus cutans and abundant strong intersecting slickensides ; many very fine, few fine biopores ; extr. hard, firm, slightly sticky and sl. plastic ; clear to gradual wavy boundary.

B22t 60 - 95 cm Greyish brown (10 YR 5/2) when moist, greyish brown (7.5 YR 5/2) when dry, heavy clay, with many fine very faint light yellowish brown (10 YR 6/4) mottles ; strong fine angular blocky ; abundant strong clay cutans abundant strong intersecting slickensides ; common very fine, few fine biopores ; extr. hard, firm, sticky and slightly plastic ; clear smooth boundary.

BC 95 - 170 cm Mixed colours: whitish/greenish with yellowish brown and black staining, gravelly to very gravelly clay ; massive structure ; few very fine biopores ; very hard, firm, slightly sticky and slightly to non-plastic ; few lime to be heard on applying HCl.

Note: Pit reached a depth of 170 cm and the lower part of the BC horizon could be considered as rotten rock (C horizon).

Profile Ra 7

Representative for: Riana - Kuna series.

Classification: acc. to Soil Taxonomy 1973: abruptic tropaqualf (actually it should be called a tropical albaqualf).

acc. to F.A.O. 1974: solodic planosol.

Location: About one km east of the Rongo-Rangwe road, just north of the Riana river.

coordinates: 34°35'48" E, 0°40'12" S ; altitude: 1362 m (4540 ft).
described by R.F. Breimer on 12-7-1975.

Physiography: slightly sloping plain, sloping towards the Riana river.
petrography: Nyanzian basalt (or perhaps old alluvium).
vegetation: 60 % grasses, 20 % trees and shrubs, 10 % herbs, 10 % bare ground.
land use: extensive grazing.
drainage class: poorly drained.
soil fauna: high activity of ants, worms, termites etc. in upper 40 cm.
root distribution: 0 - 40 cm: abundant very fine, frequent fine, few medium
40 - 75 cm: abundant very fine, common fine.
75 -150 cm: common to few very fine

Profile characteristics:

A1 0 - 7 cm Dark grey to grey (10 YR 4-5/1) when moist, silty clay loam; moderate very fine subangular blocky ; many very fine, common fine and few medium biopores ; slightly hard, very friable, slightly sticky, slightly plastic ; clear and smooth boundary.

A2 7 - 40 cm Light brownish grey (10 YR 6/2) when moist, silt loam, with many fine distinct dark yellowish brown (10 YR 4/4) mottles; moderate, very fine subangular blocky ; many very fine, common fine, few medium biopores ; slightly hard, very friable, slightly sticky and slightly plastic ; abrupt wavy boundary.

B21t 40 - 75 cm Dark grey (10 YR 4/1) when moist, heavy clay, with many fine prominent yellowish brown (10 YR 5/8) mottles ; moderate coarse prismatic, consisting of strong fine angular blocky peds ; abundant strong clay-humus cutans ; many very fine, few fine biopores ; extr. hard, friable, sticky and plastic; gradual wavy boundary.

B22t 75 - 120 cm Dark grey (10 YR 4/1) when moist, heavy clay, with common medium distinct yellowish brown (10 YR 5/8) mottles ; strong very fine angular blocky ; abundant strong clay-humus cutans and abundant strong intersecting slickensides ; common very fine biopores ; extr. hard, firm, sticky and plastic; gradual, slightly wavy boundary.

B3 110 - 150 cm Dark grey to grey (10 YR 4-5/1) when moist, clay, slightly gravelly from rotten rock, with yellow (5 Y 7/8), yellowish brown and black staining ; strong very fine angular blocky;

common moderate clayskins and few moderate slickensides ; few very fine biopores ; extr. hard, firm, slightly sticky, plastic.

Note: the B22t was found as dry and compact clay and the transition from the A2 to the B2 horizons was marked by many 10 YR 5/8 mottles.

Analytical data:

depth:	sand	silt	clay	org. C	CEC	Na	K	Ca	Mg
0 - 7	10	55	35	2.4	15.1	0.7	0.3	5.5	1.7
10 - 30	10	75	15	2.4	12.3	1.4	0.2	3.9	0.5
50 - 70	4	15	81	1.2	37.9	4.0	0.7	13.8	3.7
90 - 100	5	0	95	0.8	39.0	1.7	0.6	15.1	5.5
130 - 140	11	66	23	0.2	30.7	4.8	0.6	16.1	6.1

Profile Ra 10

Representative for: Oboke series.
Classification: acc. to Soil Taxonomy 1973: typic hapludoll
acc. to F.A.O. 1974: haplic phaeozem
Location: Oboke market, just beside the Rongo-Rangwe road
coordinates: 34°35'16" E, 0°38'54" S ; altitude: 1350 m (4500 ft).
described by R.F. Breimer on 11-8-1975.

Physiography: "footridge" of Kuna hill, higher as slightly sloping plains.
petrography: Nyanzian rhyolites (and dellenites).
vegetation: 30 % grasses, 30 % herbs, 30 % shrubs, trees 10 %.
land use: idle land (perhaps only for grazing of goats).
drainage class: moderately well drained.
soil fauna: relatively high activity of ants, termites etc. in upper 50 cm.
root distribution: 0 - 50 cm: abundant very fine, frequent fine, few medium and very few coarse
50 - 95 cm: frequent very fine. very few fine

Profile characteristics:

A1 0 - 29 cm Very dark greyish brown (10 YR 3/2) when moist, gravelly clay loam ; moderate very fine subangular blocky and very fine granular ; common very fine biopores ; soft, loose to very friable, slightly sticky and slightly plastic ; gradual wavy boundary.

AB 29 - 46 cm **Dark brown** (7.5 YR 3/2) when moist, very gravelly clay loam ; **moderate very** fine subangular blocky and few fine granular ; **common** to few very fine biopores; soft, loose, slightly sticky **and slightly** plastic ; gradual wavy boundary.

B3 46 - 95 cm **Dark** brown to brown (7.5 YR 4/2) when moist, very gravelly **clay** loam (gravels small and big, light brown coloured) ; **moderate very** fine granular to subangular blocky ; few very **fine** biopores ; soft, loose, slightly sticky and slightly **plastic** ; gradual wavy boundary.

C 95 - 120 cm **Mixed colours:** brown (10 YR 5/3) mixed with black and yellow (10 YR 7/8) rotten rock staining, very gravelly, slightly **stony** silt loam ; massive structure ; biopores only in joints; **extr.** hard (rocky) consistence.

Note: Ironstone occurs very locally from 50 - 120 cm depth, but not at the place of description. On these places you can find ironstones and boulders, developed on top of and partly mixed with rotten rock gravels.

Analytical data:

depth:	sand	silt	clay	org. C	CEC	Na	K	Ca	Mg
0 - 25	40	29	31	2.4	19.3	2.6	0.5	12.9	3.1
30 - 40	32	30	38	2.3	14.9	3.2	0.3	10.0	1.0
60 - 80	41	29	30	1.5	11.1	3.8	0.3	6.8	1.4
100 - 110	38	58	4	0.3	14.6	2.1	0.3	12.2	1.9

Profile Ra 11

Representative for: Marando series.

