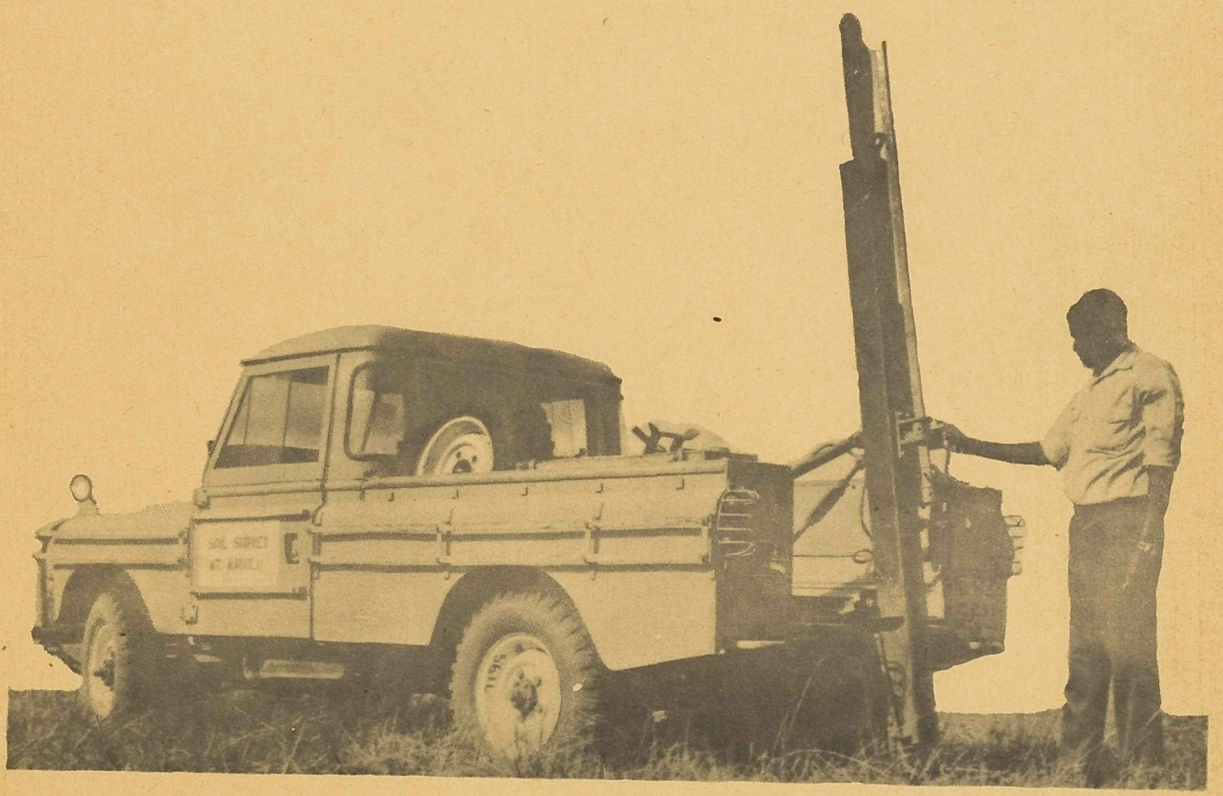
REPUBLIC OF ZAMBIA

SOIL SURVEY REPORT No. 54

SEMI-DETAILED SOIL SURVEY OF NYANGOMBI SETTLEMENT SCHEME NORTH-WESTERN PROVINCE

BY
P. G. HEILMANN



SOIL SURVEY UNIT
LAND USE BRANCH
DEPARTMENT OF AGRICULTURE
1978

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SEMI-DETAILED SOIL SURVEY OF

NYANGOMBI SETTLEMENT SCHEME

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LAND USE BRANCH

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(i) SUMMARY

The Nyangombi Settlement Scheme area, described in this report, is situated in the Mwinilunga district of Zambia's North-Western Province. The area was surveyed on a semi-detailed level in the 1977 field season; a small survey of a limited area on the Western plateau was already surveyed at the end of the 1976 season. The survey area is approximately 4518 ha in extent. The purpose of the survey was to provide the necessary data for the planning of the agricultural activities in the Settlement Scheme.

The climate is strongly seasonal. Average annual rainfall figures are about 1377 mm. The rainy season occurs from the end of October till April. June and July are the coldest months. An average of 10 frost days a year have been recorded. The area is covered by a well developed Miombo woodland, in which some remnants of dry evergreen species occur. The dambo areas have a grassland vegetation.

Before the start of the Scheme only in the Northern part of the area some agricultural activities occurred on the lighter textured soils. They consisted mainly of semi-permanent traditional agriculture with cassava as the dominant crop. The Scheme area is now being divided into farms for emerging permanent farmers.

The survey area is made up of two plateau areas separated by a small stream. A large low lying area occurs in the Northern centre part of the area. The average summit level of the plateaus ranges from 1400-1450 m. The plateaus have steep slopes towards the deeply incised streams. The lithology of the area comprises rocks of Kundelungu and Lower Roan formations, mainly carbonaceous shales, dolomites, quartzites and arkoses. The Nyangombi river in the South is the most important source of surface water, although the height difference between river and plateau level is rather considerable.

The distribution of the soils in the area is shown on the semi-detailed soil map attached to this report. The dominant soil in the area is a deep, well drained, friable and porous red clay soil with a sandy clay loam to sandy clay topsoil.

These soils have very little horizon differentiation and are very acid. (Ferralsols.) Their physical properties are good and they occupy about 1750 ha on slopes of 0-3% and about 800 ha on slopes of 3-5%. Liming is essential when these soils are continuously being farmed.

In the Northern part of the Scheme more sandy and partly less well drained soils have been found. They are also chemically very poor and need special care when opened up for continuous farming.

(ii) ACKNOWLEDGEMENT

The following staff worked together with the soil surveyor for the Nyangombi survey: Mr. B. Sitooloma, assistant soil surveyor; Mr. V. Mwale, Mr. Z. Chibwalu, and Mr. W. Mtonga, planning assistants; and Mr. G. Mubipe, compass man.

Mr. N. Nkuwa transported the teams in the field.

Assistance with local transport was provided by the Planning Section Solwezi. The Settlement coordinator, Mr. T. Baardsen, and the D.A.O. Mwinilunga assisted the teams to overcome some problems during the field work.

Drawing of the provisional map was carried out by Mr. J. Chiba at the LUS drawing office in Ndola. The final soil and land capability maps were drawn at the Carthographic Section of the LUS, Lusaka. Drawings in the text were prepared by Miss M. Yobe.

Soil samples were analyzed at Mount Makulu Research Station, Chilanga.

Preparation and duplicating of this report was done in a joint effort by a number of persons from different departments.

Mrs. J. Heilmann typed the final text on stencil during the last days of our stay in Zambia.

The help of all persons and institutions involved in this survey is gratefully acknowledged.

(iii) INTRODUCTION

This report presents the results of a soil survey of Nyangombi Scheme, N.W. Province, carried out mainly in the field season of 1977 by the Soil Survey Unit Ndola.

