Detailed Soil Survey of the Nyansiongo Area

PRELIMINARY REPORT NO 18
DETAILED SOIL SURVEY OF THE NYANSIONGO AREA

by

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Preliminary Report nr. 18
June 1976
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Preface

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

The project started in November 1973 after assent had been granted by the Office of the President of Kenya. It is meant for training of postgraduate students of the Agricultural University at Wageningen and 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 agriculture development of the area.

The project in Kisii is conducted by:
Ir. W.G. Wielemaker, teaching and research
Ing. H.W. Boxem, Management.

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

This report has been written by Mrs. I.M. Guikiag - Lens who was participating student from May 1975 to January 1976. The surveyed sample area was chosen to be representative for South-East Kisii, which was surveyed in semi-detailed by the author afterwards. Mr. H.W. Boxem compiled this report into this presentation.

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

The supervisor of the project

J. Bennema, Professor of Tropical Soil Science
1 GENERAL DESCRIPTION OF THE SURVEY AREA.

1.1 Location
Nyansiongo Area is crossed by the 35°00' E. meridian and the 0°48'S. parallel. It means that it is situated at the border of the Kisii Highlands. It lies just South of the asphalted road Kisii-Sotik, about 40 km S.E. from Kisii-town. The surface of the mapped area is about 3000 ha.

The area has been named after the village Nyansiongo, consisting of a secondary school and a catholic mission farm, a few shops and a tea factory.

1.2 Geomorphology
There is a division possible in three landscapes:
- an old strongly dissected plateau in the West
- the remainder of this plateau after a long erosion period: the "inselberg" area in the centre
- a plain, tongueing into the "inselberg" area, in the East.

These landscapes will be compared with each other.

See also table 1 on next page.

1.3 Topography (See cross-section)
The old plateau level has an altitude of 2100-2200 m, above sealevel and belongs to the undulating relief class. However it has been strongly dissected by small rivers, causing very steep (up till more than 30°, straight slopes. The lower part of the slope may be convex At the border of the plateau the valley floors have an altitude of about 1950 m.

The "inselberg" area consists of a rolling landscape, with an altitude of 1850 - 1950 m above sealevel, but with some steep conical hills, the "inselbergs", (slopes to more than 30°, ) whose tops can have an altitude of 2060 m above sealevel. Most of the (foot) slopes are straight, near the rivers slightly convex.
Table 1. Summary 1.2; Comparison of landscapes in Nyansiongo detailed Soil Survey

<table>
<thead>
<tr>
<th>Landscape</th>
<th>Plateau (west)</th>
<th>&quot;Inselberg&quot; area (east)</th>
<th>Plain area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topography</td>
<td>2100-2200 m</td>
<td>1850-2060 m</td>
<td>1815-1850 m</td>
</tr>
<tr>
<td></td>
<td>undulating</td>
<td>rolling</td>
<td>nearly</td>
</tr>
<tr>
<td></td>
<td>straight-convex slopes</td>
<td>straight-level</td>
<td>cox slopes</td>
</tr>
<tr>
<td>Hydrology</td>
<td>dendritic</td>
<td>dendritic</td>
<td>poorly drained</td>
</tr>
<tr>
<td></td>
<td>mainly well drained</td>
<td>poorly drained</td>
<td></td>
</tr>
<tr>
<td>Geology</td>
<td>rhyolites</td>
<td>alluvium (?)</td>
<td>volcanic ash influence</td>
</tr>
<tr>
<td></td>
<td>more than 1300-1400mm rainfall/year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Climate</td>
<td>1500 mm rainfall/year</td>
<td>April peak</td>
<td>January/February dry</td>
</tr>
<tr>
<td></td>
<td>April peak</td>
<td>8-27°C</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8-27°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vegetation</td>
<td>Cultivated</td>
<td>tree-grouped</td>
<td></td>
</tr>
<tr>
<td></td>
<td>with occurrence grassland</td>
<td>of many (Pennisetum Acacia's Gatabasis)</td>
<td></td>
</tr>
<tr>
<td>Landuse</td>
<td>arable land:</td>
<td>pasture</td>
<td></td>
</tr>
<tr>
<td></td>
<td>maize, millet, beans, sweet potatoes, tea, pyrethrum cattle grazing on shallow soils (hill tops)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Erosion</td>
<td>rill erosion on fallow land</td>
<td>sheet erosion gully forming</td>
<td></td>
</tr>
<tr>
<td>Soil</td>
<td>reddish brown</td>
<td>silty topsoil</td>
<td></td>
</tr>
<tr>
<td></td>
<td>silty clay-</td>
<td>heavy clayey</td>
<td></td>
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<tr>
<td></td>
<td>idem</td>
<td>but mere</td>
<td></td>
</tr>
<tr>
<td></td>
<td>clay</td>
<td>subsoil</td>
<td></td>
</tr>
<tr>
<td></td>
<td>gradual textural brown colours</td>
<td>change</td>
<td></td>
</tr>
</tbody>
</table>
The plain slopes to the East from ca. 1850 to 1815 m above seallevel, while the tongue in the "inselberg" area has an altitude of 1870 m in the most Western part. The plain is nearly level (slopes less than 3%), but also here small rivers incise, causing valley slopes of about 10%.

1.4 Hydrology
The drainage pattern of the whole area is dendritic. Except the few rivers flowing from the plateau to the west—which belong to Migori river system the whole area drains at the Sondu river via Kesaili-, Isogi-, Sisei- and Kapsomi river.

There are some springs on the plateau in depressions with a swamplike vegetation. The streams from these springs must pass a threshold at the border of the plateau.

Most of the springs, however, start just on the border of the plateau. Probably their streams have eroded the threshold already.

In the "inselberg" area springs occur just below the steep hills and at the border of the plain. The drainage class of the plateau and the "inselberg" which are somewhat excessively drained, the very wet valley bottoms and depressions— which are very poorly drained— and some nearly flat parts near Kesaili River— Which are imperfectly drained. In contrast with the above mentioned areas the plain is poorly to very poorly drained, although also here the erosion base is lowering (this is the case in the whole Nyansiongo Area). The reason for this bad drainage is the level situation; but more important is the heavy montmorillonitic clay in the subsoil.

1.5. Geology
According to the geologists J.J Schoeman, who made a geological map of the Sotik area (Western boundary of this area is the 35°00'E. meridian) in 1946/47, the Nyansiongo area belongs to the Bukoban - Kisii series, from upper Pre-Cambrium age:

Kisii series: - Big pebble conglomerate
  - Rhyolites, andesites, pyroclastics and finegrained sediments
  - Quartzite with basalt conglomerate

The conglomerates below the quartzite are as present in the center
of the Kisii district absent. Only a photo-copy of the geological map and report was available, which made map reading somewhat difficult.

Schoeman calls the rock of the plateau and "inselberg" area: Rhyolites and rhyolitical tuffs with fine-grained sediments". The plain consists of the same parent material but with "recent alluvium".

The well drained hills in the plain in the N.E. and S.E. of Nyansiongo area have been called "andesites and dacites"

The plateau and "inselberg" area recognized as rhyolitic, but the tuffs and sediments are not distinguished. Also a difference between the drained hills in the N.E. and S.E. of the mapped area was difficult to delineate. In the plain occurs a hard volcanic ash layer, varying from zero to about 30 cm in thickness, always within 150 cm, mostly between 100 and 150 cm depth. Heavy clay, occurs above as well as below the volcanic ash layer but with different colours and structures. Also when the hard ash layer is absent these two types of clay could be established. The well drained areas are also ash influenced, although no ash layer is present. Indication of the (fairy young) ash influence are:

a. The relatively brown colours of the soil, the in comparison with central and area of the Kisii district, the weathering product.

b. The "White spots" in the soil; this is a very fine sand
c. The relatively high silt percentage.
d. The low bulk density; but this may have been caused by the high biological activity in the soil.

The NaF-test was negative, so allophane seems to be absent.

It is obvious that more research is necessary for understanding the geology in the Nyansiongo area.

1.6 Climate

The Nyansiongo Area belongs to the "area with seasonal rainfall, with a lower April peak with continuous rainfall (A2)". However, this does not mean, that the climate over the whole area is identical. There is a fairly big difference in climate between the plateau and the rest of the area, due to the differences in altitude.
The plateau has annual rainfall of more than 1500 mm. Two rainfall registration stations are situated, in the "inselberg" area one gives 1400 mm/year, the other one 1300 mm/year for rainfall averages. It is probably not less than 1300 mm/year, because of the higher ridges situated in the plain in the most eastern part of Nyansionggo Area. Besides the high peak in April there is minor peak in December.

The dry period falls in the months January - February, with sometimes a completely dry month. The diurnal temperature ranges from 6-10°C just before sunrise up to about 27°C in the afternoon.

1.7 Vegetation

According to the Climate and Vegetation map, the high plateau belongs to the Western Moist Forest Zone and the plain to the Western Diospyros Forest Zone, indicated on the map with a broken (uncertain boundary).

But this boundary is pretty easy to distinguish when coming from Kisii, going to the East, just at the border of the plateau. Looking from here over the "inselberg" area and the plain, the difference in amount of Acacia's is striking.

Only on the very shallow hilltops and slopes and in the wet and very heavy textured plain remnants of the natural vegetation, can be found. The rest of the area is completely cultivated or has been cultivated in earlier years. The plain has a savannah-like appearance. This has not been caused by a dry climate, but by the alternating complete wetness and complete dryness of the top soil. It is therefore better to name it tree grouped grassland. The trees and bushes are situated on the better drained termite mounds, which are more numerous at the higher places in the plain, (about 20% bushes with a diameter of 5-10 m each). The grasses are poor and dominated by Pennisetum Catabasis. On the shallow hill tops the same vegetation type occurs. Bushes grow here only where the soil is deep enough for a good water supply during the whole year (on the termite mounds).

The well drained soils are all cultivated. At one place in the "inselberg" area, however, the land has not been used for crops for more than 10 years. So a secondary vegetation has developed: dense
bushes; among which Acacia's and fyearns.

1.8 Landuse
Before Independence of Kemya in 1963, the boundary between Kisii- and Kericho district was situated just on the East side of the plateau. Some settlers were living near the border of the Kericho district. In 1963 the boundary has been moved to the East for about 15 km. Then the former Kipsigis land has been sold to local farmers, mostly coming from the Kisii districts.

The contrast between the old Kisii district and the new settlement area consists of the size of the plots: in the old Kisii district the land has been divided among the farmers's sons since many decades, resulting in very small plots.

In the settlement area, where the relatively rich farmers could buy large plots of land, this division has not (yet) happened.

There is no difference in crop assortments between the old Kisii district and the settlement area. Maize, millet, beans and sweet potatoes are the most important subsistence crops, while tea and pyrethrum are cash crops. Furthermore, mainly on the shallow soils, black wattle is grown, used for the winning of a tinman and for building purposes. Soil tillage happens by hand and ploughing with the aid of the oxen. The main part of the shallow soils in the well drained area are used for cattle grazing, just like the physically very poor soils of the plain. In the dry season the standing hay is burned.

1.9 Erosion
In the well drained area -the plateau and "inselberg" area- erosion under natural condition is very little, but the influence of man is dangerous. During colonial times the farmers where obliged to construct terraces to prevent soil erosion, but unfortunately after Uhuru these terraces are rather neglected. Hill erosion can be observed in young tea, pyrethrum and maize fields after heavy rain showers. Footpaths change in small rivers and around drinking and washing places often only a shallow soil or bare rock occurs. It is known, that after making ridges of dead plants and tree branches on the contour lines of a pretty steep slope, small terraces of erosion products are formed within a few years.
Probably sheet erosion occurs in the plain. Near the streams, enormous gullies caused by cattle are noticeable.

2. **SOILS**

Some general characteristics of the soils in the different landscapes is given here while the next chapter more detailed information on soils will be presented. The distinction of the plateau from "inselberg" area is not relevant as far as the soils is concerned, together they form the "well drained" area. The distinction from the plain however, remains. In general it can be stated:
- the soils of the well drained area are reddish brown, silty clay with a gradual textural change with depth.
- the soils of the plain have a silty top soil and heavy clay subsoil; the textural change is abrupt.

Remark:
No distinction between the plateau and the "inselberg" area does not mean that there is no difference at all! Although the main colour is brown as well in the "inselberg" area as at the plateau, the soils in the eastern part of the "inselberg" area are a little more brownish.

2.1 **Soil Series.**

Twelve soils series, are distinguished of which nine occur in the well drained area and three in the plain. They have been named after villages, rivers and hills but because of a shortage of geographical names, one series got the name Anonymous.

The classification according to Soil Taxonomy and FAO are mentioned in the description of the series. The criteria for division into different groups (soil series), however, are not always the same as in the international classification systems. For example: Soils with a thick (more than 40 cm) humusrich (colour darker than 3 YR 3/2) top soil are seperated from soils with a less thick and/or less dark top soil. This division explains the position of the soil: Very humusrich soils in the depression, valleys etc. and less humusrich soils on slopes etc.

However, this means that soils with a less than 40 cm thick but still humusrich top soil, in the legend do not belong to soils with
2.2 Key to the soil series

The soils have been grouped according to their drainage class, except the soils with an abrupt textural change. That criterion is more important for distinction from other soils than their drainage class. However, for the uniformity of the classification system those soils are named "poorly and very poorly drained soils".

1a Soils with an abrupt textural change:

Poorly drained and very poorly drained soils (5a).

1b Other soils: (2.a)

2a (1b)

Completely reduced soils:

Very poorly drained soils: Kasaili series

2b Other soils:

3a (2b)

Soils with hyromorphic properties:

Imperfectly drained soils: Anonymous series

3b Other soils: (4.a)

4a(3b) Soils with an ABC-profile:

Well drained soils (7.a)

4b Other soils:

Somewhat excessively drained soils:

Sin goivek Series

Poorly and very poorly drained soils with an abrupt textural change

5a (1a) having hyromorphic properties throughout the profile:

Isogo Series

5b Other soils (6.a)

6a (5a) having a bleached A2: Nyansiengo Series

6b Other soils Manga series

Well drained soils with an ABC-profile

7a (4a) having a mottled B3-horizon (9.a)

7b (4a) having a thin stony B3-horizon (8.a)

8a (7a) having a dark topsoil (darker than 5 YR 3/2), more than 40 cm thick:

Nyamasibi Series

8b Other soils Kapsagut Series
9a (7a) having a dark topsoil (darker than 5 YR 3/2), more than 40 cm thicker: with the B3 starting deeper than 150 cm:

**Nyanturago Series**

B3 starting within 150 cm depth:

**Narang'ei Series**

9b Other soils (10.a)

10 (9b) Soils without a thick and/ ir dark topsoil with the B3 starting deeper than 150 cm:

**Ishuni Series**

10b B3 starting within 150 cm depth:

**Gesima Series**

2.3 Description of the Soil Series

**Sin'goiwek Series** (369 ha; 12% of the mapped surface)
Somewhat excessively drained, dark reddish brown to brown, silty clay, less than 30 cm deep soils, with an A-C/R profile, developed on rhyolite in the well drained area.

Classification: Soil Taxonomy: Lithic Oxic Eutropepts

FAO 1970 : Lithosols & Chronic Cambisols

This soil Series occurs on shallow hilltops, steep slopes and around drinking and washing places. Mostly used for cattle grazing, sometimes for growing of Black Wattle and very rarely for growing of crops. Although the roots can grow very deeply in/between the rock, they do not find enough water in the dry season.

Profile description: Appendix 1 (Profile 1) ?

**Kapsagut Series** (216 ha; 7% of the mapped surface)
Well drained, dark reddish brown to reddish brown, silty clay to clay, shallow and moderately deep soils (more than 30 cm depth), with an ABC/R profile, cambic or argillic B, thin stony B3 horizon, developed on rhyolite in the well drained area.

Classification: Soil Taxonomy: Oxic – & Lithic – & Mollic Eutropepts

Typic Oxic Tropudalfs

FAO 1970 : Chromic Cambisols & Orthic Luvisols

This soil series occurs just under the shallow hilltops and on some lower outcrops. At many places the strip of this series is too
small to indicate it on the soilmap. At those places is a very quick transition from the very shallow to the (moderately) deep soils with a mottled B3-horizon. The slopes are pretty steep: up to 30%. These soils are used for arable land, sometimes even for tea and pyrethrum, but it is obvious that the water storage in these soils is not ideal, because of the great permeability of the rock (thin stony B3 overlying a broken rock).

Profile description Appendix 1 (Profile 11).

**Nyamasibi Series** (7 ha; 0.2% of the mapped surface)

This very small soil series consists of similar soils as Kapsagut Series, but the soils of Nyamasibi Series have a dark topsoil, due to the level position. The topsoil colour requirements for Nyamasibi Series are:

- Darker than 5 YR 3/2 over a depth of more than 40 cm if the soil is deeper than 40 cm, otherwise as much as the soils depth.

Of course this means that this series is less excessively drained than the Kapsagut Series.

Classification: Soil Taxonomy: (Lithic) Oxic Hapludoll & (Lithic) Oxic Argiudolls

FAO 1970 : Haplic - & Luvic Phaeozems

Profile description: Appendix 1 (Profile 14)

**Gesima Series** (1033 ha; 35% of the mapped surface)

Well drained, reddish brown soils, silty clay to clay, with an argillic B- and a mottled B3-horizon, starting within 150 cm, sometimes containing concretions (Fe-Mn). Developed on rhyolite in the well drained area.

Classification: Soil Taxonomy: (Mellic) Oxic Tropudalfs

FAO 1970 : Luvic Phaeozems & Chromic Luvisols

It occurs on the plateau and on footslopes of the plateau and "inselberg" slopes vary from nearly level to 30%, but mostly the slopes are 6 to 20%.

These soils are (very) suitable for tea, pyrethrum and annual crops.

Profile description. Appendix 1 (Profile 1)
Ichuni Series (505 ha; 17% of the mapped surface)
A similar soil series as Gesima Series, but now the B3-horizon starts deeper than 150 cm.
Classification: Soil Taxonomy: Mollic –
depending on red-
ness of B-horizon Rhodudultic Oxic Tropudalfs
Rhodudultic Oxic Paletropudalfs & Oxic Paleudolls
FAO 1970 : Luvic Phaeozems &
Eutric Nitosols

Ichuni Series takes a big part of the undulating plateau and also occurs on foetslopes, often just under the shallow hill top or plateau border.
This means, that Inchuni Series has relatively more soils on the nearly level and steep slopes than Gesima Series. Profile description.
Appendix 1 (Profile 4)

Narang'ai Series and Nyanturago Series
Well drained, reddish brown soils, silty clay to clay, with an argillic B- and a mottled B3-horizon and with a thick (more than 40 cm) humus-rich (darker than 5 YR 3/2) topsoil. They occur in depressions of the plateau and slopes and in valleys, often in concave slopes just above springs. It has a dark topsoil partly because of less oxidation of the organic matter due to wetness, partly caused by an accumulation of topsoil from higher places (in the valleys).