Classification: acc. to Soil Taxonomy 1973: typic hapludoll
acc. to F.A.O. 1974: haplic phaeozem

Location: approx. 3 km south of Rangwe, next to the road from Rongo to Rangwe.
coordinates: 34°35'11" E, 0°37'25" S ; altitude: 1365 m (4550 ft).
described by R.F. Breimer on 15-8-1975.

Physiography: ridges **dissected** by rivers, land unit: hillslope.
petrography: Nyanzian rhyolites (and dellenites).
vegetation: trees and shrubs 30 %, grasses 40 %, herbs 10 %, bare ground 20 %.
land use: cropland for maize, sorghum etc.

drainage class: well drained

soil fauna: in upper 50 cm high activity of ants, termites, worms etc., from 50 to 75 cm moderate activity and deeper than 75 cm no activity.

root distribution: 0 - 35 cm: abundant very fine, common fine, few medium
35 - 75 cm: common very fine, very few fine
75 -125 cm: few very fine
over 125 cm: no roots.

Profile characteristics:

A11	0 - 22 cm	Dark brown (7.5 YR 3/2) when moist, gravelly light clay ; moderate fine and very fine subangular blocky and very fine granular ; many very fine, few fine and medium biopores ; hard, friable, slightly sticky and slightly plastic ; broken boundary.
A12	22 - 35 cm	Dark brown (7.5 YR 3/2) when moist, very gravelly light clay, gravels giving yellowish orange, black staining ; moderate fine and very fine subangular blocky and very fine granular ; many very fine, few fine and medium biopores ; hard, firm, sticky and slightly plastic ; gradual wavy boundary.
AB	35 - 56 cm	Brown to dark brown (7.5 YR 4/3) when moist, mixed with yellowish orange and black rotten rock colours, very gravelly light clay (small gravels) ; weak very fine angular to subangular blocky ; many very fine, few fine, medium and coarse biopores; very hard, firm, sticky and slightly plastic ; gradual and wavy boundary.
B3	56 - 75 cm	Mixed colours: brown to dark brown (7.5 YR 4/3) from soil, plus yellowish red (5 YR 5/8) and black from rotten rock gravels, very gravelly (small and bigger gravels) clay loam ; moderate fine and very fine subangular blocky ; common fine and very fine biopores ; hard, firm, sticky and slightly plastic ; gradual wavy boundary.
C1	75 - 130 cm	Predominantly yellowish red (5 YR 5/8), with dark brown (7.5 YR 3/2) in the joints ; massive structure ; pores only in the joints.
C2	130 - 150 cm	Predominantly reddish yellow (7.5 YR 6/8), massive slightly soft to hard rotten rock (more tough than C1), no pores.

Ana lytical data:

depth:	sand	silt	clay	org. C	CEC	Na	K	Ca	Mg
0 - 20	41	18	41	1.9	21.7	2.0	0.8	15.4	2.7
25 - 35	41	10	49	2.4	18.4	1.4	0.4	14.5	3.0
40 - 50	34	14	52	1.7	15.2	2.7	0.4	12.9	2.1
60 - 70	27	46	27	0.8	12.2	2.7	0.5	12.9	3.3
90 - 110	34	32	34	0.4	13.0	2.7	0.5	12.2	5.5
130 - 140	40	51	9	0.2	-	-	-	-	-

Profile Ra 12

Representative for: Nyandara I series.

Classification: acc. to Soil Taxonomy 1973; typic tropudalf

acc. to F.A.O. 1974: chromic luvisol

Location: beside the road from Rangwe to Oyugis, north of the Nyandara river valley.

coordinates: 34°35'30" E, 0°35'37" S ; altitude: 1284 m (4280 ft).

described by R.F. Breimer on 30-8-1975.

Physiography: hills, dissected by rivers and small streams.

land unit: lower part of hillslope.

petrography: Nyanzian basalt.

vegetation: grasses 40 %, trees 30 %, shrubs 20 %, herbs 10 %.

land use: extensive grazing.

drainage class: well drained.

soil fauna: high activity of termites, ants, worms etc. throughout the whole profile.

root distribution: 0 - 40 cm: abundant very fine, frequent fine, common medium

40 - 85 cm: frequent very fine, common fine, very few medium

85 -140 cm: common very fine, few fine, very few medium

Profile characteristics:

A1 0 - 22 cm Dark reddish brown (5 YR 3/2) when moist, clay loam to light clay ; moderate fine and very fine subangular blocky and fine and very fine granular ; many very fine, few fine, medium and coarse biopores ; hard, very friable, slightly sticky and slightly plastic ; clear and smooth boundary.

AB 22 - 39 cm Dusky to weak red (2.5 YR 3-4/2) when moist, light clay, with common fine distinct black mottles from iron-manganese cutans ;

moderate to strong fine and very fine subangular blocky and moderate very fine granular ; common moderate clay cutans plus few moderate to strong clay-iron.manganese cutans ; many very fine, few fine, medium and coarse biopores ; hard, friable, slightly sticky and slightly plastic ; gradual wavy boundary.

B21t 39 - 85 cm Weak red to reddish brown (2.5 YR 4/3) when moist, clay, with the same black mottling as AB horizon ; moderate to strong fine and very fine subangular blocky to angular blocky ; abundant strong clay cutans and common strong clay-iron-manganese cutans ; many very fine, few fine, medium and coarse biopores; very hard, firm, slightly sticky and plastic ; gradual wavy boundary.

B22t 85 - 120 cm Reddish brown (2.5 YR 4/4) when moist, clay, with the same cutan mottling as the B21t horizon ; strong fine and very fine subangular blocky and strong fine and very fine granular; common strong clay cutans and few moderate clay-iron-manganese cutans ; many very fine, few fine and medium, very few (very) coarse biopores ; hard, friable, slightly sticky and plastic ; gradual wavy boundary.

B3 120 - 140 cm Reddish brown (2.5 YR 4/4) when moist, clay, with many fine distinct black mottles (from cutans as well as from concretions of iron-manganese) ; structure, cutans, porosity and consistence same as B22t ; slightly gravelly from iron-manganese concretions.

Note: at 140 cm depth the present groundwater table was found.
It should be emphasized that this profile is a rather wet variant of the central concept of the Nyandara I series.

Analytical data:

depth:	sand	silt	clay	org. C	CEC	Na	K	Ca	Mg
0 - 20	29	31	40	2.1	15.3	3.5	0.1	10.3	2.1
25 - 35	27	31	42	1.9	11.1	3.3	0.5	7.4	2.5
50 - 70	26	24	50	1.0	13.1	1.3	0.4	7.1	4.4
90 - 110	21	14	65	0.7	13.1	0.5	0.4	7.1	4.7
120 - 140	30	19	51	0.6	11.5	0.4	0.4	11.3	5.2

Profile Ra 14

Representative for: Rabuor series.
Classification: acc. to Soil Taxonomy 1973: typic argiudoll
acc. to F.A.O. 1974: luvic phaeozem.
Location: about 200 m west of the Rongo-Rangwe road, about one km north of Awundo's Village.
coordinates: 34°35'04" E, 0°37'22" S ; altitude: 1363 m (4545 ft).
described by R.F. Breimer on 2-9-1975.