The Scheme is currently assisted by NORAD aid. The purpose of the survey was to supply the Planning Office Solwezi with sufficient soil and land capability data to carry out the planning of the agricultural activities in the area concerned.

The site of the Scheme was already chosen before the soil survey started. Some farmers had been settled already.

After completion of the survey a draft land capability map was prepared and submitted to the Planning Section Solwezi.

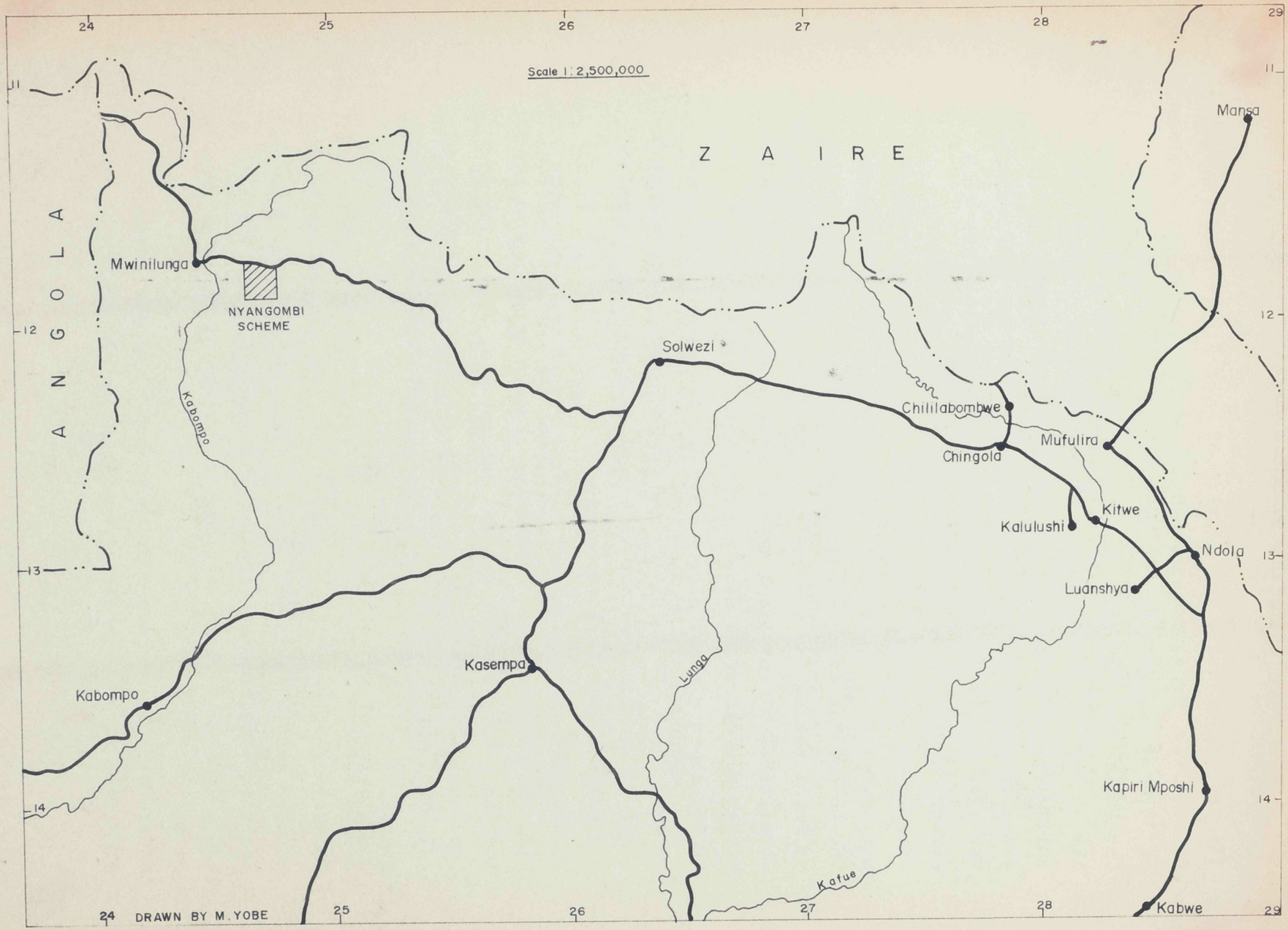
Due to several circumstances the release of laboratory data by Mount Makulu for the soils in Nyangombi has been very slow. Compilation of the final maps and the preparation of this report has therefore been considerably delayed.

On the steep plateau slopes (570 ha) red clayey soils are present which are slightly less leached. The steep slopes and their occurrence together with shallow soils make their agricultural use less attractive.

In the land evaluation part of this report the soil units have been grouped into land capability classes according to the Zambian LUS system for rainfed agriculture. When using the land evaluation data for Nyangombi, it should be remembered that this Scheme is situated in the high rainfall zone of Zambia.

In the surveyed area 49% consists of good arable land; 24.8% is moderately good arable land; 1.8% is moderately good to poor arable land; and 18.1% is poor arable land. Some 5.5% has been considered as grazing land while 0.8% is unsuitable land. Crop suitability ratings are given for the soil mapping units.

In the closing chapter some recommendations are given with regard to the properties of the soils in the area.


Scale 1:2,500,000
ANGOLA
ZAIRE
Mwinilunga
NYANGOMBI SCHEME
Kabompo
Solwezi
Chililabombwe
Chingola
Mufulira
Kitwe
Kalulushi
Ndola
Luanshya
Mansa
Kasempa
Lunga
Kabompo
Kapiri Mposhi
Kafue
Kabwe
24 DRAWN BY M. YOBE
24
25
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11
12
13
14

Fig 1

I. THE ENVIRONMENT

I.1 LOCATION

Nyangombi Scheme is situated in Mwinilunga District, North-Western Province, about 25 km East of Mwinilunga Boma and South of the main road between the Kanyama turn off and Samuteba school (see fig. 1).
The area was formerly called Samuteba Scheme. The Solwezi-Mwinilunga road forms the boundary of the Scheme in the North, the Kampemba stream in the West, the Nyangombi river in the South and the Lwamitova stream in the East.
It can be located on the 1:50.000 topographical maps nos. 1124D1 and D3.
The total area surveyed amounts to 4518 ha.

I.2 CLIMATE

The nearest meteorological station for Nyangombi Scheme is situated in Mwinilunga, some 25 km to the West. The altitude of this station is about 1360 m which is about the same height as the survey area. Detailed climatological data for the Mwinilunga station are presented in table 1; a rainfall/temperature diagram is shown in fig. 2.
The climate in the area is strongly seasonal with a dry season from May till October and a rainy season from the end of October till the beginning of April. Total annual rainfall amounts to 1377 mm.
There is very little variation in the mean monthly temperature during the rainy season (19.7 - 19.8° C); the mean monthly temperature in the dry season ranges from 15.7 - 21.4° C. June and July are the coldest months.
The average number of frost days is 10, occurring in May, June and July.
Relative humidity varies from about 45-65% in the dry season to about 75-85% in the rainy season.

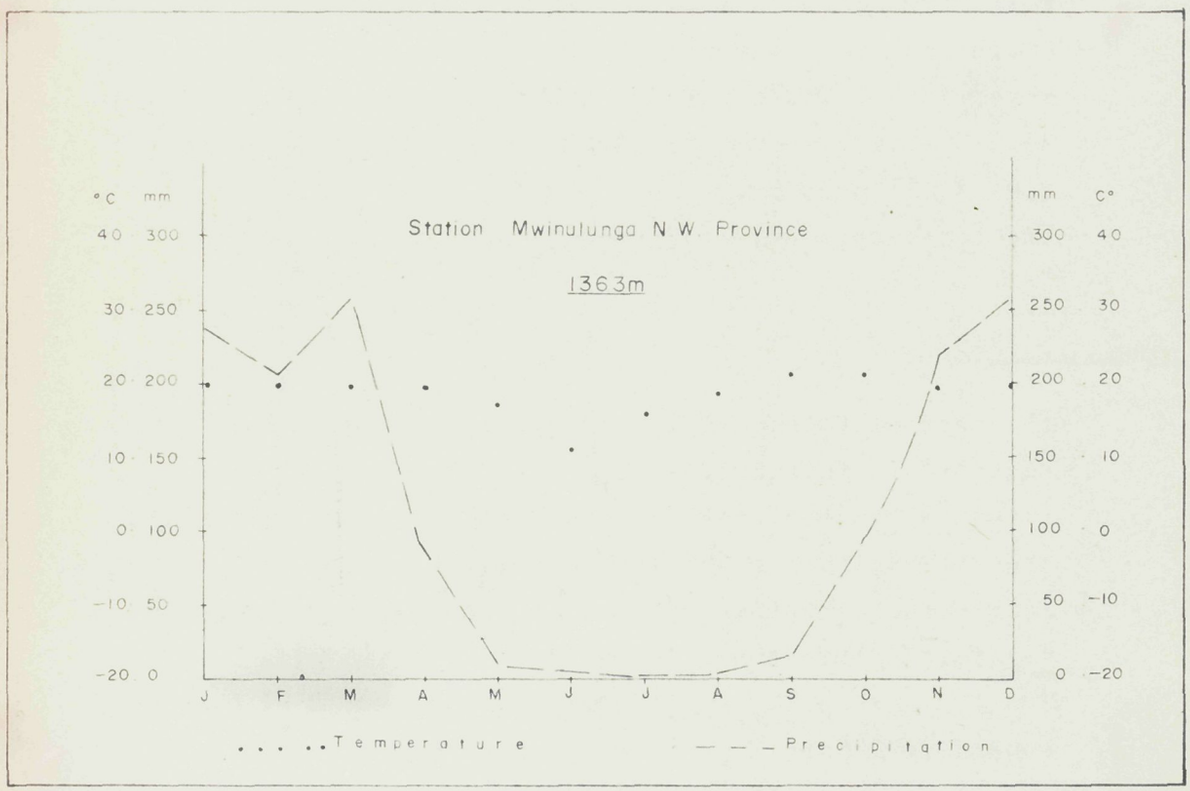
Station Mwinulunga N.W. Province
1363m
°C mm
40 300
30 250
20 200
10 150
0 100
-10 50
-20 0
mm C°
300 40
250 30
200 20
150 10
100 0
50 -10
0 -20
J F M A M J J A S O N D
. . . . Temperature
— — — Precipitation

Fig 2

Table 1

Month	Pressure (0800)	Thermograph Mean Temperature °C	Mean Max Temperature °C	ABS Max Temperature °C	Mean of ABS Max Temperature °C	Mean Min Temperature °C	ABS Min Temperature °C	Mean of ABS Min Temperature °C	Dew Point °C	Rel Hum %	Sunshine Hours Per Day	Wind Speed Knots	Evaporation mm	Rainfall Total mm	0.01" Rain Days	0.04" Rain Days (1 mm)	0.40" Rain Days (10 mm)	Frost Days	Radiation (Langleys)
No. of Yrs. Available	10	20	30	20	20	30	20	20	18	18	14	3	30	30	2	2	3	14	
July	867.2	15.8	26.0	30.0	28.6	6.3	1.1	3.7	6	53	9.9	2.3	Ø	Ø	0	0	3	519	
August	867.0	18.4	28.4	33.3	30.7	8.8	-0.5	4.6	7	47	9.5	2.6	1	Ø	0	0	0	557	
September	865.8	21.4	30.8	34.4	33.2	12.5	6.1	7.7	9	46	8.5	2.9	15	2	1	0	0	572	
October	365.2	21.4	30.2	34.4	33.3	14.5	10.0	10.6	12	57	7.5	1.7	94	11	9	3	0	560	
November	865.3	19.7	27.1	32.8	30.7	15.7	10.6	13.3	16	79	4.7	2.1	217	22	16	8	0	466	
December	864.5	19.7	25.9	32.2	29.2	16.0	12.8	14.3	17	84	4.1	1.5	255	25	23	9	0	447	
January	864.0	19.8	26.0	30.6	29.2	16.3	12.8	14.1	17	84	4.0	1.7	237	24	24	8	0	464	
February	864.1	19.8	25.9	31.1	28.9	16.2	12.8	14.1	17	84	4.2	1.9	208	22	18	7	0	450	
March	864.8	19.9	26.3	31.1	29.2	16.1	10.0	13.1	17	83	4.8	1.8	257	23	21	9	0	457	
April	864.9	19.8	27.1	30.6	29.1	14.3	7.8	10.5	16	76	7.7	2.0	94	10	6	2	0	521	
May	866.5	17.9	26.8	30.0	29.0	9.9	1.7	5.0	11	63	3.6	2.3	8	1	Ø	Ø	2	535	
June	868.4	15.7	25.5	28.9	28.1	6.5	-1.6	2.9	8	58	9.6	2.0	1	Ø	0	0	5	501	
Year	865.6	19.2	27.2	34.4	30.0	12.8	-1.6	9.4	13	68	7.0	2.4	1377	140	119	46	10		

MWINILUNGA

LAT. 11° 45 'S LONG. 24° 26'E ALT. 1363 m

I.3 PHYSIOGRAPHY

The survey area consists of two plateau areas separated by a small subsidary stream of the Nyangombi river and an extensive dambo area on the watershed. In the N.W. part a small tributary of the Kampemba stream is deeply incised in the Western plateau. The area in general is sloping towards the South. Especially in the Southern half of the area the plateau has rather steep slopes towards the dambo's (over 5%). The altitude of the highest upland parts is about 1400 m in the Western part and 1450 m in the Eastern part; this is about 50-75 m above the level of the surrounding streams and rivers.
The altitude of the vast dambo area in the centre of the Scheme is approx. 1380 m.
No detailed geological maps have been published for the area. On the geological map 1:1.000.000 (1961), edited by the Geological Survey Department Lusaka, the following formations, both belonging to the Katanga series, are present:

a) Kundelungu, arenaceous facies, consisting of dolomite and carbonaceous shales;
b) Lower Roan, consisting of quartzites, arkoses, shales, dolomites and conglomerates.

During the survey a few outcrops of iron-rich shales/ schists have been found. In general the weathering mantle of red clayey material is rather thick. Outcrops of laterite blocks are present especially on the break of slope towards the streams and in the narrow dambo's along the streams.

I.4 VEGETATION AND PRESENT LAND USE

The plateaus are covered with a good, rather uniform stand of Miombo woodland (Brachystegia longifolia, Julbernardia paniculata and Isoberlinia angolensis). The trees are rather well developed but not too closely spaced.
Some other trees recognized during the survey were: Uapaca kirkiana ('musuku'), Marquesia macroura ('musamya'), Syzigium guineense ('musafwa'), Marquesis acuminata ('museshe'), Albizzia antunesiana ('musase') and Erythrophloeum africanum ('mukoso'). For some trees no species names have been found; their local names were: Kapepe,

Chimpepa, Mulema and muntikuni. Some of the above mentioned trees are remnants of a dry evergreen forest in this Miombo woodland.

Before the start of the Settlement Scheme the agricultural activities in the area were mainly concentrated along the Solwezi-Mwinilunga road, and in some patches with lighter textured soils further to the South.

The land use type of the region is called by Schultz (1974) 'intermediate shifting/semi-permanent cultivation system'. In this traditional agricultural system many characteristics of the 'chitemene' (shifting cultivation) have been preserved although cassava has become the main staple crop. Together with cassava, finger millet and maize are the main crops in the area. The preference for the tuberous cassava crop is rather extreme. Good research experiments on cassava growing have been carried out at the Mwinilunga Research Station by De Boer (1977).

II. SURVEY METHODS

II.1 OFFICE METHODS

Prior to the fieldwork, aerial photographs, topographical maps and old survey data were studied. Aerial photographs, scale 1:30.000 (1968, nos. 712-714 and 797-800), were used. The quality of these photographs was good, although their scale was not quite appropriate for this survey.

There existed a photo-mosaic for the area, but its scale of 1:25.000 was not adequate to use it as a base map. Instead a 1:10.000 enlargement of the 1:50.000 topographical map has been used as the base map for field work.

All aerial photographs were studied stereoscopically, before going into the field, to delineate the major physiographic soil units.

The soil survey results were plotted on the 1:10.000 base map and a preliminary land capability map was produced which was sent to the Planning Section Solwezi.

For production of the final map, the original draft was reduced to 1:20.000 scale. The drawing of the final maps was carried out at the Carthographic Section of the Land Use Branch in Lusaka.

II.2 FIELD METHODS

A semi-detailed soil survey was carried out of a small area on the Western plateau in September 1976; the rest of the area has been surveyed in October 1977. The survey was done on a regular grid system using the Scheme road in the Western part as a base line; a S.W.-N.E. running cutline served as baseline for the traverses in the Eastern part. Traverses were initially 300 m apart but it was soon felt that 500 m distance would be sufficient in view of the rather uniform soil distribution.
Soil augerings were carried out each 300 m. Traverse data sheets were kept of all the soil augerings and other observations (vegetation, rock outcrops etc.). All soil augerings were done by hand till 90 cm depth or shallower wherever an obstructive layer occurred. A total number of 410 augerings was made. For the main representative soils, sites were selected for profile pits. The sampling sites are indicated on the soil map annexed to this report. The pits were 180-200 cm deep where soil depth allowed. A total number of 14 pits was described according to the FAO Guidelines and soil samples were taken.
The method of continuous sampling of each horizon was used.
Analysis of the soil samples was carried out in Mount Makulu Research Station. Methods of analysis are outlined in Appendix 1 which also gives the full profile descriptions and the analytical data. In Appendix 2 guidelines can be found for the interpretation of the analytical results.

III. THE SOILS

III.1 PREVIOUS WORK

On the schematic map accompanying 'Soils, vegetation and agricultural systems of N.W. Rhodesia' (Trapnell and Clothier, 1936) the Nyangombi area is represented as 'Northern Brachystegia woodlands on clay soils'.
The Land Use Planning Section in Solwezi carried out a general land capability survey of the area in December and January 1975.

The map produced on a 1:25.000 scale only indicates the broad land capability land types using the pre 1974 LUS classification. No indications of limitations for the different units were presented and the map has no legend. Reliability of this map is not known as all the original survey data seem to have been lost and no old traverse maps have been found.

III.2 GENERAL PROPERTIES OF THE SOILS

The general pattern of the soils in the Nyangombi area is mainly determined by the parent material, geomorphology and climate. The area consists of two sloping plateau areas surrounded by rather steep slopes towards the dambo's. In the centre, just South of the road, a somewhat lower lying area with large dambo's occurs. The dominant soils in the area consists of well drained, deep, red clayey soils which are present on the gently sloping plateaus in the Southern half of the area. They are friable and porous and have a good micro-aggregation due to considerable amounts of iron (hydr)oxides. Infiltration and permeability are moderately rapid and these soils are relatively erosion resistant. Horizon boundaries are diffuse or gradual. Soil structures are very weak. They are strongly leached and show a very acid soil reaction (pH $CaCl_2$ less than 4.5). On the shoulders of the plateaus these soils are present on slopes from 3 - 5%, while on the steeper slopes towards the dambo's they are associated with shallower soils and some rock or laterite outcrops.

The N.N.E. part of the survey area has distinctively lighter textured soils probably related to a somewhat sandier parent material. The extensive dambo areas in this part are fringed by very light textured soils which are moderately well to imperfectly drained. The slopes in this area are very gentle (0-3%).

The dambo's along the river and the streams are rather narrow and often scattered outcrops of laterite have been found.

III.3 TAXONOMIC SOIL CLASSIFICATION

The taxonomic classification of soils in Zambia has been based some time on the so-called 'soil series' concept. However, during the last years this system has hardly been maintained by lack of a soil correlator.
The grouping of the soils in Nyangombi Scheme is basically done according to the series concept. However, no series names have been introduced but the different soils can easily be translated into series and phases whenever this becomes necessary.

III.4 DESCRIPTION OF SOIL MAPPING UNITS

A general description of each mapping unit is given below. For detailed descriptions and analytical data of each soil pit the reader is referred to Appendix 1.
Some differences existing between field textures and laboratory textures are probably due to insufficient dispersion of the soil caused by the high amount of iron (hydr)oxides.
The distribution of the mapping units is shown on the semi-detailed soil map annex to this report. For the acreage (in ha) of the soil mapping units reference is made to table 2. It should be noted that, for the land capability classes given below, the soil fertility has not been used to downgrade the classes (see also chapter IV). However, the Nyangombi area is part of the high rainfall zone of Zambia.

PLATEAUS

Mapping unit 1 - 1753 ha (38.9% of total area)

The soils in this unit are deep, well drained, dark red clay loams to clays with a dark reddish brown sandy clay loam to sandy clay surface layer. These are the dominant soils in the area and they occur as a very uniform cover on the very gently sloping (0-3%) top parts of the plateaus.
The vegetation is a well developed Miombo woodland.
The soils have an ABC horizon sequence and are strongly leached. The slightly stained surface horizon is about 6-10 cm thick.

TABLE 2 - AREA (IN HA) OF SOIL MAPPING UNITS AND CORRESPONDING LAND CAPABILITY CLASSES

Soil Mapping unit no.	Corresponding Land Cap. Class	ha
1	C1	1753
1s	C2s	814
1d	C2d	6
	C3dg	27
	C2dg + C3dr	38
1ds	C2ds	8
	C3ds	47
1t	C1	28
1b	C2s + C2ds	51
2	C1	29
3	C1	47
4	C3sd + C3s	570
5	S1	167
5d	S3d	168
	S2d + S3dg	15
5a	S1 + S2d	17
6	S1	189
6d	S2d + S3dg	27
6r	S3dg + Gdr	56
15	S2w	51
15a	S2w	88
16	S2w	87
17	S3w + S3dr	4
20	Gw	186
25	Gdr	8
	UR	16
Swamp	Uw	21
TOTAL AREA		4518 ha

The horizon boundaries are gradual to diffuse. Soil structure is (very) weak subangular blocky. Micro-aggregation is good and rather stable due to considerable amounts of iron (hydr)oxides. Average clay content is about 30% for the surface layer and 45% for the B horizons. In the topsoil organic carbon levels are low and available phosphorus averages about 12 ppm. Soil reaction (ph $CaCl_2$) is very strongly acid (4.1 - 4.3) for the A horizon and 4.1 - 4.4 for the B horizons, making liming essential when cropping these soils.

Base saturation is very low and mostly less than 10%. The CEC/100 gr clay is low with an average of 8 m.e., which is typical for a kaolinitic nature of the clay minerals. Only some patchy thin cutans have been observed in these soils. They are thought to have an 'oxic' horizon.

Five soil pits have been described and sampled: NWP 1/76 and 2/76, and NWP 12/77, 19/77 and 21/77.

Land Capability Class: C1

Typical LUS Code : 1 D F F F - -
A - - 10R/2.5YR3/6

Mapping unit 1s - 814 ha (18.1% of total area)

The same soil as unit 1 but on slopes of 3-5%. In view of the good structural stability of these soils there is not much danger of erosion when cultivating these soils. Proper cultivation and conservation practices should however been followed as much as possible.

The soils with a sandy clay loam top soil are somewhat more sensitive to sheet erosion. From the data of the two soil pits analyzed in this unit (NWP 13/77 and 20/77) it appears that the soil reaction of the topsoil is slightly less acid (pH from 4.8 - 5.6) and that also the pH in the subsoil is slightly higher than in unit 1 (pH from 4.2 - 4.9). This may be due to the fact that decomposed rock is present at shallower depth.

Land Capability Class: C2s

Typical LUS Code : 1 D F F F - -
B - - 10R/2.5YR3/6

Mapping unit 1d - 71 ha (1.6% of total area)

As unit 1 but moderately deep and moderately shallow over laterite gravel. In some places some small outcrops of laterite blocks or some laterite gravel on the surface may occur. These soils occupy a small area. They have been found as islands in unit 1 and on the break in the plateau slope towards the dambo. No soil pits have been described.

Land Capability Class: C2d/C3dg
Typical LUS Code : 2/3 D F F (F) g L
A - 10R/2.5YR3/6

Mapping unit 1ds - 55 ha (1.2% of total area)

As unit 1d but on slopes of 3-5%. The extent of this unit is very limited. They occur together with the soils of unit 1s. No soil pits have been described.

Land Capability Class: C2ds/C3ds
Typical LUS Code : 2/3 D F F (F) - L
B - - 10R/2.5YR3/6

Mapping unit 1t - 28 ha (0.6% of total area)

The soils of this unit occupy a small, slight depression area on the Western plateau, which joins the headwaters of the strongly incised Kampemba stream. They differ from unit 1 in their thick surface layer of sandy clay loam texture. They also have a somewhat lighter subsoil texture. Their chemical properties are not significantly different from those of unit 1 soils.
One soil pit has been described: NWP 18/77

Land Capability Class: C1
Typical LUS Code : 1 C C E F - -
A - - 2.5YR3/6

Mapping unit 1b - 51 ha (1.1% of total area)

This unit consists of an association of unit 1s and unit 1d soils. It occurs in the N.E. part of the survey area over a rather small area. No soil pits have been described.

Land Capability Class: C2s + C2ds
Typical LUS Code : 1/2 D F F F - (L)
B - - 10R/2.5YR3/6

Mapping unit 2 - 29 ha (0.6% of total area)

The soils of this unit occupy very small areas in the Northern part of the area, often in lower slope position. They are well drained, deep and very much like mapping unit 1t. Only their Hues are 5YR instead of 2.5YR. No soil pits have been described for these soils.

Land Capability Class: C1
Typical LUS Code : 1 C C E F - -
A - - 5YR5/8

Mapping unit 3 - 47 ha (1.0% of total area)

The soils of this unit have been found in a small area on the S.E. part of the low lying area in the centre of the Scheme. They are deep, well and moderately well drained, with a sandy clay loam surface horizon and a sandy clay loam to (sandy) clay subsoil. Horizon boundaries are diffuse and soil structure is very weak to massive porous. These yellowish brown soils resemble the soils of mapping unit 6. The latter soils have a sandy loam topsoil.
No soil pits have been analyzed.

Land Capability Class: C1
Typical LUS Code : 1 C C D F - -
A - - 10YR3/6

Mapping unit 4 - 570 ha (12.6% of total area)

This mapping unit is quite extensive in the area. It occupies the sloping areas (5-8% slope) between the plateau surfaces and the dambo's, and consists of an association of soils similar to unit 1ds and 1s (but on slopes of 5-8%). Some small outcrops of rock or laterite blocks occur in this unit. The weathered bedrock is in general at lesser depth than for unit 1s soils, which is reflected in somewhat higher pH and CEC values.

One soil pit has been described: NWP 11/77.

Land capability Class: C3s + C3sd

Typical LUS Code : 1/3 D F F F - (L)
C - - 10R/2.5YR3/6

Mapping unit 5 - 167 ha (3.7% of total area)

The soils of this mapping unit are very similar to those of unit 1t, but they have a distinct sandy loam surface layer. They are well drained, and deep, and occupy an area in the centre of the Scheme, just South of the main road. No soil pits have been analyzed. The chemical data of unit 1t (NWP 18/77) will be applicable to these soils.

Land Capability Class: S1

Typical LUS Code : 1 B B C C - -
A - - 2.5YR3/6

Mapping unit 5d - 183 ha (4% of total area)

Same as mapping unit 5 but moderately deep and moderately shallow over laterite gravel. Some small outcrops of laterite blocks and laterite gravel occur. These soils occupy a rather extensive area in the N.E. part of the Scheme.

Land Capability Class: S2d/S3dg

Typical LUS Code : 2/3 B B C (g L)
A - - 2.5YR3/6

Mapping unit 5a - 17 ha (0.4% of total area)

This unit comprises an association of 5 and 5d soils. Its extent is very limited in the area.

Land Capability Class: S1 + S2d
Typical LUS Code : 1/2 B B C C - (L)
A - - 2.5YR3/6

Mapping unit 6 - 189 ha (4.2% of total area)

These soils are well and moderately well drained, deep, yellowish brown sandy clay loams to sandy clays with a sandy loam surface layer. They have a strongly acid soil reaction with pH $CaCl_2$ of 4.2/4.4 for the topsoil and 4.1/4.5 for the B horizons. Soil structure is very weak to massive and horizon boundaries are diffuse. Base saturation is less than 50%. CEC values for 100 gr clay are between 4 and 7 m.e. Available phosphorus values are low (7-13 ppm). These soils occur in the Northern part of the survey area on slopes from 0-3%. They are very prone to capping when cultivated. For cassave cultivation they are very much favoured. Two soil pits have been described for this unit: NWP 14/77 and 23/77.

Land Capability Class: S1
Typical LUS Code : 1 B B C C - -
A - - 7.5YR5/8

Mapping unit 6d - 27 ha (0.6% of total area)

As unit 6 but moderately deep and moderately shallow over laterite gravel. Some laterite outcrops may occur.

Land Capability Class: S2d/S3dg
Typical LUS Code : 2/3 B B C - g L
A - - 7.5YR5/8

Mapping unit 6r - 56 ha (1.2% of total area)

As unit 6 but moderately shallow and shallow over laterite gravel. Frequent outcrops of laterite blocks occur and laterite gravel on the surface is very common.

Land Capability Class: S3dg + Gdr

Typical LUS Code : 3/4 B B - - r L
A - -

DEPRESSIONS AND DAMBO EDGES

Mapping unit 15 - 51 ha (1.1% of total area)

This unit comprises some moderately well drained and sometimes imperfectly drained yellowish brown, loamy sand and sandy loam soils with a dark grayish brown loamy sand surface layer. Soil structure is massive. They occur on the transition to the dambo's. Their soil reaction is strongly acid and they are strongly leached with a base saturation of less than 10%. Available phosphorus is low. The CEC/100 gr clay value of 25-35 m.e. for some horizons in soil pit 22/77 is rather anomalous and is probably due to an analytical error. In view of the other chemical data a CEC of 7-8 m.e. would be expected. Soil pit NWP 22/77 is representative for this unit.

Land Capability Class: S2w

Typical LUS Code : 1 X B B B - -
A - W1 10/7.5YR5/8

Mapping unit 15a - 88 ha (1.9% of total area)

This unit is very similar to no. 15 but the soils have a sandy clay loam subsoil. They occur in the N. fringe area of the dambo's in the centre of the Scheme.

Land Capability Class: S2w

Typical LUS Code : 1 X B C C - -
A - W1 10/7.5YR5/8

Mapping unit 16 - 87 ha (1.9% of total area)

These soils are imperfectly drained, deep, loamy sands to sandy loams with a loamy sand surface layer. The very lightly textured soils are very strongly to strongly acid and have a massive structure. CEC values for 100 gr soil are very low (1-2 m.e.) and make the high value of the base saturation (90-100%) quite meaningless.

The soils occur on the transition to the dambo's in the centre of the area. One soil pit has been described: NWP 17/77.

Land Capability Class: S2w (or S2wt if texture from 40-60 cm is loamy sand)

Typical LUS Code : 1 X X B B - -
A - W2 10YR5/8

Mapping unit 17 - 4 ha (less than 0.1% of total area

This very small mapping unit occupies a narrow, dambo like area in the N.E. part. It consists of deep to moderately shallow, imperfectly drained, sandy loams with a lomay sand surface layer. Laterite is often present in the subsoil and frequent patches with laterite blocks occur.

Land Capability Class: S3w + S3dr

Typical LUS Code : 1/3 X B B (B r L)
A - W3 10YR5/8

Mapping unit 20 - 186 ha (4.1% of total area)

The soils in this mapping unit are very poorly drained. They occur in the dambo sites over the area and have not been differentiated. In general they have a sandy loam surface layer over a massive, mottled, sandy clay loam to sandy clay subsoil. Sometimes laterite outcrops have been found especially in the narrow dambo's along the streams. One soil pit has been described: NWP 16/77.

Land Capability Class: Gw

UNDIFFERENTIATED

Mapping unit 25 - 24 ha (0.5% of total area)

This unit comprises very shallow and stony soils, which have not been differentiated.

Land Capability Class: Ur/Gdr

Swamps - 21 ha (0.5% of total area)

In the centre of some oval shaped dambo's in the N. part of the area, permanently wet soils occur. They have not been surveyed. Their Land Capability classification is Uw.

III.5 SOIL CLASSIFICATION

In Zambia the new FAO/UNESCO Classification System for the soil map of the world (FAO/UNESCO, 1974) is used to correlate broadly the various soils. This system however does not have a proper taxonomy for detailed categoric levels as it was first aimed at small scale continent-wise mapping.
The other widely used international system, the USDA 'Soil taxonomy' (USDA, 1978) uses a more morphometric approach which requires many field and laboratory data. The latter are often not available and in the same time this system tends to take insufficient account of soil differences relevant in tropical countries.
Table 3 shows the FAO/UNESCO Classification for the soil pits in the Nyangombi area. For comparison reasons the approximate equivalent name in the USDA system has been given.

The classification units of the main soils present in Nyangombi are:

a) Ferralsols

These soils have an ABC sequence of horizons with gradual to diffuse horizon boundaries. They are strongly weathered and have an 'oxic' B horizon i.e. a subsoil horizon which is: at least 30 cm thick, friable or very friable and porous; has a massive or weak subangular blocky structure which is characteristically stable, has more than 15% clay sized particles; has gradual or diffuse horizon boundaries; contains no more than traces of easily weatherable minerals; has a CEC of the organic matter free clay of less than 16 m.e., and has little or no silt.

TABLE 3 - SOIL CLASSIFICATION FOR NYANGOMBI SOILS ACCORDING TO FAO/UNESCO SYSTEM AND USDA 'SOIL TAXONOMY'

Mapping unit	Soil pit no.	CLASSIFICATION
1	NWP 1/76 NWP 2/76 NWP 12/77 NWP 19/77 NWP 21/77	FAO/UNESCO: Rhodic Ferralsol, fine textured USDA: Typic Haplustox
1s	NWP 13/77 NWP 20/77	FAO/UNESCO: Rhodic Ferralsol, fine textured USDA: Typic Haplustox
1t	NWP 18/77	FAO/UNESCO: Rhodic Ferralsol, fine/medium textured USDA: Typic Haplustox
4	NWP 11/77	FAO/UNESCO: Rhodic Ferralsol, fine textured intergrade to dystric Nitosol USDA: Troperptic Haplustox
6	NWP 14/77 NWP 23/77	FAO/UNESCO: Xanthic Ferralsol, medium textured USDA: Ustoxic Dystropept
15	NWP 22/77	FAO/UNESCO: Ferralic Arenosol USDA: aquic ustoxic Dystropept
16	NWP 17/77	FAO/UNESCO: Ferralic Arenosol USDA: aquic ustoxic Dystropept
20	NWP 16/77	FAO/UNESCO: Dystric Gleysol, fine textured USDA: aeric Tropaquept

The clay fraction of the Ferralsols consists predominantly of the 1:1 lattice silica clay minerals (kaolinite group) and more or less well crystallized iron, aluminium and manganese oxyde. The Ferralsols are the equivalent of the 'oxisols' of the USDA 'Soil taxonomy'.

In the FAO/UNESCO legend six subunits are discerned. In the survey area only the rhodic, xanthic and orthic Ferralsols have been found.

The rhodic Ferralsols have a red to dusky red colour and tend to have relatively high CEC values. Soils of mapping units 1, 1s, 1t and 4 compare with this subunit.

The xanthic Ferralsols have a (pale) yellow B horizon (Hues of 7.5YR or yellower). The soils of mapping unit 6 need the requirements of this subunit.

The orthic Ferralsols compare with mapping unit 2. Their 5YR Hues are not red enough to qualify for the rhodic subunit and are not pale enough to meet the requirements for the xanthic subunit.

b) Arenosols

Some of the soil units in the Nyangombi area, mapping units 15 and 16, have a B horizon which does not meet the requirements for an 'oxic' horizon, as their clay content is less than 15%. The soils therefore have to be classified as Arenosols: these are soils of coarse texture showing characteristics of argillic, cambic or oxic B horizons, which, however, do not qualify as diagnostic horizons because of the textural requirements. The FAO/UNESCO system recognizes 4 subunits, but in the survey area only the ferralic Arenosols are present.

This subunit of the Arenosols has a CEC of less than 24 m.e./100 gr clay in at least some sub-horizons of the cambic B, or immediately underlying the A horizon. In the Nyangombi area the mapping units 15 and 16 (soil pits NWP 22/77 and 17/77) have been classified as ferralic Arenosols.

N.B. The CEC values/100 gr soil of soil pit NWP 22/77 are considered to be too high (see also the description of mapping unit 15). If the analysis repeat confirms the analytical data this soil will meet the requirements for cambic Arenosol.

c) Gleysols

These soils have hydromorphic properties within 50 cm of the surface. They are normally formed from unconsolidated material exclusive of recent alluvial deposits. The FAO/UNESCO legend distinguishes seven subunits. In the survey area probably only the dystric Gleysols are present. The soils of mapping unit 20 have been classified as dystric Gleysols as they have a base saturation of less than 50% between 20 and 50 cm depth and lack plinthite within 1-5 cm of the surface. (Compare soil pit NWP 16/77.)

IV. INTERPRETATION OF SURVEY DATA

IV.1 GENERAL

Each soil survey provides the basic information about soils and land characteristics. To enable a better understanding of the meaning and consequences of these data, they can be processed according to certain methods, the so-called Land Evaluation.
In Zambia the LUS Land Capability System is used to evaluate the land (Land Use Branch, 1977). It is a broad, qualitative system for agricultural use only, based on the concept of long term 'safe use of the land'. It takes into account the present soil and land limitations. No land use alternatives are being considered. This system has been basically designed for dry land farming of maize and tobacco.
In 'Land Evaluation in Zambia' (Mumba and Heilmann, 1978) the LUS system has been reviewed in connection with the new FAO Land Evaluation Guidelines (FAO, 1978) and some recommendations are given to improve and extend the system.

IV.2 LUS LAND CAPABILITY SYSTEM FOR NON IRRIGATED AGRICULTURE

At the hoghest level there is a division into four 'types of land':

(i) Arable land
(ii) Marginal Arable land
(iii) Grazing land
(iv) Unsuitable land

Only the units Arable land and Marginal Arable land are subdivided into Land Classes. The LUS system distinguishes 3 'clayey' ('C') and 4 'sandy' ('S') classes according to certain site or soil limitations; the distinction between clayey and sandy classes being a function of the texture of the topsoil. Further subdivision of land classes into subclasses is provided by a symbol reflecting the kind of limitation. In Appendix 4 the criteria are listed for determining LUS land classes and the accompanying symbols for subclasses.

Soil fertility has not been used anymore for downgrading the classes. At the 1979 annual soil survey unit meeting it was agreed to drop the fertility index as a downgrading criterium. It was recognized that this index did not correlate sufficiently with productivity potential of certain soils especially in the high rainfall areas. The introduction of agroclimatological zones in the LUS system is now under study in order to provide the necessary differentiation in ecological background. As a general indication the Nyangombi area can be considered to belong to the high rainfall zone in Zambia.

IV.3 THE LAND CAPABILITY OF THE NYANGOMBI AREA

A semi-detailed land capability map has been prepared, scale 1:20.000, which is annexed to this report. Reference is made to this map. Land capability codes for the most important units have been indicated. The abbreviations used in the code are explained in Appendix 3. The acreage (in ha) of the different land capability classes is shown in table 4.

TABLE 4 - AREA (IN HA AND %) OF LAND CAPABILITY MAPPING UNITS

Land Capability mapping unit	Sub Class (ha)	Class (ha)	%	Related soil mapping unit
Good Arable land		2213	49.0	
C1	1857			1, 1t, 2, 3
S1	356			5, 6
Mod. good Arable land		1122	24.8	
S1 + S2d	17			5a
C2d	6			1d
C2ds	8			1ds
C2s	814			1s
C2s + C2ds	51			1b
S2w	226			15, 15a, 16
Mod. good/Poor Arable land		80	1.8	
C2dg + C3dr	38			1d
S2d + S3dg	42			5d, 6d
Poor Arable land		816	18.1	
C3dg	27			1d
C3ds	47			1ds
C3ds + C3s	570			4
S3d	168			5d
S3w + S3dr	4			17
Grazing land		250	5.5	
S3dg + Gdr	56			6r
Gw	186			20
Gdr	8			25
Unsuitable land		37	0.8	
Ur	16			25
Uw	21			Swamp
TOTAL AREA		4518 ha	100%	

The following LUS Land Classes have been distinguished and are defined as follows:

a) Good Arable land

Good arable land is suitable for intensive use on a sustained economic basis with normal use of fertilizers and lime. The farmer is free to choose annual or semi-perennial crops.

b) Good to moderately good Arable land

Same as a) but the level of production is locally restrained by insufficient depth of soil or the occurrence of rock outcrops.

c) Moderately good Arable land

Land capable of being maintained at a high level of production under an intensive cropping system but requiring special attention to soil conservation or management in relation with the limitations. (Soil depth, slope, and wetness.)

d) Moderately good to poor Arable land

Same as c) but areas are included which do not support a long term intensive use of the land for arable crops without great risks for poor yields. In the latter areas the choice of crops is limited. In the survey area the main limitations are soil depth and rock outcrops.

e) Poor Arable land

Land with severe limitations for cultivation which either greatly increase the costs of production or reduce yields to marginal levels. There is limited freedom of choice of crops. Soil depth and slopes are the main limitations for this class in the Nyangombi area.

f) Poor Arable/Grazing land

As e); it includes areas which are not suitable for sustained arable cropping but are suitable for grazing. The limitations in the survey area are shallowness of the soil and rock outcrops.

g) Grazing land

This class comprises land that is not suitable for arable cropping, but is suitable for grazing. It includes land that is too wet and land where shallowness of the soil is the limiting factor.

h) Unsuitable land

This class includes land with too severe limitations for arable cropping or grazing.

IV.4 CROP SUITABILITY

Each kind of soil has chemical and physical properties which affect its response to management and influence the crop yields. The various soils in Nyangombi have been rated to their suitability for the production of certain rainfed and irrigated crops. These ratings are called crop suitability classes and they range from class 1 to class 4. This rating is based on the assumption that the crops will be grown at a slightly above average level of management which includes the application of fertilizers and lime, and the use of a proper rotation. It is also assumed that the costs of management necessary to grow the indicated crops on the specific soils, will be within economic limits of crop production based upon long term price trends. The grading does not take into account prices of bush clearing and other land preparation work.

It is important to realize that many crops are tolerant to a wide range of soil conditions and that good management can produce good crops from less suitable soils in years with very favourable weather conditions or with extremely high management.

Ratings for the more common crops in the Nyangombi area are given in table 5.

TABLE 5 - CROP SUITABILITY RATINGS FOR NYANGOMBI SOILS

Soil Mapping Unit	rainfed crops												(partly) irrigated crops				
	Maize	Bulrush Millet	Sorghum	Finger Millet	Groundnuts	Soyabeans	Beans	Sunflower	Potatoes	Virginia Tobacco	Cassava	Pineapple	Tomatoes	Sugar Cane	Bananas	Citrus	Wheat
1	2	1	1	1	2	1	1	2	2	4	2	3	1	1	1	1	1
1s	2	1	1	1	2	1	1	2	2	4	2	3	1	1	1	1	1
1d	3	2	2	2	3	3	3	3	4	4	3	3	2	2	3	3	3
1ds	4	3	3	3	4	4	3	4	4	4	3	3	2	3	3	3	3
1t	2	1	1	1	1	1	1	2	2	3	1	2	1	1	1	1	1
1b	2	2	2	2	2	2	1	2	2	4	2	3	3	3	4	4	4
2	2	1	1	1	1	1	1	2	2	3	1	3	1	1	1	1	1
3	2	1	1	1	1	1	1	2	1	3	1	3	1	1	1	1	1
4	4	3	3	3	3	3	3	4	4	4	3	4	2	3	3	3	3
5	2	1	1	1	1	1	1	2	2	1	1	1	1	2	2	1	1
5d	3	2	2	2	2	2	2	3	3	3	2	2	2	3	3	3	3
5a	3	2	2	2	2	2	2	3	3	2	1	1	2	3	3	3	3
6	2	1	1	1	1	1	1	2	2	1	1	1	1	1	1	1	1
6d	3	2	2	2	2	2	2	3	3	3	2	2	2	3	3	3	3
6r	4	3	3	3	3	4	4	4	4	4	3	3	3	4	4	4	4
15	4	3	3	3	3	3	2	4	3	3	2	2	2	2	3	4	3
15a	3	3	3	3	3	3	2	3	3	3	2	2	2	2	3	4	3
16	4	3	3	3	3	3	3	4	4	4	3	3	3	3	4	4	4
17	4	4	4	4	4	4	3	4	4	4	4	4	3	3	4	4	4
20	4	4	4	4	4	4	4	4	4	4	4	4	4	3	4	4	4
25	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4

Absence of a crop from the table should not be taken as an indication of unsuitability. It should be further remembered that the Nyangombi area is situated in the high rainfall zone and that liming is essential for most crop productions.

The four crop suitability classes used are defined as follows:

Suitability class 1: well suited

With above average management the crops grow well and produce relatively high yields. For the crops under consideration the soil has favourable physical properties and has a fertility level which is responsive to good management.

Suitability class 2: moderately well suited

With the same amount of management techniques as in class 1 (but not necessarily the same) the crops will produce moderate yields. The soil may have less favourable physical or chemical characteristics for the crops or be only moderately responsive to good management.

Suitability class 3: poorly suited

The soil is poorly suited for the crop. Response to management is low and the crop must be considered marginal.

Suitability class 4: not suited

The soil is not suited for the crop in question. Little, if any, production can be expected.

It should be noted that a low rating for a given crop does not mean that the crop cannot be produced. It does indicate that some unfavourable characteristics, such as poor physical properties of the soils, would need to be overcome by extra inputs. The economics of such corrective measures would need a very careful evaluation.

V. GENERAL RECOMMENDATIONS WITH REGARD TO SOIL PROPERTIES

All the soils in the Nyangombi area are chemically poor. Soil reaction is strongly to very strongly acid. Liming is essential to obtain adequate crop results over the years. The lime applications recommended by De Boer (1977) of the Mwinilunga Research Station should be taken as a guideline. In this respect it should be considered to start the production of agricultural lime as soon as possible in the Mwinilunga area. Extensive outcrops of (dolomitic) limestones have been reported to occur East of Mwinilunga and South along the Lungu river. However, liming only does not guarantee good yields. Use of the recommended fertilizers, good management and a proper crop rotation are essential too.

Ploughing of the soils should be very superficial. Trials with minimum tillage should be considered as soon as possible.

Organic carbon content of the upland soils is low and appropriate measures should be taken to maintain or even increase this level.

The very sandy soils in the Northern part of the area should not be used for continuous cropping. Only cassava growing can be done in a more or less permanent way when fertilizers are being used. For other crops fallow periods are recommended for these soils.

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APPENDIX 1

SOIL PROFILE DESCRIPTIONS AND ANALYTICAL DATA

(i) General

In the following soil profile descriptions, the style and nomenclature of the FAO Guidelines for Soil Description (1967) have been used. These are based on those described in detail in the USDA Soil Survey Manual (U.S. Dept. of Agriculture, 1951).

It has to be noted that:

a) Textural classes are those of the USDA system. The major difference with the older 'International System' is the limit between the silt and the sand fractions. In the 'International System' this limit is at 0.02 mm, while the USDA system puts it at 0.05 mm. Experience shows that the 0.05 mm limit correlates more closely with the 'soil feel' and the soil behaviour. The 'International System' has been previously used in Zambia, but has now been abandonned. The analytical data presented for each profile in this Appendix show only USDA particle size classes.

b) Soil reaction relate to the pH determined in Calcium Chloride. Values of pH determined in $CaCl_2$ are in general lower (by an average of 0.7 of a unit) than the pH determined in H_2O.

(ii) Analytical methods

The following methods were used to obtain the various analytical data:

- Particle size classes:
  Samples were passed through a 2 mm sieve. Only samples of the first 20-40 cm were pretreated with hydrogen-peroxide to correct for organic matter. All samples were pretreated with hydrochloric acid in order to get a better dispersion. Calgon (sodium hexametaphosphate + sodium carbonate) was used as a dispersing agens. Clay and silt were determined by the hydrometer method; sand fractions by wet sieving.

- