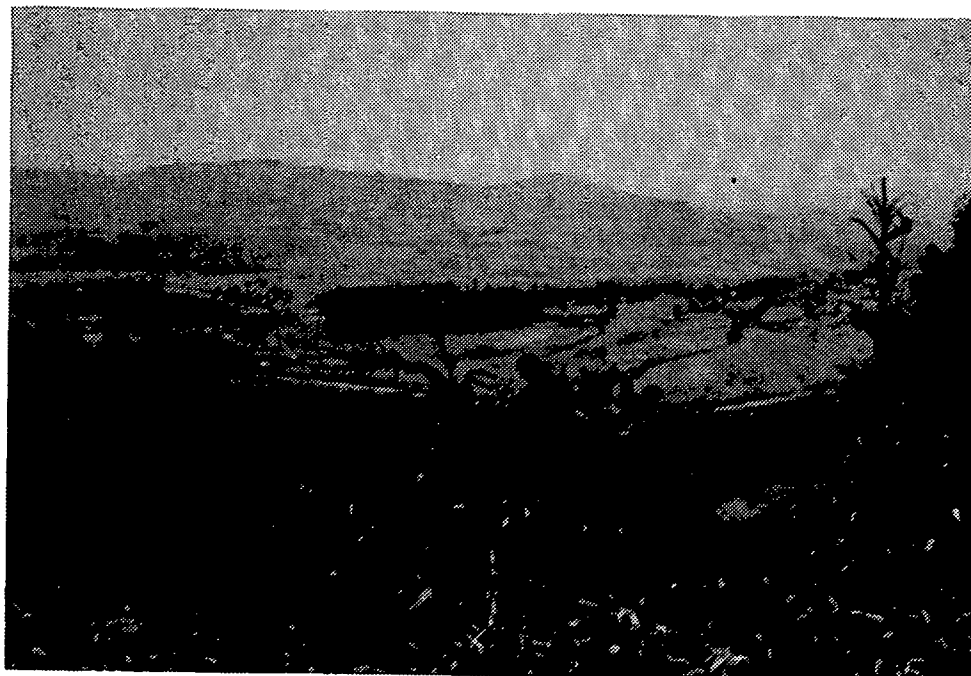


TRAINING PROJECT IN PEDOLOGY

KISII KENYA



Detailed Soil Survey of the Nyansiongo Area

PRELIMINARY REPORT NO 18

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DETAILED SOIL SURVEY OF THE
NYANSIONGO AREA

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by
I.M. Guiking - Lens

Preliminary Report nr. 18
June 1976

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

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Contents

Preface

1.	General description of the survey area	3
1.1	Location	3
1.2	Geomorphology	3
1.3	Topography	3
1.4	Hydrology	5
1.5	Geology	5
1.6	Climate	6
1.7	Vegetation	7
1.8	Landuse	8
1.9	Erosion	8
2	Soils	9
2.1	Soil series	9
2.2	Key to the Soilseries	10
2.3	Description of the soilseries	11
3	Mapping units	16
3.1	Textural classes of the topsoil	17
3.2	Soil depth classes	17
3.3	Slopeclasses	17
3.4	Example of a mapping unit	17
4	The maps	18
5	Land suitability maps	18
5.1	Suitability of the well drained area for growing tea	18
5.1.1	Rainfall, water and soil requirements for tea	18
5.1.2	Assumed rainfall and evapotranspiration data	18
5.1.3	Moisture storage in the soil	19
5.1.4	Suitability classes, for growing tea	19
5.2	Suitability of the poorly and imperfectly drained area for grassland	20
5.2.1	Suitability classes for grassland	21
6.	References.	21
Appendix 1: Profile description		22
Appendix 2: Legend to the soil map.		49

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 post-graduate 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. Bexem, Management.

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

This report has been written by Mrs. I.M. Guiking - 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. Bexem 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-Setik, 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 sheps 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 (foet) slopes are straight, near the rivers slightly convex.