Physiography: ridges, dissected by rivers, land unit: hillslope.
petrography: Nyanzian rhyolites (and dellenites).
vegetation: 30 4 grasses, 30 % shrubs, 20 % trees and 20 % herbs.
land use: grazing, next to a large maize and beans plot.
drainage class: moderately well drained.
soil fauna: high activity of worms, ants, termites etc. throughout the whole profile.
root distribution: 0 - 30 cm: abundant very fine, very frequent fine, few med.
30 - 60 cm: frequent fine and very fine, very few medium
60 - 90 cm: common very fine, very few fine
90 -180 cm: few very fine

Profile characteristics:

A1 0 - 15 cm Dark brown (7.5 YR 3/2) when moist, clay ; moderate very fine subangular blocky and very fine granular ; many very fine, few fine, medium and coarse biopores ; hard, very friable, slightly sticky and slightly plastic ; clear smooth boundary.

A3 15 - 26 cm Dark brown (7.5 YR 3/2) when moist, slightly gravelly light clay; moderate fine and very fine subangular blocky and very fine granular ; many very fine, few fine, medium and coarse biopores; hard, friable, slightly sticky and sl. plastic ; clear smooth boundary.

B1 26 - 60 cm Dark reddish brown (5 YR 3/2) when moist, heavy clay ; moderate very fine and fine subangular blocky ; common moderate clay cutans ; many very fine, few fine and medium biopores ; very hard, firm, sticky and sl. plastic ; gradual, slightly wavy boundary.

B2t 60 - 90 cm Weak red (2.5 YR 4/2) when moist, heavy clay ; moderate fine and very fine angular to subangular blocky ; abundant strong clay cutans and common clay-humus cutans ; many very fine and few fine biopores ; very hard, firm, sticky and plastic ; gradual wavy boundary.

B31 90 - 120 cm Weak red to reddish brown (2.5 YR 4/3) when moist, mixed with common fine distinct black-yellow mottling (from rotten rock gravels or concretions) , slightly gravelly clay ; moderate fine and very fine subangular blocky ; common strong clay cutans ; many very fine, few fine and medium biopores ; very hard, firm, sticky and plastic ; diffuse wavy boundary.

B32 120 - 180 cm Weak red to reddish brown (2.5 YR 4/3), with more of the same mottling as B31, gravelly (from rotten rock) clay ; strong fine and very fine angular blocky ; abundant strong clay cutans ; few fine and very fine biopores ; very hard, firm, sl. sticky and plastic.

Note: the B31 horizon seems to have more biological activity than the B2t horizon. It should be emphasized that this profile is a rather wet variant of the central concept of the Rabuor series.

Analytical data:

depth:	sand	silt	clay	org. C	CEC	Na	K	Ca	Mg
0 - 15	20	33	47	2.4	18.5	0.4	0.7	11.3	5.2
15 - 25	21	30	49	2.3	17.3	0.3	0.4	12.5	2.4
40 - 50	19	15	66	1.1	18.7	0.4	0.4	13.2	3.6
70 - 80	20	11	69	0.8	18.9	1.3	0.4	12.5	3.3
100 - 110	19	0	81	0.8	18.9	1.5	0.4	11.9	3.9
140 - 160	15	25	60	0.4	17.4	1.1	0.6	12.5	3.6

Profile Ra 15

Representative for: Alluvial soils, undifferentiated.
Classification: acc. to Soil Taxonomy 1973: aquic eutropept
acc. to F.A.O. 1974: eutric fluvisols
Location: in the Riana river valley, about 300 m east of the Kongo-Rangwe road.
coordinates: 34°35'30" E, 0°40'23" S ; altitude: 1341 m (4470 ft).
described by R.F. Breimer on 22-9-1975.

Physiography: river plain (valley), land unit: river bank levee.
petrography: Nyanzian basalt (probably), covered by recent alluvium.
vegetation: probably originally bushy.
land use: cropland for maize, sorghum and sugar cane.
drainage class: imperfectly drained.

soil fauna:- high activity of ants, worms and other small insects, especially in the upper 85 cm.
root distribution: 0 - 35 cm: abundant very fine, common fine, very few medium
35 - 85 cm: very frequent very fine, few fine
over 85 cm: frequent very fine, very few fine

Profile characteristics:

IA 0 - 35 cm Dark reddish grey (5 YR 4/2) when moist, silt loam, with blackish mottles, common, fine, faint ; weak moderate and fine subangular blocky and very fine granular ; many very fine, common fine and few medium biopores ; slightly hard, very friable, slightly sticky and slightly plastic ; gradual wavy boundary.

IB 35 - 83 cm Reddish brown (5 YR 4/3) when moist, silt loam to silty clay loam, with common fine faint blackish mottles ; moderate medium and fine subangular blocky ; many very fine, common fine, few medium biopores ; slightly hard, very friable, slightly sticky and sl. plastic ; abrupt wavy boundary.

IIB 83 - 115 cm Reddish brown (5 YR 4/3) when moist, loamy sand, with many, medium, distinct blackish mottles ; weak medium and fine subangular blocky ; many very fine, few fine and medium biopores ; loose, very friable, non-sticky and non-plastic.

Note: at 115 cm depth the present groundwater table was found.

Profile Ra 16

Representative for: Nyandara II series.
Classification: acc. to Soil Taxonomy 1973: typic hapludoll
acc. to F.A.O. 1974: haplic phaeozem
Location: near Awundo's Village, on the side of the road from Rongo to Kangwe.
coordinates: 34°35'16" E, 0°37'52" S ; altitude: 1383 m.
described by R.F. Breimer on 8-10-1975.

Physiography: round topped ridges, land unit: near top of the ridge.
petrography: Nyanzian basalt.
vegetation: trees and shrubs 20 %, grasses 30 %, arable land 50 %.
land use: cropland for maize and sorghum mainly.
drainage class: well drained.
soil fauna: high activity in upper 50 cm, down to 140 cm moderate to low activity.

root distribution: 0 - 50 cm: abundant very fine, frequent fine, very few medium
50 -100 cm: common very fine, very few fine

Profile chracteristics:

A1 0 - 10 cm Dark brown (7.5 YR 3/2, moist), slightly gravelly silty clay loam ; moderate very fine subangular blocky to very fine granular ; many very fine, common fine, few medium pores ; loose, very friable, slightly sticky and slightly plastic ; clear wavy boundary.

B21 10 - 45 cm Dark brown (7.5 YR 3/3, moist), very gravelly, slightly stony clay ; moderate very fine subangular blocky and granular ; common very fine, few fine and medium biopores ; hard, very friable, slightly sticky and sl. plastic ; gradual wavy boundary.

B22 45 - 85 cm Dark brown (7.5 YR 3/3) when moist, plus brownish-orange-black rotten rock colours, gravelly and stony clay ; moderate fine and very fine subangular blocky structure ; few very fine and fine pores ; hard, friable, slightly sticky and sl. plastic ; broken boundary.