Marng'ai Series (36 ha; 1% of the mapped surface)
The B3-horizon starts within 150 cm depth and contains Fe-Mn concretion (water conveying layer).
Classification: Soil Taxonomy: Oxic Argiudolls
FAO 1970 : Luvic Phaeozems

Nyanturago Series (114 ha; 4% of the mapped surface)
The B-horizon starts deeper than 150 cm and also contains concretions.
Classification: Soil Taxonomy: Oxic Argiudolls &
depending on
Oxic Paleudolls redness of
FAO 1970 : Luvic Phaeozems B-horizon

It must be obvious that these two soil series have the highest Agricultural value in Nyansiongo Area: everything can grow and the water supply is, especially on the Nyanturago Series sufficient during the year.
Profile description, Appendix 1 (Profile 3 and 6)

Anonymous Series (17 ha; 0.6% of the mapped surface)
Imperfectly drained soils, with oxidation-reduction mottles within 30 cm depth, silty clay to clay. Developed on rhyolite on flat parts near the poorly drained Kesaili River plain.
Classification: Soil Taxonomy: Aeric Mollic Tropaqualfs
FAO 1970 : Gleyic Luvisols
There is a not yet established, theory that these soils have been developed from the poorly drained soils with an abrupt textural change in the plain, after lowering of the erosion base, coupled with an increase of the biological activity, whereby the silty topsoil and the heavy subsoil could be mixed.
People use these soils sometimes for cropland: maize, millet etc., but they are too wet for tea and pyrethrum. The best use is grazing land.
Profile description: Appendix 1 (profile 12)
Kasaili series (9 ha; 3% of the mapped surface)
Very poorly drained, completely reduced soils, sometimes with a thin peaty topsoil.
Classification: Soil Taxonomy: Typic Tropaquents
FAO 1970 : Eutric Fluvisols
These soils occur in the flat depression in which the spring of a river is situated and in some broad flat Valley bottoms. In both cases developed on rhyolite in the well drained area. The vegetation on these soils is reeds. They are unsuitable for agriculture. There is no profile description of this soil series.
Manga series (520 ha; 17% of the mapped surface, 76% of the soils with an abrupt textural change).
Poorly drained soils with a bleached, silty topsoil overlying-sometimes tongueing into- a heavy bentonitic (slickensides!) subsoil. In the A2-horizon occur Fe-and Mn-mottle, at the abrupt textural change also Fe-Mn concretions. In the B-horizon occur only a few mottle and/or concretions. At certain depth, mostly between 100 and 150 cm, yellowish-white (hardened) ash layer occurs, varying from 0 to 30 (?) cm thickness. Below this layer also a heavy clay occurs, but this one is calcareous in contrast with the higher clay horizon and structure and colour are
The plain in which this soil series occurs is nearly level (slopes less than 3%), but has a micro relief formed by termite mounds with a diameter of about 5 to 10m and a height of ca. 1m. They take about 10-15% of the surface. The land is unsuitable for crop growing, due to the poorly physical condition of the soil:
- the roots can not grow in the heavy B-horizon.
- after rains the topsoil is too wet.
- after draught the topsoil is too dry.
Also for rice it looks unsuitable because the area lies too high (more than 1800m above sealevel) and because the water supply in the dry season is insufficient.
Some farmers have burned the termite mounds and grow maize and other crops, but these are very small spots. Normally the land is used for pasture. Profile description: Appendix 1 (Profile ....

**Nyansiongo series** (39 ha; 1% of the mapped surface, 6% of the soil with an abrupt textural change).
This soil series has the same characteristics as Manga Series, except the bleached topsoil. The description is: Poorly drained soils with a dark, silty topsoil overlying a heavy montmorillonitic subsoil. The topsoil is slightly mottled and concretions are rare.
Classification: Soil Taxonomy: Aeric Mollic Vertic Tropaqualfs
FAO 1970 : Gleyic – & Luvic Phaeozems
This soil occurs at the highest (best drained) places of the plain; probably they have been developed from soils of Nyansiongo Series after lowering of the erosion base. The density of the termite mounds (and bushes) is somewhat higher (about 20%) than in Nyansiongo series. Although also here the easiest landuse is pasture, some farmers grow maize.
Profile description: Appendix 1 (Profile 2).

**Isoge Series** (127 ha; 4% of the mapped surface, 18% of the soils with an abrupt textural change).
Very poorly drained soils with an abrupt textural change and hydromorphic properties throughout the profile.
This means: a completely reduced subsoil and a somewhat peaty topsoil in the incision of the plain in the "inselberg" area.

- Many (50-90%) Fe-Mn mottles and concretions throughout the profile (also in the B-horizon!) with sometimes a some. at peaty of the topsoil in the Eastern part of the plain.

Classification: Soil Taxonomy: Mollic Vertic Albaquic Tropaqualfs
FAO 1970: Mollic – Eutric Planosols

These soils occur along the rivers and in swamps around springs. The soils are unsuitable for cattle, due to the soft topsoil. But because of the importance of drinking water, cows are passing frequently, this has a often eroded topsoil as a result. On the wettest places reed is growing, on the somewhat drier places a pretty dense hush occurs. In contrast with the very wet soils of Kasaili Series, these soils are not completely unsuitable for agriculture. In the tongue of the plain in the "inselberg" area it is possible to grow vegetables like cabbage on the peaty soil.

Profile description: Appendix 1 (Profile 13)

3 Mapping units
The mapping units consists of a combination of:
- Soil Series (see 1.4.2)
- texture class of the topsoil
- rootable soil depth class
- slope class

In the mapping units of Nyansienge Area a symbol for the parent material do not occur, because all soils in the well drained area have been developed in rhyolite with volcanic ash influence, while all soils (3 series) in the plain have been formed in alluvium with a volcanic ash influence and here the parent material is of no importance for the soils.

Also I do not give symbols for rockiness and stoniness of the surface, because where they occur the soils are very shallow and form a separate soil series apart.
The same is in force for soils with a gradual textural change and hydromorphic properties: they form together the Anonymous series.

The soils in the plain (developed in alluvium; abrupt textural change) to which belong Nyansiengo-, Manga- and Isoge Series, do not have a symbol for the soil depth because:
- here the soil depth is of minor importance for the plant growth
- the absence of the hardened ash layer at some places is not visible in the landscape, which made mapping of it very difficult.

3.1 Texture classes of the topsoil
In Nyansiengo Area occur two classes:
M: medium fine textured topsoil: 17 - 35 % clay
C: coarse textured topsoil: less than 17 % lutum clay

3.2 Soil depth classes
There are five classes:
0: rootable soil depth more than 150 cm
1: " " " 100 - 150 cm
2: " " " 50 - 100 cm
3: " " " 20 - 50 cm
4: " " " 0 - 20 cm

3.3 Slope classes
A: level - nearly level: 0 - 3 %
B: gently sloping 3 - 8 %
C: sloping 8 - 15 %
D: moderately steep 15 - 30 %
E: steep 30 - 65 %
F: very steep: more than 65%, does not occur in Nyansiengo area.

3.4 Example of a mapping unit

Gesima Series Medium textured topsoil

G - M1 Soil depth 100 - 150 cm
C Slope 8 - 15%
4. The Maps
The mapping units have been drawn on panchromatic aerial photographs, with an approximate scale of 1:12,500, and, with the aid of a base map and sketch-master, transferred to a map with the exact scale 1:12,500.
One map has been provided with the mapping units: the soil map; another one with the location of the augerings and pits.

5. Part II
Land suitability in surveyed area.

5.1 Suitability of the well drained area (plateau and "inselbergs" area) for growing tea

5.1.1 Rainfall, water and soil requirements of tea
"Although tea tolerates dry spells, it only gives continuous flush growth when there is adequate soil moisture throughout the year. In long dry spells, in the absence of irrigation, flush growth ceases, the bushes wilt and eventually defoliate. "Mature tea requires a minimum of 100 mm of rainfall or irrigation water per month in some areas however this figure may be as high as 150 mm. The minimum average annual rainfall is sometimes quoted as being 1400 mm, but tea is grown successfully at Limuru (N.W. of Nairobi) with an annual rainfall of only 1250 mm; in this area evapo-transpiration is restricted for several months in the middle of the year by mists and low cloud". A deep well drained soil with a good water retaining capacity is essential because tea is a deep rooted crop and it requires an uninterrupted supply of water. The minimum soil depth is usually quoted as being 180 cm". Most of the roots, however, are found in the upper 90 cm". (J.D.Acland East African Crops, Longman 1973)

5.1.2 Assumed rainfall and evapo-transpiration data
The mean annual rainfall on the plateau is assumed to be 1600 mm and on the "inselberg" area 1350 mm (last figure is concluded from two rainfall registration stations, one gives 52 the other one 56 inch/year).
The evaporation from open water (Eo, Penman) is supposed to be

The potential evapo-transpiration (Ep) is supposed to be equal to Eo (according to Van Meurik). The actual evapotranspiration (Ea) is Ep.

R(rainfall) -Ep is positive in April-May and assumed to be 150 mm on the plateau and 100 mm in the "inselberg" area.

In the other months R-Ep is negative with the lowest values in December-January: -200 mm on the plateau and -350 mm in the "inselberg" area (assumptions).

These R-Ep figures have been deduced from Van Meurik's climatic contribution to the preliminary report no. 1, because there are no monthly rainfall and evapo-transpiration data available of Nyansiongo Area.

5.1.3 Moisture storage in the soil

From pF data of profile no. 8 (see A.1.4) moisture percentages (volume %) are readable.

If the moisture between pF 2.3 and pF 3.6 is considered as for the plant easily available moisture, then the A-horizon contains 2.3 mm moisture/cm soildepth, the B2 1.7 mm moisture/cm soildepth and the B3 1.4 mm moisture/cm soildepth.

Profile no. 8 can be considered as representative for the well drained, moderately deep and deep soils.

5.1.4 Suitability classes for growing tea

Because:
- the fertility of the well drained soils is pretty high (however fertilizer gifts cause higher yields) and is pretty equal in Nyansiongo Area,
- erosion danger is little on slopes less than 15% in an adult tea crop, which has a close foliage, covering the soil completely,
- the slope % is minor importance for tea picking and weed control, which happen by hand,

I have based the suitability classes on the above mentioned possibility of water storage, with other words; the soildepth.
Classes:

3 very suitable: no damage to tea plants in dry spells
2 suitable: damage to the tea plants in dry spells is rare
1 moderately suitable: damage chance in dry spells is pretty big
0 unsuitable: growing tea not remunerative

In these suitability classes next soil groups occur:

<table>
<thead>
<tr>
<th>Plateau</th>
<th>&quot;Inselberg&quot; Area</th>
</tr>
</thead>
</table>
| 3 well drained, med. deep | Well drained, deep soils with extra water supply (situated in depressions or under shallow tops and scarps).
| and deep soils, with extra water supply (situated in depressions or under shallow tops and scarps). |
| 2 Well drained soils, deeper than 50 cm, or, if situated water supply (situated in depressions or under shallow tops and scarps). |
| 1 Well drained soils, 50-100 cm deep, situated on slopes 100 cm of more than 15%. |
| 0 somewhat excessively drained soils, less than 50 cm deep, ivy drained soils, less than 100 cm deep, and imperfectly and poorly drained soils. |
| 0 poorly drained soils. |

Suitability of the poorly drained plain and the imperfectly drained areas of the "Inselberg" Area for grassland

The vegetation in the plain consists of a natural, poor tree-grouped-grassland. The imperfectly drained soils of the "Inselberg" area do not have their natural vegetation, but at most places are used for grassland and sometimes for crepland. My knowledge of grasses and grasslands is too small to pass pronouness about sowing or planting of better grasses. I will give some information about the physical properties of the soils, which are important for every kind of grassland with as purpose cattle grazing.
5.2.1 Suitability classes

For dividing in different classes you can ask next questions:

- can the rain water pass through the profile?
- if not: how quickly is the rain water removed by streaming through the topsoil or over the surface or by evaporation?
- how moisture is available for the grasses during dry periods?
- how big is the erosion danger of the topsoil?