Table 1. Summary 1.2; Comparison of landscapes in Nyansionge detailed Soil Survey

para-
graph

	Landscape	Plateau (west)	"Inselberg" area	Plain (east)
1.3	Topography	2100-2200 m undulating straight- convex slopes	1850-2060 m rolling straight- convex slopes	1815-1850 m nearly level
1.4	Hydrology		dendritic mainly well drained	dendritic poorly drained
1.5	Geology		rhyolites volcanic ash influence	alluvium (?) ash influence
1.6.	Climate	more than 1500 mm rain- fall/year April peak 8-27°C	1300-1400mm rainfall/year April peak January/February dry 8-27°C	
1.7	Vegetation	Cultivated	Cultivated with occurrence of many Acacia's	tree-grouped grassland (Pennisetum Gatabasis)
1.8	Landuse	arable land: maize, millet, beans, sweet potatoes, tea, pyrethrum cattle grazing on shallow soils (hill tops)		pasture
1.9	Erosion	rill erosion on fallow land		sheet erosion gully forming
2.	Soil	reddish brown silty clay- clay gradual textural change	idem but more brown colours	silty topsoil heavy clayey subsoil

The plain slopes to the East from ca. 1850 to 1815 m above sealevel, 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 Kapsoni river.

There are some springs on the plateau in despressions with a swampy vegetation. The streams from these springs must pass a treshold 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 treshold 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 despressions- which are very poorly drained - and some nearly flat parts near Kesaili River - Which are imperfectly drained. In contrast with the above mentioned area's the plain is poorly to very poorly drained, although also here the erosion base is lowering (this is the case in the whole Nyansionge Area). The reason for this bad drainage is the level situation; but more important(2) 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 Setik area (Western boundary of this area is the 35°00'E. meridian) in 1946/47, the Nyansionge 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, ~~thru~~ 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 (fairly 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 Nyansiongo 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° 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 Diospiros 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 ferns.

1.8 Landuse

Before Independence of Kenya 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 tinnan 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 were obliged to construct terraces to prevent soil erosion, but unfortunately after Uhuru these terraces are rather neglected. Rill 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 separated 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

a thick humusrich top soil, but in the Soil Taxonomy, but not always, belong to the Mollisols.

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 goiwek 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:

Nyanturage Series

B3 starting within 150 cm depth:

Narang'ai Series

9b Other soils (10.a)

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

Ichuni 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 & Chromic 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: (Mollic) 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-	Rhodudultic Oxic Tropudalfs
ness of B-horizon	Rhodudultic Oxic Paletropudalfs & Oxic Paleudolls

FAO 1970 : Luvic Phaeozems &
Eutric Nitesols

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 concretions (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 tonguing into- a heavy mentmorillonitic (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

different.

Classification: Soil Taxonomy: Vertic Albaquic Tropaqualfs

FAO 1970 : Mollic - Eutric Planosols

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 Trepaqualfs
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 Nyansionge 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 (E_o, Penman) is supposed to be

1700 mm/year (F.F.Ojany and R.B.Ogendo, Kenya, a Study in Physical and Human Geography, Longman 1973).

The potential evapo-transpiration (E_p) is supposed to be equal to E_e (according to Van Meurik). The actual evapotranspiration (E_a) is E_p .

R (rainfall) - E_p 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 $R - E_p$ is negative with the lowest values in December-January: -200 mm on the plateau and -350 mm in the "inselberg" area (assumptions).

These $R - E_p$ 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 Nyansienge 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 Nyansienge 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:

- | | <u>Plateau</u> | <u>"Inselberg" Area</u> |
|----------|---|---|
| <u>3</u> | well drained, med. deep
and deep soils, with extra
water supply (situated in
depressions or under shallow
tops and scarps). | |
| <u>2</u> | Well drained soils, deeper
than 50 cm, or, if situated
on slopes of more than 15%,
more than 100 cm deep. | Well drained, deep soils with extra
water supply (situated in depres-
sions or under shallow tops and
scarps). |
| <u>1</u> | Well drained soils, 50-100
cm deep, situated on slopes
of more than 15%. | Well drained soils deeper than
100 cm. |
| <u>0</u> | somewhat excessively drained
soils, less than 50 cm deep,
and imperfectly and poorly
drained soils. | Well drained and somewhat excess-
sively drained soils, less than 100
cm deep, and imperfectly and
poorly drained soils. |

5.2

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

The vegetation in the plain consists of a natural, poor tree-
grouped-grassland. The imperfectly drained soils of the "Inse-
lberg" area do not have their natural vegetation, but at most
places are used for grassland and sometimes for cropland.

My knowledge of grasses and grasslands is too small to pass
pronouncement 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 Nyansioge 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 Isege Series.