C 85 - 140 cm Mixed colours: yellow-orange-black + few brown of soil material, mainle massive soft rotten rock, with few soil in the joints.

Analytical data:

depth:	sand	silt	clay	org. C	CEC	Na	K	Ca	Mg
0 - 10	14	54	32	2.2	24.0	0.3	1.3	13.2	4.2
20 - 30	21	15	64	2.0	18.0	1.8	0.8	7.1	3.2
60 - 70	19	3	78	1.3	16.9	0.4	0.8	8.4	2.8
90 - 120	9	64	27	0.5	19.6	0.4	0.6	11.6	7.0

Note: the texture figures are not very certain, because they differ enormously within short vertical distances.

Profile Ra 17

Representative for: Mrando series.

Classification: acc. to Soil Taxonomy 1973: typic eutropept
acc. to F.A.O. 1974: chromic cambisol

Location: beside Rangwe-Oyugis road, very near to the junction with the Rangwe-Asumbi road.

coordinates: 34°35'30" E, 0°35'49" S ; altitude: 1285 m.
described by R.F. Breimer on 8-10-1975.

Physiography: ridges with steep tops; less steep lateral slopes and small velleys in between, land unit: lateral slope.

petrography: Nyanzian rhyolites.

vegetation: 50 % trees, 20 % shrubs, 15 % herbs, 5 % grasses (dense bushy woodland).

land use: none (perhaps only goat grazing).

drainage class: well drained.

soil fauna: moderate to high activity down to 90 cm.

root distribution: 0 - 25 cm: abundant very fine, frequent fine, few medium and coarse.
25 - 90 cm: common very fine, very few fine
over 90 cm : few very fine

Profile characteristics:

A1 0 - 25 cm Dark reddish grey (5 YR 4/2) when moist, gravelly clay loam ; moderate very fine subangular blocky to very fine crumb; common very fine, few fine pores ; loose, very friable, slightly sticky and slightly plastic ; gradual wavy boundary.

B2 25 - 60 cm Weak red (2.5 YR 4/3, moist), plus creamy yellow of rotten rock gravels and stones ; very gravelly, slightly stony light clay; moderate very fine crumb ; few very fine pores ; hard, very friable, slightly sticky, slightly plastic ; gradual wavy boundary.

B3 60 - 90 cm Reddish brown (2.5 YR 4-5/4, moist), plus creamy yellow of rotten rock ; very gravelly, slightly stony light clay ; moderate very fine crumb ; few very fine pores ; hard, very friable, slightly sticky and sl. plastic ; gradual irregular boundary.

BC 90 - 150 cm Mixed creamy yellow with reddish brown in the joints, massive rotten rock, with very few crumby soil in pores and joints.

Profile Ra 18

Representative for: Orero series.

Classification: acc. to Soil Taxonomy 1973: lithic ustorthent
acc. to F.A.O. 1974: eutric regosol

Location: at the junction of the Oyugis-Rangwe and the Asumbi-Rangwe roads.

coordinates: 34°35'26" E, 0°35'55" S ; altitude: 1287 m.

described by R.F. Breimer on 8-10-1975.

Physiography: ridges with steep tops, less steep lateral slopes and small valleys in between.
land unit: steep top
petrography: Nyanzian rhyolites.
vegetation: bushy woodland (mainly trees and shrubs)
land use: none
drainage class: excessively drained.
soil fauna: moderate activity, only in upper 20 cm.
root distribution: 0 - 20 cm: abundant very fine, frequent fine, very few medium
deeper than 20 cm: very few very fine

Profile characteristics:

A1 0 - 20 cm — Dark brown (7.5 YR 3/2) when moist, very gravelly clay loam ; moderate very fine granular structure ; few very fine pores ; loose, very friable, slightly sticky and slightly plastic consistence ; clear irregular boundary.

C deeper than 20 cm — Whitish-yellowish rotten rock with few brown soil in the joints.

Profile EXC 1

Representative for: Wv unit.
Classification: acc. to Soil Taxonomy 1973: typic tropudalf
acc. to F.A.O. 1974: eutric nitosol
Location: along road Marani - Manga, about one km east of the Mogusii river.
coordinates: 34°59'20" E, 0°35'44" S ; elevation: 1620 m.
described by H. van Reuler, November 1975.

Physiography: rounded hills, land unit: top of hill.
petrography: Bukoban basalt.
vegetation: removed for cultivation.
land use: cropland.
drainage class: well drained.
soil fauna: ants and worms.
root distribution: 0 - 25 cm: abundant very fine, very frequent fine and a few medium roots.
over 25 cm: common very fine and fine roots.

Profile characteristics:

A1 0 - 25 cm — Reddish brown (5 YR 4/3) when moist; clay; moderate fine subangular blocky; few medium, common fine and many very fine

biopores; very friable when moist, slightly sticky and slightly plastic when wet; clear and smooth boundary.

B1 25 - 81 cm Reddish brown (2.5 YR 4/4 - 5 YR 4/3) when moist; clay; moderate, fine to medium subangular blocky; few coarse, few medium, many fine and very fine biopores; few weak clay cutans; very friable when moist, slightly sticky and slightly plastic when wet; gradual and wavy boundary.

B21 81 - 170 cm Reddish brown (2.5 YR 4/4) when moist; clay; moderate medium angular blocky; few very coarse, few coarse, common medium, many fine and very fine biopores; strong, common to abundant clay cutans; friable when moist, sticky and slightly plastic when wet; gradual and wavy boundary.

B22 170^{+} cm Reddish brown to red (2.5 YR 4/5) when moist; clay; moderate medium to coarse angular blocky; few very coarse, few coarse, common medium, many fine and very fine biopores; strong, common to abundant clay cutans; very friable when moist, sticky and slightly plastic when wet.

Remark: augering in the bottom of the pit makes clear that the B3 horizon starts at 370 cm depth.

Profile EXC 13

Representative for: Awundo series.
Classification: acc. to Soil Taxonomy 1973: aquentic chromudert
acc. to F.A.O. 1974: chromic vertisol
Location: near Lwala school, along 'Tanzania road', South Nyanza district.
coordinates: 31°31'23" E, 0°55'19" S ; elevation: 1435 m.
described by J. van Keulen and H. van Reuler, on 4-12-1975.

Physiography: dissected plateau.
petrography: Nyanzian basalt.
vegetation: trees 20 % (Acacia), shrubs 10 %, grasses 70 %.
land use: extensive grazing, small parts of cropland.
drainage class: poorly to imperfectly drained.
soil fauna: ants.
root distribution: 0 - 20 cm: very frequent very fine, frequent fine, common medium and few coarse roots.
deeper : frequent very fine, common fine and few coarse roots.

Profile characteristics:

A1 0 - 15 cm Very dark grey (10 YR 3/1) when moist; clay; moderate fine to medium subangular blocky; few medium, many fine and many very fine biopores; friable when moist, sticky and plastic when wet; clear and broken boundary.

B1 15 - 51 cm Brown (7.5 YR 5/2) when moist; few fine distinct mottles (strong brown 7.5 YR 5/6); clay; few small gravels, 1-3 mm; moderate medium angular blocky; few medium, many fine, many very fine biopores; firm when moist, sticky and plastic when wet; small intersecting slickensides; gradual and wavy boundary.

B2 51 - 80 cm Greyish brown (10 YR 5/2) when moist; many medium prominent mottles (yellowish red 5 YR 5/8); few small gravels, 2-10 mm; clay; moderate medium angular blocky; common very fine and fine biopores; friable when moist, sticky and plastic when wet; small intersecting slickensides; abrupt and broken boundary.

R 80+ cm Basalt hard rock.

Profile EXC 14

Representative for: Pvr unit.
Classification: acc. to Soil Taxonomy 1973: typic chromudert
acc. to F.A.O. 1974: chromic vertisol
Location: about one km west of Marinde, along the Magena - Marinde road.
coordinates: 34°30'56" E, 0°39'12" S ; elevation: 1334 m.
described by W.G. Wielemaker and R.F. Breimer, October 1975.

Physiography: top of flat ridges.
petrography: basic volcanic rocks (Tertiary volcanics).
vegetation: mainly grasses, just some scattered trees and shrubs.
land use: extensive grazing.
drainage class: poorly to imperfectly drained.
soil fauna: many insects in upper 30 cm.
root distribution: 0 - 30 cm: abundant very fine and fine, few medium roots.
30 - 80 cm: common very fine, few fine roots.
80 -100 cm: few very fine roots.

Profile characteristics:

A 0 - 30 cm Very dark brown (10 YR 2/2) when moist; clay loam; strong very fine granular to subangular blocky; many very fine, few fine, few medium biopores; hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; abrupt and smooth boundary.

B21t 30 - 44 cm Very dark grey (10 YR 3/1) when moist; heavy clay; strong medium prismatic; common very fine, few fine biopores; extremely hard when dry, firm when moist, sticky and very plastic when wet; clear and smooth boundary.

B22t 44 - 80 cm Dark grey to grey (10 YR 4-5/1) when moist; heavy clay; strong very coarse angular blocky, breaking into moderate medium angular blocky peds; few very fine biopores; extremely hard when dry, firm when moist, sticky and very plastic when wet; intersecting slickensides; clear and wavy boundary.

B3 80 - 100 cm Grey (10 YR 5/1) when moist, mixed with brown and yellow rotten rock colours; gravelly clay; strong fine angular blocky; few very fine biopores; extremely hard when dry, firm when moist, sticky and very plastic when wet.

Profile EXC 16

Representative for: Ipm unit.
Classification: acc. to Soil Taxonomy 1973: abruptic, aeric tropaqualf.
acc. to F.A.O. 1974: eutric planosol.
Location: approx. 2.5 km south of Ligisa Omoya, along the Imbo - Ligisa road.
coordinates: 34°32'19" E, 0°32'07" S ; elevation: 1271 m.
described by R.F. Breimer, November 1975.

Physiography: valley slope.
petrography: Nyanzian rhyolite.
vegetation: mainly grasses and some scattered trees and shrubs.
land use: extensive grazing.
drainage class: imperfectly drained.
soil fauna: moderate activity of ants, termites in upper 30 cm.
root distribution: 0 - 30 cm: many very fine and common fine roots.
30 -110 cm: common very fine roots.

Profile characteristics:

A1 0 - 8 cm Dark brown (7.5 YR 3/2) when moist, brown (7.5 YR 5/2) when dry; common, fine, faint brown to dark brown (7.5 YR 4/3) mottles; silt loam; weak, subangular blocky; many very fine, few fine and medium biopores; very hard when dry, friable when moist, slightly sticky and slightly plastic when wet; gradual and smooth boundary.

A2 8 - 27 cm Brown (7.5 YR 5/2) when moist; pinkish grey (7.5 YR 6/2) when dry; common fine faint brown (7.5 YR 5/3) mottles; silt loam; weak subangular blocky; many very fine, few fine and medium biopores; very hard when dry, friable when moist, slightly sticky and slightly plastic when wet; clear and smooth boundary.

B2t 27 - 80 cm Dark grey (10 YR 4/1), dry and moist; heavy clay; weak, coarse prismatic, breaking into strong, medium and fine angular blocky peds; silt coatings from A2 material on peds and pressure cutans; common very fine and few fine biopores; extremely hard when dry, sticky and plastic when wet, firm when moist; gradual and wavy boundary.

B3 80 - 110 cm Dark greyish brown (10 YR 4/2) when moist, greyish brown to brown (10 YR 5/2-3) when dry; silty clay loam; very weak structure; common medium clay cutans; hard when dry, firm when moist, sticky and plastic when wet. (calcareous).

Profile EXC 17

Representative for: Mmm unit.
Classification: acc. to Soil Taxonomy 1973: typic tropudalf (tending to aquic tropudalf).
acc. to F.A.O. 1974: gleyic luvisol (petric phase).
Location: about 2.5 km south of Ligisa Omoya, along the road from Ligisa to Imbo.
coordinates: 34°32'16" E, 0°32'09" S; elevation: 1268 m.
described by R.F. Breimer, November 1975.

Physiography: valley slope.
petrography: Nyanzian rhyolite.
vegetation: mainly grasses, with scattered trees and shrubs.
land use: cropland for cassava.
drainage class: moderately well drained.

soil fauna: high activity of ants, worms, termites down to 70 cm.

root distribution: 0 - 70 cm: abundant very fine and fine, common medium, few coarse roots.
70 -110 cm: common very fine, few fine roots.

Profile characteristics:

A 0 - 25 cm Dark reddish grey to dark reddish brown (5 YR 4-3/2) when moist, dark reddish grey (5 YR 4/2) when dry; light clay loam; moderate fine and very fine subangular blocky and very fine crumb; many very fine, common fine, few medium and coarse biopores; hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; clear and smooth boundary.

B2 25 - 70 cm Dark grey to very dark grey (5 YR 4-3/1) when moist, dark grey (5 YR 4/1) when dry; common, medium faint reddish brown (5 YR 4/3) mottles; light clay; moderate, fine and medium subangular blocky; many very fine, common fine, few medium and coarse biopores; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; clear and wavy boundary.

B ir 70 - 110 cm Accumulation of iron-manganese concretions, at places indurated to ironstone; yellowish-black; gravel to stony.

Profile EXC 18

Representative for: Ss unit.

Classification: acc. to Soil Taxonomy 1973: ruptic lithic ustorthentic lithic haplustoll.
acc. to F.A.O. 1974: haplic phaeozem/eutric regosol.

Location: near the junction of the road from Ligisa Omoya to Achego with the Sare river.

coordinates: 34°33'34" E, 0°31'37" S ; elevation: 1185 m.

described by R.F. Breimer, December 1975.

Physiography: hillslope.

petrography: Nyanzian rhyolite.

vegetation: 40 % trees, 30 % shrubs, 15 % herbs, 15 % grasses.

land use: none (idle land).

drainage class: somewhat excessively drained (to exc. drained).

soil fauna: moderate activity of insects in upper 20 cm.

root distribution: abundant very fine and fine, common medium, few coarse and very coarse roots in the upper 20 cm.

Profile characteristics:

A1 0 - 20 cm Very dark grey (10 YR 3/1) when moist; very gravelly clay loam; moderate very fine granular and fine subangular blocky ; common very fine, few fine biopores; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; gradual and wavy boundary.

AC 20 - 40 cm Very dark grey (10 YR 3/1) when moist; brownish rock mottles; gravel with less than 10 % soil with clay loam texture ; moderate, very fine granular structure; few very fine biopores; hard when dry, friable when moist, slightly sticky and slightly plastic when wet.

R 40^{+} cm hard rhyolitic rock.

Profile EXC 19

Representative for: Msgl unit.
Classification: acc. to Soil Taxonomy 1973: entic udic haplustoll.
acc. to F.A.O. 1974: haplic phaeozem (petric phase).
Location: about 1.5 km east of Luora school (north of Bondo).
coordinates: 34°37'10" E, 0°30'20" S ; elevation: 1266 m.
described by R.F. Breimer, November 1975.

Physiography: top of a flat ridge.
petrography: Oyugis granite (post-Nyanzian intrusive).
vegetation: mainle poor grasses, not covering the soil completely, locally trees and shrubs.
land use: cropland for cassava and some maize and sweet potatoes.
drainage class: moderately well drained.
soil fauna: moderate activity of insects in upper 40 cm.
root distribution: 0 - 35 cm: abundant very fine, common fine, few medium and coarse roots.
35 - 70 cm: common very fine, few fine, medium and coarse roots.

Profile characteristics:

A 0 - 35 cm Dark brown (7.5 YR 3/2) when moist, brown (7.5 YR 5/2) when dry; sandy loam; weak medium and fine subangular blocky ; many very fine, common fine, few medium and coarse biopores; hard when dry, very friable when moist, non-sticky and non-plastic when wet; clear and wavy boundary.

AC 35 - 70 cm Dark brown (7.5 YR 3/2) when moist, brown (7.5 YR 5/2) when dry; very gravelly sandy loam; weak fine subangular blocky; common very fine, few fine and medium biopores; hard when dry, very friable when moist, non-sticky and non-plastic when wet; gradual and irregular boundary.

C ir 70 - 100 cm Indurated ironstone and at some places rotten rock with iron-manganese concretions.

Remark: gravel in this profile mainly consists of iron-manganese concretions.

Profile EXC 20

Representative for: Ipg unit.
Classification: acc. to Soil Taxonomy 1973: aquic tropudalfic aeric tropaqualf.
acc. to F.A.O. 1974: solodic planosol.
Location: about 2 km east of Luora school (north of Bondo).
coordinates: 34°37'27" E, 0°30'21" S ; elevation: 1251 m.
described by R.F. Breimer and H. van Reuler, November 1975.

Physiography: lateral slope of a flat ridge.
petrography: Oyugis granite.
vegetation: 30 % shrubs, 5 % trees, 50 % grasses and herbs, 15 % bare ground.
land use: extensive grazing land.
drainage class: imperfectly drained.
soil fauna: moderate activity of insects in the upper 30 cm.
root distribution: 0 - 35 cm: frequent very fine and fine, few medium and coarse.
35 -130 cm: common very fine, few fine and medium roots.

Profile characteristics:

A1 0 - 16 cm Very dark greyish brown (10 YR 3/2) when moist, grey to greyish brown (10 YR 5/1.5) when dry; sandy loam; weak medium subangular blocky; common very fine and fine, few medium biopores; slightly hard when dry, friable when moist, non-sticky and slightly plastic when wet; clear and wavy boundary.

A21 16 - 30 cm Dark greyish brown (10 YR 4/2) when moist, light brownish grey (10 YR 6/2) when dry; loamy sand ; weak medium subangular blocky; many very fine, common fine and few medium biopores; slightly hard when dry, friable when moist, non-sticky and non-plastic when wet ; clear and wavy boundary.

B1 30 - 56 cm Same colours as A21 and in addition dark greyish brown colours of cutans; sandy clay loam ; moderate coarse columnar structure (with rounded columntops), breaking into fine angular blocky peds; common moderate clay-humus cutans; common very fine, few fine and medium biopores; very hard when dry, very firm when moist, slightly sticky and slightly plastic when wet; clear and wavy boundary.

B21t 56 - 80 cm Very dark grey (10 YR 3/1), when moist or dry ; heavy clay; with common medium prominent reddish mottles; moderate coarse prismatic to columnar, breaking into strong fine angular blocky peds; many moderate pressure cutans; common very fine and few fine biopores; very hard when dry, very firm when moist, sticky and plastic when wet ; gradual wavy boundary.

B22t 80 - 130 cm Grey and dark grey (10 YR 4/1 and 5/1); slightly gravelly clay; strong medium to fine angular blocky; some pressure cutans and slickensides; few very fine and fine biopores; very hard when dry, very firm when moist, sticky and plastic when wet.

Profile SN 1

Representative for: Mmb unit.
Classification: acc. to Soil Taxonomy 1973: typic tropudalf.
acc. to F.A.O. 1974: orthic luvisol.
Location: near Majiwa school (2 km north-west of Imbo).
coordinates: 34°31'38" E, 0°34'39" S ; elevation: 1338 m.
described by R.F. Breimer on 28-11-1975.

Physiography: dissected small plateau, land unit: slightly sloping edge of plateau.
petrography: Nyanzian basalt.
vegetation: semi-evergreen thicket.
land use: extensive grazing.
drainage class: moderately well drained.
soil fauna: moderate activity of ants, termites etc.
root distribution: 0 - 25 cm: abundant very fine, common fine, few medium roots.
25 - 70 cm: common very fine, very few fine roots.

Profile characteristics:

A1 0 - 4 cm Very dark grey (10 YR 3-4/1) when moist, dark grey (10 YR 4/1)

when dry; silty clay loam; strong very fine granular structure; few fine pores; hard, friable, slightly sticky and slightly plastic ; clear and smooth boundary.

B2 4 - 25 cm Dark grey (10 YR 4/1), both moist and dry; fine clay (montmorillonitic); strong medium angular blocky, breaking into fine and very fine angular peds; many clear pressure cutans and probably clay cutans; many very fine, few fine and medium biopores; very hard when dry, firm when moist, sticky and plastic when wet ; clear and wavy boundary.

B3 25 - 50 cm Dark greyish brown (10 YR 4/2, moist and dry); gravelly clay; strong fine angular blocky structure; many clear pressure cutans (+ clay cutans ?); common very fine pores ; very hard, firm, sticky and plastic ; gradual irregular boundary.

C 50 - over 70 cm yellowish black rotten rock.

Note: this profile is a rather shallow variant of the central concept of the Mmb soils.

Profile MA 1

(taken from the Maroroto detailed soil survey, Ndiwa series)

Representative for: Wmg unit.

Classification: acc. to Soil Taxonomy 1973: typic tropudalf.
acc. to F.A.O. 1974: chromic luvisol.

Location: along the road from Rongo to Riosiri (East Nyokal, South Nyanza).

coordinates (in top. map kilometer grid): 9915.30 N, 680.15 E

altitude: 1485 m (4950 ft).

described by G.R. Hennemann and J.H. Kauffman, on 4-1-1974.

Physiography: summit of convex slope.

petrography: Kitere granite.

land use: grassland for grazing.

drainage class: well drained, water table deeper than 2.00 m.

soil fauna: few krotovinas to a depth of 0.80 m.

root development: mainly at depth of 0 - 30 cm.

Profile characteristics:

A1 0 - 30 cm Dark reddish brown (5 YR 3/4) when dry; fine clay; weak very fine subangular blocky; very many, very 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) when 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) when 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; boundary clear to gradual and wavy.

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

Profile EK 1

(taken from the East Konyango soil survey, Misathe sandy loam)

Representative for: Ppg unit.

Classification: acc. to Soil Taxonomy 1973: abruptic tropaqualf.
acc. to F.A.O. 1974: dystric planosol.

Location: approximately 1.25 miles south east of Magena an the large flat plateau between the Riana and the Misadhi rivers.

Physiography: nearly level to gently sloping plains.

petrography: Kitere granite.

vegetation: grass with Pennisetum catabasis dominant, also Brachiaria soluta, Andropogon sp. and Hyparrhenia sp.

land use: used mainly as pasture, but small areas are planted to sweet potatoes, finger millet and cassava. A small patch of sugar cane was observed on this soil, but it appeared to be doing very poorly.

drainage class: poorly to imperfectly drained; runoff is medium to slow. Internal drainage is slow. Seasonally fluctuating water table.

Profile characteristics:

A1 0 - 15 cm — Very dark grey to very dark greyish-brown (10 YR 3/1.5) sandy loam; moderate medium, granular structure; soft when dry, friable when moist, non-sticky and non-plastic when wet; abundant fine and medium roots, non calcareous (pH 4.8); lower boundary clear and smooth. 15 - 20 cm thick.

A2 15 - 48 cm — Very dark greyish-brown (10 YR 3.5/2) sandy loam, grey to light grey (10 YR 5/1) when dry; moderate medium subangular blocks, breaking to fine granular structures; slightly hard when dry, friable when moist, non-sticky and non-plastic when wet; abundant fine and medium roots; non-calcareous (pH 5.0); abrupt and smooth boundary. 33 to 38 cm thick.

B2 48 - 81 cm — Black to very dark grey (10 YR 2.5/1) clay ; weak to moderate prisms, in places breaking to strong, medium, angular blocky structure; hard when dry, firm when moist, sticky and plastic when wet; plentiful fine and medium roots, some through peds; thick clay flows on all ped faces; common, fine, distinct, strong brown (7.5 YR 5/6) mottles and common, fine, prominent, red (2.5 YR 4/8) mottles; contains a few fine quartz grains; non-calcareous (pH 5.0), boundary gradual and wavy. 33 to 36 cm thick.

B3 81 - 122 cm — Dark greyish-brown (10 YR 4/2) clay; structure and consistence like above horizon; plentiful fine and medium roots; common, fine, faint, light yellowish-brown (10 YR 6/4) mottles; many quartz fragments and weathered white gneissic fragments; many black manganese stains and spots; a few thin clay discontinuous skins; (pH 4.5). 36 - 46 cm.

C1 122 cm^{+} — Variegated colours of equal proportions, olive (5 Y 5/3) and grey-brown (2.5 Y 5/2) gravelly clay, strong, medium, angular blocky structure; hard when dry, firm when moist, sticky and plastic when wet; a few fine roots; common, fine, distinct, strong brown mottles (7.5 YR 5/6). The gravels are weathered gneissic fragments and difficult to auger; lower boundary undetermined; non-calcareous (pH 4.5).

Profile EK 2

(taken from the East Konyango soil survey, Kibigori clay loam)

Representative for: Pvv unit.

Classification: acc. to Soil Taxonomy 1973: typic pelludert.
acc. to F.A.O. 1974: pellic vertisol.

Location: about ½ mile south of the Gem peak.

Physiography: nearly level stream terraces, lake beds and old swamps.

petrography: fine textured sediments (from basalt-type rock) and volcanic ash.

vegetation: mostly tall grassy areas with Pennisetum catabasis dominant and flat topped Acacia sp. along the streams.

land use: maize, sugar cane and pasture. A good soil for sugar cane if managed properly.

Drainage class: Poorly to imperfectly drained, runoff is slow during most of the year, internal drainage is slow during the rainy periods and medium during the drier seasons.

Profile characteristics:

A1 0 - 13 cm — Black to very dark grey (10 YR 2.5/1) clay loam; moderate, very fine to fine subangular blocky; hard (dry), firm (moist), slightly sticky and plastic (wet); abundant fine and medium roots; many yellowish-red concretions due to burning; slightly acid (pH 6.1) ; lower boundary clear and smooth. 13 - 15 cm thick.

B2 13 - 41 cm — Black (10 YR 2/1) clay; moderate coarse prisms breaking to strong, coarse, angular blocks; very hard (dry), firm (moist), very sticky and very plastic (wet); plentiful roots with some through peds; thick clay skins on all ped surfaces, and common fine prominent yellowish-red (5 YR 5/6) mottles; mildly alkaline (pH 7.6); clear smooth boundary, 28 - 30 cm thick.

B3 41 - 66 cm — Very dark grey to dark grey (10 YR 3.5/1) clay; strong, medium, angular blocky; very hard (dry), very firm (moist), very sticky and very plastic (wet); plentiful fine roots; a few thin clay skins and many slickenside faces; has 10 % fine brown-black concretions; moderately alkaline (pH 8.1); lower boundary gradual and wavy. 25 - 28 cm thick.

Cca-1 66 - 140 cm — Dark grey to grey (10 YR 4.5/1) clay; strong medium to coarse lenticular structure; consistence as above; plentiful fine roots; some flattened between peds; contains many rounded lime concretions of o.5 - 1 cm in size, mainly in the lower part of the horizon; mainly calcareous; mildly alkaline (pH 7.8) gradual wavy lower boundary. 71 to 81 cm thick.

Cg 140 - 190 cm Variegated colours in equal proportions of olive grey (5 Y 5/2) and olive brown (2.5 Y 4/2) clay with many black manganese spots and stains and 10 % brownish-yellow mottles (10 YR 6/6); strong medium subangular blocky structure; hard (dry), friable to firm (moist), sticky and plastic (wet); very few fine roots; neutral (pH 7.2); lower boundary undetermined.

190 cm+ Auger stopped by basalt float rock.

Profile EK 3

(taken from the East Konyango soil survey, Magina loamy coarse sand)

Representative for: Msg2 unit.

Classification: acc. to Soil Taxonomy 1973: aquic hapludoll.
acc. to F.A.O. 1974: haplic phaeozem (petroferric phase).

Location: about 100m south of Magena market, on the north side of the road going to Rongo.

Physiography: nearly level to sloping hills and ridges.

petrography: Kitere granite.

vegetation: much of the original vegetation has been removed. On the ridgetops a few Combretum sp. and Bauhinia sp. trees remain. The grasses are mainly Hyparrhenia sp.

land use: These soils are farmed intensively and produce fair to poor yields of finger millet, simsim, sweet potatoes, cowpeas, cassava and some maize.

drainage class: moderately well to well drained, runoff is rapid and internal drainage is rapid.

Profile characteristics:

A1 0 - 15 cm Dark reddish brown (5 YR 3/2) loamy coarse sand, dark reddish grey (5 YR 4/2) when dry; weak fine granular structure; loose (dry), very friable (moist), non-sticky and non-plastic (wet); abundant fine and medium roots; strongly acid (pH 5.4) ; abrupt smooth boundary. 10 - 15 cm thick.

B2 15 - 36 cm Dark reddish brown (5 YR 3/2) gravelly coarse sand; weak very fine subangular blocky structure; consistence as above; plentiful fine and medium roots; a few thin discontinuous clay skins in pores; gravels are iron-oxide concretions; medium acid (pH 5.6); gradual wavy boundary. 20 - 30 cm thick.

B21r 36 - 71 cm Dark reddish brown indurated laterite horizon; strongly cemented in place but can be broken out to 9 x 15 cm pieces; contains a few roots; medium acid (pH 5.8); gradual wavy boundary. 36 - 43 cm thick.

C2 52 - 100 cm+ Weathered granitic material containing a few fine roots ; slightly acid (pH 6.1).

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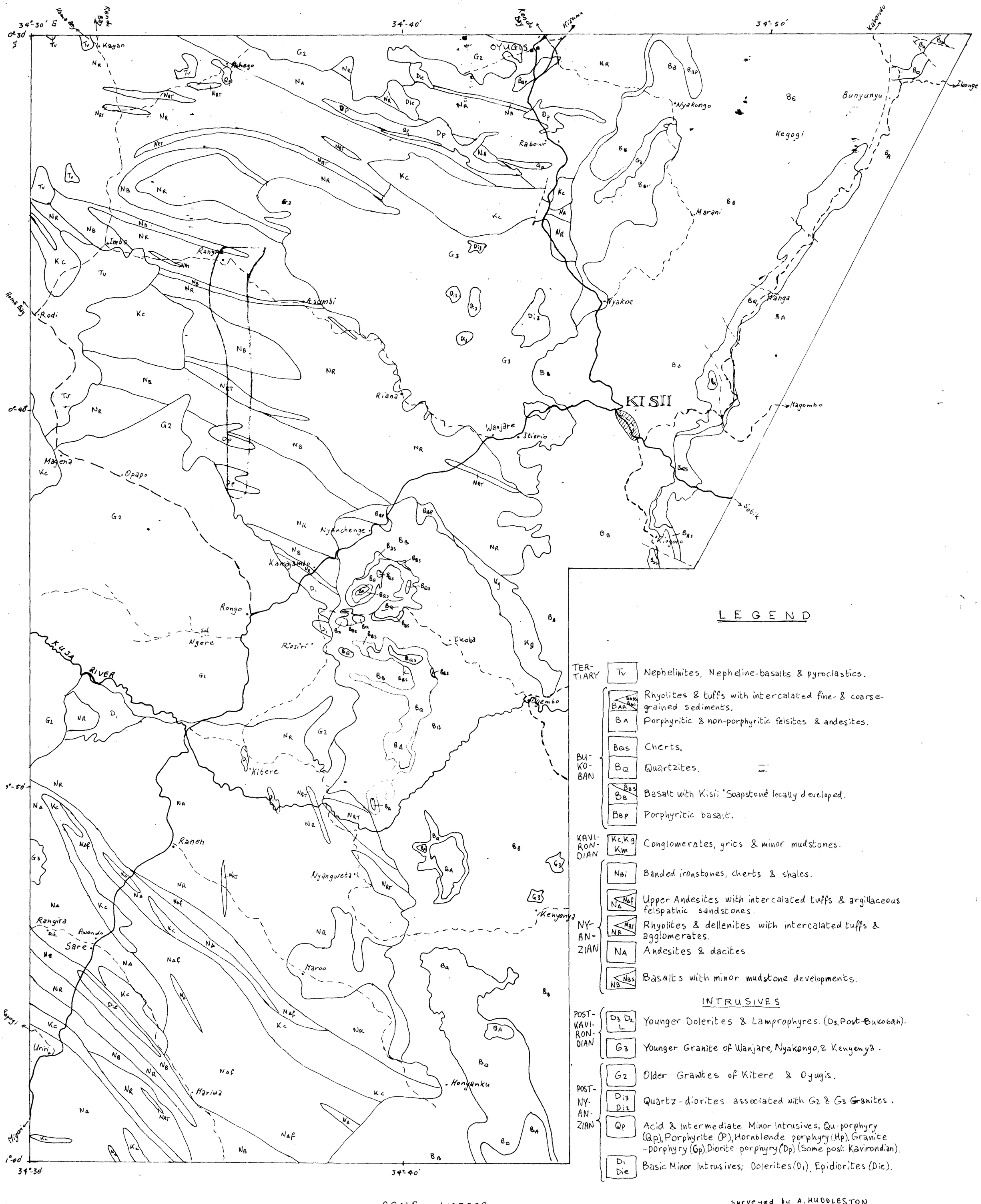
GEOLOGICAL MAP OF THE KISII DISTRICT (partly)



LEGEND

TERTIARY

- Tv — Nephelinites, Nepheline-basalts & pyroclastics.

BUKOBAN

- BAR — Rhyolites & tuffs with intercalated fine- & coarse-grained sediments.
- BA — Porphyritic & non-porphyritic felsites & andesites.
- Bqs — Cherts.
- BQ — Quartzites.
- BB — Basalt with Kisii "Soapstone" locally developed.
- BBP — Porphyritic basalt.

KAVIRONDIAN

- Kc, Kg, Km — Conglomerates, grits & minor mudstones.

NYANZIAN

- NBi — Banded ironstones, cherts & shales.
- NA — Upper Andesites with intercalated tuffs & argillaceous felspathic sandstones.
- NR — Rhyolites & dellenites with intercalated tuffs & agglomerates.
- NA — Andesites & dacites.
- NB — Basalts with minor mudstone developments.

INTRUSIVES

POST-KAVIRONDIAN

- D3 D2 L — Younger Dolerites & Lamprophyres. (D3, Post-Bukoban).
- G3 — Younger Granite of Wanjare, Nyakongo, & Kenyenya.

POST-NYANZIAN

- G2 — Older Granites of Kitere & Oyugis.
- Di3 Di2 — Quartz-diorites associated with G2 & G3 Granites.
- Qp — Acid & Intermediate Minor Intrusives, Qu-porphyry (Qp), Porphyrite (P), Hornblende porphyry (Hp), Granite-porphyry (Gp), Diorite-porphyry (Dp) (Some post-Kavirondian).
- D1 Die — Basic Minor Intrusives; Dolerites (D1), Epidiorites (Die).

SCALE 1:125,000

0 1 2 3 4 5 6 7 8 9 10 KILOMETRES

surveyed by A. HUDDLESTON, geologist, between August 1947 & May 1949