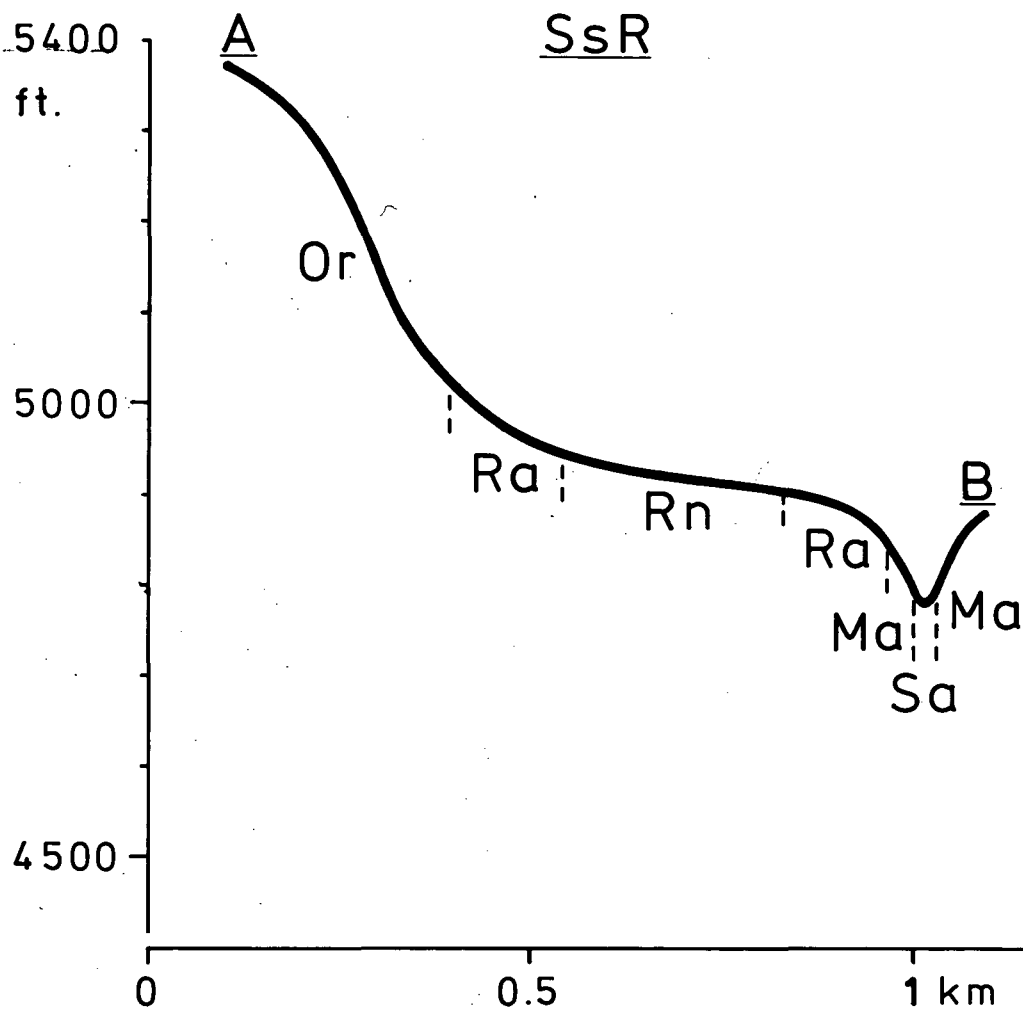


# TRAINING PROJECT IN PEDOLOGY

KISII

KENYA



A detailed soil survey of the  
Ranen area

PRELIMINARY REPORT NO 16

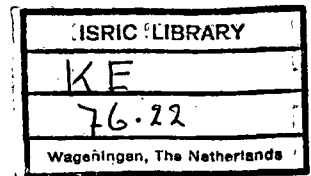
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**A DETAILED SOIL SURVEY OF**  
**THE RANEN AREA**

by

**J. van Keulen**

and

**H. van Reuler**

**Preliminary report no. 16**

**December 1976**

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**TRAINING PROJECT IN PEDOLOGY, KISII KENYA**  
**Agricultural University, Wageningen - The Netherlands**

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## Preface

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

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

The project in Kisii is conducted by :

Ir. W.G. Wielemaker, Teaching and research

Ing. H.W. Boxem, Management.

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

This report is the result of a detailed soil survey of the Ranen area carried out by Mr. J. van Keulen and Mr. H. van Reuler, who also wrote the report. The field work was carried out under guidance of Mr. W.G. Wielemaker. Mr. Boxem corrected the text of the report and compiled it into this presentation.

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

The supervisor of the project  
J. Bennema, Professor of Tropical Soil Science

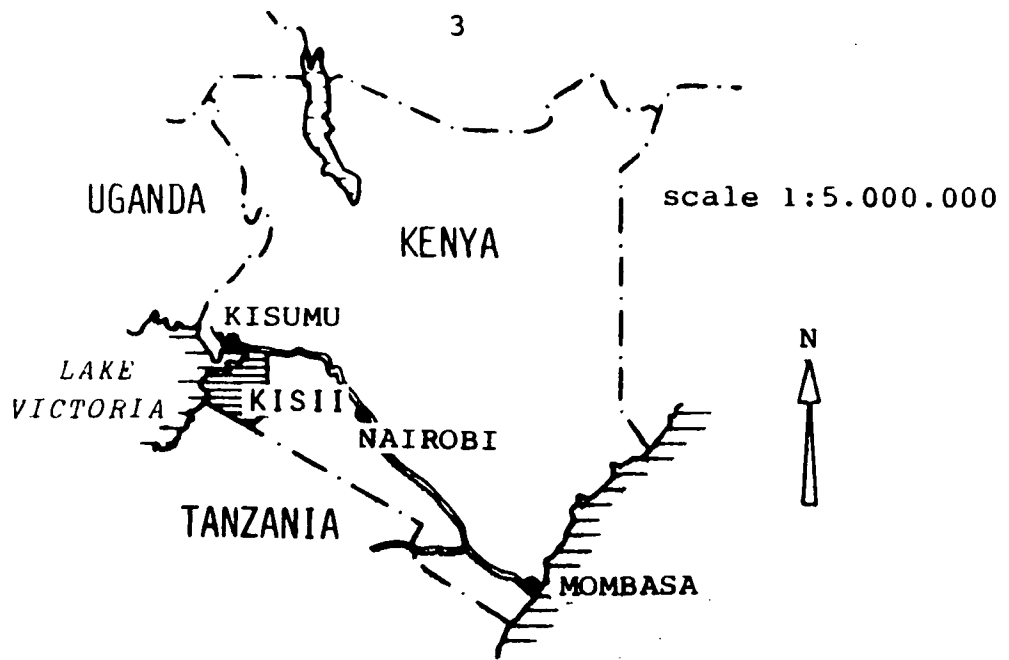


Fig.1.1 Location of the project area within Kenya.

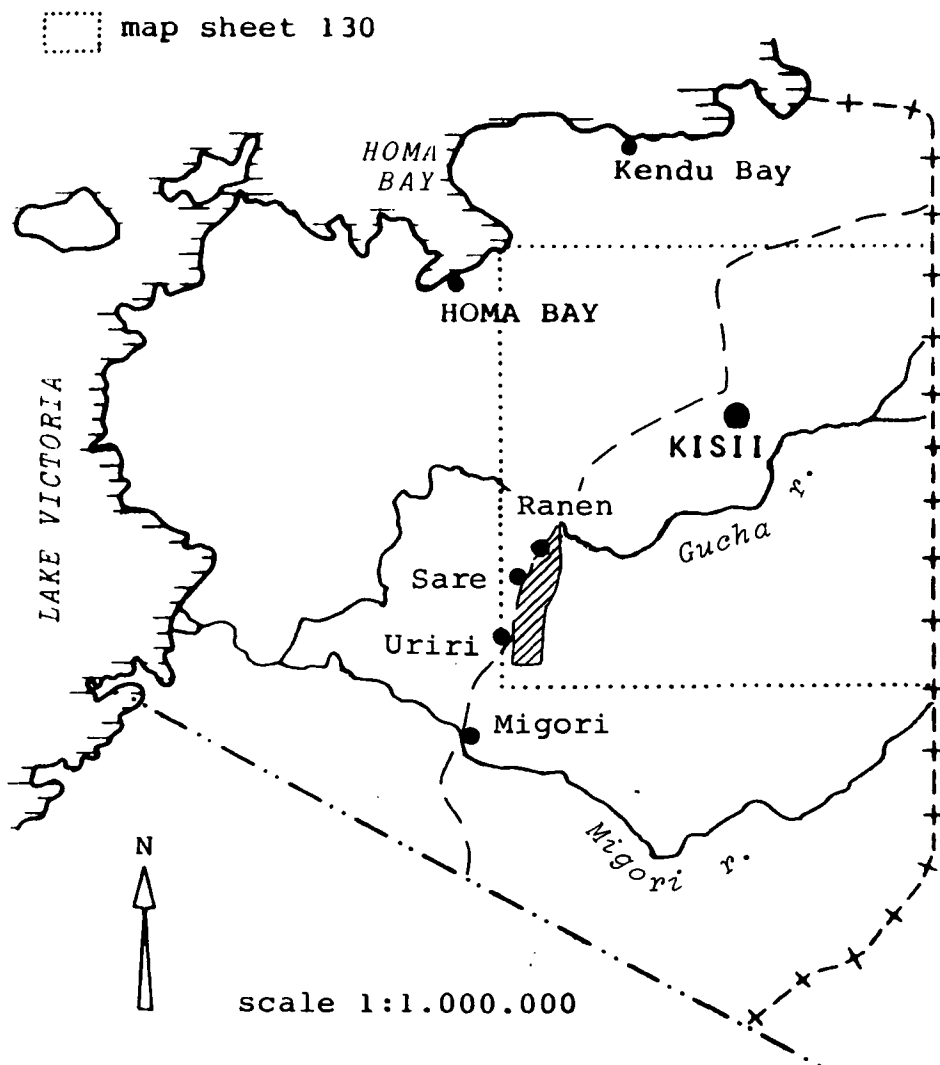


Fig. 1.2 Location of the survey area.

## 1 The Environment (PART I).

### 1.1 Location and extent

The survey area is situated South West of Kisii Highlands where the Luo tribe is living. The area is covering parts of the East Nyokal and Kanyamkago location of the South- Nyanza district (Nyanza province).

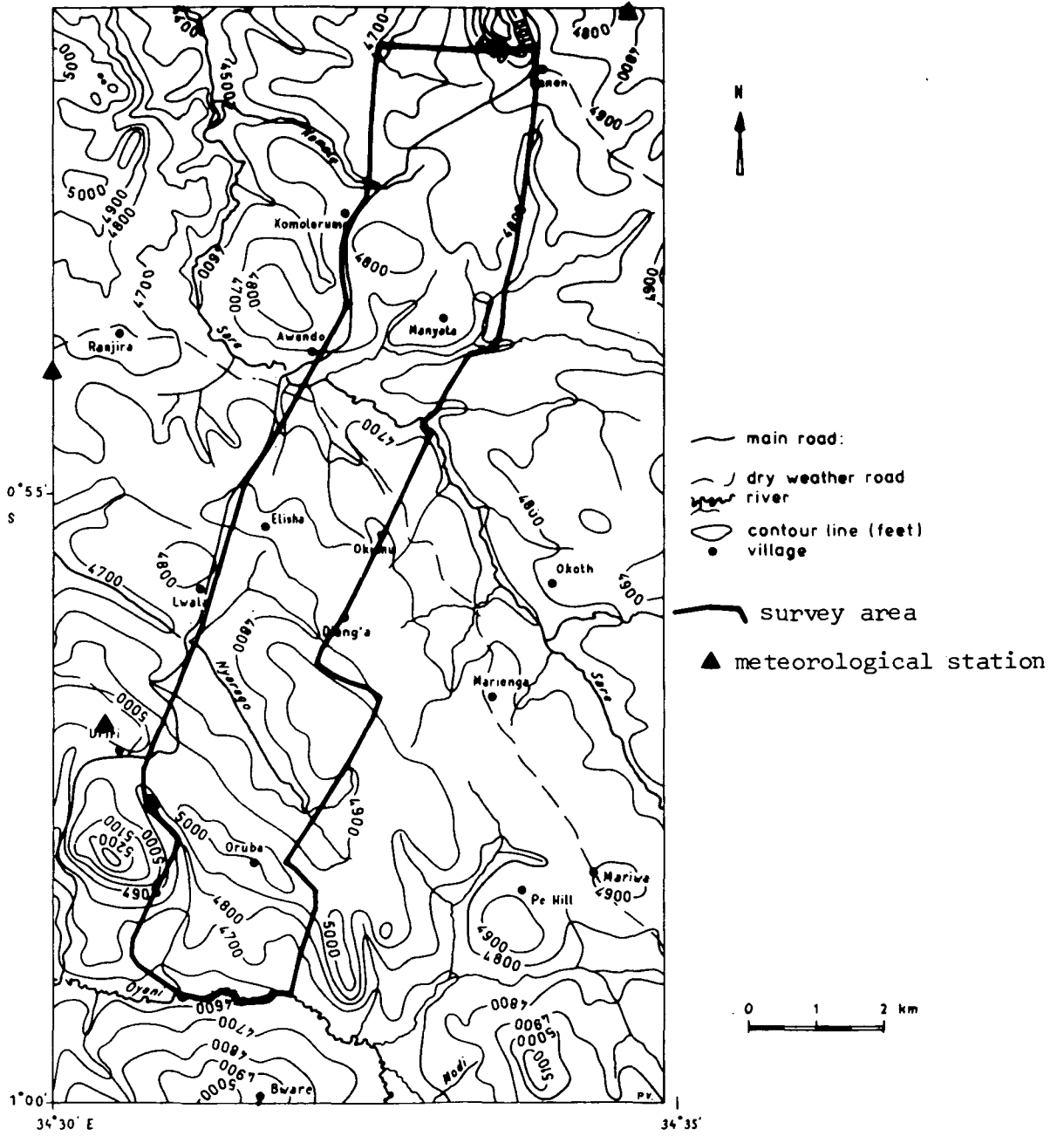
It is roughly situated 100km S. of Kisumu, 45km S.E. of Kisii, 65km E. of Lake Victoria and 50km from the Tanzania border. It is found between  $34^{\circ} 30'E$  and  $34^{\circ} 35'E$  between  $0^{\circ} 50'S$  and  $1^{\circ} - 00'S$ . On the topographic 1:50.000 maps of Kenya it occurs on the 'Kitere sheet' (130/3) between 669 and 674 km E. and 9891 and 9906 km N.

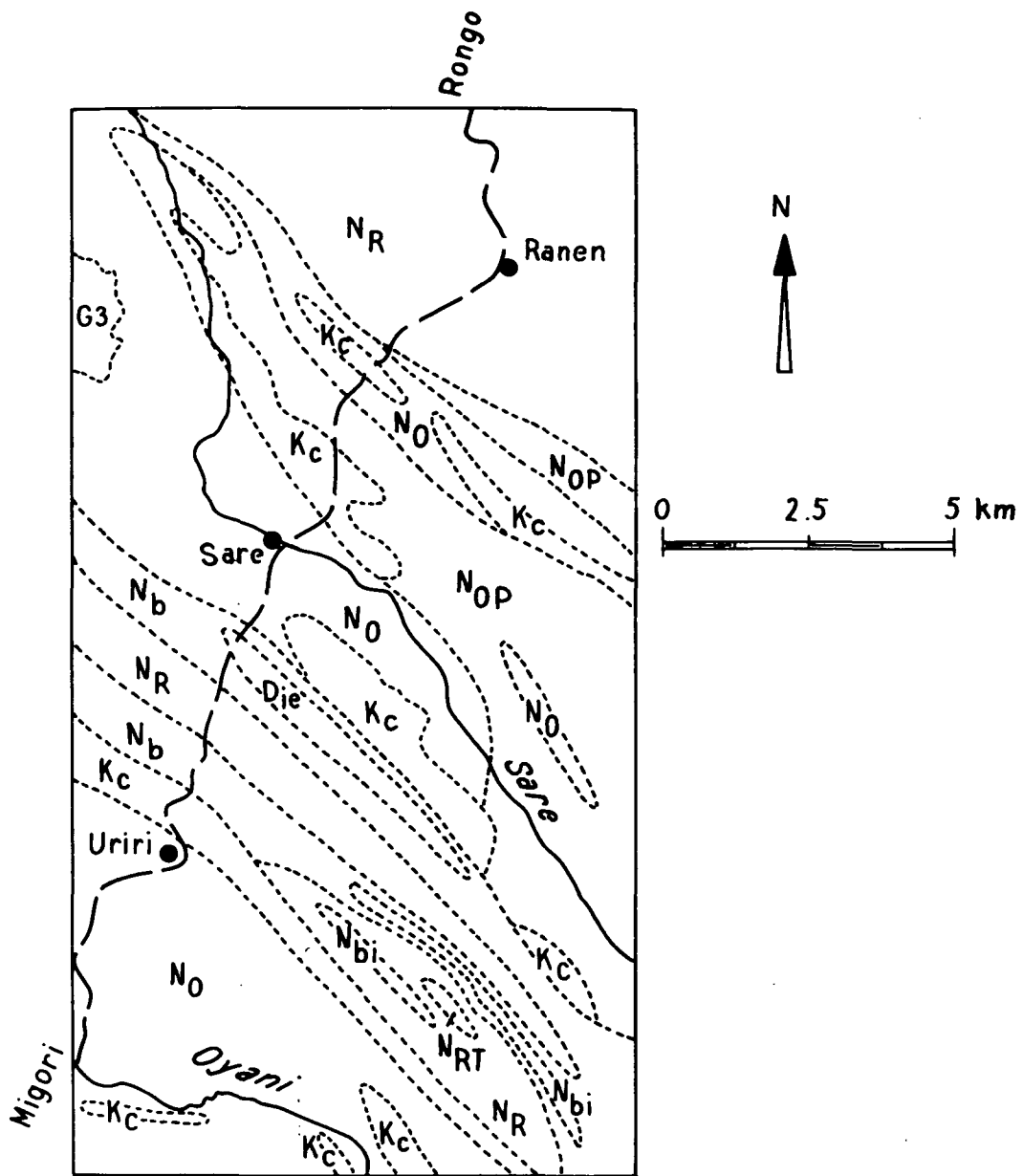
The survey area occupies a strip of about 2.5km wide along the road Tanzania from Ranen to the Oyani river (14km). Mostly - lying on the east side of it. The total surveyed area covers 3500 ha. The elevation ranges between 4600 and 5400 ft. above Mombasa sealevel (1400 - 1650M).

### 1.2 Climatic condition

Three meteorological stations are more or less situated in the neighbourhood of the survey area, Uriri, Rapogi and Kitere. The one at Uriri is nearest. The rainfall is bimodal, highest peak in April, May and a second less important peak in October / November.

January or January and February and July are dry. Only little is known about the evaporation. Van Mourik (12) gives some data. For this area 120 - 150 mm seems to be a reasonable estimation for the monthly evapotranspiration.





after A.Huddleston

Fig. 4 Simplified Geological Map

Legend

Kavirondian system:	K <sub>c</sub> -conglomerates	Nyanzian system:	N <sub>O</sub> -andesites
Nyanzian system	: N <sub>b</sub> -basalt		N <sub>OP</sub> -andesites with intercalated tuffs and sand stones
	N <sub>R</sub> -rhyolites		N <sub>bi</sub> -banded ironstones cherts and shales
	N <sub>RT</sub> -rhyolites with intercalated tuffs and agglomerates	Intrusives:	Post-Kavirondian: G <sub>3</sub> -granite
			Post-Nyanzian: D <sub>ie</sub> -epidorites

### 1.3 Geology and Parentmaterial

According to the geological map after A. Huddleston (1948) the area is made up of Nyanzian and Kavirondian rocks, which are of pre-Cambrium age.

Nyanzian system is entirely composed of rhyolite, andesite and basalt with minor local developments of tuffs and agglomerates, some thin bands of very fine grained sedimentary cherts and banded ironstones.

Kavirondian system is a series of discontinuous lenses of sedimentary material ranging from coarse boulder conglomerates through grits and sandstones to fine-grained mudstones and shales.

Description of the units which occur in the survey area.

Nyanzian system:

**Nb-Basalt** ; the basalt occurs in two rather narrow strips south of the Sare river. Unweathered outcrops are scarce, the rock has a dark grey-green colour.

**Nr-Rhyolite** ; the rhyolites are prominent in the northern part of the area on the map of Huddleston this type of rock forms the greatest proportion of the Nyanzian system. The colour range from creamy white to pinkish

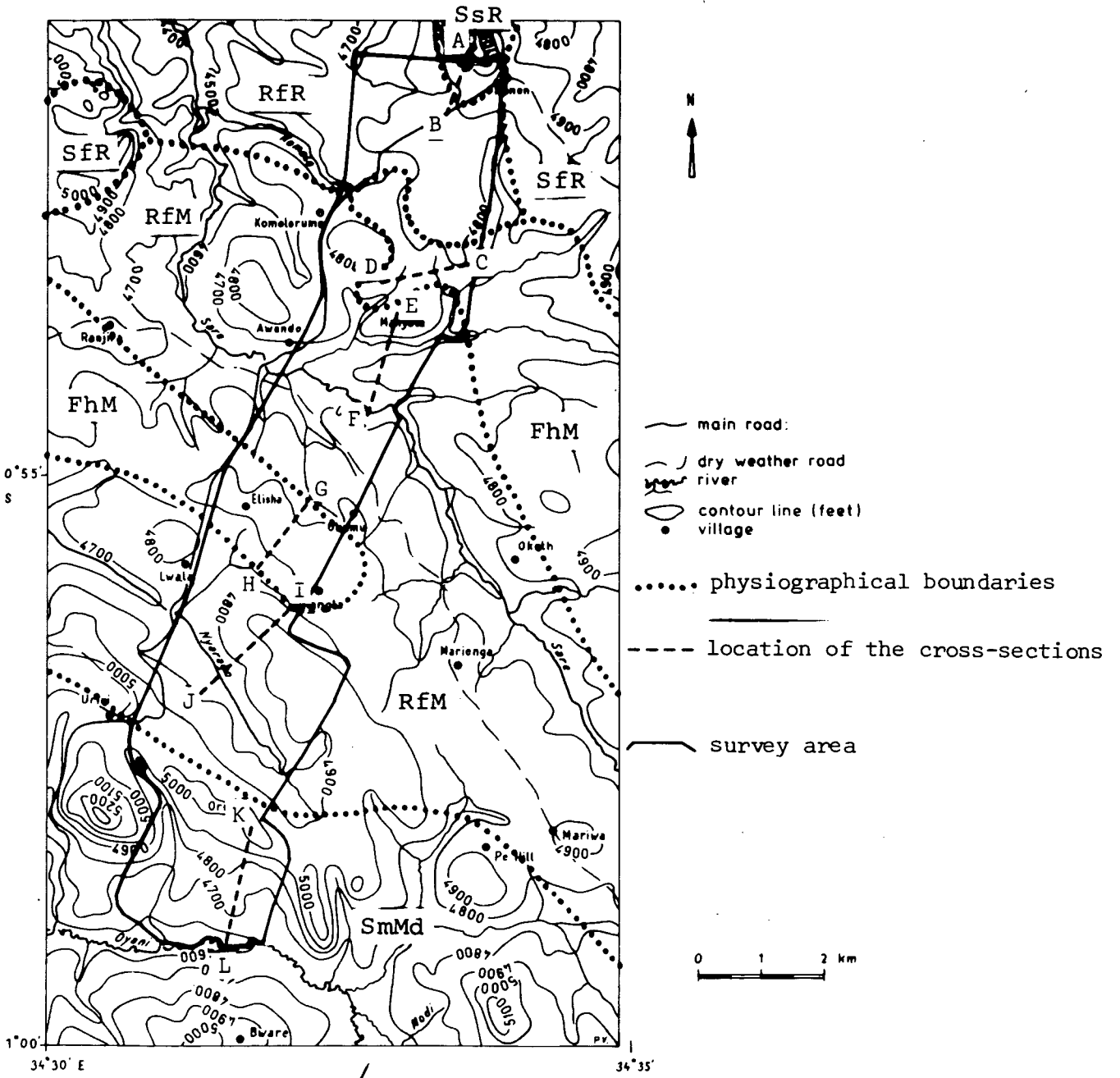
**No-Andesite** ; with intercalated tuffs and agglomerates:

These rocks are considered to be the youngest Nyanzian rocks exposed in the area. The andesite has a green colour.

The Nop type is only seen in the Sare area. They are mapped as two bands separated by conglomerates and andesite but are probably one band, repeated by folding.

Kavirondian system:

**Kc-Conglomerate**; about twenty different rock types occur as boulders in the conglomerates, ranging in size up to 3 ft. diameter. The large size on many of the boulders suggested that the conglomerate was deposited under torrential conditions.





Intrusive

Post-Nyanzian:

Die-Epidorites, not described in the geological report.

#### 1.4 Physiography (see fig. 5)

For distinction of the different physiographic units we followed the legend of the physiographic map of W.G. Wielemaker (18).

In our area we distinguished four different units. These units are described as follows

- SsR ; landscape with stable (foot) slopes up to 20%, covered with deep red soils, with steeper tops than footslopes occupying up to 50% of the landscape, developed on Rhyolite (last capital refers to the parent material).
- RfR/RfM ; ridges with lateral slopes between 6 and 20% covered shallow to moderately deep reddish soils with tops less steep than footslopes developed on Rhyolite and different parent materials like andesite, conglomerate and rhyolite.
- FhM ; (flat to) slight undulating landscape with maximum slope of 5%, developed on mixed parent material.
- SmMd ; landscape with stable (foot) slope to 20%, covered with deep red soils, with steeper tops footslopes occupying up to 30% of the landscape, with deeply incised rivers which have strong lateral slopes developed on mixed parent material.

For this particular area in detail this means:

- SsR ; The steep Ranen hill (about 25%) covered with shallow gravelly soils, with footslopes of about 10% having deep red soils and narrow V-shaped valleys.
- RfR/RfM ; Undulating ridges (5-8%), covered with shallow and moderately deep soils, with rather broad flat hydromorphic valley bottoms. In this area near Sare the ridges are lower and slopes are shater than in the northern and southern area. In the southern area the upper part of the valley's is narrow and dry.
- FhM ; The flat to slight-undulating area north of Sare is formed by very wide flat to slightly undulating

hydromorphic valley heads and bottom with some small gently undulating to undulating ridges (slopes up to 6%). South of Sare a hydromorphic plateau with lateral slopes up to 6% is situated.

-SsMd : Steep hills (15 - 30%) with shallow and stony soils and undulating to rolling footslopes and ridges (7-10%) The later being strong influenced by the Oyani river. Consequently there is a clear general slope towards this river. Because of this strong influence most soils are moderately deep to shallow and gravelly.

### 1.5 Hydrology (fig. 2)

The survey area is drained by the Sare and Oyani river and their tributaries like the Komenya, Komolo and Nyarango, which are very small.

Almost the entire area is drained in north eastern direction, except for a small part of the Ranen hill which is drained southwards to the Sare river (streaming NE) and the area south of Uriri which is draining straight southwards to the Oyani river (streaming E). In general the area is well drained although most of the rivers, and tributaries have a rather broad flat bottom with poor drainage conditions.

The only rather big areas with poor drained conditions are a complex of very wide flay valley heads and bottoms NE of Sare market and a plateau south of Sare market.

### 1.6 The soils (see fig. 5,6,7 and the soil map)

In this chapter a brief description of the soils of the area is given and their relation to the physiography and parent material if present. In general it can be stated that only a weak relation between soil and parent material is found (based on field observations may be the chemical data will bring another view). On the other hand we find a rather strong relation with the physiography. The soils are dealt with according to the physiographic units from North to South.

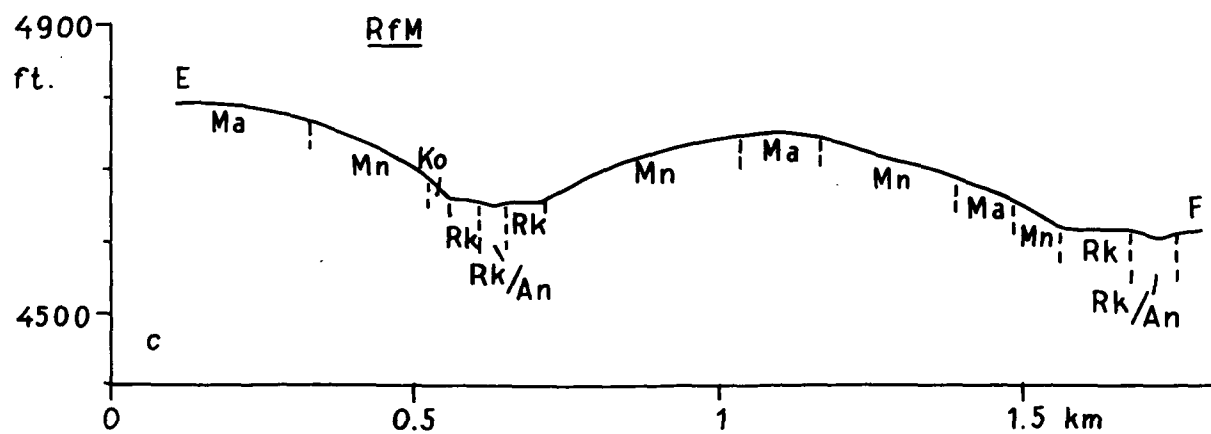
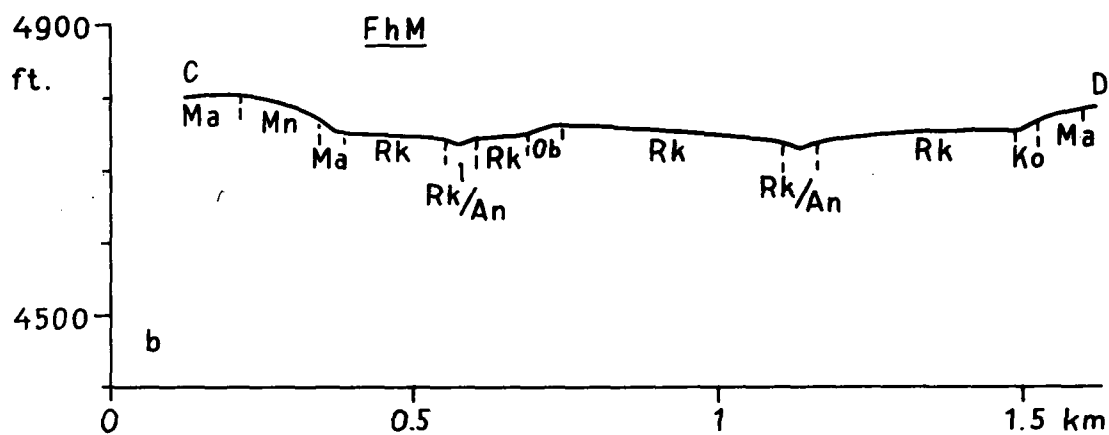
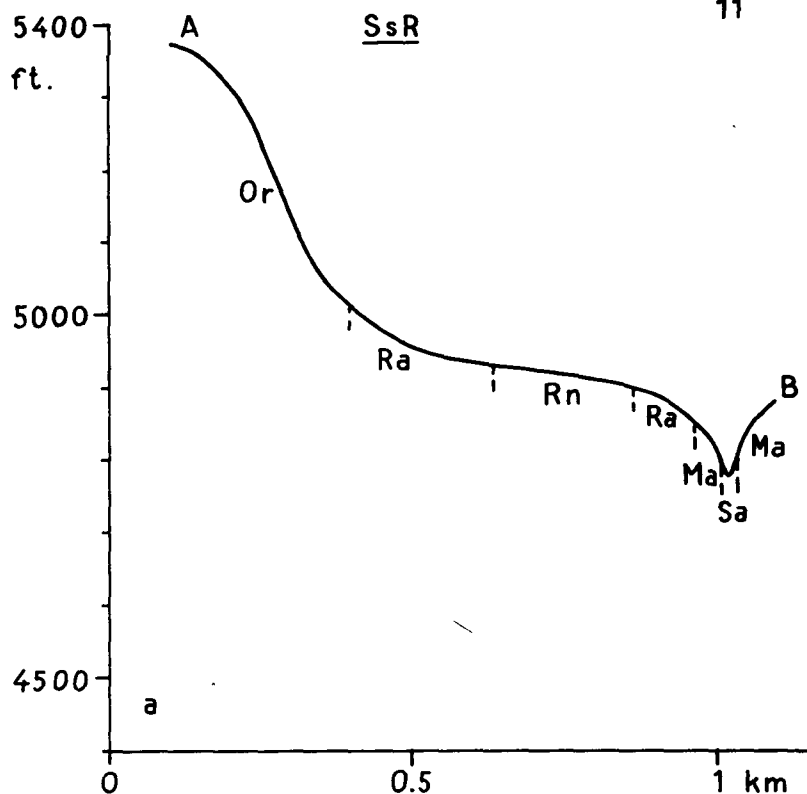


Fig. 6 (a,b,c): the relation between soil series and physiography, every figure representing one physiographic unit, locations of cross sections shown on the physiographic map (Fig.5)

The Northern part of the survey area (physiographic unit: SsR, see fig. 5,6a) is dominated by the Ranen hill, a rather high hill (5350 ft.) with steep slopes ( $\pm$  20%). These slopes are covered with mainly very shallow gravelly soils (lithosols and regosols - Oreru series (O)). On slopes up to 5%, the less deep ones (luvisols-Rabuor series (Rn)) on steeper slopes. The very deep soils are also found around valley heads on slopes steeper than 5%. The valleys are V-shaped and narrow with moderately deep to shallow gravelly soils on the valley slopes (cambisols, phaeozems-Marando series (Ma)) and a small strip of fluvisols at the bottom (Sare series (Sa)). The gravelly soils are also found on some low ridges in this part of the area.

To the south the landscape is changing in one with ridges (RfR, see fig. 5), the ridges are rather low with broad valleys. Which kind of soil occurs depend on the slope percentage.

On the tops and on the steeper slopes (5-8%) rather shallow gravelly soils occur (cambisols, phaeozems - Marando series (Ma)) sometimes very shallow gravelly soils occur on the tops (lithosols- regosols - Oreru series (Or)). On slopes up to 5% moderately deep to deep red soils occur (luvisols- Ranen series (Ra)). Only on some isolated places with very low slope gradients (0-3%) very deep red soils occur (luvisols - Ranen series (Rn) . In the broad valley's poorly drained soils with an abrupt textural change below a bleached horizon are found (planosols- Riana Kuna series (Rk)). This kind of soil also occurs in some isolated more or less rounded areas with poorly drainage conditions surrounded by well drained soils. The transition between the dry and wet soils is often accompanied by ironstone on a certain depth or at the surface (petroferric cambisols-Kokuru series (Ko)).

The beds of the streams have dark gray heavy clay soils (gleyic luvisols- phaeozems- Aornam series (An)) which are shown on the map in an association with the planosols which occur on the slopes near stream, having a textural change on minor depth, within 40cm, see also fig. 6b+c. In the above described units the parent material generally consist of Rhyolite (see fig. 4). In the rest of the survey area andesite is the dominating parent material.

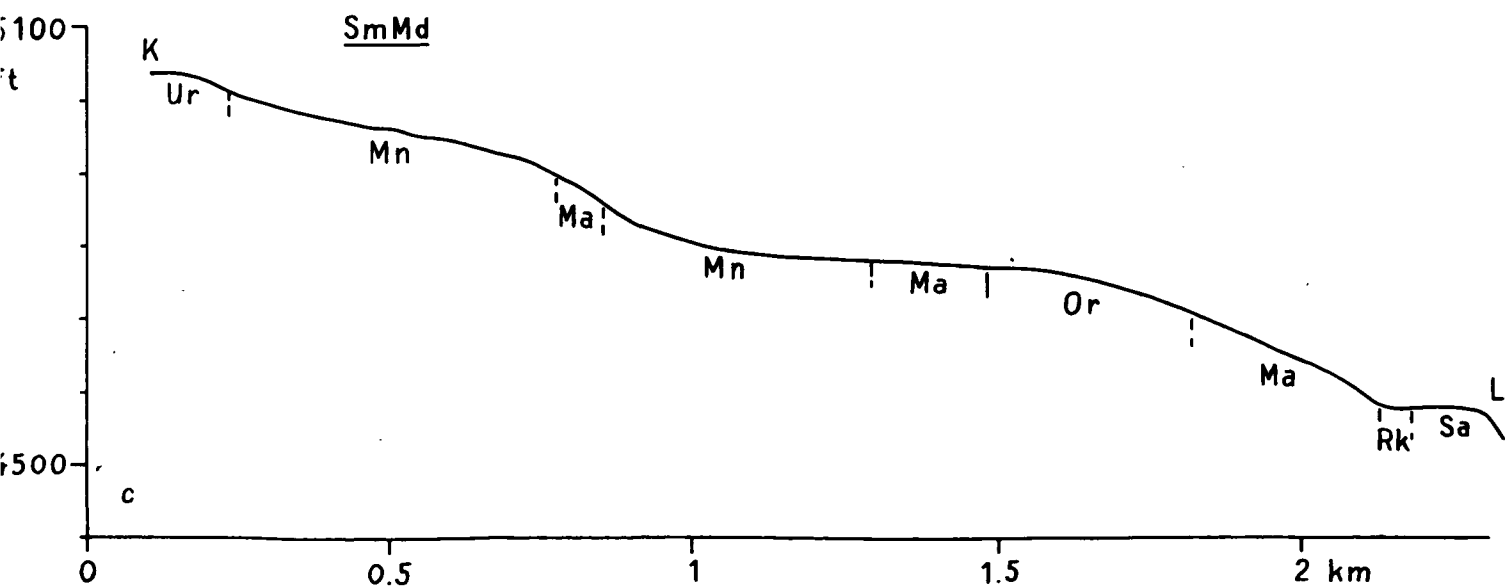
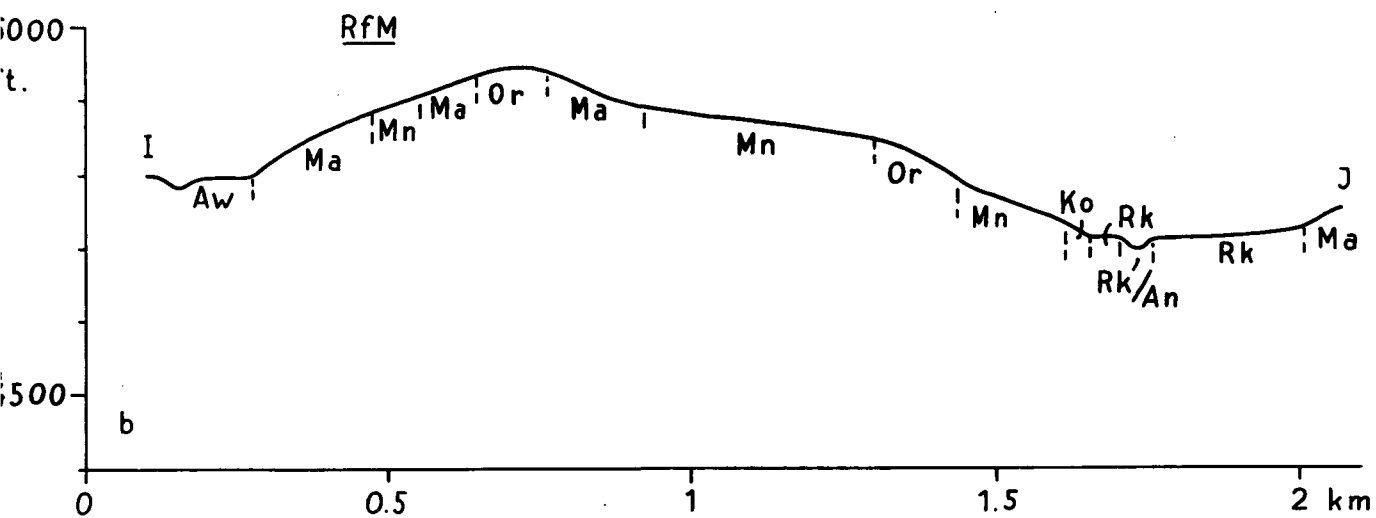
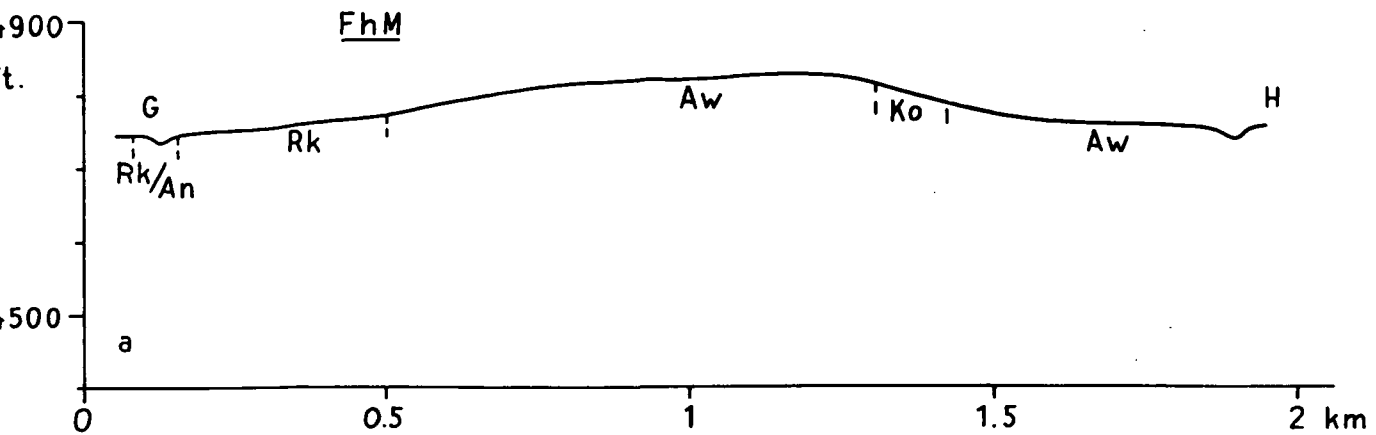


Fig. 7 (a,b,c): the relation between soil series and physiography, every figure representing one physiographic unit, Locations of cross sections shown on the physiographic map (Fig. 5)

In the other physiographic units the soils are less red (mostly 5 YR instead of 2,5 YR). Also the rotten rock horizons are never as thick as in the Rhyolite area (less than 50cm). Therefore the 'red' soils are separated in different soil series. Other soils are more or less similar except for some very shallow 'Andesite' soils in the south which are not gravelly but very stony and rocky.

The first flat (FhM) landscape (see fig. 5+6b) can be considered as a continuation of the broad poorly drained valley's in the ridges landscape. Similar soils occur mainly planosols, the depth of the textural change is highly variable on the flatter parts (0-3%), on steeper slope most of the times less than 40 cm. On some higher places somewhat dryer gravelly soils often with ironstone occur (Luvisols and Regosols - Kokuru series (Ko)). Two small low hills are found in this area, disturbing the general character of this physiographic unit, which are having similar soils. Infact they belong to the landscape of the ridges.

South of this area the ridge type landscape returns (RfM, see fig. 5+6c) with some slight differences from the northern one. The ridges are somewhat smaller and more flat, and the hydromorphic valley's are larger. Due to this fact, slopes are never very long (200m) making the map rather complex. Conform to the northern ridges on top of the ridges and on steeper slopes rather shallow gravelly soils are found (cambisols, phaeozems- Marando series (ma)) sometimes very shallow soils are found on the tops. Slopes up to about 5% are covered with the 'brown' moderately deep to deep red soils (luvisols- Manyata series (Mn)). In the valley's planosols are found. Near the Sare river a small strip of fluvisols is found. No very deep red soils occur in this area.

South of this unit another kind of flat (FhM) unit occurs (see fig. 5+7a) unlike the another one it is a kind of plateau covered with dark poorly drained soils with vertic characteristics (Vertisols - Awundo series (Aw)). Slope towards the plateau are slightly undulating up to 3% and long 400m).

On the slopes towards the plateau the same soils occur except on places where the slopes are deeper (3-5%) or sometimes on the transition between plateau and slope where drier soils occur. Sometimes these soils are gravelly and moderately well drained (phaeozems- Oboke series (Ob)) sometimes they are well drained and red (luvisols-Manyata series (Mn)). It is remarkable that the boundaries of this unit coincide with the boundaries of an area with basalts as shown on the geological map (fig. 4).

The southern RfM unit (see fig. 5+7b) resembles the northern area but the ridges are higher and the upper part of the valley's is narrow V-shaped and dry, having a rather big area of well drained deep red soils around the valley heads. Also a rather big area of very shallow and gravelly soils occurs of the top (lithosols, regosols-Oreru series (Or)). The lower part of the valley's and the rest having similar soils on similar places.

The utmost southern part of the survey area belonging to the SmMd unit (see fig. 5+7c) is dominated by the Oyani river. Near the Tanzania road Uriri hill is found (only a smaller part of it is mapped), which has about the same height as the Ranen hill. This hill is covered with shallow dark brown soils with boulders and rock outcrops (phaeozems and Cambisols - Uriri series (Ur)). The footslopes, also covering only a little part of the map have deep to very deep red soils (luvisols- Manyata series (Mn)). The bigger part of this area can be considered as one slope from the road Uriri - Oruba school (see fig. 2), towards the Oyani river.

On top, most of the times the same soils as on the Uriri hill are found. The higher part of slope has moderately deep to deep red soils (luvisols- Manyata series (Mn)). On the lower part, strongly influenced by the Oyani river, only gravelly soils occur.

Shallow to moderately deep gravelly soils (cambisols, phaeozems -Marando series (Ma)) and very shallow gravelly soils (lithosols, regosols Oreru series (Or)). The Oyani river is bordered with planosols (Riana kuna series (Rk)) and fluvisols (Sare series (Sa)). A rather big isolated area of ironstones occurs (Luvisols and Regosols - Kokuru series (Ko)).

## 1.7 Population, landuse and vegetation

### Population

The Luo tribe living in this area constitutes the largest group of the Nilotes and the second largest tribe in Kenya according to the 1962 population census.

This area was formerly inhabited by members of the Masai tribe who moved away 200 years ago. The Kisii tribe then occupied the area for about 2 generations and their turn were displaced by the Luo tribe. The Luo's came originally up the Nile river from Sudan and settles along the shores of Lake Victoria. The first settlers were engaged primarily in fishing later on when their number increased they start raising cattle and growing crops like sorghum, finger millet and sweet potatoes.

The houses were built on hills and ridges for protection against the raiding Masai. The population density is at the moment about 100-200 persons per square kilometer. The better drained area are preferred above the poorly drained area's.

### Landuse

The well drained parts of the area are, except for the very shallow and stony parts, for 100% cultivated. About one third of the land is fallow and used for grazing.

The poorly drained areas are used for extensive grazing.

Only where better, drier soils are rare, sometimes the 'drier' parts (higher or with a higher slope percentage) are used as cropland. Maize is by far the most important subsistence crop of the area. It is grown on different soil types. Millet and whimby are also grown but do not occupy a big area. Some beans are grown as an intercrop with maize. Some sweet potatoes and cassave are found (cassave especially on gravelly soils). Sugar cane is the most important cash crop in the area. It is grown on a great variety of soils, the deeper well drained to poorly drained soils. Bananas are found near the villages or at the lower part of the slopes near the streams. Groundnuts are grown often on gravelly soils and as an intercrop with maize.

In the area South of Uriri tobacco is the common cashcrop instead of sugar cane.



Some other less important cashcrops which are grown in the area are: coffee, sunflower, sisal and pineapple, only a few coffee fields are found and all of them suffered from a lack of management. Sisal is often used for demarkation of ones property, some neglected plantations are found.

Pineapple is only seen near Sare Uriri market.

On some places bricks are carved from ironstone or baked from sub-soil clay of the poorly drained areas.

### Vegetation

In the well drained part of the area hardly something of the original vegetation is found. Only in the poorly drained areas the probably original of grasses with scattered bushes on termite mounds has remained near rivers and streams often a dense bush vegetation is found. According to the Climate and Vegetation map (1:250.000) the vegetation can be seperated in two types.

W.S-Western Combretum savannah zones

W.D-Western Diospyros forest zone

The boundaries of the last type coincide with the boundaries on the soilmap of the area with impeded drainage, roughly situated around Sare.

## 2 The Soils

### 2.1 Survey methods

The procedure followed for this detailed soil survey was a physiographic airphoto interpretation of a small area which was checked in the field the day after the interpretation, followed by correction and drawing of the final soil boundaries on the photo. The interpretation was carried out with airphoto's (scale 1:12,500 obtained from the survey of Kenya (photo's northern part from 1966, southern part of 1971) and a Topcon stereoscope. Supplementary information has been taken from the geological map (1951, scale 1:125,000) and the topographical map, sheet 130/3 Kitere (1962, scale 1:50,000). The most important elements for the interpretation were relief and landuse.

The fieldwork implied augerhole and profile pit observations. About 2000 augerings have been made if possible to a depth of 2.00m with an Eldeman soil auger. The following aspects of soil and surrounding were observed like soil depth and thickness of the horizons, colour of the soil (Munsell colour charts), texture and stoniness of the horizons, parent material, surface stoniness and rockiness, slope form and slope gradient (measure with an 'Abney level'), vegetation and landuse.

For every soil series observations have completed with at least one detailed description of a soil profile. About 25 pits were dug and described (depth's varying from 50 to 200 cm)

The profiles have been described using 'Soil Profile Descriptions Forms' with Guidelines (1974) of the Kenya Soil Survey Project derived from the Soil Survey Manual (1952) and the F.A.O. Guidelines for soil profile description)

Soil samples were taken for analyses. From some interesting profiles soil peels have been made. Finally a detailed soil map (scale 1:12,500) has been made. First a base map was prepared with the slotted template method using the airphoto's and information from the topographical map. The soil boundaries and other data were transferred from the photo's to the base using a sketchmaster (vertical sketchmaster of Keuffel and Essen). Four maps are produced, a soil map, a map for the location of the augerings and profile pits and two land suitability maps.

The landsuitability maps have been made with help of the soil map after a study of the suitability of the different soil series for several crops.

## 2.2 Criteria for distinction of series, types and phases.

The main criterion for the distinction of the different series is the drainage class. The soils of the area are divided in 4 classes according to the Soil Survey Manual: poorly, imperfectly to moderately well, well and (somewhat) excessively drained soils.

The poorly drained soils are subdivided according to the presence of an abrupt textural change of vertic characteristics:

- soils with an abrupt textural change
- soils without an abrupt textural change and with vertic characteristics
- soils without an abrupt textural change and with vertic characteristics.

The imperfectly to moderately well drained soils are subdivided according to the parent material:

- soils developed on rock (partly covered with ironstone)
- soils developed on riverdeposits.

The well drained soils are subdivided according to the soildepth, presence of diagnostic horizons, colour, type and weathering of the material.

I deep to very deep (more than 100 cm) soils with an argillic B-horizon,

- hues 2,5 YR and a thick layer of rotten rock occurs.

subdivided in soils with an argillic -B less deep and deeper than (150 cm.1)

- hues yellower than 2,5 YR and a thin or no layer of rotten rock

II moderately deep soils (50-100cm) with a cambic or sometimes a thin argillic B horizon.

III shallow to very shallow soils (less than 50 cm)

- on andesite
- on ironstone

The names of the series are derived from places in the Ranen area or sometimes from the Rangwe area (3) as the series are more common in that area.

The criterion for the distinction of the soil type is the clay percentage of upper 6 inches (or approximately equivalent to the cultivated surface layer of arable soils) there are 3 types:

- A clayey (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 criterions for the distinction of the phases are soil depth, slope percentage, percentage stoniness and rockiness and for poorly drained soils the depth of the textural change.

The following classes are used,

soil depth	: 0-20, 20-50- 50-100- 100-150 and more than 150 cm deep
slope	: 0-3, 3-8, 8-15, 15-30, 30-65 and more than 65%
stoniness	: 0-3, 3-15, 15-90, 90-100% stones
rockiness	: 0-2, 2-10, 10-25, 25-50, 50-90% rocks
depth of abrupt textural change	: 0-40, 40-80.

- 1) Remark. This division has been made because soils with an argillic B deeper than 150 cm might have to be classified as Nitosols. Clay percentage data however show that the clay percentage decreases with more than 20% from its maximum within 150 cm.

### 2.3 Explanatory Legend of the detailed survey

#### 1. Poorly drained soils

- Rk- Riana kuna series: Dark gray brown, heavy clay soils, with an abrupt textural change below a bleached horizon (Planosols)
- Aw- Awundo series : Black to dark gray, heavy cracking clay soils, having vertic characteristics (no abrupt textural change), developed on Basalt (Vertisols)
- An- Aoranam series : Dark gray, heavy clay soils, sometimes having an argillic B-horizon (Luvisols and Phaeozems)

#### 2. Imperfectly to moderately well drained soils

- Ob- Oboke series : Dark brown, gravelly, loam to clay soils with iron-manganese concretions, developed on rocks partly covered with ironstone (Phaeozems)
- Sa- Sare series : Dark brown, sandy loam to clay soils, developed on riverdeposite (Fluvisols)

#### 3. Well drained soils

##### A. Deep to very deep soils with an argillic B-horizon

- Rn- Ranen series : Reddish brown to red, clay to clay loam soils, B<sub>3</sub>- horizon starts deeper than 1.50 m, developed on Rhyolite rock (Luvisols)
- Ra- Rabuor series : Reddish brown to red (hue 2.5 YR), clay to clay loam soils, B<sub>3</sub>-horizon starts within 1.5m, overlying a thick (about 100 cm, or more) layer of weathered Rhyolite rock (Luvisols)
- Mn- Manyata series : Reddish brown (hue's yellower than 2.5 YR), clay to clay loam soils, overlying a thin layer of rotten rock or hard rock (Luvisols and Phaeozems)

B. Moderately deep soils, with a cambic or sometimes an argillic B-horizon

Ma- Marando series : Brown to reddish brown, slightly gravelly to gravelly clay to clay loam soils (Cambisols, Phaeozems and Luvisols)

C. Shallow to very shallow soils

Ur- Uriri series : Dark brown to reddish brown, extremely stony and rocky clay loam soils, with a boulder-like weathering, developed on Andesite (Phaeozems and Cambisols)

Ko- Kokuru series : Brown to yellowish brown, clay loam soils on ironstone (Luvisols and Regosols)

4. Excessively drained soils

Or- Oreru series : Very shallow to shallow, dark brown gravelly stony and rocky clay loam soils (Lithosols, Regosols and Cambisols)

SOIL ASSOCIATION

Plateau-River association (PR) ; 50% Aoranam and 50% Riana-kuna series.

Notice: If the parent material is not specified, the soil series is developed on various parent material, like rhyolite, andesite, conglomerate, basalt, e.o.

Each mapping unit is indicate with the symbols for series types and phases as shown below,

Abbreviated series name

Ra - A2

BR1- S1

textural class of the upper 6 inches

soil depth class or depth

class of the abrupt textural.

slope class      Surface Stoniness  
class

change (Riana-kuna series)

**Surface Rockiness class**

soil depth classes	slope classes	Surface Rockiness classes	(Surface Stoni- ness classes)
0- 150cm	A- 0- 3%	R1 - 0 - 2%	S1 - 0 - 3%
1- 100 - 150cm	B- 3- 8%	R2 - 2 -10%	S2 - 3 -15%
2- 50 - 100cm	C- 8-15%	R3 -15 90%	S3 -15 90%
3- 20 - 50cm	D-15-30%	R4 -90-100%	S4 -90-100%
4- 0 - 20cm	E-30-65%	R5 -50- 90%	
	F- +65%		

textural classes of the upper 6 inches

A - clayey (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)

depth of the abrupt textural change

0 - 0-40 cm.

1 - +40 cm.

#### 2.4. Description of the soilseries and its range in characteristics

Rk- Riana kuna series (see Appendix I, profile 4, 13, 14, and 16)

Surface in ha: 573 (16%)

The Kuna series are poorly drained dark gray to dark brown clay soils with an abrupt textural change below a bleached horizon.

Classification: Soil Taxonomy (1970) : (Albic) Tropaqualf

F.A.O. (1974) : Eutric Planosol

##### Profile characteristics:

Poorly drained, soil depth in general more than 150 cm.

The A1-horizon has a thickness of 5-25 cm., dark gray to very dark grayish brown colours (hues 7.5 and 10 YR, values 3-4, chroma's 1-2) with few to common weak brown mottles, a silt loam texture and a very fine subangular blocky structure and clear boundary.

The A2-horizon has a thickness of 5-50 cm., dark gray to light brownish gray colours (hues 7.5 YR 10 YR, values 4-6, chroma's 1-2) with many fine distinct mottles, a siltloam texture, a fine subangular blocky structure and an abrupt boundary often accompanied by yellow to reddish mottles and / or iron/manganese concretions.

B2-horizon has a thickness of 50-100 cm, dark gray colours changing to gray to grayish brown downwards (hue 7.5 and 10 YR, values 4 in top, down 5, chroma's 1-3) with many fine prominent red orange to yellow mottles in top changing to yellow brown mottles, sometimes also black mottles occur, a clay texture, often a coarse prismatic structure composed of fine angular blocky structure, many interesting slickensides, and a gradual boundary.

B3- horizons, if present, has the same colours as the lower part of the B2-horizon, together with various rotten rock colours, texture decrease with the depth from about 70% clay to 3% clay, percentage gravel increases with the depth, some lime may be found.



**Environmental characteristics**

**Physiography:** the series is found on slight undulating plains, in rather flat and broad valley bottoms and in some small areas which have poor drainage. Slope percentage ranges from 0-5%.

**Geology:** the series is formed on several parent materials.

**Landuse and vegetation:** The use of these soils is limited because of the frequent excess of water.

The biggest part of the surface which is covered with this soil type is used for extensive grazing. The natural vegetation is still present consisting of grasses and scattered shrubs on termite mounds. Sometimes better drained parts (higher slope percentage) are used for growing sugar-cane and maize.

**Erosion:** whereas the slope gradient is normally low and a vegetation cover is present surface run-off can not cause erosion.

Aw: Awundo series (see Appendix I, profile 6 and 25)

Surface in ha: 330 (11%)

The Awundo series are poor drained, black to dark gray, heavy cracking clay soils with vertic characteristics but without an abrupt textural change.

Classification: Soil Taxonomy (1970) : Entic Peludert  
F.A.O. (1974) : Pellic Vertisol

Profile characteristics !):

Poorly drained, soil depth generally more than 150 cm.

The A1-horizon has a thickness of 15-35 cm, very dark gray colours (hue's 7.5 and 10 YR, value 3, chroma 1), sometimes with dark brown mottles, a clay texture, a subangular blocky structure and an abrupt to clear boundary.

The B1-horizon has a thickness of about 30 cm. brown to dark grayish brown colours (7.5 YR 5/2-4/1) with strong brown mottles, a clay texture and an angular blocky structure, a clear boundary. The B2-horizon has a thickness of 40-100 cm., brown to dark gray colours (10 YR, value 4-5, chroma 1-3) with strong brown mottles intersecting slickensides and a gradual boundary towards the C-horizon or sometimes an abrupt boundary towards a R-horizon. The C-horizon has pale brown to greyish brown colours (10 YR, value 4-6, chroma 2-3), a light clay texture.

Environmental characteristics:

Physiography- the soils are found on a plateau and on the lateral slopes of this plateau. Slope percentage ranges from 0-4%.

Geology- the parent material of this series is basalt.

Landuse and vegetation: The major part of these soils is still having its natural vegetation which consists of grasses and scattered bushes. Sometimes the soils with some slopes are used for growing maize, sugar cane. The soils are difficult to cultivate.

Erosion: Because of the rather flat topography and because most soils are having their natural vegetation this series is not very susceptible to erosion.

1) the horizon designation, which differs from the usual A1C designation used for vertisols, already shows that these soils are not typical vertisols.

Ara-Nam series (see Appendix I, profile 1)

Surface in hectares: this series is only occurring in complex 55 ha complex (1.5%)

The Ara-Nam series are poorly drained heavy with dark gray topsoil and a dark gray mottled subsoil.

Classification: Soil Taxonomy (1970) : Typic Argiaquoll, Typic Tro-paqualf

F.A.O. (1974) : Gleyic Phaeozem, Gleyic Luvi-sol

## Profile characteristics:

Poorly drained, soil depth ranging from 100 to more than 150 cm.

The A-horizon has a thickness of 10-50 cm. very dark gray to very dark brown colours (10 YR, values 2-3, chroma's 1-2) with fine dark brown mottles, a clay to clayloam texture and fine subangular blocky structure, gradual to clear boundary.

The B2-horizon has a thickness of 70-140 cm. dark gray colours (10 YR, values 4-5, chroma's 0-1), common fine brown (7.5 YR 5/6) mottles, a heavy clay texture, a compound angular blocky structure breakable in strong fine angular blocks, may intersecting slickensides, gradual to clear boundary.

The B3-horizon has a thickness of 30-80 cm, gray to grayish brown colours (10 YR, values 5-6, chroma's 1-2), some greenish coloured pieces of rotten rock, a heavy clay texture, a coarse and medium angular blocky structure breakable in fine angular block, many intersecting slickensides.

## Environmental characteristics:

Physiography- this series is found in stream and rivervalleys in slightly undulating to undulating landscapes only as small strips along rivers in undulating to rolling landscapes. Slope percentage less than 6%.

Geology- the series can be developed on various types of parent materials.

## Landuse and vegetation:

The natural vegetation consists of grass with bushes and is only used for extensive grazing. Similar soils- Awundo series, but this soils have no light textured topsoil but are heavy textured

Ob: Oboke series (see Appendix I, Profile Ranen 20)

Surface in hectares 47: (1.5%)

Oboke series are imperfectly to moderately well drained, dark brown, gravelly, loam to clayloam soils, with iron-manganese concretions, developed on rocks partly covered with ironstone.

Classification : Soil Taxonomy (1970) : (Plinthic) Hapludoll

F.A.O. (1974) : Haplic Phaeozem (petroferic phase)

#### Profile characteristics

Imperfectly to moderately well drained, drainage class depending on the occurrence of impermeable ironstone and on the slope gradient. Soil depth ranges from 10-100 cm, most soils are however less than 50 cm deep. Surface gravel ranges from 0-30%, surface stoniness 0-10%, rockiness 0-3%. The A<sub>1</sub>-horizon has a thickness of 10-40 cm, very dark brown to dark brown colours (hues 7.5 and 10 YR, 2-3, chroma's 1-3), a slightly gravelly to gravelly loam to clayloam texture, a fine subangular blocky to granular structure, a clear to abrupt boundary. The B-horizon, if present, has a thickness of 30-70 cm, dark brown to dark grayish brown colours (hues 7.5 and 10 YR, values 3-4 chroma's 2-3), sometimes (in the imperfectly drained soils) with yellowish brown mottles (10 YR 5/6-8) gravelly loam to clayloam (gravels are rockpieces and iron-manganese concretions), a fine subangular blocky structure, a clear to abrupt boundary.

The C/R-horizon consist of (rotten) rock and often ironstone which is not always continuous) formed directly on this rock.

#### Environmental characteristics

Physiography- the series occurs on sloping edges of hydromorphic plains and on higher or sloping places within these plains. Slopes Percentage ranges from 0-6%. Geology- the series is formed on various materials.

#### Landuse, vegetation and erosion.

Large parts are used for grazing and still having its natural vegetation of grasses and scattered bushes. Small parts are cultivated. Generally the slope gradient is low and the subsoil drainage is high only on very shallow soils with steep slope erosion occurs.

**Sa: Sare series (see Appendix I, Profile Ranen 21)**

**Surface in hectares : 73 (2%)**

**The Sare series are imperfectly to moderately well drained, dark brown sandy loam to clay soils, developed on riverdeposites.**

**Classification : Soil Taxonomy (1970) : (Typic) Tropofluvent  
F.A.O. (1974) : Eutric Fluvisol**

**Profile characteristics**

**Generally imperfectly and sometimes moderately well drained soils, soil depth in general more 150cm.**

**The Al-horizon, if present, has a thickness of 10-60 cm, brown to dark brown colours (hue 7.5 and 10 YR, values 4-5 chroma's 1-2), with dark brown mottles, sandy loam to clay texture, a weak sub-angular blocky structure, a clear boundary.**

**The Cg- horizon is having reduction colours due to a high ground-waterlevel.**

**Environmental characteristics**

**Physiography- the series is found a long rivers and streams.**

**Geology- the series is formed on riverdeposites.**

**Landuse and Vegetation**

**The soils of this series are not often used for agriculture because they are usually covered with a dense bush-vegetation.**

**The moderately well drained soils are used for growing bananas, sugarcane and sometimes maize or millet.**

**Erosion**

**Because these soils are generally found on level places, often with their natural vegetation little or no erosion occurs.**

**Remark : The series is very variable so this description is not complete.**

Ra: Ranen series (see Appendix I, Profile Ranen 2)

Surface in hectares: 39 (1%)

The Ranen series are well drained, deep to very deep, reddish brown to red clay soils. B<sub>3</sub>-horizon starts deeper than 1.50 cm.

Classification: Soil Taxonomy (1970) : (Typic) Tropudalf

F.A.O. (1974) : Chromic Luvisol

#### Profile characteristics

Well drained soils, soil depth always more than 150cm. The A<sub>1</sub>-horizon has a thickness of 10-40 cm, dark reddish gray to dark reddish brown colours (hues 5 YR, values 3+4, chroma's 2+3), a clay (Occasionally a clay loam) texture, a granular to subangular blocky structure, a clear boundary. The B<sub>1</sub>-horizon has a thickness of about 40 cm, reddish brown to dark reddish brown colours (hues 5 YR, values 3+4, chroma's 3+4) a clay texture, a subangular blocky structure, a clear boundary. The B<sub>2</sub>-horizon has a thickness of more than 100 cm, always reaches a depth of more than 150 cm, reddish brown to red colours (2,5 YR 4/4-6), a clay texture, common to many moderately clayskins, a subangular blocky structure, a clear boundary. The B<sub>3</sub>-horizon, as indicated above, always starts deeper than 150 cm.

#### Environmental characteristics

Physiography- the series is formed on the rather straight middle part of footslopes and near valley heads, where they often have a dark topsoil. The slope percentage ranges from 3-8%.

Geology- the series is formed on Rhyolite rock.

Landuse and vegetation: The series is for nearly 100% cultivated and is used for all kinds of crops.

Erosion: Because of the high infiltration rate of the soils erosion will only occur where slopes are steep and vegetation absent. Similar soils are the soils of the Rabuor and Manyata series, which have about same characteristics, the B<sub>3</sub>-horizon only starts within 150cm. Remark: during the fieldwork we separated this soiltype from the other tropudalf within the back of our mind the definition of the Nitosols (F.A.O. system). The textural analysis showed however a higher decrease of the claycontent than allowed.

**Ra: Rabuor series (see Appendix I, Profile Ranen 11)**

Surface in hectares: 260 (7%)

Rabuor series are well drained, deep to very deep reddish brown to red, hues 2.5 YR, clay to clayloam soils with an argillic B-horizon, overlying a thick (about 100 cm, or more) layer of Rhyolite rock.

B3- horizon starts within 1.50 cm.

Classification : Soil Taxonomy (1970) : (Typic) Tropudalf

F.A.O. (1974) : Chromic Luvisol

#### Profile characteristics

Well drained soils, soil depth ranges from 70 cm, to more than 150cm

The A1-horizon has a thickness of 15-30 cm, dark reddish brown to weak red colours (7.5 YR 3/2, 5 YR 3/3-4, and 4/2-3, 2,5 YR 4/2), a clay to clayloam texture, a granular to subangular blocky structure a clear boundary.

The B1-horizon has a thickness of 10-30 cm, reddish brown to weak red colours (hues 5 and 2,5 YR, value 3-4, chroma's 2-4), a clay texture, some weak clay skins, a subangular blocky structure, a clear boundary.

The B2-horizon has a thickness of 15-100 cm, weak red to red colours (hues 2.5 YR, value 4, 3-5), a clay texture, with common moderately thick clayskins, a subangular blocky structure, a clear boundary.

The B3-horizon has a thickness of 20-50 cm, red to reddish brown colours (2.5 YR 4/4, 4/5) colours of weathered rock (mainly yellow and orange) and black iron-manganese concretions.

#### Environmental characteristics

Physiography- the series is found on footslopes and on the lateral slopes of ridges. Slope percentage ranges from 2-8%.

Geology- the series is formed on Rhyolite rock.

Landuse and vegetation: The series is for nearly 100% cultivated.

Erosion: Because of the high infiltration rate of the soils erosion will only occur where slopes are steep and vegetation absent.

Similar soils are of the Ranen series, which are deeper and the Manyata series, which are developed also on other parent materials and have colours browner than 2.5 YR.

Mn: Manyata series (see Appendix I, Profile 5,15,17,23 and(26))

Surface in hectares: 912 (26%)

Manyata series are well drained, deep to very deep, reddish brown hues' yellower than 2.5 YR, clay to clay loam soils with an argillic B-horizon, overlying a thin layer of rotten rock or hardrock.

Classification : Soil Taxonomy (1970): Tropudalf, (Lithic) Tropudalf (Typic) Tropudalf.

F.A.O. (1974): Chromic Phaeozems, Chromic Luvisol, Chromic Luvisol (Lithic phase).

Profile characteristics:

Well drained soils, soil depth ranges from 40-200 cm, but is in general less than 120 cm, surface stoniness range from 0-5%, rockiness from 0-2%. The A1-horizon has a thickness of 10-30 cm, dark brown to reddish brown colours (hues 7.5 and values 3,5-4, chroma's 2-3, sometimes slightly gravelly clay loam to clay texture, a granular boundary. The B2-horizon has a thickness of 20-130 cm. (in general less than 100 cm), reddish brown colours, hues 5 YR or somewhat redder, but never really 2.5 YR, value 4, chroma's 3-4, sometimes slightly gravelly clay to clayloam texture, a subangular blocky structure, a clear boundary towards a B3-horizon or abrupt boundary towards an R-horizon. The B3-horizon has a thickness of 0-30 cm, (sometimes the B2-horizon is directly overlying a continuous layer of boulders). The R-horizon is generally formed by a continuous layer of boulders which can give the soils a big range in depth over short distances.

Environmental characteristics:

Physiography- the series is found on the less steeper slopes of ridges and on footslopes. Slope percentage ranges from 2-10%.

Geology- the series is formed on various parent materials (like andesite, rhyolite, conglomerate a.o.) Landuse, vegetation and erosion:

The series is used for agriculture like the Ranen and Rabuor series. Especially the soils with lower clay percentage and with a high slope percentage are susceptible to erosion. Similar soils are those of the Rabuor series which are developed on Rhyolite and have redder colours.



Ma: Marando series (see Appendix I, profiles Ranen 1,2 and 12)

Surface in hectares: 910 (26%)

Marando series are generally well drained, moderately deep brown to reddish brown, slightly gravelly clayloam to clay soils with a cambic and sometimes an argillic B-horizon.

Classification : Soil Taxonomy (1970) :(Typic) Tropudalf, (Typic) Entropept,(Lithic)Argindoll, (Lithic) Hapludoll.

F.A.O. (1974) :Chromic Luvisol, Chromic Cambisol, Luvic Phaeozem (Lithic phase),Haplic phaeozem(lithic-phase)

Profile characteristics.

Well drained, soil depth ranges from 40-100cm, in fact where soils are shallow and on places which are strongly sloping they should be called somewhat excessively drained.

**Surface gravel ranges from 10-40%, stoniness from 0-5%.**

The A1-horizon has a thickness of 10-40cm, dark brown to dark reddish gray colours (hues 7.5 and 5 YR, values 3-4, chroma's 2-3), a slightly gravelly to gravelly loam to clay loam texture, a fine granular to subangular blocky structure, a clear boundary.

The B2-horizon if present has a thickness of less than 20 cm, reddish brown colours (2,5 YR 4/4), a clayloam texture, a subangular blocky structure, a clear boundary. The B/C-horizon has a thickness of 20-100cm, dark brown to reddish brown colours (5 YR values 3-4, chroma's 2-4) mixed with strong brown, yellow to orange and black colours of rotten rock, a gravelly to very gravelly clayloam sometimes clay texture, a subangular blocky structure, a gradual to clear boundary. The C-horizon has a thickness depending on the kind of rock and has mixed yellowish, reddish and blackish colours.

Environmental characteristics

Physiography- the series is found on slopes of river valleys, tops and steeper the valley lateral slopes of ridges and as a transition between the very shallow soils of hills and the deeper soils of their footslopes. Slopes percentage ranges from 0-15%.

Geology- the series is mainly formed on rhyolite but also on other types of parent materials like p.e. andesite.

Landuse- the soils are used for all kinds of subsistence crops. About 30% of the soil is fallow, having a secondary vegetation of grasses, herbs and some shrubs and are used for grazing.

Ur: Uriri series (see Appendix I, Profile Ranen 24)

Surface in hectares: 60 (2%)

Uriri series are well drained shallow to very shallow dark a boulder-like weathering on andesite.

Classification: Soil Taxonomy (1970) :(Lithic) Entropept, (Lithic)  
Hapludoll

F.A.O. (1974) :Eutric Cambisol (lithic phase)  
Haplic phaeozems(lithic phase)

Profile characteristics :

Well drained, soil depth ranges from 5-70cm, surface stoniness from 20-70 % (diameter of the stones 40,60,150cm), rockiness from 5-10%. The A<sub>1</sub>-horizon has a thickness of 5-25cm., dark brown to dark reddish brown colours (hues 7.5 and 3/2, a clay to clayloam texture, a granular to weak subangular blocky structure, a clear boundary towards a B- or an abrupt boundary, to an R-horizon. The B<sub>2</sub>-horizon has a thickness of 0-50cm, dark reddish gray to reddish brown colour (5 YR 4/2,3), a clay texture, a subangular blocky structure and an abrupt broken boundary towards an R-horizon. The R-horizon consist of boulders which are giving the soils a big range in depth over short distances.

Environmental characteristics:

Physiography- the series is found on the steeper parts and tops of hills and ridges. Slope percentage ranges from 10-40%.

Geology- the series is formed on andesite.

Landuse , vegetation and erosion:

The natural vegetation consists of grasses and shrubs. Only the less steep parts are used for grazing. Because the natural vegetation is present no severe erosion occurs.

Ko: Kokuru series (see Appendix I, Profile Ranen (3) and 19)

Surface in hectares 151 (4%)

Kokuru series are well drained, shallow to very shallow, brown to yellowish brown clayloam soils on ironstone.

Classification : Soil Taxonomy (1970) : (Plinthic) Tropudalf, (Plinthic) Troporthent  
 F.A.O. (1974) : Plinthic Luvisol, Eutric Regosol (petroferric phase)

#### Profile characteristics

Well drained, soil depth ranges from 5-50 cm.

The Al-horizon has a thickness of 5-30 cm, brown to reddish brown, colours (hues 5 and YR, value 4, chroma 3-4), a clayloam texture, a granular to subangular blocky structure. If only an A-horizon is present iron-manganese concretions are found in the lower part of the horizon, a clear to abrupt boundary. The B2-horizon has a thickness of 0-30 cm, yellowish red colours (5 YR 4/6) a clayloam texture, a subangular blocky structure, iron-manganese concretions are found in the lower part of the horizon, an abrupt boundary. The R-horizon consists of continuous indurated ironstone.

#### Environmental characteristics:

Physiography- these soils are mainly found as narrow strips between the dry soils of the ridges and wet soils of the valleys but are always lying considerably higher than the latter soils. Sometimes they occur as rather small isolated areas within the dry areas.

Slope percentage range from 0-8%.

Geology- the series is mainly formed on rhyolite and andesite.

#### Landuse and vegetation

Most of these soils are rather intensively used for grazing. Occasionally the deeper soils are used for growing crops.

#### Erosion

Because of the ironstone the major part of the water is removed as surface runoff. Therefore if the slope gradient is high and the vegetation absent a high runoff will cause erosion resulting in ironstone outcrops. Similar soils are those of the Oboke series, which are moderately well drained and don't always have a continuous ironstone layer.

Or: Oreru series (see Appendix I, Profiles Ranen (10), 18 and 22)

Surface in hectares : 98 (3%)

Oreru series are (somewhat) excessively drained, shallow to very shallow, dark brown gravelly, stoney and rocky clay loam soils.

Classification : Soil Taxonomy (1970) : (Lithic) Eutropept

F.A.O. (1974) : Lithosol, Eutric Regosol  
(Lithic phase), Eutric  
Cambisol (lithic phase)

#### Profile characteristics

(somewhat) excessively drained, soil depth ranges from 5-30 cm. sometimes narrow strips of deeper soils (40 cm) are found on the lower part of the slopes. Surface stoniness ranges from 10-70% gravels. The A1-horizon has a thickness of 5-40 cm, dark brown to brown colours (hues 7.5 YR, value 3-4, chroma's 2-3) a gravelly to very gravelly loam to sandy clay loam texture, a fine granular to weak subangular blocky structure, a clear boundary.

The A+C/R-horizon consists of soft or hard rock with A1-material in the joints.

#### Environmental characteristics:

Physiography- the series is found on strongly sloping to moderately steep ridges and hills, which are surrounded by footslopes with generally undulating topography. Slope percentage ranges from 0-30%.

Geology- the series is mainly formed on rhyolite but also on andesite.

#### Landuse and vegetation:

The series is used for grazing and occasionally for cropland with poor result due to the high stoniness and rockiness percentage and the lower retention capacity.

#### Erosion:

As soon as these soils are used as arable land, due to the high runoff and the lack of vegetation cover, the soils are severely eroding.

### 3. Interpretation of the survey data

For a complete landevaluation a lot of knowledge of social and economic factors is needed to define several important data like the land utilisation types and distinguish the different management levels. At the times of preparing this report this knowledge was not available. Therefore in this chapter we only consider the soil characteristics. For the well drained soils slope classes are not considered because they do not influence the suitability for the crops at the present management level. But they do influence the suitability of the poorly drained soils. The suitability of the poorly drained soils can be improved with low capital investment. The main problem is the excess of water, a solution can be the construction of some shallow ditches. Irrigation is not relevant for the area because of obtaining enough water suitable for irrigation would be very expensive. Two types of suitability maps are produced one for sugarcane and for several groups of crops. The criterious which are used to rate the suitability of the soil series (partly based on the system used by the K.S.S.P.) are:

#### Wateravailability

The waterretention capacity of the soils is very important. Due to the lack of reliable data some assumptions are made. The table shows that there is a strong relation with the depth classes of the soil series. The total productive and readily available moisture throughout the rootable zone (TPRAM-value, the ratio in vol% in the range pF 2.3 and 3.7) was estimated, five classes were distinguished.

(++)	more than 200 mm	available water		
(+ )	150-200 mm		"	"
(+-)	100-150 mm		"	"
(- )	50-100 mm		"	"
(--)	less than 50 mm		"	"

The presence of profile hindrances

A horizon with gravel (B<sub>3</sub>-horizon), heavy clay or stratification and an abrupt textural change have been considered as profile hindrances, provided they occur within the rootable zone (generally within 1 m.). Three classes have been made.

- ( ) no hindrances occur
- (+ -) low hindrances (gravel/rotten rock, pieces of heavy clay)
- (- -) severe hindrances (stratified horizons with abrupt textural changes)

The risk that waterlogging occurs

Most crops are susceptible to waterlogging. Based on the field experience the soils are rated in 4 classes:

- ( ) no risk that waterlogging occurs.
- (+ -) very low risk that waterlogging occurs
- ( - ) rather high risk that waterlogging occurs
- (- -) high " " " "

The different soil series are subdivided upon soil depth or slope class if they (strongly) influence the properties given above.

Soil depth and slope classes are shown behind the names of the soil series using the symbols the legend

### 3.1. Interpretation of the data for sugar cane

Kenya has a high demand for sugar, it has been unable to meet this demand at the moment. To become selfsupporting in the future the Government tries to increase the amount sugarcane. In the sample area near Sare a sugar factory is planned with a nucleus estate and a large area with outgrowers. At the moment sugarcane is already the most important cash crop in the area. Brown sugar is produced in jaggeries.

#### Climate and soil requirements:

Optimum growth is achieved in temperatures between 24° and 30° C. A temperature of less than 5° C is harmful even to resistant varieties. Fluctuations in temperature have a noticeable influence on enrichment of sucrose: so does the daily amount of sunshine.

Relative air humidity does not have much influence on the vegetative phase provided there is an adequate water supply. A precipitation of 2000-2500 mm/year is mentioned for reaching high yields provided it is evenly distributed. Other authors stated that 1500 mm is the minimum average.

Sugar cane can grow on a large variety of soils. The oxygen supply is very important. The ideal sugar cane soil should have a deep profile, considerable capacity for moisture storage a friable consistency ~~and~~ a well developed structure enabling roots to penetrate several feet and excess water to drain away. Comparing the climate requirements with the given climatic data it will be clear that the conditions are sub-optimal for cane grow.

Three suitability classes are made

class I - suitable for growing sugar cane with low risks

class II- suitable for growing sugarcane with medium-high risks

class III-suitable for growing sugar cane with high risks

According to the soil properties mentioned before and shown in the table the soil series are rated as follows:

Ranen (0), Rabuor (0), Manyata (0), Rabuor (1), Manyata (1), class I  
Manyata (2), Rabuor (2), Marando (2), Riana-kuna (B), Awundo (B) class  
II Oboke (3)

Sare, Riana-kuna (A), Awundo (A), Manyata (3), Marando (3) class III  
Oboke (4), Kokuru (3), Uriri (3), Aoranam , Oreru (4)

If the series have the same suitability class, it does not mean they are equally suitable. Above the first mentioned soil series is expected to give the highest yield the last one the lowest.

### 3.2. Evaluation of the series for several groups of crops.

The crops which are considered are:

Coffee, maize, sweet potatoes, groundnuts, cassave, sorghum, grazing land and sugar cane.

Short description of the crops

coffee - perennial crop that needs about 1500 mm., of rainfall evenly distributed. The soil must be well drained, deep with a high moisture retention capacity. Coffee occurs in the area on a small scale due to several reasons; climate factors, soil factors and probably the most important socio-economic factors.

maize -- annual crop, in the first growth stage rather drought resistant but after five weeks it needs a fairly high amount of waterlogging decreases the yield remarkable.

sweet potatoes- perennial vine, mostly treated as an annual crop. It is a very drought resistant crop, minimum annual rainfall of 75 mm. We choose this crop because it can grow on rather shallow (gravelly) soils. It is often found as intercrop with maize.

groundnuts- annual crop. The rainfall must be well distributed for satisfactory yields. Dry conditions are needed for harvesting and drying. Groundnuts grow well in reasonable fertile, light soils.

cassave - perennial crop. The advantages of cassave are its drought resistance, its ability to give good yields on poor soils, its resistance to pests, its ability to remain in the soil as a famine reserve. The soil fertility requirements is low. The main need is a free drainage and shallow and very gravelly soils restrict the tuber expansion.

sorghum - annual crop. It is drought resistant and resistant to waterlogging. The yields are still reasonable on infertile soils. In the sample area this crop is not important (in fact the same can be said about cassave and sweet potatoes). It is chosen because it still gives yields on the shallow soils.



grazing land- This is a very general term. At the moment there is grazing on the poorly drained parts and on fallow parts during the crop rotation.

sugar cane - described above; sugar cane is an exception, on shallow soils the conditions are bad due to the lack of moisture. On the poorly drained soils it gives reasonable yields despite risks of waterlogging and the heavy subsoil.

Nine groups of crops are made as follows:

Group	coffee	maize	sweet potatoes	ground nuts	cassave	sorghum	grazing land	sugar cane
1	+	+	+	+	+	+	+	+
2	+ -	+	+	+	+	+	+	+
3	-	+	+	+	+	+	+	+
4	-	+ -	+	+	+	+	+	+ -
5	-	-	+ -	+	+	+	+	-
6	-	-	-	+ -	+ -	+ -	+	-
7	-	-	-	-	-	+ -	+	+ -
8	-	-	-	-	-	-	+ -	-
9	-	-	-	-	-	-	-	-

+ -crop(s) gives reasonable yields

+ - -crop(s) can still grow but the circumstances are sub-optima

- -crop(s) if growed the yields are very low

With regard to the mentioned soil properties (Water availability and profile hindrances) and risks that waterlogging occurs.

The soil series are rated for the groups of crops as follows:

Soil series	groups of crops
Ranen (0), Rabuor (0), Manyata (0)	1
Rabuor (1)	2
Manyata (1), Rabuor (2)	3
Manyata (2), Marando (2)	4
Marando (3), Kokuru (3)	5
Uriri (3), Kokuru (3),	6
Riana-kuna (B), Awendo (B), Oboke (3)	7
Sare, Oboke (4), Ogeru (4)	8
Riana-kuna (A), Awendo (A), Aoranam	9

## 3.2 Final rating of the soil series

The final rating is given in the following table.

Series name	class				Sugar cane	Final-rating group no. of crops
	slope depth 0-4	A/B Watervai- lability	Profile hindrance	Risks of wa- terlogging		
Riana-kuna	A	++	--	-	III	8
Riana-kuna	B	++	--	+-	II	7
Awundo	A	++	-	-	III	8
Awundo	B	++	-	+-	II	7
Aoranam		++	-	--	III	9
Oboke	3	-	-	+-	II	7
Oboke	4	--	-	+-	III	8
Sare		++	--	-	III	8
Ranen	0	++			I	1
Rabuor	0	++			I	1
Rabuor	1	+			I	2
Rabuor	2	+-	-		II	3
Manyata	0	++			I	1
Manyata	1	+			I	3
Manyata	2	+-	-		II	4
Manyata	3	-	-		III	5
Marando	2	+-	-		II	4
Marando	3	-	-		III	5
Uriri	3	--			III	6
Kokuru	3	--			III	6
Orure	4	--			III	8

Remark: The left open places means that no profile hindrances are present and no risk that waterlogging occurs.

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**Appendix I**  
**Profile descriptions**



Profile Ranen : Ranen series  
 Classification : Soil Taxonomy (1970); Tropudalf  
 F.A.O. (1974): Chromic Luvisol  
 Near Ranen, South Nyanza district; sheet 130/3  
 coordinates 34°33'41''E, 0°51'33''S,  
 elevation 1503 m, described by H.van Reuler  
 (11 -09 -1975)

Physiographic position : upper part of a linear convex slope  
 Surrounding landform : gently undulating- undulating  
 Slope : 4%  
 Parent material : Rhyolite  
 Vegetation : cultivated  
 Landuse : cropland  
 Soil fauna : ants, termites, worms  
 Drainage : well drained  
 Root distribution : 0-40 cm: abundant very fine, frequent fine, few  
 medium and very few coarse roots 40- 100 cm:  
 frequent very fine, common fine and medium  
 roots  
 + 100: common fine and medium roots

Effective soil depth : 150 cm

Soil profile:

A1 0 - 18 cm : Dark reddish gray to reddish brown (5 YR 4/2,5  
 moist); clay loam, moderate to weak compound  
 structure nonsisting of very granular and fine  
 subangular blocky; many very fine and common  
 fine biopores, very friable, slightly sticky  
 and slightly plastic; clear and smooth boundary

A3 18 - 36 cm : Reddish brown (5 YR 4/4, moist); silty clayloam  
 weak fine subangular blocky, many very fine,  
 common medium and a few coarse biopores; very  
 friable slightly sticky and slightly plastic;  
 clear and smooth boundary.

**B2t 36-120 cm** : Reddish brown (2.5 YR 4/4, moist); clay; moderate fine to medium subangular blocky; abundant strong clay skins; many very fine, fine, common medium, a few coarse and very coarse biopores, very friable, slightly plastic; clear and smooth boundary.

**B3I 120-140+cm** : the same as the B2t horizon only a clay loam texture

**Analytical data**

depth	sand	silt	clay	C.E.C.	Na	K	Ca	Mg	Org.C (W%)
0 - 18 cm	48	18	34	17.50	1.57	0.68	7.08	0.42	2.0
18 - 36 cm	21	47	32	16.95	1.79	0.37	7.40	1.35	1.6
36 - 80 cm	20	28	52	16.95	0.76	0.25	8.05	0.70	1.1
80 -120 cm	13	28	59	13.69	1.79	0.32	6.44	0.74	0.9
120-180 cm	33	36	31	12.71	2.50	0.44	3.86	0.82	0.5

**Profile Ranen 3**

**: Kokuru series**

**Classification**

: Soil Taxonomy (1970) : (Plinthic) Tropudalf  
F.A.O. (1974) : (Plinthic Luvisol

: 1 km south of Ranen, South Nyanza district, sheet 130/3, coordinates 34° 33' 22''E, 0°52'0''S, elevation 148m, described by Van Keulen, (26-06-1975)

**Physiographic position:** edge of a depression (dambo)

**Surrounding landform** : gently undulating

**Slope** : 2%

**Parent material** : Rhyolite

**Vegetation** : 5% shrub, 95% grasses and herbs

**Landuse** : grazing land

**Soil fauna** : ants, worms

**Draiange** : well drained

**Root distribution** : 0-30 cm: very frequent very fine and fine, few medium roots

**Effective soil depth** : 70 cm



## Soil profile:

- A1 0 - 30 cm : Reddish brown (5 YR 4/4, moist); clay loam; strong very fine granular; slightly hard, friable, sticky and slightly plastic; gradual and wavy boundary.
- B2t 30- 70 cm : Yellowish red (5 YR 4/6); clay; moderate weak fine granular and fine subangular blocky; common weak clay skins; many very fine and common medium biopores; slightly hard, friable, slightly sticky and slightly plastic; abrupt and smooth boundary.
- R 70-120+ cm : Ironstone

- Profile Ranen 4 : Riana Kuna series
- Classification : Soil Taxonomy (1970): (Albic) Tropaqualf  
F.A.O. (1974): (Entric Planosol
- Location : 3 km south of Ranen, South Nyanza district, sheet 130/3, coordinates 34° 33' 2''E, 0°52'21''S, elevation 1463m.
- Physiographic position : flat valley bottom
- Surrounding landform : flat-very gently undulating
- Slope : 1%
- Parent material : Rhyolite
- Vegetation : 95% grasses and herbs, 5% shrubs
- Landuse : grazing land
- Soil fauna : ants, worms
- Drainage : poorly drained
- Root distribution : 0-20 cm: frequent very fine and fine very few coarse and medium roots
- Effective soil depth : 175 cm
- Soil profile:
- A1 0 - 10 cm : Very dark grey (10 YR 3/1, moist); with many fine distinct strong brown (7.5 YR 5/6) mottles; loam; weak very fine granular, few medium; common fine and many very fine biopores; slightly hard, friable non sticky and slightly plastic, gradual and wavy boundary.

- A2 0 - 43 cm : Reddish gray (5 YR 5/2) when moist, with many fine distinct dark reddish gray (5 YR 4/2), few fine prominent reddish yellow (5 YR 6/8) and prominent black (5 YR 2/1) mottles, loam, weak fine subangular blocky, few medium common fine and many very fine biopores, hard when dry, friable when moist, slightly sticky and slightly plastic when wet, clear and wavy boundary.
- A3 43- 48 cm : Reddish gray (5 YR 5/2, moist); many fine distinct dark reddish brown (5 YR 3/2) and many fine prominent reddish yellow (5 YR 6/8) mottles moderate fine subangular to angular blocky; very fine gravelly, loam; common medium fine and very fine biopores; hard, very friable, slightly sticky and slightly plastic, 70% small (2mm) and 2% big (10mm) iron-manganese concretions; clear and wavy boundary.
- B2I 48- 70 cm : Dark gray (5 YR 4/1, moist); with many fine prominent red (2.5 YR 5/8) mottles; slight gravelly clay; moderate fine angular blocky; common medium fine very fine biopores; very hard, very friable, slightly sticky and slightly plastic; 10% iron-manganese concretions (size: 1-3mm), clear and wavy boundary.
- B22 70-130 cm : Brown (7.5 YR 5/4, moist), with many fine distinct strong brown (7 YR 5/8) mottles; moderate medium angular blocky; abundant strong clay skins; few moderate slicken sides; few medium and common fine and very fine biopores ; very hard, friable, sticky and plastic; clear and wavy boundary.
- B23 103-180cm : Yellowish brown (10 YR 5/4, moist), with many fine distinct strong brown (7.5 YR 5/8) mottles; clay; moderate common strong slickensides; few medium, common fine and very fine biopores; very hard, friable, sticky and plastic; clear and wavy boundary.
- B3 180-230+cm : Yellowish brown (10 YR 5/4, moist); yellow (10 YR 7/8) and strong brown (7.5) mottles, the rest as the B23 horizon

Profile Ranen 5 : Manyata series  
 Classification : Soil Taxonomy 1970 : (Typic) Tropudalf  
                   F.A.O.           1974 : Chromic Luvisol  
 Location : Near Manyata school, South Nyanza district,  
            sheet 130/3, coordinates 34°32'23''E, 0°  
            53'42''S, elevation 1451m, described by  
            H. van Reuler (04-80-1975)  
 Physiographic position : upper part of a linear convex slope  
 Surrounding landform : rounded hills  
 Slope : 7%  
 Parent material : Conglomerates  
 Vegetation : cultivated  
 Landuse : crop land (maize)  
 Surface stoniness : **very few (75cm)**  
 Soil fauna : **ants, worms, termites**  
 Drainage : well drained  
 Root distribution : 0-15cm: very frequent fine, frequent fine  
   common medium and a very few coarse roots  
 Effective soil depth : 90 cm

Soil Profile:

Ap 0 - 15 cm: Dark brown (7.5 YR 4/2, moist); clay; weak very fine  
                   and subangular blocky; many very fine; common fine; few  
                   medium and coarse biopores; hard, very friable, slightly  
                   sticky and slightly plastic, clear and wavy boundary.  
 AI2 15-38 cm : See Ap: weak fine granular; abrupt and wavy boundary .  
 BI 38-55 cm : Reddish brown (5 YR 4/3, moist); sandy clay loam; weak  
                   medium fine angular blocky; many very fine and few  
                   medium biopores, hard, friable, slightly sticky and  
                   slightly plastic; clear and wavy boundary.

B2t 55-85 cm: Weak red to reddish brown (2,5 YR 4/3, moist); clay loam; weak very fine subangular blocky; many very fine few fine biopores; common medium clay skins; hard, friable, slightly sticky and slightly plastic; clear and wavy boundary.

B3 85-90 cm : See B2t; very gravelly clay loam; common very fine and few fine biopores; slightly hard, friable, non-sticky and non-plastic ; abrupt and smooth boundary.

R 90-130+cm : Conglomerate rock

#### Analytical data

depth	sand	silt	clay	C.E.C	Na <sup>+</sup>	K <sup>+</sup>	Ca <sup>++</sup>	Mg <sup>++</sup>	Org.C(W%)
0 - 38cm	39	13	48	15.43	1.08	1.41	7.40	1.66	2.3
38- 55cm	51	18	31	13.26	0.38	0.68	7.73	1.02	1.6
55- 85cm	32	32	36	13.86	0.38	7.40	0.81	1.35	1.3

Profile Ranen 6 : Awundo series

Classification : Soil Taxonomy (1970) : Entric Peludert  
F.A.O. (1974) : Pellic Vertisol

Location : Near Lwala **school** South Nyanza district, **sheet** 130/3, coordinates 34°31'24''E, 0°55'19''S, elevation 1458m, described by J. van Keulen and H. van Reuler (10-09-1975)

Physiographic position: top of a plateau

Surrounding landform : flat-gently undulating

Micro-relief : somewhat irregular surface

Slope : 0-3%

Parent material : Basalt

Vegetation : cultivated

Landuse : cropland

Soil fauna : ants

Drainage : poorly drained

Root development : very frequent very fine, frequent fine, few medium roots

Effective soil depth : 100 cm

## Soil Profile :

A1 0 - 38cm : Very dark gray to dark brown (7,5 YR 3/2, moist); clay moderate medium subangular blocky; many very fine, common fine and medium biopores; hard, friable, sticky and plastic; gradual and wavy boundary.

B1 38- 70 cm : Brown (7.5 YR 5/2, moist); common fine distinct strong brown (7.5 YR 5/6) mottles; clay; moderate medium angular blocky; many very fine, fine and a few medium biopores; very hard, firm, sticky and plastic; gradual and wavy boundary.

B2 +70 cm : Pale brown to brown (10 YR 5,5/3, moist); many fine to medium yellowish brown (10 YR 5/8) distinct mottles clay; moderate medium to coarse angular blocky; common very fine biopores; very hard, firm, sticky and plastic.

remarks : at about 60 cm and deeper, intersecting slickensides (+ 10cm)  
 - augering in the bottom of the pit made clear that the rotten rock starts at 150 cm  
 - this profile is almost the same as profile 25, the big difference lies in the subsoil

## Analytical data

depth	sand	silt	clay	C.E.C	Na <sup>+</sup>	K <sup>+</sup>	Ca <sup>++</sup>	Mg <sup>++</sup>
0 - 38 cm	13	35	52	16.57	1.52	1.18	7.71	1.97
38- 70 cm	24	6	70	39.89	3.04	0.52	17.68	9.19
70-120 cm	13	3	84	46.95	3.36	0.55	22.50	13.75

Profile Ranen 7 : Marando series  
 Classification : Soil Taxonomy (1970) : (Lithic) Eutropept  
 F.A.O. (1974) : Chromic Cambisol  
 Location : Near Oruba school, South Nyanza district,  
 sheet 130/3, coordinates  $34^{\circ}31'45''E$ ,  
 $0^{\circ}58'2''S$ , elevation 1530 cm, described by  
 J. van Keulen (08-09-1975)  
 Physiographic position : upper part of a convex slope  
 Surrounding landform : rounded hills  
 Slope : 2%  
 Parent material : Andesite  
 Vegetation : grasses  
 Landuse : school compound  
 Drainage : well drained  
 Root distribution : 0-20 cm: very frequent, very fine, frequent  
 o fine and few medium fine roots  
 Effective soil depth :  
 Soil Profile:  
 A1 0 - 15 cm : Very dark brown (10 YR 2/2, moist); gravelly  
 sandy clayloam; moderate medium granular;  
 many very fine, few fine and medium biopores,  
 very friable, sticky and slightly plastic;  
 clear and wavy boundary.  
 B2 15 - 45 cm : Dark reddish grey (5 YR 4/2, moist); very  
 gravelly, clayloam; moderate fine granular;  
 clear and wavy boundary.  
 C 45 - 50+ cm : Rotten rock

Profile Ranen 8 : Uriri series

Classification : Soil Taxonomy (1970) : (Lithic) Eutropept  
 F.A.O. (1974) : Eutric Cambisol  
 (Lithic phase)

Location : Near Oruba primary school, South Nyanza  
 district sheet 130/3, 34°31'48"E, 0°58'  
 2'S, elevation 1526 m, described by J. van  
 Keulen and H. van Reuler (10-09-1975)

Physiographic position : top of a rounded hill

Surrounding landform : gently undulating - undulating

Slope : 12%

Parent material : Andesite

Vegetation : 60% shrubs, 20% grasses, 20% herbs

Soil fauna : ants, termite

Landuse : extensive grazing

Surface stoniness : stony- very stony

Drainage : well drained

Root distribution : abundant very fine, very frequent fine, few  
 medium, very few coarse roots

Effective soil depth : 46 cm

Soil Profile :

A11 0 - 2 cm : Very dark gray (5 YR 3/1, moist); clay loam; moderate  
 fine granular to subangular blocky; many very fine,  
 fine and common medium biopores; friable, slightly  
 sticky and slightly plastic; abrupt and wavy boundary

A12 2 - 28 cm : Dark gray to dark reddish gray (5 YR 4/1, moist);  
 clay loam; moderate fine to medium subangular blocky;  
 many very fine, fine and common medium biopores;  
 friable, slightly sticky and slightly plastic; clear  
 and wavy boundary.

A3 28 -46 cm : Dark gray to dark reddish gray (5 YR 4/1,5, moist);  
 stony gravelly clay loam; moderate fine subangular  
 blocky; common very fine and fine biopores; friable,  
 non- sticky and non-plastic; clear wavy boundary.





- B2 20 - 45 cm : Reddish brown to yellowish red (5 YR 5/5, moist) gravelly sandy clay loam; moderate very fine; subangular blocky; many very fine, common fine and a few medium biopores; soft, very friable, non-sticky and non-plastic; clear and smooth boundary.
- C/R 45 - 90+ cm : Rhyolite rock yellow (10 YR 7/8)
- Profile Ranen 10 : Oreru
- Classification : Soil Taxonomy (1970) : Lithic Eutrocept  
F.A.O. (1974) : Eutric Cambisol  
(Lithic phase)
- Location : top of the Ranen hill, South Nyanza district, sheet 130/3, 34°33'19"E, 0°51'10"S, elevation 1632 m, described by H. van Reuler (07-06-1975)
- Physiographic position: top of the Ranen hill
- Surrounding landform : hilly
- Slope : top flat, footslope 350m, convex concave irregular
- Parent material : Rhyolite
- Vegetation : 15% shrubs, 25% herbs, 70% grasses
- Landuse : extensive grazing (the Government has made a start with reforestation) charcoal burning
- Rock outcrops : fairly rocky
- Surface **stoniness** : fairly stony
- Drainage : (somewhat) extensive drained
- Root distribution : common very fine and fine roots, few medium roots
- Effective soil depth : 40 cm

Soil Profile :

A1 0 - 12 cm : Dark brown to brown (7,5 YR 4/2, moist); gravelly loam; strong very fine and fine granular soft, very friable, non-sticky and non-plastic clear and smooth boundary.

AR 12- 40 cm : Dark reddish gray (5 YR 4/2, moist); gravelly stony loam to clay loam; moderate fine sub-angular blocky; many very fine and fine and few medium biopores; slightly hard, friable, slightly sticky and slightly plastic; abrupt and wavy boundary.

R 40 - 60+cm : Rhyolite rock

Profile Ranen 11 : Rabuor series

Classification : Soil Taxonomy (1970) : (Typic) Tropudalf  
F.A.O. (1974) : Chromic Luvisol

Location : Near Ranen, head of Komenya river, South Nyanza district, sheet 130/3 34°33'30''E, 0°51'39''S, elevation 1487m, described by J. van Keulen. (23-06- 1975)

Physiographic position: upper part of valley head

Surrounding landform : undulating footslopes

Slope : 7%

Parent material : Rhyolite

Vegetation : cultivated

Landuse : cropland (millet)

Drainage : well drained

Soil fauna : ants, worms, moles, mice

Root distribution : 0-50 cm: very frequent very fine and fine and few medium roots.  
: +50 cm: frequent very fine and fine roots

Effective soil depth : 150 cm

## Soil Profile

- A1 0 - 30 cm : Dark reddish brown (5 YR 3/4, moist); clay; strong fine granular to subangular blocky; many fine and very fine, common medium and few coarse biopores; slightly hard, very friable, slightly sticky and slightly plastic; clear and wavy boundary.
- BI 30 - 55 cm : Weak red (2,5 YR 4/2, moist); clay; moderate fine subangular blocky; few weak clay skins; many fine and very fine, few medium and coarse biopores; hard, friable, slightly sticky and slightly plastic; clear and wavy boundary.
- B2t 55-130 cm : Reddish brown (2,5 YR 4/4, moist); clay; moderate fine to medium subangular blocky; abundant to common moderate clay skins; many fine and very fine common medium and few coarse biopores; hard, friable, sticky and slightly plastic; gradual and wavy boundary.
- B3 +130 cm : Reddish brown (2,5 YR 4/4, moist); many distinct, medium sized, black iron-manganese mottles and concretions; very gravelly clay; the rest as the B2 horizon

Profile Ranen 12 : Marando series  
 Soil series : Soil Taxonomy (1970) : (Typic) Tropudalf  
 F.A.O. (1974) : Chromic Luvisol  
 Location : 1 km. South of Ranen, South Nyanza district,  
 sheet 130/3, coordinates 34°33'34"E, 0°51'  
 56'S, elevation 1487m, described by J. van  
 Keulen (26-06-1975)  
 Physiographic position : upper convex part of a slope  
 Surrounding landform : gently undulating to undulating ridges  
 Slope : 4%  
 Parent material : Rhyolite  
 Vegetation : cultivated  
 Landuse : cropland  
 Drainage : well drained  
 Soil fauna : ants, termites, worms, mice and moles  
 Root distribution : 0-40cm: frequent very fine and few medium  
 roots deeper: frequent very fine and common  
 fine roots  
 Effective soil depth : 60 cm

## Soil Profile:

AI 0 - 25 cm : Dark reddish gray (5 YR 4/2, moist); clay loam; mode-  
 rate fine subangular blocky to granular; many fine and  
 fine common medium and few coarse biopores; slightly  
 hard, friable, slightly sticky and slightly plastic;  
 clear and wavy boundary.  
 B2t 25-32 cm : Reddish brown (2,5 YR 4/4, moist); clay; moderate fine  
 subangular blocky; many very fine, common fine and  
 medium and a few coarse biopores; slightly hard,  
 friable, sticky and slightly plastic; clear and wavy  
 boundary.  
 B3 32- 60cm : Reddish brown (2,5 YR 4/4, moist); brownish yellow  
 (10 YR 6/8) to red (2,5/6) weathering and rock colours  
 30% iron-manganese concretions (about 4mm big), grada-  
 al and wavy boundary.  
 C 60-120 cm : Rotten rock  
 R 120-160+cm : Hard rock

- Profile Ranen 13 : Riana series
- Classification : Soil Taxonomy (1970) : (Albic) Tropequalf  
F.A.O. (1974) : Eutric Planosol
- Location : 1 km south of Ranen, South Nyanza district,  
sheet 130/3, coordinates 34°33'47''E, 0°  
52'09''S, elevation 1460, described by J. van  
Keulen (24-06-1975)
- Physiographic position : river plain
- Surrounding landform : undulating ridges
- Slope : 4%
- Parent material : Rhyolite (Nyanzian)
- Vegetation : grasses and some scattered shrubs
- Land use : grazing
- Drainage : poorly drained, groundwater at 100 cm
- Root distribution : 0-30 cm; Few coarse and medium, common fine  
and very fine roots  
deeper: frequent fine and very fine roots
- Effective soil depth : 100 cm
- Soil Profile:
- A1 0 - 10 cm : Dark grayish brown (10 YR 4/2, moist); with  
many fine distinct strong brown (7.5 YR 5/6)  
mottles; silty clayloam; fine subangular blo-  
cky; few medium many fine and very fine bio-  
pores, slightly sticky and slightly plastic;  
clear and wavy boundary.
- A2 10 -26 cm : Brownish gray (7.5 YR 5/1, moist), with many  
fine faint reddish brown (2,5 YR 4/3 mottles;  
silty loam; fine subangular blocky; many fine  
and very fine biopores; hard, friable, slight-  
ly sticky and slightly plastic; abrupt and  
wavy boundary.
- B2I 26-35 cm : Brownish gray (7.5 YR 5/1, moist); with common  
fine distinct red (2,5 YR 5/8) mottles; very  
gravelly clay (gravels are iron-manganese  
concretions), subangular blocky; many fine

and very fine biopores, hard, non-sticky and non-plastic; abrupt and wavy boundary.

B22 35 - 45cm : Brown (7.5 YR 5/2, moist); with common fine yellowish brown (10 YR 5/8) mottles; clay angular blocky; many fine and fine biopores; very hard, friable, sticky and slightly plastic; clear and wavy boundary.

B23 45 - 90cm : Brownish yellow (10 YR 6/8, moist); common district reddish yellow (7.5 YR 6/8) mottles; clay; angular blocky structure, common fine biopores; very hard, friable sticky and slightly plastic; groundwater at 100 cm.

Profile Ranen 14 : Riana Kuna series

Classification : Soil Taxonomy (1970) : (Albic) Tropaqualf  
F.A.O. (1974) : Eutric Planosol

Location : Near Komomloreme primary school, South Nyanza district, sheet 130/3 coordinates 34°32'24'' E, 0°52'40''S, elevation 1448m, described by H. van Reuler (14-07-1975)

Physiographic position : dambo

Surrounding landform : flat, very gently undulating

Slope : 0-2%

Micro-relief : termite mounds

Parent material : Andesite

Vegetation : grasses

Landuse : grazing

Drainage : poorly drained

General groundwater level : temporarily moderate deep, 60-120cm

Soil fauna : ants, termites

Root distribution : 0-65cm: Very frequent very fine, frequent fine, common medium and few coarse roots  
65-100cm: common very fine and few fine roots  
+100 cm : few very fine roots

Effective soil depth : 80 cm

## Soil Profile :

- AI 0 - 20 cm : Very dark gray (5 YR 3/1, moist); silty loam; strong very fine granular; friable, slightly sticky and slightly plastic; abrupt and smooth boundary.
- A2 20- 41 cm : Reddish gray (5 YR 5/2, moist); many fine distinct-reddish brown to yellowish red (5 YR 5/5) mottles; sandy clay loam; moderate very fine, and fine sub-angular blocky; **many very fine, fine** common medium biopores; friable; slightly sticky and slightly plastic; abrupt and wavy boundary.
- BII 41-64 cm : Brown (7.5 YR 5/2, moist) ; many fine reddish brown to yellowish red (5 YR 5/5) mottles; sandy clay loam; moderate fine subangular blocky; many very fine and fine, common medium biopores; about 15% iron-manganese concretions (4mm) friable, slightly sticky and slightly plastic; clear and smooth boundary.
- BI2 64-68 cm : the same as the BII horizon only gravelly sandy loam; abrupt and smooth boundary.
- B2 +68 cm : Dark gray (10 YR 4/1, moist); many medium distinct reddish yellow (7.5 YR 6/8) and red (2.5 YR 4/8) mottles; clay; moderate fine to medium angular blocky; small intersecting slickensides (10 cm); common very fine, fine and few medium biopores; very firm; sticky and plastic.

Remark : bottom of the pit at 120 cm.





Profile Ranen 16 : Riana-Kuna series  
 Classification : Soil Taxonomy (1970) : (Albic) Tropudalf  
 F.A.O. (1974) : Eutric Planosol  
 Location : Near Manyata primary school, South Nyanza  
 district, sheet 130/3, coordinates  $34^{\circ}32'$   
 $II''E$ ,  $0^{\circ}53'21''S$ , elevation 1449m, descri-  
 bed by H. van Reuler (08-08-1975)  
 Physiographic position : middle of a broad valley  
 Surrounding landform : flat-very gently undulating  
 Micro relief : termite mounds  
 Slope : 0-2%  
 Parent material : Andesite  
 Vegetation : 20% shrubs, 60% grasses, 20% herbs  
 Landuse : grazing land  
 Soil fauna : worms, ants, termites  
 Drainage : poorly drained  
 Root distribution : 0-45 cm: very frequent, very fine, common  
 fine and very few medium roots  
 Effective soil depth : 45 cm  
 Soil Profile :  
 AII 0 - 8 cm : Dark gray (10 YR 4/1, moist); clay loam; moderate  
 very fine and fine subangular blocky; many very fine  
 and fine, common medium biopores; very friable; slight-  
 ly sticky and slightly plastic; abrupt and smooth  
 boundary.  
 AI2 8 - 23 cm : Dark gray (7,5 YR 4/1, moist); common fine distinct  
 reddish brown (2,5 YR 4/4) mottles; clay loam; mode-  
 rate fine subangular blocky; many very fine and  
 common fine biopores; friable, slightly sticky and  
 slightly plastic; abrupt and smooth boundary.  
 A2 23 - 45 cm : Brown (7,5 YR 5/2, moist); many fine distinct dark  
 gray (7,5 YR 4/4) mottles; silt clay loam, moderate  
 fine to medium subangular blocky; common very fine  
 and fine biopores; very friable, slightly sticky and  
 slightly plastic; abrupt and smooth boundary.

- B21 45- 105 cm : Very dark gray (10 YR 3/1, moist); many fine distinct yellowish brown (10 YR 5/6) mottles; clay moderate medium angular blocky; common very fine and fine biopores; hard, firm, sticky and plastic gradual and smooth boundary.
- B22 105-135 cm : Gray (7, 5 YR 5/1, moist); many fine distinct yellowish brown (10 YR 5/6) mottles; clay; moderate coarse angular blocky; many very fine and a few fine biopores, very hard, firm, sticky and plastic; abrupt and wavy boundary.
- C 135-175 cm : Rotten rock

- Profile Ranen 17 : Manyata series
- Classification : Soil Taxonomy (1970) : (Lithic) Tropudalf  
F.A.O. (1974) : Chromic Luvisol  
(Lithic phase)
- Location : Manyata primary school, South Nyanza district, sheet 130/3, coordinates  $34^{\circ}32'13''E, 0^{\circ}53'33''S$ , 1452m, described by J. van Keulen and Reuler (04-08-1975)
- Physiographic position : top of a rounded hill
- Surrounding landform : rounded hills gently undulating
- Slope : 2% linear regular
- Parent material : Andesite
- Vegetation : maize
- Land use : cropland
- Soil fauna : ants, termites
- Rock outcrops : fairly rocky, surface stoniness, very few
- Drainage : well drained
- Root distribution : abundant very fine, very frequent fine and a few medium roots.
- Effective soil depth : 45cm

## Soil Profile :

- AI 0 - 35 cm : Dark reddish gray to dark reddish brown (5 YR 5/2, moist); clay loam, moderate fine subangular blocky; many very fine and fine and few medium biopores; slightly sticky and slightly plastic; gradual and wavy boundary.
- B2t 35- 44 cm : Reddish brown (2, 5 YR 4/4, moist), moderate fine subangular blocky; common weak clay cutans; many very fine and fine and a few medium biopores; slightly hard, friable, sticky and slightly plastic; clear and wavy boundary.
- B3 44 - 50 cm : Reddish brown (2,5 YR 4/4, moist), slightly gravelly clay, moderate fine subangular blocky; common very fine and fine and a few medium biopores; slightly hard, friable, sticky and slightly plastic; abrupt and broken boundary.
- R 50 - 90+ cm : Andesite rock
- Remark : at other places we find that sometimes no B3 horizon is present.

**Profile Ranen 18** : Oreru series  
**Classification** : Soil Taxonomy (1970) : (Lithic) Troorthent  
 F.A.O. (1974) : Lithosol or Eutric  
 Regosol (Lithic phase)  
**Location** : On Ranen hill near Ranen, South Nyanza dis-  
 trict, sheet, 130/3, coordinates 34°33'49'  
 'E, 0°48'22''S, elevation 1555m, described  
 by J. van Keulen (08-09-1975)  
**Physiographic position** : slope of the Ranen hill  
**Surrounding landform** : hilly with undulating to rolling footslopes  
**Slope** : 25%  
**Parent material** : Rhyolite  
**Vegetation** : 20% shrubs and 80% grasses  
**Land use** : extensive grazing  
**Drainage** : extensively drained  
**Stoniness** : 5%  
**Rock outcrops** : 10%  
**Soil fauna** : ants, termites  
**Root distribution** : 0-10 cm: abundant fine and very fine roots  
**Effective soil depth** : 20 cm

**Soil Profile:**

AI 0 - 7 cm : Brown to dark (7,5 YR 4/2, moist), very gravelly sandy  
 clay loam; strong fine granular to subangular blocky;  
 many fine and very fine biopores; slightly hard,  
 friable, slightly plastic; clear and wavy boundary.  
 AR 7 - 30 cm : Brown to dark brown (7,5 YR 4/2, moist); very grave-  
 lly stony clay loam: strong fine granular to sub-  
 angular blocky; common fine biopores; abrupt and  
 wavy boundary.  
 R 30 - 60 cm : Rhyolite rock

Profile Ranen 19 : Kokuru series  
 Classification : Soil Taxonomy (1970) : (Plinthic) Troporthent  
 F.A.O. (1974) : Eutric Regosol  
 (petrofeeric phase)

Location : 1km South of Ranen, near Tanzania road, South  
 Nyanza district, sheet 130/3, coordinates 34°  
 33'22''S, elevation 1480m, described by J.van  
 Keulen (02-09-1975)

Physiographic position: border of a dambo

Surrounding landform : slightly undulating-undulating

Slope : 2%

Parent material : Rhyolite (Nyanzian)

Vegetation : grass with scattered bushes (10%)

Land use : grazing

Drainage : well drained

Soil fauna : worms, ants, termites

Root distribution : abundant fine and very fine roots

Effective with soil depth: 30 cm

#### Profile characteristics

AI 0 - 30 cm : Reddish brown (5 YR 4/3,5, moist); clay loam; moderate  
 fine subangular blocky; many very fine and common fine  
 biopores; slightly hard, friable, slightly sticky and  
 slightly plastic; 10% iron-manganese concretions  
 (2-3mm); abrupt and smooth boundary.

R 30 - 70 cm : Indurated ironstones

Profile Ranen 20 : Oboke series  
 Classification : Soil Taxonomy (1970) : (Plinthic) Hapludoll  
 F.A.O. (1974) : Haplic phaeozem  
 (petroferric phase)  
 Location : 400m North of Komolorume School, South Nya-  
 nza district, sheet 130/3, coordinates 34°  
 32'33''E, 0°52'34''S, elevation 1445m, des-  
 cribed by J. van Keulen (02-09-1975)  
 Physiographic position : border of a hydromorphic plane  
 Surrounding landform : undulating ridge and flat to undulating  
 plains  
 Slope : 4%  
 Parent material : Andesite (probably)  
 Vegetation : grass with scattered bushes (10%)  
 Landuse : extensive grazing  
 Stoniness : 5%  
 Drainage : moderately well drained  
 Soil fauna : ants, termites, worms  
 Root distribution : abundant fine and very fine roots  
 Effective soil depth : 16 cm  
  
 AI 0 - 16 cm : Very dark grayish brown (10 YR 3,5/2, moist);  
 slightly gravelly, clay loam; weak fine subangular  
 blocky; common fine and many very fine biopores; hard  
 friable, sticky and slightly plastic; 5% iron-manga-  
 nese concretions; abrupt and wavy boundary.  
  
 R 16 - 80+cm : Indurated ironstone mixed with rock

Profile Ranen 21 : Sare series  
 Classification : Soil Taxonomy (1970) : Tropofluvent  
 F.A.O. (1974) : Eutric Fluvisol  
 Location : Sare river 2km east of Awendo, South  
 Nyanza district, sheet 130/3, coordinates  
 34° 32'53''E, 0° 54'42''S, elevation 1420m,  
 described by J. Keulen (08-09-1975)

Physiographic position : riverbank  
 Surrounding landform : undulating ridges  
 Slope : 0%  
 Parent material : riverdeposit  
 Vegetation : dense bush  
 Landuse : tree plantation  
 Drainage : imperfectly drained  
 Soil fauna : worms, ants termites  
 Root distribution : few coarse, common medium, very frequent  
 fine and very fine roots

Soil Profile:

CI 0 - 30 cm : Brown (10 YR 5/3, moist); loamy sand; weak fine  
 subangular blocky to single grain; many fine and very  
 fine biopores; slightly hard, very friable, non-sticky  
 and non-plastic; abrupt and smooth boundary .  
 C2 30- 70 cm : Very dark gray (10 YR 3/1, moist); clay loam; weak  
 coarse subangular blocky; common medium and many fine  
 biopores; hard, firm, sticky and plastic.  
 Remark : depth of the pit, 120 cm.

Profile Ranen 22 : Oreru series  
 Classification : Soil Taxonomy (1970) : (Lithic) Troprothent  
                   F.A.O. (1974) : Eutric Regosol (Lithic phase)  
 Location : Near the road to Mariwa, east South-east  
           Awendo, South Nyanza district, sheet 130/3,  
           coordinates 34°32'53''E, 0°54'27''S,  
           elevation 143m,  
           described by J. van Keulen (08-09-1975)  
 Physiographic position :  
 Surrounding landform : undulating ridges  
 Slope : 3%  
 Parent material : probably Andesite (Nyanzian)  
 Vegetation : cultivated (maize)  
 Landuse : cropland  
 Drainage : somewhat excessively drained  
 Soil fauna : worms, ants  
 Root distribution : common medium, very frequent fine and very  
                   fine roots  
 Effective soil depth : 40 cm  
 Profile characteristics  
 AI 0 - 22 cm : Dark to dark reddish gray (5 YR 4/1, moist); gravelly  
               clay loam; moderate fine granular to subangular blocky  
               slightly hard, friable, slightly sticky and slightly  
               plastic; clear and wavy boundary.  
 C 22 - 40 cm : ?  
 R 40 - 60 cm : ?



Profile Ranen 23 : Manyata series  
 Classification : Soil Taxonomy (1970) : (Typic) Tropudalf  
                   F.A.O. (1974) : Chromic Luvisol  
 Location : 500m South of Sare School, South Nyanza  
            district, sheet 130/3, coordinates 34°31'  
            58''E, 0°54'39''S, elevation 1445m, des-  
            cribed by J. van Keulen (08-09-1975)  
 Physiographic position : upper part of a slope  
 Surrounding landform : undulating ridges  
 Slope : 2%  
 Parent material : probably Andesite (Nyanzian)  
 Vegetation : cultivated  
 Landuse : crop-land  
 Drainage : well drained  
 Soil fauna : ants, termites, moles  
 Root distribution : 0-50 cm: abundant fine and very fine roots  
                   deeper: frequent fine and abundant very  
                   fine roots  
 Effective soil depth : more than 135 cm

## Soil Profile:

AI 0 - 20 cm : Dark reddish gray to weak red (4 YR 4/2, moist); clay  
               loam moderate fine subangular blocky; common medium  
               and many fine biopores; hard, friable, slightly sticky  
               and slightly plastic; clear and wavy boundary.  
 B2 20- 130cm : Reddish brown ( 4 YR 4/4, moist); clay to clay loam;  
               moderate fine subangular blocky; common moderate clay  
               skins; **many** fine and very fine biopores; hard, friable  
               sticky and slightly plastic; clear and wavy boundary.  
 B3 130-135+cm : Andesite rock and rotten rock.  
 Remark : depth of the pit, 135 cm



Profile Ranen 25 : Awendo series  
 Classification : Soil Taxonomy (1970) : Eutric Pelludert  
                   F.A.O. (1974) : Pellic Vertisol  
 Location : Near Lwala School, South Nyanza district,  
            sheet 130/3, coordinates 31°31'23''E, 0°  
            55'19''S, elevation 1435m, described by  
            J. van Keulen and H. Reuler (04-12-1975)  
 Physiographic position : dissected plateau  
 Surrounding landform : flat to very gently undulating  
 Micro relief : somewhat irregular surface  
 Slope : 0-2%  
 Parent material : Basalt (Nyanzian)  
 Vegetation : trees 20%, (Accacia), shrubs 10%, grasses 70%  
 Landuse : extensive grazing, small parts cropland  
 Rock outcrops : 0-2%  
 Soil fauna : ants  
 Drainage : poorly drained  
 Erosion : very slightly sheet erosion  
 Root distribution : 0-2 cm, very frequent very fine, frequent  
                   fine, common medium and few coarse roots.  
 Effective soil depth : 60 cm

Soil Profile :

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

- BI 15 - 51 cm : Brown (7,5 YR 5/2, moist); few fine distinct strong brown (7, 5 YR 5/6) mottles; clay; few small gravels 1-3mm; moderate medium angular blocky; few medium many fine, and many very fine biopores; firm, sticky and plastic; small intersecting slickensides, gradual and wavy boundary.
- B2 51 - 80 cm : Grayish brown (10 YR 5/2, moist); many medium prominent yellowish red (5 YR 5/8) mottles; few small gravels, 2-10mm; clay; moderate medium angular blocky; common very fine and fine biopores; friable, sticky and plastic; small intersecting slickensides; abrupt and broken boundary.
- R 80 -120 cm : Basalt rock
- Remarks : see also profile 6.

- Profile Ranen 26 : Manyata series
- Classification : Soil Taxonomy (1970) : Ruptic Hapludallic  
Tropudalf  
F.A.O. (1974) : Chromic Phaeozem /  
Chromic Luvisol
- Location : Near Komolorume School, South Nyanza district sheet 130/3, coordinates 34°32'32"E, 0°52'42"S, elevation 1430 m, described by H. van Reuler
- Physiographic position : convex part of a slope
- Surrounding landform : gently undulating to undulating
- Slope : 6%
- Parent material : Andesite (Nyanzian)
- Vegetation : 15% trees, 50% shrubs, 35% grasses
- Landuse : extensive grazing
- Rock outcrops : rocky
- Soil fauna : ants, worms, termites
- Drainage : well drained
- Erosion : very slight sheet erosion

Root distribution : 0-20cm: abundant very fine, frequent fine  
and a very fine medium roots  
deeper: common very fine roots

Effective soil depth: 25-100 cm

Soil Profile :

AI 0 - 21 cm : Dark reddish brown (5 YR 3/2, moist); clay; weak  
very fine and fine subangular blocky; many very fine  
and common fine biopores; very friable, slightly  
sticky and slightly plastic; gradual and smooth bound-  
ary.

B2 21 - 67 cm : Reddish brown (5 YR 3/2, moist); clay; moderate  
medium subangular blocky; moderate common clay cutans;  
few very fine coarse and medium, many fine and very  
fine biopores; very friable, slightly sticky and  
slightly plastic; abrupt and broken boundary.

R 67 -100+cm : Andesite rock

Remark : see profile 15.

## Appendix 2

Comparison of series with other detailed reports with regards to analytical data.

Some soil series occur also in the Rangwe sample area (F.R. Breimer-Preliminary Report no.17). From these profiles analytical data are available.

Soil series	Ranen sample area (this report)	Rangwe sample area (P.R.17)
Aora Nam series		profile Ra 1
Riana-Kuna series	profiles 4.13.14.16	profile Ra 7
Oboke series	profiles 20	profile Ra 10
Marando series	profiles 1.7.9.12	profile Ra 11
Rabuor series	profiles 11	profile Ra 14

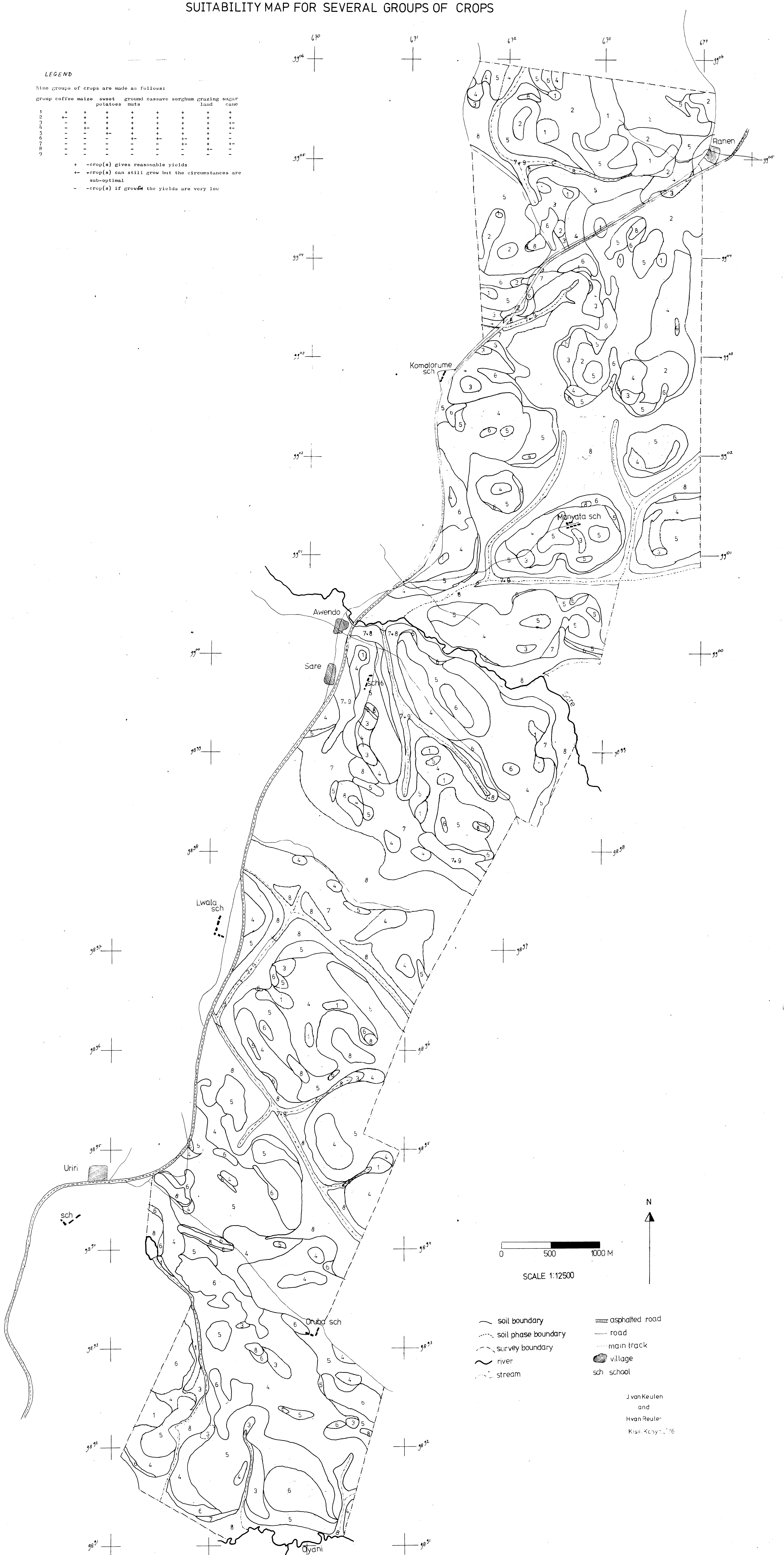
SUITABILITY MAP FOR SEVERAL GROUPS OF CROPS

LEGEND

Nine groups of crops are made as follows:

Group	coffee	maize	sweet potatoes	ground nuts	cassava	sorghum	grazing land	sugar cane
1	+	+	+	+	+	+	+	+
2	+	+	+	+	+	+	+	+
3	+	+	+	+	+	+	+	+
4	+	+	+	+	+	+	+	+
5	+	+	+	+	+	+	+	+
6	+	+	+	+	+	+	+	+
7	+	+	+	+	+	+	+	+
8	+	+	+	+	+	+	+	+
9	+	+	+	+	+	+	+	+

- + -crop(s) gives reasonable yields
- + -crop(s) can still grow but the circumstances are sub-optimal
- -crop(s) if grown the yields are very low



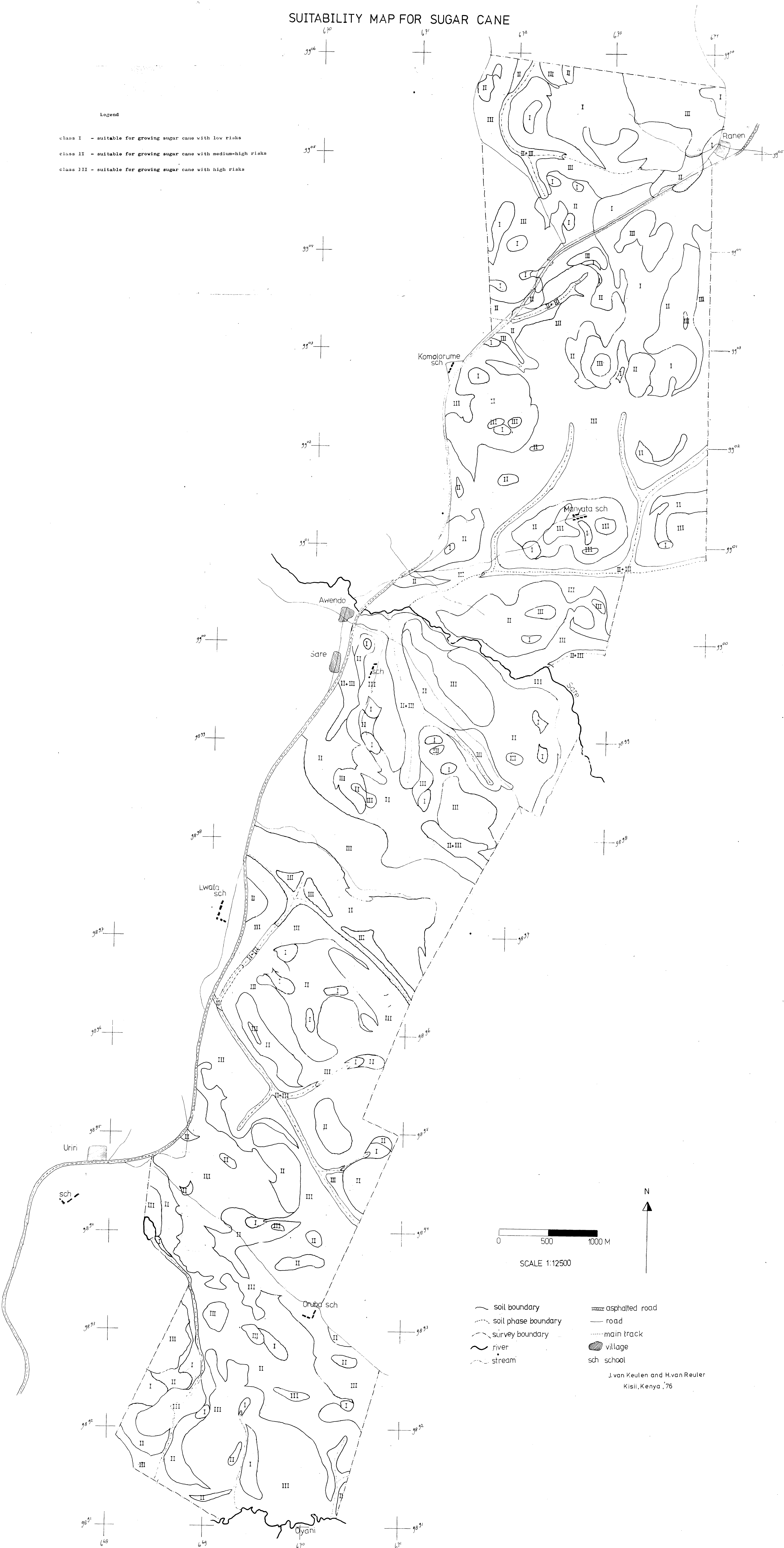
- soil boundary
- soil phase boundary
- survey boundary
- river
- stream
- asphalted road
- road
- main track
- village
- sch school

J van Keulen  
and  
H van Reuler  
Kisumu, Kenya, 1976

### SUITABILITY MAP FOR SUGAR CANE

**Legend**

- class I - suitable for growing sugar cane with low risks
- class II - suitable for growing sugar cane with medium-high risks
- class III - suitable for growing sugar cane with high risks



- soil boundary
- soil phase boundary
- survey boundary
- river
- stream
- asphalted road
- road
- main track
- village
- sch school

SCALE 1:12500

J. van Keulen and H. van Reuler  
Kisii, Kenya, '76

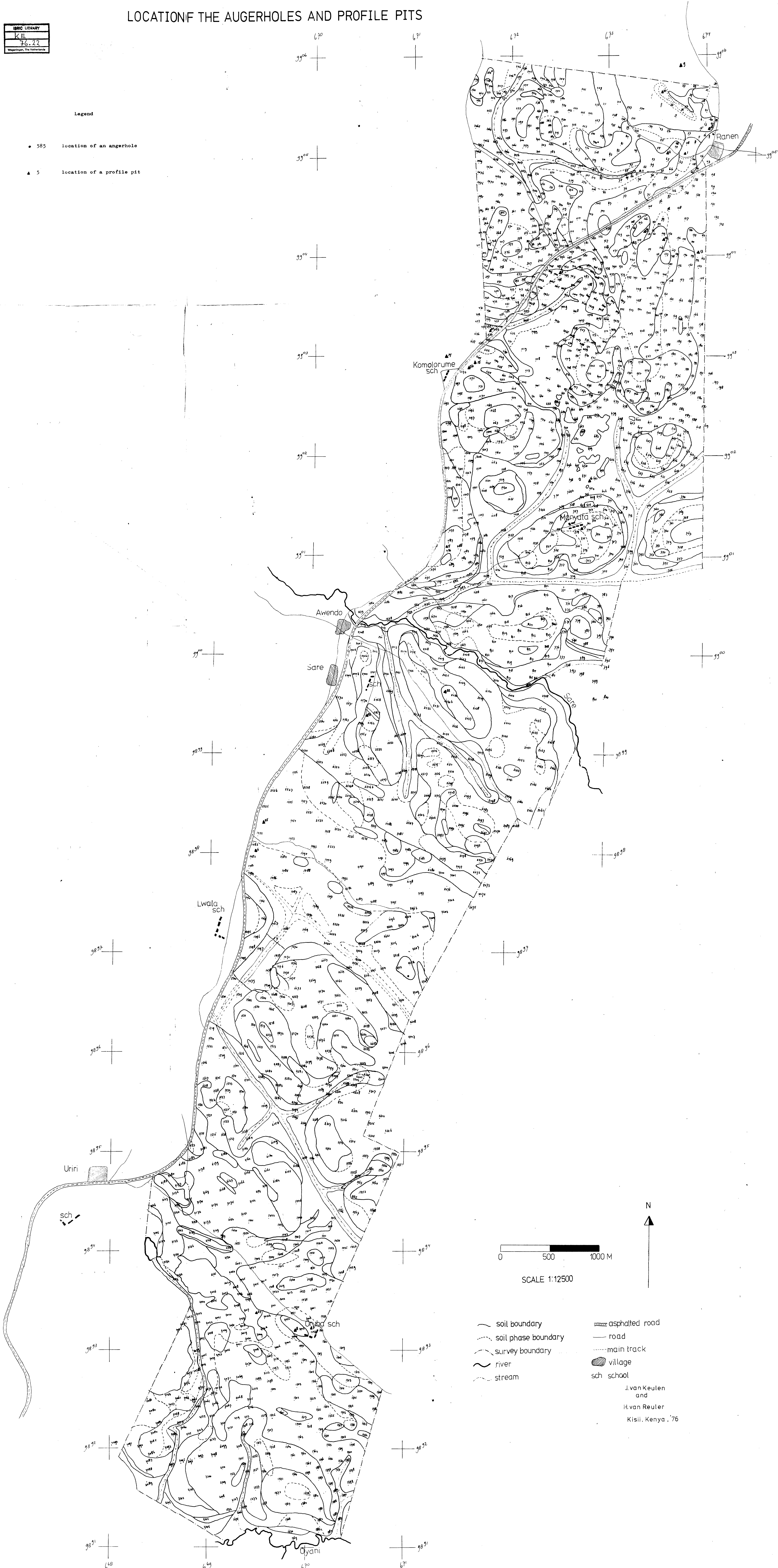


# LOCATION OF THE AUGERHOLES AND PROFILE PITS

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### Legend

- 585 location of an augerhole
- ▲ 5 location of a profile pit



SCALE 1:12500

- soil boundary
- - - soil phase boundary
- survey boundary
- ~ river
- ~ stream
- == asphalted road
- road
- main track
- ▭ village
- sch school

J. van Keulen  
and  
H. van Reuler  
Kisii, Kenya, '76



# THE SOIL MAP

LANDBOUWRECHTOEK  
 HOB3  
 Valgroep Tropische Plantenont  
 6700 AH WAGENINGEN

66x129

67° 67° 67° 67°  
 99° 99° 99° 99°



0 500 1000 M  
 SCALE 1:12500

- soil boundary
- - - soil phase boundary
- survey boundary
- ~ river
- ~ stream
- == asphalted road
- road
- main track
- ▭ village
- sch school

van Keulen and H. van Reuler  
 Kisumu, Kenya '76