6. References

- F.F.Ojany and R.B.Ogendo, 1973 Longman
 - Kenya, a study in Physical and Human Geography
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 - East African Crops
- P.N.Beerma, G.R.Hennemann, J.H.Kauffman, H.E.Verwey, 1974.
 - A Detailed Soil Survey of the Maronge Area
 Preliminary Report no. 3
- G.R.Hennemann, J.H.Kauffman, D. van Meurik, 1974
 - A Semi-detailed Soil Survey of the Kisii West Area

Preliminary Report no. 5**Geological Maps (scale 1:125.000) and Reports:**

F.W.Binge, 1948-1949

- Kericho Area

A.Huddleston, 1947-1949

- Kisii District

J.J.Schoeman, 1946-1947

- Setik Area

Topographical Maps (scale 1:50.000):

- Belgut

- Kisii

- Chemagel

- Kitere

- Nyangweso

- Chepalungu

Anonymous, 1970

- Climate and Vegetation, sheet 3 (scale 1:250.000)

Soil Survey Staff, 1962

- Soil Survey Manual

FAO

- FAO Guidelines for Soil Description

Kenya Soil Survey Project

- Guidelines for "Soil Profile Description Form

Soil Survey Staff,

- Soil Taxonomy, 7 th Approximation 1967

FAO-Unesco, 1974

- Soil Map of the World, 1:5,00.000, Volume I, Legend

Appendix 1 Profile descriptions of Soil Series**1. Sin'geiwek 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 : Upperclass of Bukoban 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) loam; 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 stoniness up to 80% 5-20 cm thick;

R : stones / rock with many joints.

2. Kapsagut Series (profile no. 11 Nyansieng Area)

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

Classification : Soil Taxonomy: Ultic Oxic Trepudalf
FAO : Orthic Luvisol

Location : Nyansieng 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 land-

form : rolling

Geology : Upper class of Bukoban system: rhyolites

Regional vege. : 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

A1	thickness	: 20 - 40 cm
	colour	: dark reddish brown (Hue's 2,5 YR and 5 YR)
	texture	: silt loam
	structure	: moderate to strong, very fine to fine subangular blocky
	consistence	: friable when moist, slightly to non-sticky and slightly to non-plastic when wet
	biopores	: many to common
B2(t)	thickness	: 20 - 50 cm
	colour	: dark reddish brown to reddish brown (Hue's 2,5 YR and 5 YR)
	texture	: silt loam to silty clay, sometimes with stones
	structure	: weak to moderate, very fine to fine subangular blocky
	consistence	: friable when moist, slightly sticky and slightly plastic when wet
	biopores	: many to common
C/R	Rock with many joints, often meters deep	

3. Nyamasibi Series (profile no. 14 Nyansiongo Area.)

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

Classification : Soil Taxonomy: Ultic Oxic Hapludell
FAO : Haplic PhaezemLocation : Nyansiongo Area, Kisii District; 34°59'15" E.,
0°47'09" S.; altitude 2035Physiographic

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

Surrounding land-

form: rolling

Geology : upper class of Bukuban system, rhyelites

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 soildepth: 60 cm

Profile characteristicsA1 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 (rhyelite) with many joints.

Range of profile characteristicsA1 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
 colour : 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 Reck with many joints, often meters deep

Analytical data profile 14: pF, moisture percentages

depth cm	bulk density	Sat.	pF 0.4	pF 1	pF 1.5	pF 2	pF _v 2.3	pF 2.8	pF 3	pF 3.6	pF 4.2	pF 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 Nyansiengo Area.)

Description : 5-6-1975, I.M.Guiking-Lens
 Classification : Soil Taxonomy: Mollic Oxic Trepudalf
 FAO : Luvic Phaeozem
 Location : Nyansiengo Area, Kisii District; 35°00'45"E.,
 0°47'42"S.; altitude 1890 m

Physiographic

position : lower part of footslope, 8%

Surrounding land-

form: rolling

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

Regional Vegeta-

tion : cultivated, with occurrence 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); loam; 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); loam; 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; loam; 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 loam; 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 loam; weak very fine subangular blocky; friable, sticky and slightly plastic; continuous, thick clay cutans; ca. 40% Fe-Mn concretions, 3-5 mm ϕ ; 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

<u>depth</u>	<u>(cm)</u>	<u>CEC</u>	<u>Na</u>	<u>K</u>	<u>Ca</u>	<u>Mg</u>	<u>base saturation (%)</u>
0- 20		19.94	2.50	1.87	12.88	1.49	94
60-110		12.44	2.44	1.99	6.12	2.00	100

particle size (mm)

	<u>2.00-</u>	<u>1.00</u>	<u>0.50-</u>	<u>0.25-</u>	<u>0.10-</u>	<u>0.05-</u>	<u>clay</u>
	<u>1.00</u>	<u>0.50</u>	<u>0.25</u>	<u>0.10</u>	<u>0.05</u>	<u>0.002</u>	
0- 20	1.3	3.1	6.6	8.3	6.3	48.8	25.6 %
60-110	1.6	2.5	2.9	4.4	4.5	60.8	23.2 %

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

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

Classification : Soil Taxonomy: Mollic Ultic Oxic Trepudalf
FAO : Luvic Phaeozem

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

Physiographic

position : footslope, 12%

Surrounding land-

form : rolling

Geology : Upper class of Bukoban system, rhyelites, 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 soildepth: 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 ϕ ; 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 ϕ ; 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 3/4, 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 ϕ ; common very fine biopores; abrupt and wavy to irregular boundary.
- B32 96/135-375 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
 colour : 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
 colour : 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 Nyansionge 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
 biperes : common to many

B3 thickness : 10 cm to some meters, always starting within 150 cm
 colour : red to yellowish red, plus rotten rock colours
 nettles : Mn-nettles
 concretions : few to 90%
 stones : few to 80%
 cutans : mostly thick continuous (clay) cutans

5. Ichuni Series (profile no. 4 Nyansionge Area)

Description : 19-6-1975, I.M. Guiking-Lens

Classification : Soil Taxonomy: Ultic Oxic Trepudalf
 FAO : Eutric Nitosol

Location : Nyansion Area, Kapsagut hill, Kisii District;
 35 00'32"E., 0 48'24".S; altitude 1870 m

Physiographic

position : foetslope, 12%

Surrounding land-

farm: rolling

Geology : Upper class of Bukuban 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.
- B2t 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 concretions; 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 Nyansiengo Area.)

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

Classification : Soil Taxonomy: Ultic Oxic Argiudell
FAO : Luvic Phaezem

Location : Nyansiengo Area, near Nyansiengo Secondary School.
Kisii District; 35 00'52".E. 0 47' 21 S.; altitude

1880 m + sealevel

Physiographic

Position : depression within foot slope, 8%

Surrounding land-

form rolling

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

Regional Vegeta.: cultivated, with many acacia's

Landuse : cropland and grassland

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

Drainage : moderately well drained

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

Effective soildepth: 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 biopres; 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 Argiudell
FAO : Luvic Phaeozem

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

Physiographic

position : border of depression in plateau

Surrounding land-

form: steeply dissected

Mese relief : undulating plateau

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

Regional vegeta.: 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 soildepth: 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 mottles (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.

- B2t1 66 -125 cm: Dark reddish brown (2,5 YR 3/4 - 5 YR 3/3, moist); silty clay; weak, very fine subangular blocky; moderately thick, continuous clay cutans; friable, sticky and plastic; many very fine and fine biopores; clear and wavy boundary.
- B3 125-175+cm: Dark reddish brown (2,5 YR 3/4 - 5 YR 3/3, moist); with light spots; silty clay; moderate, fine angular blocky; thick continuous clay +Mn cutans; firm, sticky and plastic; few, very fine and fine biopores.

Range of profile characteristics

- A thickness : 40 - 70 cm
 colour : dark reddish brown to black (10 YR 3/2-2,5/1)
 texture : silt loam to loam
 structure : moderate to strong, very fine subangular blocky to granular structure
 consistence : (very) friable when moist, slightly sticky and slightly plastic when wet
 biopores : many
 mottles : sometimes few, small, faint to distinct yellowish red
- Bt thickness : 40 - 110 cm
 colour : 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)
 texture : silt loam to silty clay loam
 structure : moderate to weak, very fine to fine, subangular to angular blocky
 consistence : friable when moist, sticky and plastic when wet
 biopores : many to common
 mottles : sometimes few, small, faint to distinct yellowish red
 cutans : thin patchy continuous clay+Mn cutans
- B3 thickness : 10 cm to some meters, but always starting within 150 cm soil depth
 colour : reddish brown to red or yellowish red or brown, often a mixture of colours

concretions : up to 90% Fe-Mn concretions
stones : do

7. Nyanturage Series (profile no. 6 Nyansonge Area.)

Description : 11-7-1975, I.M. Guiking-Lens

Classification : Soil Taxonomy: Oxic Paleudoll
FAO : Luvic Phaezem

Location : Nyansonge Area, valley between Sin'goiwek and
Narang'ai 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 Bukuban system, rhyolites, with
volcanic ash influence

Regional vegetation: bush and herbs: acacia's, ferns (!)

Vegetation at

location : grasses

Landuse : arable land since about 10 years

Soil fauna : ants, moles (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

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 %

depth cm	bulk dens.	saturation	pF 0.4	pF 1.0	pF 1.5	pF 2.0	pF 2.3	pF 2.8	pF 3.0	pF 3.6	pF 4.2
0-10	0.94	57.5	58.2	57.9	56.2	51.6	50.3	45.8	36.2	22.1	20.7%
40-45	1.13	47.3	47.5	45.5	41.9	38.8	38.5	35.5	34.8	22.1	18.1%
80-85	1.25	45.4	43.5	42.1	37.8	36.7	36.1	33.9	32.0	23.1	18.7%

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

biopores : few to common

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

Description : 27-6-1975, I.M. Guiking-Lens

Classification : Soil Taxonomy: Aeric Mollic Vertic Tropaqualf
FAO : Gleyic Solonetz

Location : Nyansiengo Area, plain East of road Nyansiengo-
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 soildepth: 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 biopores; 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 biopores; 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

A1 thickness : 20 - 40 cm
 colour : dark reddish brown to black (Hue's 5, 7, 5, 10 YR)
 mottles : no or few, fine, faint rust mottles
 texture : silt loam
 structure : moderate to strong, very fine to fine, crumb or subangular blocky
 consistence : friable when moist, slightly sticky and slightly plastic when wet
 concretions : no or few Fe-Mn concretions
 biopores : common

B2t thickness : 100 - 120 cm
 colour : black to dark reddish brown
 mottles : few to common Fe-Mn mottles
 texture : clay
 structure : coarse prismatic breaking into fine subangular to angular blocky; at some depth prisms have disappeared
 consistence : friable to firm when moist, sticky and plastic when wet
 cutans : pressure and/or clay cutans, slickensides are thick and continuous

concretions : 10-80% Fe-Mn concretions
 biopores : few to common
 lime : sometimes calcareous

10. Nyansiengo Series (profile no. 2 Nyansiengo Area.)

Description : 6-6-1975, I.M. Guiking-Lens
 Classification : Soil Taxonomy: Udollic Vertic Albic Tropaqualf
 FAO : Mollic Planosol
 Location : Nyansiengo Area, plain East of road Nyansiengo-
 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 soildepth: 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 pores; volcanic ash.

Analytical data

depth (cm)	CEC	Na	K	Ca	Mg	base saturation(%)	Org.C (weight %)
0 - 17	22.55	2.82	0.79	9.02	2.23	66	1.9
30 - 35	17.60	1.41	1.15	9.98	0.64	75	?
35 - 60	35.16	3.69	2.11	19.97	2.53	81	1.5
60 -107	44.23	2.88	2.59	29.63	1.93	84	1.0

particle size							
depth	2.00-	1.00-	0.50-	0.25	0.10-	0.05-	clay
(cm)	1.00	0.50	0.25	0.10	0.05	0.002	
0 - 17	0.4	0.5	0.8	1.0	3.2	68.1	26.0%
35 - 60	5.3	4.7	2.6	2.6	2.6	16.8	65.5%
60 -107	0.9	1.0	0.7	1.1	1.2	19.4	75.7%

Nyansionge Series (profile no. 7 Nyansionge Area.)

Description : 12-7-1975, I.M. Guiking-Lens

Classification : Soil Taxonomy: Udollic Vertic Albic Tropaqualf
FAO : Mollic (or Deledic?) Planosol

Location : Nyansionge Area, plain East of road Nyansionge-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 soildepth: 35 cm.

Profile characteristics

A1 0 - 15 cm: Dark reddish brown (5 YR 2,5/2, moist); silt loam;
moderate, fine subangular blocky; 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, sticky to very sticky and plastic when wet; few very fine biopores; limeconcretions (!)

Range of profile characteristics

- A1 thickness : 10 - 20 cm
 colour : Dark reddish brown to black (5 YR 2.5/2-2,5/1)
 texture : silt loam
 structure : moderate to strong, fine to very fine subangular blocky
 consistence: friable when moist, slightly sticky and slightly plastic when wet
 biopores : common to many
- A2g thickness : 10 - 30 cm. sometimes tonguing into B
 colour : Light brownish gray to brown when moist, dark grayish brown to dark gray when wet (Hue's 10 YR)
 mottles : strong brown to yellowish red; common to many
 texture : silt loam
 structure : weak structure, sometimes prismatic
 consistence: friable when moist, non-slightly sticky and non-slightly plastic when wet
 biopores : common to many
 concretions: no or few Fe-Mn concretions
- A2/B thickness : 0 - 20 cm (this variation possible in one profile)
 colour : dark brown to dark grayish brown
 mottles : common to many strong brown to yellowish red and black mottles
 texture : partly silt loam (upper part); partly clay (lower part)
 structure : prismatic breaking into fine to very fine, subangular or angular blocky
 consistence: hard when dry, firm when moist, slightly sticky to sticky and slightly plastic to plastic when wet
 biopores : few
 concretions: many (up to 90%) Fe-Mn concretions
- B2t1 thickness : 10 - 30 cm
 /B1 colour : dark reddish brown to dark brown (5 YR 2,5/2-7,5 YR 3/2)
 mottles : few to common strong brown to yellowish red
 texture : clay

- 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 (net 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 Isege Series (profile no. 13. Nyansionge Area.)
 Description : 4-9-1975, I.M. Guiking-Lens
 Classification: Soil Taxonomy: Typic Albic Trepaqualf
 FAO : Ochric Planosol
 Location : Nyansionge Area, Kisii District; 35 01'36"E.,

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

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

Classification

7th: Lithic Oxid Eutropepts
FAO: Lithosols &
Chromic Cambisols

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).

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

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

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

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)

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

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

7th: Mollic - & Rhodudultic
Oxid Tropudalfs &
Rhodudultic Oxid Pale-
udolls.
FAO: Luvic Phaeozem &
Eutric Nitosols

Narang'ai Series (Na)

moderately deep soils, with a thick humus-rich topsoil.

7th: Oxic Argiudolls

FAO: Luvic Phaeozems

Nyanturago Series (Nt)

deep soils (more than 150 cm deep with a thick humusrich topsoil.

7th: Oxic Argiudolls &
" Paleudolls

FAO: Luvic Phaeozems

Imperfectly drained soils

Anonymous Series (A)

moderately deep soils, silty clay to clay, with mottles within 30 cm depth.

7th: Aerice Mollic Tropequalfs

FAO: Gleyic Luvisols

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.

7th: Aerice Mollic Vertic Tropequalfs

FAO: Gleyic - Luvic Phaeozems

Nyansiengo Series (Ns)

soils with a bleached, silty topsoil, overlying the heavy B-horizon.

7th: Vertic Albaquic Tropequalfs

FAO: Mollic - & Eutric Planosols

Isege Series (Is)

soils with wetness characteristics throughout the profile.

7th: Mollic Vertic Albaquic Tropequalfs

FAO: Mollic - & Eutric Planosols

Very poorly drained soils

Kesaili Series (Ke)

soils with a peaty topsoil and a reduced subsoil.

7th: Typic Tropequalfs

FAO: Eutric Fluvisols

textural class of topsoil depth classes

C
M

0: C/R-horizon deeper than 150 cm
1: " between 100 and 150 cm depth
2: " " 50 and 100 cm depth
3: " " 20 and 50 cm depth
4: " " 0 and 20 cm depth

slope classes

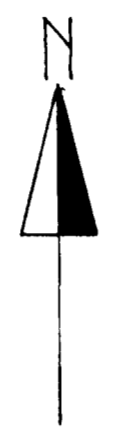
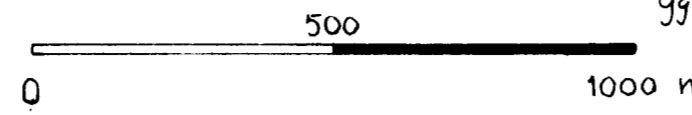
A: 0 - 3 %
B: 3 - 8 %
C: 8 - 15 %
D: 15 - 30 %
E: 30 - 65 %

6355 b

NYANSIONGO AREA

suitability map for grassland on the poorly drained plain

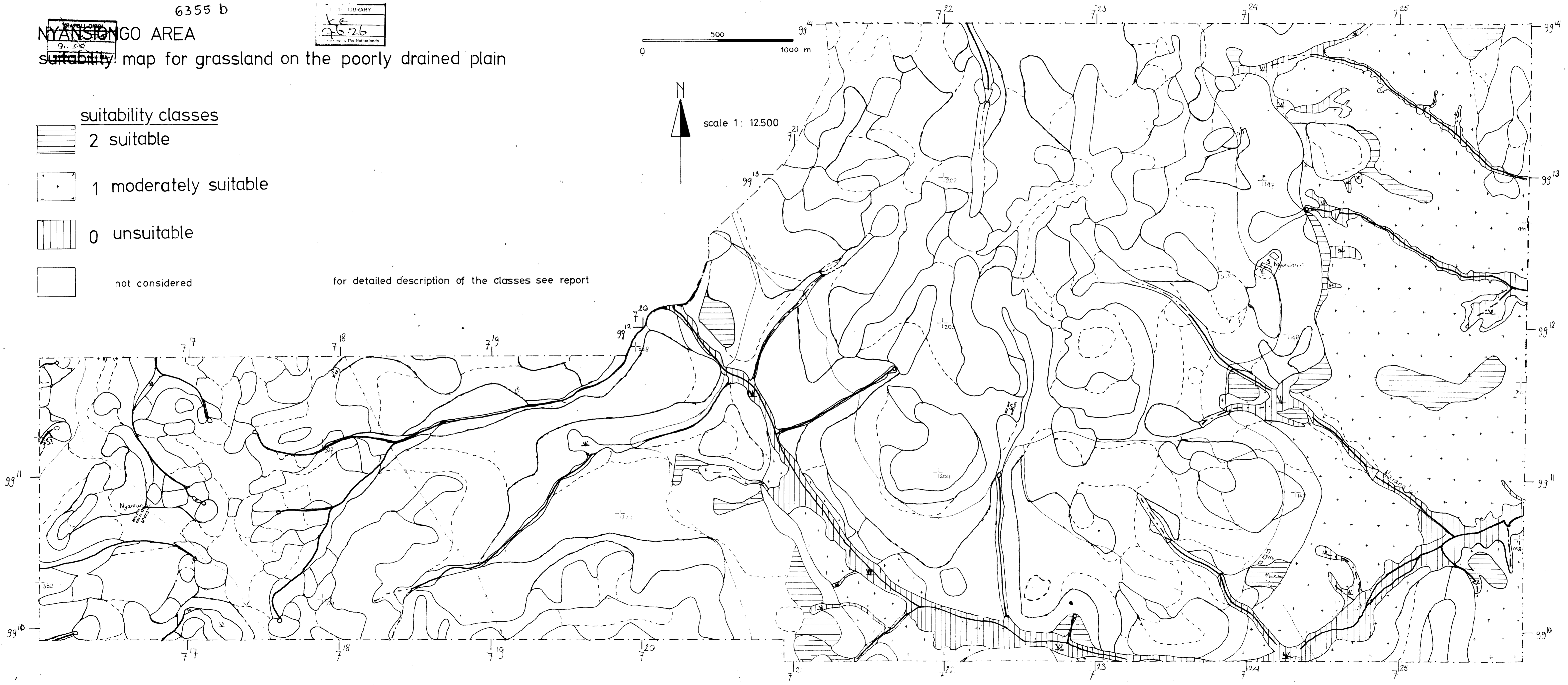
LIBRARY
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 76.26
 Wageningen, The Netherlands



scale 1: 12.500

- 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

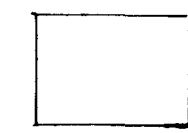
suitability classes

 3 very suitable

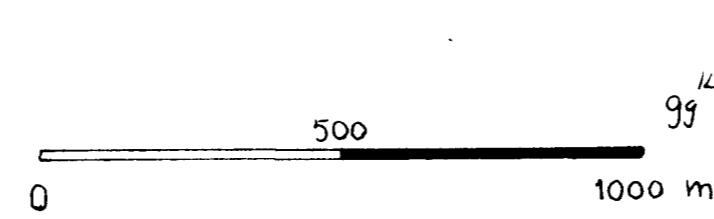
 2 suitable

 1 moderately suitable

 0 unsuitable

 not considered, unsuitable

for detailed description of the classes see report



scale 1 : 12.500