With respect to these questions I have composed the following suitability classes:

2 Suitable: (Top) soil is completely wet only during short spells; no or little removal of surplus rainwater through or over the topsoil; pretty good water retaining capacity; low erodibility.

To this class belong Anonymous Series and Manga Series.

1 Moderately suitable: Topsoil is completely water saturated during one or two months (April-May) and for short times after heavy rain showers; removal of surplus rainwater through and partly over the topsoil; strong growth reduction during dry months; pretty susceptible to erosion due to passing cattle.

To this class belongs Nyansionge Series.

0 Unsuitable: Wet during the whole or the greater part of the year; no grass growth reduction due to draughty; highly susceptible to erosion, low carrying capacity.

To this class belongs Isoge Series.

6. References

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Appendix 1 Profile descriptions of Soil Series

1. Sin'goiwek Series (according to augerings).

Range of Characteristics:
Classification: Soil Taxonomy: Lithic Oxic Eutropepts
FAO: Lithosels & Eutric Regosels

Meso relief: tops of "inselbergs", border of plateau steeply dissected valley slopes

Micro relief: termite mounds

Surrounding
Landform: rolling
Geology: Upper class of Bukeban system, rhyolites
Regional Vegetation: Tree-grouped-grassland
Landuse: pasture, black wattle planting
Soil Fauna: termites, ants other insects
Drainage: (somewhat) excessively drained
Root development: few or no coarse roots, few to common medium roots, many fine and very fine roots in the A-horizon, deeper: few fine and very fine roots

Effective soil-
depth: less than 30 cm
Horizon:
succeeding: A-AC-R

A1: Dark reddish brown to reddish brown (5 YR 3/2-4/4) when moist; (silt) lean; moderate to strong, very fine to fine subangular blocky; common to many biopores; 0-50% stones; less than 20 cm thick;

AC: do but with steminess up to 80% 5-20 cm thick;

R: stones / rock with many joints.

2. Kapsagut Series (profile no. 11 Nyansiege Area)
Description: 21-5-1975, I.M.Guiking-Lens
Classification: Soil Taxonomy: Ultic Oxic Tropudalf
FAO: Orthic Luvisol
Location: Nyansiege Area, hills near Nyanturage, Kisii District; 34°58'02"E., 0°48'44"S.; altitude 2075 m

Physiographic position: steep slope (30%) of plateau border, just under shallow hill top

Surrounding landform: rolling
Geology: Upper class of Bukeban system: rhyolites
Regional vegetation: tree-grouped-grassland
Landuse: pasture, black wattle
Soil fauna: termites, ants
Drainage: well drained

Root development: many fine and very fine roots in A1
  common fine and very fine roots in B2t
  few fine and very fine roots in R

Effective soil depth: 106 cm.

Profile characteristics

A1 0 - 28 cm: Dark reddish brown (5 YR 3/3 - 2,5 YR 3/4, moist); silt loam; moderate, very fine granular structure; very friable, slightly sticky and slightly plastic; many very fine biopores; clear and smooth boundary.

B2t 28 -106 cm: Dark reddish brown (2,5 YR 3/4), more down reddish brown (2,5 YR 4/4, moist); silt loam with a few stones; very weak subangular blocky; very friable, slightly sticky and slightly plastic; common very fine biopores; abrupt and wavy boundary.

C/R 106 + cm: Stones

Range of profile characteristics

<table>
<thead>
<tr>
<th></th>
<th>A1</th>
<th>B2(t)</th>
<th>C/R</th>
</tr>
</thead>
<tbody>
<tr>
<td>thickness</td>
<td>20 - 40 cm</td>
<td>20 - 50 cm</td>
<td>Rock with many joints, often meters deep</td>
</tr>
<tr>
<td>colour</td>
<td>dark reddish brown (Hue's 2,5 YR and 5 YR)</td>
<td>dark reddish brown to reddish brown (Hue's 2,5 YR and 5 YR)</td>
<td></td>
</tr>
<tr>
<td>texture</td>
<td>silt loam</td>
<td>silt loam to silty clay, sometimes with stones</td>
<td></td>
</tr>
<tr>
<td>structure</td>
<td>moderate to strong, very fine to fine subangular blocky</td>
<td>weak to moderate, very fine to fine subangular blocky</td>
<td></td>
</tr>
<tr>
<td>consistence</td>
<td>friable when moist, slightly to non-sticky and slightly to non-plastic when wet</td>
<td>friable when moist, slightly sticky and slightly plastic when wet</td>
<td></td>
</tr>
<tr>
<td>biopores</td>
<td>many to common</td>
<td>many to common</td>
<td></td>
</tr>
</tbody>
</table>
3. Nyamasibi Series (profile no. 14 Nyansiongo Area.)

Description: 26-9-1975, I.M. Guiking-Lens

Classification: Soil Taxonomy: Ultic Oxic Hapludell
- FAO: Haplic Phaeozem

Location: Nyansiongo Area, Kisii District; 34°59'15" E., 0°47'09" S.; altitude 2035

Physiographic
- position: nearly level part of top of "inselberg" ridge

Surrounding landform: rolling

Geology: upper class of Bukoban system, rhyolites

Regi vegetation: cultivated

Landuse: tea

Soil fauna: termites, ants

Drainage: well drained

Root development: many very fine and fine roots in the A1; common fine and very fine roots in AC

Effective soil depth: 60 cm

Profile characteristics

A1 0 - 15 cm: Dark reddish brown to black (5 YR 2,5/2, moist); silt loam with a few stones; moderate, fine subangular blocky; common fine and very fine biopores; friable, slightly sticky and plastic; diffuse and smooth boundary.

AC 15 - 60 cm: Dark reddish brown (5 YR 3/2, moist); sandy clay with 20% stones; moderate, very fine to fine subangular blocky; friable, slightly sticky and slightly plastic.

C/R 60 + cm: Rock (rhyolite) with many joints.

Range of profile characteristics

- A1 thickness: 20 - 40 cm
- Colour: 5 YR 3/2 and darker (Hue 5 YR) when moist
- Texture: silt loam
- Structure: moderate to strong, very fine to fine subangular blocky
- Consistence: friable when moist, slightly to non-sticky and
and slightly to non-plastic when wet

biopores: many

AC/B thickness: 10 - 50 cm

ceur: dark reddish brown to red (5 YR 3/2 - 2,5 YR 3/2 - 2,5 YR 4/6) when moist
texture: silt loam to silty clay
structure: moderate to weak, very fine to fine subangular blocky
consistence: friable when moist, slightly sticky and slightly plastic when wet

biopores: many to common

B3 Stoniness up to 80%, 10-60 cm thick
C/R Rock with many joints, often meters deep

Analytical data profile 14: pF, moisture percentages

def shall bulk Sat. pF pF pF pF pF pF pF pF pF pF

cm density 0.4 1 1.5 2 2.3 2.8 3 3.6 4.2 x

5-10 1.11 56.3 54.8 54.8 54.7 46.6 44.8 39.7 35.0 24.9 21.7%
15-20 1.06 58.8 56.2 51.6 45.8 38.7 38.4 34.8 29.3 21.9 20-35

4. Gesima Series (Profile no. 1 Nyansionge Area.)

Description: 5-6-1975, I.M.Guiking-Lens
Classification: Soil Taxonomy: Mollic Oxic Tropudalf

FAO: Luvic Phaeozem
Location: Nyansionge Area, Kisii District; 35°00'45''E.,
0°47'42''S.; altitude 1890 m

Physiographic
position: lower part of feetslepe, 8%

Surrounding landform: rolling

Geology: Upper class of Bukobam system, rhyolites;
with volcanic ash influence

Regional Vegetation: cultivated, with occurence of acacia's

Landuse: cropland: banana's, beans, maize

Soil fauna: ants; termites, moles (Spalax)
Drainage: well drained

Root development: few coarse, common medium, many fine and very fine roots, decreasing with depth

Effective soil depth: 105 cm

Profile characteristics:

Ap 0-20 cm: Dark reddish brown (5 YR 3/2, moist); lean; moderate, very fine subangular blocky; friable, slightly sticky and slightly plastic, many very fine and fine biopores; diffuse and smooth boundary.

A12 20-40 cm: Dark reddish brown (5 YR 3/3, moist); lean; moderate, very fine subangular blocky; friable, slightly sticky and slightly plastic; many to common very fine and fine biopores; diffuse and smooth boundary.

AB 40-60 cm: Reddish brown (5 YR 4/4, moist); few fine and faint yellowish red (5 YR 5/6-5/8) mottles; lean; moderate to weak, very fine subangular blocky; friable, slightly sticky and slightly plastic; broken, thin clay cutans; common very fine and fine biopores; diffuse and wavy boundary.

B21t 60-99 cm: Reddish brown (5 YR 4/4, moist); few fine and faint yellowish red (5 YR 5/6-5/8) mottles; silt lean; weak, very fine subangular blocky; friable, sticky and slightly plastic; continuous, thick clay cutans; few very fine and fine biopores; abrupt and smooth boundary.

B22t 99-107 cm: Reddish brown (5 YR 4/4, moist, few fine and faint yellowish red (5 YR 5/6-5/8) mottles; silt lean; weak very fine subangular blocky; friable, sticky and slightly plastic; continuous, thick clay cutans; ca. 40% Fe-Mn concretions, 3-5 mm Ø; few very fine to fine biopores; abrupt and wavy boundary.

B3 107-135 cm: Mottles material: reddish yellow, strong brown, dark red, with 90% Fe-Mn concretions; abrupt and wavy boundary.

R 135+ cm: Rotten rock
Analytical data

<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>CEC</th>
<th>Na</th>
<th>K</th>
<th>Ca</th>
<th>Mg</th>
<th>Base Saturation (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-20</td>
<td>19.94</td>
<td>2.50</td>
<td>1.87</td>
<td>12.88</td>
<td>1.49</td>
<td>94</td>
</tr>
<tr>
<td>60-110</td>
<td>12.44</td>
<td>2.44</td>
<td>1.99</td>
<td>6.12</td>
<td>2.00</td>
<td>100</td>
</tr>
</tbody>
</table>

Particle size (mm)

<table>
<thead>
<tr>
<th>Range (mm)</th>
<th>2.00-</th>
<th>1.00</th>
<th>0.50-</th>
<th>0.25-</th>
<th>0.10-</th>
<th>0.05-</th>
<th>Clay</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-20</td>
<td>1.3</td>
<td>3.1</td>
<td>6.6</td>
<td>8.3</td>
<td>6.3</td>
<td>48.8</td>
<td>25.6 %</td>
</tr>
<tr>
<td>60-110</td>
<td>1.6</td>
<td>2.5</td>
<td>2.9</td>
<td>4.4</td>
<td>4.5</td>
<td>60.8</td>
<td>23.2 %</td>
</tr>
</tbody>
</table>

Gesima Series (Profile no. 8, Nyansiongo Area.)

Description: 22-7-1975, I.M. Guiking-Lens

Classification: Soil Taxonomy: Mollic Ultic Oxic Tropudalf

FAO: Luvic Phaeozem

Location: Nyansiongo Area, Tinderet Range, Kisii District; 34°59'19"E., 0°46'58" S., altitude 1900 m

Physiographic position: foetslope, 12%

Surrounding landform: rolling

Geology: Upper class of Bukoban system, rhyolites, with volcanic ash influence

Regional vegetation: cultivated

Landuse: farm yard

Soil fauna: ants, termites

Drainage: well drained

Root development: few coarse, common medium, many fine and very fine roots, decreasing with depth

Effective soil depth: 135 cm, few roots till 240 cm

Profile characteristics

A1 0 - 23 cm: Dark reddish brown (5 YR 3/2-3/3, moist); silty clay lean; moderate, very fine granular structure; very friable, slightly sticky and slightly plastic; many very fine biopores; abrupt and smooth boundary.
B1 23 - 55 cm: Dark reddish brown (5 YR 3/3-2,5 YR 3/4, moist); silty clay loam; weak, very fine subangular blocky; very friable, slightly sticky and slightly plastic; few Fe-Mn concretions, ca. 3 mm Ø; common, very fine biopores; clear and smooth boundary.

B2t 55 - 81 cm: Dark reddish brown (2,5 YR 3/4, moist); silty clay loam; moderate to weak, fine subangular blocky; very friable, sticky and plastic; few Fe-Mn concretions, 5 mm Ø; common very fine biopores; broken, thin to moderately thick clay cutans; clear and smooth boundary.

B31 81-96/135 cm: Dark reddish brown (2,5 YR 3A, moist); clay loam; moderate to strong, very fine subangular blocky; friable, sticky and plastic; continuous, moderately thick clay cutans; Fe-Mn concretions, 40 % 5 mm Ø; common very fine biopores; abrupt and wavy to irregular boundary.

B32 90/135-375 cm: Very mottled material (many black mottles); 80% Fe-Mn concretions; few quartz pebbles; abrupt and wavy boundary.

C/R 375 + cm: Reddish yellow (7,5 YR 6/6) material; soft.

Range of profile characteristics Gesima Series

A thickness: 20 - 40 cm
 couleur: dark reddish brown (5 YR 3/2-3/3 - 2,5 YR 3/4)
texture: loam to silty clay loam
structure: granular fine to very fine to moderate fine to very fine subangular blocky
consistence: (very) friable when moist, non-to slightly sticky, non- to slightly plastic when wet
biopores: many

B2t thickness: 20 - 110 cm
couleur: dark reddish brown to red (2,5 YR 3/4-4/6), or dark reddish brown to yellowish red (5 YR 3/3-4/6); the former occurring in central and West-; the latter in central and East Nyansiongo Area
texture : silty clay loam; loam; clay loam
structure : moderate to weak very fine to fine subangular to angular blocky
consistence : friable when moist, slightly sticky to sticky to sticky and slightly plastic to plastic when wet
cutans : brown, thin to continuous, thick (clay) cutans, often destroyed by soil fauna
Concretions : be to some small Fe-Mn concretions
biopores : common to many
B3 thickness : 10 cm to some meters, always starting within 150 cm
colour : red to yellowish red, plus rotten rock colours
mottles : Mn-mottles
concretions : few to 90%
stones : few to 80%
cutans : mostly thick continuous (clay) cutans

5. Ichuni Series (profile no. 4 Nyansiente Area)
Description : 19-6-1975, I.M.Guiking-Lens
Classification : Soil Taxonomy: Ultic Oxic Tropudalf
FAO : Eutric Nitosol
Location : Nyansiente Area, Kapsagut hill, Kisii District; 35°00'32"E., 0°48'24"S; altitude 1870 m
Physiographic
position : footslope, 12%
Surrounding landform: rolling
Geology : Upper class of Bukoban system, rhyolites, with volcanic ash influence
Regional vegeta.: cultivated, with occurrence of acacia's
Landuse : arable land
Soil fauna : ants, termites
Drainage : well drained
Root development: many very fine and fine roots in the A, deeper common very fine and fine roots
Effective soildepth: more than 180 cm.
Profile characteristics

A1 0 - 20 cm: Dark reddish brown (5 YR 3/3, moist); silt loam; moderate very fine subangular blocky; slightly hard, slightly sticky and slightly plastic; common fine biopores; diffuse and smooth boundary.

A3 20 - 45 cm: Dark reddish brown (5 YR 3/3, moist); silt loam; moderate to weak, very fine subangular blocky; slightly hard, slightly sticky and slightly plastic; many fine biopores; diffuse and smooth boundary.

B2t1 45 - 90 cm: Dark reddish brown (5 YR 3/3, moist); silty clay loam; moderate, very fine crumb structure; slightly hard, slightly sticky and slightly plastic; many fine biopores; diffuse and smooth boundary.

B2t2 90 - 125 cm: Dark reddish brown (5 YR 3/3, moist); silty clay loam; moderate, very fine to fine subangular blocky; firm, sticky and plastic; thin, moderately thick patchy to broken clay cutans; common fine biopores.

B2t3 125 - 185 cm: Dark reddish brown (5 YR 3/3, moist); few, very fine and faint strong brown (7.5 YR 5/8) and black mottles; silty clay; moderate, coarse, angular blocky; firm, sticky and plastic; thick continuous clay+Mn cutans; common to few very fine and fine biopores.

B3/C 185 + cm: Mottled material; ca. 20% Fe-Mn mottles and concretion s; continuous clay+Mn cutans.

Range of profile characteristics

See range of characteristics of Gesima Series, but not the B3-horizon always deeper than 150 cm below the surface.

6. Narang'ai Series (profile no. 3 Nyansiong'e Area.)

Description : 10-6-1975 I.M. Gwaking-Lens

Classification : Soil Taxonomy: Ultic Oxic Argiudoll

FAO : Luvic Phaeozem

Location : Nyansiong'e Area, near Nyansiong'e Secondary School.

Kisii District; 35 00'52". E. 0 47' 21 S.; altitude
1880 m + seal level

Physiographic

Position: depression within foot slope, 8%

Surrounding landform: rolling

Geology: Upper class of Bukoban system, rhyolites, with volcanic influence

Regional Vegetation: cultivated, with many acacia's

Landuse: cropland and grassland

Soil fauna: ants, termites, worm (1), moles (Spalax)

Drainage: moderately well drained

Root development: very fine medium fine roots, many, decreasing with depth

Effective soil depth: 110 cm

Profile characteristics

Ap 0 - 35 cm: Dark brown (7.5 YR 3/2, moist); few fine distinct yellowish red (5 YR 5/8) mottles; silt loam, weak to moderate, very fine subangular blocky very friable, slightly sticky and slightly plastic; many very fine and fine biopores; diffuse and smooth boundary.

A3 35 - 60 cm: Dark brown (7.5 YR 3/2 moist); few fine distinct yellowish red (5 YR 5/8 mottles; silt loam; moderate very fine subangular blocky; friable, slightly sticky and slightly plastic; many fine biopores; diffuse and smooth boundary.

B1 60 - 87 cm: Dark reddish brown (5 YR 3/3, moist); few, fine distinct yellowish red (5 YR 5/8) mottles; silty clay moderate, very fine subangular blocky; friable, sticky and slightly plastic; thin, patchy clay+Mn cutans; few small Fe-Mn concretions; common fine biopores; abrupt to clear and smooth boundary.

B2t 87-100/110 cm: Brown to dark brown (7.5 YR 4/4, moist); few fine distinct yellowish red (5 YR 5/8) mottles; moderate, fine crumb structure; friable, sticky and slightly plastic; thin, broken clay+Mn cutans 10% Fe-Mn concretions; abrupt and wavy boundary.
B3/C 100/110+ cm: Brownish yellow material (10 YR 6/6), probably ash layer; many fine pores.

Narang'at Series (profile no. 15 Nyansienge Area.)

Description: December 1975, I.M. Guiking-Lens

Classification: Soil Taxonomy: Ultic Oxic Argyudell

FAO: Luvic Phaeozem

Location: Nyansientge Area, Nyamasibi plateau, Kisii District;
34° 57'23" E., 0° 48'42" S.;
altitude 2145 m

Physiographic

position: border of depression in plateau

Surrounding landform: steeply dissected

Meso relief: undulating plateau

Geology: Upper class of Bukoban syssem, rhyolites, with volcanic ash influence

Regional vegetation: cultivated

Landuse: cropland

Soil fauna: termites, ants, some worms

Drainage: well drained

Root development: fine and very fine roots, mainly in upper 60 cm

Effective soil depth: very deep

Profile characteristics

Ap 0 - 22 cm: Dark reddish brown (5 YR 3/2, moist); silt loam; moderate to strong, fine subangular blocky; very friable, slightly sticky and slightly plastic; many very fine and fine biopores; gradual and smooth boundary.

A3 22 - 66 cm: Dark reddish brown to dusky red (2.5-5 YR 3/2, moist); few, distinct fine reddish yellow mettles (burning); silt loam; weak, very fine subangular blocky; very friable, slightly sticky and slightly plastic; many very fine and fine biopores; gradual and smooth boundary.
### Range of profile characteristics

<table>
<thead>
<tr>
<th>Thickness</th>
<th>Colour</th>
<th>Texture</th>
<th>Structure</th>
<th>Consistence</th>
<th>Biopores</th>
<th>Mottles</th>
<th>Cutans</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A</strong></td>
<td>: 40 - 70 cm</td>
<td>: dark reddish brown to black (10 YR 3/2-2.5/1)</td>
<td>: silt loam to loam</td>
<td>: moderate to strong, very fine subangular blocky to granular structure</td>
<td>: (very) friable when moist, slightly sticky and slightly plastic when wet</td>
<td>: many</td>
<td>: sometimes few, small, faint to distinct yellowish red</td>
</tr>
<tr>
<td><strong>Bt</strong></td>
<td>: 40 - 110 cm</td>
<td>: dark reddish brown to red (2,5 YR 3/4-4/6) or dark reddish brown to yellowish red or brown (Hue's 5 YR resp. 7.5 YR)</td>
<td>: silt loam to silty clay loam</td>
<td>: moderate to weak, very fine to fine, subangular to angular blocky</td>
<td>: friable when moist, sticky and plastic when wet</td>
<td>: many to common</td>
<td>: sometimes few, small, faint to distinct yellowish red</td>
</tr>
<tr>
<td><strong>B3</strong></td>
<td>: 10 cm to some meters, but always starting within 150 cm soil depth</td>
<td>: reddish brown to red or yellowish red or brown, often a mixture of colours</td>
<td>: thin patchy continuous clay+Mn cutans</td>
<td>: thin patchy continuous clay+Mn cutans</td>
<td>: thin patchy continuous clay+Mn cutans</td>
<td>: thin patchy continuous clay+Mn cutans</td>
<td></td>
</tr>
</tbody>
</table>
concretions : up to 90% Fe-Mn concretions
stones : do

7. Nyanturage Series (profile no. Nyansieoge Area.)
Description : 11-7-1975, I.M.Guiking-Lens
Classification : Soil Taxonomy: Oxic Paleudoll
FAO : Luvic Phaeozem
Location : Nyansiongo Area, valley between Sim'geiwek and
Narang'au Hill, Kisii District; 35 00'18"E.
0 47'31" S., altitude 1930 m

Physiographic
position : valley bottom
Surrounding land-
form : rolling
Geology : upper class of Bukoban system, rhyolites, with
volcanic ash influence
Regional vegetation: bush and herbs: acacia's, ferns (1)
Vegetation at
location : grasses
Landuse : arable land since about 10 years
Soil fauna : ants, meles (Spalax), beetles
Drainage : well fine and very fine roots throughout the
profile
Effective soil-
depth : more than 200 cm

Profile characteristics
Ap 0 - 15 cm: Dark reddish brown (5 YR 2.5/2, moist); silt loam;
moderate, very fine granular structure; very friable,
slightly sticky and slightly plastic; many fine and
very fine, common medium biopores; abrupt and smooth
boundary.

A3 15 - 65 cm: Dark reddish brown (5 YR 3/2-3/3, moist); silt loam;
moderate, very fine to fine subangular blocky; very
friable, slightly sticky and slightly plastic; many
fine and very fine biopores; clear and smooth boundary.
B1 65 - 97 cm: Dark reddish brown (5 YR 3/2, moist); silty clay; moderate very fine subangular blocky; friable, slightly sticky and slightly plastic; many very fine and fine biopores; clear and smooth boundary.

B2t1 97 -120 cm: Dark reddish brown (5 YR 3/2, moist); silty clay: moderate, very fine subangular blocky; thin, patchy (clay) cutans; friable, slightly sticky and slightly plastic; common, very fine and fine biopores; gradual and smooth boundary.

B2t2 120-154 cm: Dark reddish brown (5 YR 3/3, wet); few, medium, distinct yellowish red mottles; clay; moderate, very fine subangular blocky; thick, continuous clay cutans; friable to firm, slightly sticky and slightly plastic; diffuse and smooth boundary.

B23 154-190 cm: Dark reddish brown (5 YR 3/4, wet); Fe-Mn mottles; clay; few stones; moderate, fine angular blocky; very thick continuous clay cutans; firm, slightly sticky and slightly plastic

B3/C 190 + cm: Rotten rock mixed with soil

Remarks: in the A3- and B1- horizon red mottles occur, due to burning years ago.

Conclusion: colluvial influence.

Range of profile characteristics

A see Narang'ai Series

Bt thickness : 110-160 cm
colour : Dark reddish brown to red or to yellowish red (2.5 YR 3/4-4/6 or 5 YR 3/2-4/4)
texture : silt loam to silty clay
structure : moderate to weak, very fine to fine, subangular to angular blocky
consistence : friable to very friable, slightly sticky to sticky, slightly plastic to plastic
biopores : many to common
mottles : sometimes, few, small, distinct yellowish red
cutans : thin patchy to thick continuous clay-Mn cutans
B3 see Narang'aei Series

6. Anonymous Series (profile no 12 Nyansienge Area.)

Description : 21-8-1975 I.M.Guiking-Lens

Classification : Soil Taxonomy: Aeric Mellic Tropaqualf
                : Gleyic Luvisol

Location : Nyansienge Area, Kisii District; 34° 58' 47"E.,
          046°11'S., altitude 1880 m

Physiographic position : very gently sloping part of lower footslope, 4%

Surrounding form : rolling

Geology : Upper class of Bukoban system, rhyolites

Regional vegetation: Cultivated

Landuse : grass land

Soil fauna : ants, termites, meles (Spalax)

Drainage : poorly drained

Root development : many fine and very fine roots in A-horizon,
                  decreasing with depth

Effective soil depth: 70 cm

Profile characteristics

A1 0 - 25 cm: Dark reddish brown (5 YR 2.5/2, moist); silt loam;
               weak, medium sized subangular blocky; friable,
               slightly sticky and slightly plastic; few Fe-Mn
               concretions; clear and smooth boundary.

B1g 25 - 69 cm: Dark gray (5 YR 4/2, moist); strong brown (7.5 YR 5/8)
                 and black mottles, few, small and very faint; silty
                 clay loam; moderate, fine subangular blocky; firm,
                 sticky and plastic; ca. 10% Fe-Mn concretions; few
                 fine and common very fine biopores; gradual and wavy
                 boundary.

B2tg1 69-140 cm: Brown to dark brown (10 YR 4/3, moist); approximately;
                 many, distinct, medium sized black mottles, few,
                 faint strong brown mottles; silty clay; very weak
                 structure; moderately thick, patchy Fe-Mn cutans; firm,
                 sticky and plastic; more than 50% Fe-Mn concretions;
few to common, very fine biopores; clear and wavy boundary.

B2tg2 140-200+cm: Colour as B2tg1, many mottles; silty clay; strong very coarse angular blocky; thick continuous clay cutans; hard, sticky and plastic; few biopores; many concretions.

Analytical data:

pF data of Anonymous Series, moisture in volume %

<table>
<thead>
<tr>
<th>depth cm</th>
<th>bulk dens.</th>
<th>saturation</th>
<th>pF 0.4</th>
<th>pF 1.0</th>
<th>pF 1.5</th>
<th>pF 2.0</th>
<th>pF 2.3</th>
<th>pF 2.8</th>
<th>pF 3.0</th>
<th>pF 3.6</th>
<th>pF 4.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10</td>
<td>0.94</td>
<td>57.5</td>
<td>58.2</td>
<td>57.9</td>
<td>56.2</td>
<td>51.6</td>
<td>50.3</td>
<td>45.8</td>
<td>36.2</td>
<td>22.1</td>
<td>20.7%</td>
</tr>
<tr>
<td>40-45</td>
<td>1.13</td>
<td>47.3</td>
<td>47.5</td>
<td>45.5</td>
<td>41.9</td>
<td>38.8</td>
<td>38.5</td>
<td>35.5</td>
<td>34.8</td>
<td>22.1</td>
<td>18.1%</td>
</tr>
<tr>
<td>80-85</td>
<td>1.25</td>
<td>45.4</td>
<td>43.5</td>
<td>42.1</td>
<td>37.8</td>
<td>36.7</td>
<td>36.1</td>
<td>33.9</td>
<td>32.0</td>
<td>23.1</td>
<td>18.1%</td>
</tr>
</tbody>
</table>

1) Saturation is considered not complete

Range of Profile characteristics

A thickness: 20 - 40 cm
colour: dark reddish brown to black (5 YR 3/2 or darker)
mottles: no or few, small, faint strong brown to yellowish red mottles
texture: silt loam
structure: weak to moderate, fine to medium, subangular blocky
consistence: friable when moist, slightly sticky and slightly plastic when wet
concretions: no or few small Fe-Mn concretions
biopores: common

B2tg thickness: 40-.. cm
colour: brown to gray (Hue's 5 YR 7.5 YR, 10 YR)
mottles: 10 to 60% black and strong brown to yellowish red
texture: silty clay to clay
structure: moderate, fine subangular blocky to strong, very coarse angular blocky (down in the profile), massive
consistence: firm to hard when moist, sticky and plastic when wet
concretions: up to 80; Fe-Mn concretions
bioperes: few to common

9. Manga series (profile no. 5 Nyansionge Area.)

Description: 27-6-1975, I.M.Guiking-Lens
Classification: Soil Taxonomy: Aeric Mollic Vertic Tropaqualf
FAO: Gleyic Solonetz
Location: Nyansionge Area, plain East of road Nyansionge-
Manga, Kisii District; 35 01'17"E., 0 47'55"S.;
altitude 1845 m

Physiographic
position: higher place in very gently to gently undulating
plain

Geology: recent alluvial (?) with ash influence
Regional vegetation: tree-grouped-grassland
Landuse: pasture, little cropland
Soil fauna: termites
Drainage: imperfectly drained
Rootdevelopment: many fine and very fine roots in upper 22 cm
deeper

Effective soil depth: more than 180 cm

Profile characteristics

A1 0 - 22 cm: Black (10 YR 2,5/ moist); silt loam; strong, very
fine to fine crumb structure; friable, slightly
sticky and slightly plastic; common very fine and
fine bioperes; clear and smooth boundary.

B1 22 - 68 cm: Dark brown (7,5 YR 3/2, moist); few, very fine
strong brown mottles; silty clay; moderate, coarse
prismatic, breaking into moderate, very fine sub-
angular blocky; very firm, very sticky and plastic;
common, very fine and fine bioperes; diffuse and
smooth boundary.

B2t1 68 - 80 cm: Black (10 YR 2,5/1, moist), few very fine, faint
strong brown mottles; clay; few quartz pebbles;
strong, very fine to fine subangular blocky; clay
or pressure cutans; firm, very sticky and plastic;
few, very fine biopores; clear and smooth boundary.

B2t2 80 - 125 cm: Very dark grayish brown (10 YR 3/2, moist); common, medium, distinct reddish yellow mottles; clay; few quartz pebbles; moderate, very fine to fine subangular blocky; clay or pressure cutans; intersecting slickensides; firm, sticky and plastic; 10, locally 80% concretions few, very fine biopores; clear and wavy boundary.

B3 125 - 180 cm: Dark brown to brown (10 YR 4/3, moist); mixed with rotten rock colours (volcanic ash layer); silty clay; moderate, very fine to fine subangular blocky; friable, sticky and plastic; Fe-Mn concretions; common very fine biopores; soft reaction with HCl.

C/R 180 + cm: Rotten rock with a few quartz pebbles.

Range of profile characteristics

<table>
<thead>
<tr>
<th></th>
<th>A1 thickness</th>
<th>B2t thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>colour</td>
<td>dark reddish brown to black (Hue's 5, 7, 5, 10 YR)</td>
<td>black to dark reddish brown</td>
</tr>
<tr>
<td>mottles</td>
<td>no or few, fine, faint rust mottles</td>
<td>few to common Fe-Mn mottles</td>
</tr>
<tr>
<td>texture</td>
<td>silt loam</td>
<td>clay</td>
</tr>
<tr>
<td>structure</td>
<td>moderate to strong, very fine to fine, crumb or sub-angular blocky</td>
<td>coarse prismatic breaking into fine subangular to angular blocky; at some depth prisms have disappeared</td>
</tr>
<tr>
<td>consistence</td>
<td>friable when moist, slightly sticky and slightly plastic when wet</td>
<td>friable to firm when moist, sticky and plastic when wet</td>
</tr>
<tr>
<td>concretions</td>
<td>no or few Fe-Mn concretions</td>
<td>pressure and/or clay cutans, slickensides are thick and continuous</td>
</tr>
<tr>
<td>biopores</td>
<td>common</td>
<td></td>
</tr>
</tbody>
</table>
concretions : 10-80% Fe-Mn concretions
biopores : few to common
lime : sometimes calcareous

10. Nyansiongo Series (profile no. 2 Nyansiongo Area.)
Description : 6-6-1975, I.M. Guiking-Lens
Classification : Soil Taxonomy: Udolic Vertic Albic Tropaqualf
FAO : Mollic Planosol
Location : Nyansiongo Area, plain East of road Nyansiongo-Manga, Kisii District; 35°01'17"E., 0 46'34"S., altitude 1850 m
Physiographic position : very gently to gently undulating plain
Micro relief : termite mounds
Geology : recent alluvial, with volcanic ash influence
Regional vegetation: tree-grouped-grassland
Landuse : pasture
Soil fauna : termites
Drainage : poorly drained
Root development : many fine to very fine roots in upper 30 cm, deeper along peds only
Effective soil depth: 30 cm.
Profile characteristics
A1 0 -17 cm: Dark reddish brown (5 YR 2,5/2, moist); silt loam; moderate, very fine to fine subangular blocky; friable, slightly sticky and slightly plastic; many fine biopores; clear and smooth boundary.
A2g 17 -30 cm: Very dark gray to dark grayish brown (10 YR 3/1-3/2, moist); yellowish red (5 YR 5/8) mottles; silt loam; moderate very coarse prismatic; breaking into weak, fine subangular blocky; friable, slightly sticky and slightly plastic; many fine biopores; abrupt and wavy boundary.
A/Bg 30 - 35 cm: Dark grayish brown (10 YR 4/2, moist); common, fine and distinct yellowish red mottles; silty clay; strong, fine subangular blocky to angular blocky; firm, slightly sticky and plastic; 90% Fe-Mn concretions on places of water see page; few fine and common very fine biopores; irregular broken boundary (A2 is somewhat tonguing in B).

B2t1 35 - 60 cm: Dark reddish brown (5 YR 2,5/2, moist); few fine and faint yellowish red mottles; clay; moderate to strong, very coarse subangular blocky, deeper fine subangular blocky; firm, slightly sticky and plastic; moderately thick, continuous clay pressure cutans; clear and smooth boundary.

B2t2 60 -107 cm: Black (5 YR 2,5/1, dry); few fine, faint yellowish red mottles; clay; strong fine angular blocky; very hard; sticky and plastic; moderately thick clay pressure cutans; intersecting slickensides; few fine biopores; diffuse and smooth boundary.

B3 107 -116 cm: Dark brown (7,5 YR 3/2, dry); very pale brown (10 YR 7/4) mottles, few, fine and faint; clay; moderate, very fine angular blocky; hard, sticky and plastic; pressure cutans; few, fine fine pores; diffuse and smooth boundary.

C/R 116 + cm: Very pale brown (10 YR 7/4); few mottles of dark material porous; volcanic ash.

Analytical data

<table>
<thead>
<tr>
<th>depth (cm)</th>
<th>CEC</th>
<th>Na</th>
<th>K</th>
<th>Ca</th>
<th>Mg</th>
<th>base saturation(%)</th>
<th>Org.C (weight %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 17</td>
<td>22.55</td>
<td>2.82</td>
<td>0.79</td>
<td>9.02</td>
<td>2.23</td>
<td>66</td>
<td>1.9</td>
</tr>
<tr>
<td>30 - 35</td>
<td>17.60</td>
<td>1.41</td>
<td>1.15</td>
<td>9.98</td>
<td>0.64</td>
<td>75</td>
<td>?</td>
</tr>
<tr>
<td>35 - 60</td>
<td>35-16</td>
<td>3.69</td>
<td>2.11</td>
<td>19.97</td>
<td>2.53</td>
<td>81</td>
<td>1.5</td>
</tr>
<tr>
<td>60 -107</td>
<td>44.23</td>
<td>2.88</td>
<td>2.59</td>
<td>29.63</td>
<td>1.93</td>
<td>84</td>
<td>1.0</td>
</tr>
</tbody>
</table>
Particle size

<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>2.00-</th>
<th>1.00-</th>
<th>0.50-</th>
<th>0.25</th>
<th>0.10-</th>
<th>0.05-</th>
<th>clay</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 17</td>
<td>0.4</td>
<td>0.5</td>
<td>0.8</td>
<td>1.0</td>
<td>3.2</td>
<td>68.1</td>
<td>26.0%</td>
</tr>
<tr>
<td>35 - 60</td>
<td>5.3</td>
<td>4.7</td>
<td>2.6</td>
<td>2.6</td>
<td>2.6</td>
<td>16.8</td>
<td>65.5%</td>
</tr>
<tr>
<td>60 - 107</td>
<td>0.9</td>
<td>1.0</td>
<td>0.7</td>
<td>1.1</td>
<td>1.2</td>
<td>19.4</td>
<td>75.7%</td>
</tr>
</tbody>
</table>

Nyansionge Series (profile no. 7 Nyansionge Area.)

Description: 12-7-1975, I.M. Guiking-Lems
Classification:
- Soil Taxonomy: Udolic Vertic Albic Tropaqualf
- FAO: Mollic (or Dalodic?) Planosol
Location: Nyansionge Area, plain East of road Nyansiongo-Manga, Kisii District; 35°01'49"E., 0°47'57"S.; altitude 1830 m

Physiographic position: very gently to gently undulating plain
Micro relief: termite mounds
Geology: recent alluvial, with volcanic ash influence
Regional vegetation: tree-grouped-grassland
Landuse: pasture, little cropland
Soil fauna: termites
Drainage: poorly drained
Root development: fine and very fine roots, most in upper 30 cm, but also deeper along peds

Effective soil depth: 35 cm.

Profile characteristics

A1: 0 - 15 cm: Dark reddish brown (5 YR 2.5/2, moist); silt loam; moderate, fine subangular blecky; friable, slightly sticky and slightly plastic; common very fine biopores; clear and smooth boundary.
A2g 15 - 35 cm: Light brownish gray to brown (10 YR 6/2-5/3, moist); common, fine and distinct yellowish red mottles; silt loam; very weak structure; friable, non-sticky and slightly plastic; many very fine biopores; abrupt and wavy boundary.

A2/B1 35-45 cm: Dark brown (7.5 YR 4/2-3/2, moist); common, fine and faint strong brown mottles; clay silt loam (mixed). strong, medium prismatic; very hard; ca. 90% Fe-Mn concretions; common to few very fine biopores; abrupt and broken boundary.

B1 30/45-53 cm: Dark brown (7.5 YR 3/2, moist); common, fine and faint to distinct strong brown mottles; clay; strong medium prismatic; thin patchy clay/pressure cutans; extremely firm; sticky and plastic; ca. 5% Fe-Mn concretions; common to few very fine and fine biopores; abrupt and smooth boundary.

B2t 53 - 85 cm: Black (5 YR 2.5/1, moist); common, fine and distinct strong brown mottles; clay; strong, very fine angular blocky; thick, continuous pressure cutans; extremely firm when moist, sticky and plastic when wet; few Fe-Mn concretions; few, very fine biopores; abrupt and wavy boundary.

IC1 85 -100 cm: Pink to reddish yellow (7.5 YR 8/4-8/6, dry); compact ash layer; soft reaction with HCl; abrupt and broken boundary.

IC2 85 -124 cm: Light gray (10 YR 7/2, dry); compact ash layer; clear reaction with HCl; abrupt and broken boundary.

IIA2/B 110-125cm: Brown (10 YR 4/3, moist); ca. 90% Fe-Mn concretions; abrupt and broken boundary.

IIB2 87/124-180cm: Dark brown (10 YR 4/3, moist); clay; strong very fine angular blocky; pressure cutans; firm when moist, stick sticky to very sticky and plastic when wet; few very fine biopores; limeconcretions (!)
Range of profile characteristics

<table>
<thead>
<tr>
<th>A1</th>
<th>thickness</th>
<th>10 - 20 cm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>colour</td>
<td>Dark reddish brown to black (5 YR 2.5/2-2.5/1)</td>
</tr>
<tr>
<td></td>
<td>texture</td>
<td>silt loam</td>
</tr>
<tr>
<td></td>
<td>structure</td>
<td>moderate to strong, fine to very fine subangular blocky</td>
</tr>
<tr>
<td></td>
<td>consistence</td>
<td>friable when moist, slightly sticky and slightly plastic when wet</td>
</tr>
<tr>
<td></td>
<td>biopores</td>
<td>common to many</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>A2g</th>
<th>thickness</th>
<th>10 - 30 cm, sometimes tonguing into B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>colour</td>
<td>Light brownish gray to brown when moist, dark grayish brown to dark gray when wet (Hue's 10 YR)</td>
</tr>
<tr>
<td></td>
<td>mottles</td>
<td>strong brown to yellowish red; common to many</td>
</tr>
<tr>
<td></td>
<td>texture</td>
<td>silt loam</td>
</tr>
<tr>
<td></td>
<td>structure</td>
<td>weak structure, sometimes prismatic</td>
</tr>
<tr>
<td></td>
<td>consistence</td>
<td>friable when moist, non-slightly sticky and non-slightly plastic when wet</td>
</tr>
<tr>
<td></td>
<td>biopores</td>
<td>common to many</td>
</tr>
<tr>
<td></td>
<td>concretions</td>
<td>no or few Fe-Mn concretions</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>A2/B</th>
<th>thickness</th>
<th>0 - 20 cm (this variation possible in one profile)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>colour</td>
<td>dark brown to dark grayish brown</td>
</tr>
<tr>
<td></td>
<td>mottles</td>
<td>common to many strong brown to yellowish red and black mottles</td>
</tr>
<tr>
<td></td>
<td>texture</td>
<td>partly silt loam (upper part); partly clay (lower part)</td>
</tr>
<tr>
<td></td>
<td>structure</td>
<td>prismatic breaking into fine to very fine, subangular or angular blocky</td>
</tr>
<tr>
<td></td>
<td>consistence</td>
<td>hard when dry, firm when moist, slightly sticky to sticky and slightly plastic to plastic when wet</td>
</tr>
<tr>
<td></td>
<td>biopores</td>
<td>few</td>
</tr>
<tr>
<td></td>
<td>concretions</td>
<td>many (up to 90%) Fe-Mn concretions</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B2t1</th>
<th>thickness</th>
<th>10 - 30 cm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>/B1 colour</td>
<td>dark reddish brown to dark brown (5 YR 2.5/2-7.5 YR 3/2)</td>
</tr>
<tr>
<td></td>
<td>mottles</td>
<td>few to common strong brown to yellowish red</td>
</tr>
<tr>
<td></td>
<td>texture</td>
<td>clay</td>
</tr>
</tbody>
</table>
structure: strong to weak, medium prismatic, breaking into moderate to strong subangular blocky
consistence: firm to extremely firm when moist, sticky and plastic when wet
biopores: few
concretions: few to common Fe- Mn concretions
B2t2 thickness: 30-60 cm
colour: black to dark reddish brown
mottles: few or no mottles
texture: clay
structure: subangular to angular blocky
cutans: clay and pressure cutans
consistence: extremely firm when moist, sticky and plastic when wet
biopores: few
I)C thickness: 0-... cm (not passable)
ash) colour: pink to reddish yellow to light gray
lime: soft reaction with Hcl
pores: many
II A2/B thickness: 0 - 15 cm
colour: brown to grayish brown
texture: silt loam and clay
concretions: many (up to 90%)
II B2 thickness: unknown
colour: dark brown (10 YR 4/3)
texture: clay
structure: strong very fine angular blocky
cutans: pressure cutans
consistence: firm when moist, sticky to very sticky and plastic to very plastic when wet
biopores: few
II Isoge Series (profile no. 13. Nyansiongo Area.)
Description: 4-9-1975, I.M.Guiking-Lens
Classification: Soil Taxonomy: Typic Albic Tropaqualf
FAO: Ochric Planosol
Location: Nyansiongo Area, Kisii District; 35°1′36″E,
Physiography: border of valley slope

Surrounding landform: gently undulating plain
Micro relief: termite mounds
Geology: recent alluvial, with volcanic ash influence
Regional Vegetation: tree-grouped grassland
Landuse: pasture
Soil fauna: some termites
Drainage: poorly drained
Erosion: beginning of gully forming

Root development: common, fine and medium fine roots

Effective soil depth: more than 94 cm

Profile characteristics

A1 0 - 18 cm: Black (5 YR 2,5/1, moist); silt loam; moderate fine crumb structure; friable, slightly sticky and slightly plastic; common, very fine biopores; clear smooth boundary.

A2g1 18 - 49 cm: Dark gray (10 YR 4/1, moist); common, medium prominent black and strong brown mottles; silt loam; weak, fine subangular blocky; friable when moist, no-sticky and non-plastic when wet; ca. 10% Fe-Mn concretions; few, fine to medium biopores; clear and wavy boundary.

A2g2 49-90/94 cm: Dark gray to gray (10 YR 4/1-5/1, moist); many, medium prominent and strong brown mottles; silt loam; very weak structure; moderately hard, non-sticky and non-plastic; ca. 30% Fe-Mn concretions; few, fine to medium biopores; clear and wavy boundary.

B2t 80/90 + cm: Black (5 YR 2,5/1, moist); common, medium and faint black and strong brown mottles; clay; moderate, medium angular blocky; very hard, sticky and plastic when wet; ca. 20% Fe-Mn concretions; few, very fine biopores.

Remark: A1 is partly eroded due to cow influence.
Range of profile characteristics

A1 varies from a mineral horizon (see profile description), which can be partly or completely eroded, to a somewhat peaty horizon, up to 20 cm thickness.

A2 0 - 100 cm thick, always Fe-Mn mottles and concretions

B2t see profile description; always many Fe-Mn mottles and/or concretions, sometimes completely reduced
Appendix 2
LEGEND DETAILED SOIL MAP "NYANSIONGO AREA"

Somewhat excessively drained soils

Sim'goiwek Series (S)  very shallow soils (less than 30 cm deep), dark reddish brown to brown, silty clay to clay.

Well drained soil

Dark reddish brown to brown soil, silty clay to clay, cambic or argillic B-horizon, thin stony B3-horizon.

Kapsagut Series (K) moderate deep and shallow soils (more than 30 cm deep).

Nyamasibi Series (Nm) moderate deep and shallow soils (more than 30 cm deep), with a thick, humus rich topsoil.

Dark reddish brown to reddish brown soils, silty clay to clay, argillic B-horizon B3-horizon mottled, sometimes with concretions.

Gesima Series (G) Moderate deep soils (less than 150 cm deep)

Ichumi Series (I) deep soils (more than 150 cm deep)

Classification

7th: Lithic Oxic Eutropepts
FAO: Lithosels & Chromic Cambisols

7th: Oxic Eutropepts & Lithic - & Mollic - & Typic Oxic Tropudalfs
FAO: Chromic Cambisols & Orthic Luvisols

7th: (Lithic) Oxic Hapludolls
" " Argiudolls
FAO: Haplic - & Luvic Phaeozems

7th: Mollic) Oxic Tropudalfs
FAO: Luvic Phaeozem & Chromic Luvisols

7th: Mollic - & Rhodudultic Oxic Tropudalfs & Rhodudultic Oxic Paleudolls.
FAO: Luvic Phaeozem & Eutric Nitosols
Narang'ai Series (Na) moderately deep soils, with a thick humus-rich topsoil.

Nyanturago Series (Nt) deep soils (more than 150 cm deep with a thick humus-rich topsoil.

Imperfectly drained soils
Anonymous Series (A) moderately deep soils, silty clay to clay, with mottles within 30 cm depth.

Poorly and very poorly drained soils
Dark brown to brown, heavy clay soils, with an abrupt textural change.
Manga Series (M) soils with a dark, silty topsoil, overlying the heavy B-horizon.

Nyansiongo Series (Ns) soils with a bleached, silty topsoil, overlying the heavy B-horizon.

Isogo Series (Is) soils with wetness characteristics throughout the profile.

Very poorly drained soils
Kesaili Series (Ke) soils with a peaty topsoil and a reduced subsoil.

Textural class of topsoil depth classes

<table>
<thead>
<tr>
<th>C</th>
<th>M</th>
</tr>
</thead>
<tbody>
<tr>
<td>0: C/R-horizon deeper than 150 cm</td>
<td>&quot; between 100 and 150 cm depth</td>
</tr>
<tr>
<td>1: &quot;</td>
<td>&quot; 50 and 100 cm depth</td>
</tr>
<tr>
<td>2: &quot;</td>
<td>&quot; 20 and 50 cm depth</td>
</tr>
<tr>
<td>3: &quot;</td>
<td>&quot; 0 and 20 cm depth</td>
</tr>
</tbody>
</table>

Slope classes

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 3%</td>
<td>3 - 8%</td>
<td>8 - 15%</td>
<td>15 - 30%</td>
<td>30 - 65%</td>
</tr>
</tbody>
</table>

7th: Oxic Argiudolls
FAO: Luvic Phaeozems
7th: Oxic Argiudolls & Paleudolls
FAO: Luvic Phaeozems
7th: Aeric Mollic Tropaqualfs
FAO: Gleyic Luvisols
7th: Aeric Mollic Tropaqualfs
FAO: Gleyic - Luvic Phaeozems
7th: Vertic Albaquic Tropaqueals
FAO: Mellic - & Eutric Planosols
7th: Mellic Vertic Albaquic Tropaqualfs
FAO: Mellic - & Eutric Planosols
7th: Typic Tropaquents
FAO: Eutric Fluvisols
suitability classes

2 suitable
1 moderately suitable
0 unsuitable
not considered

for detailed description of the classes see report
NYANSIONGO AREA
suitability map for tea in the "well drained" area

suitability classes

3 very suitable
2 suitable
1 moderately suitable
0 unsuitable

For detailed description of the classes see report.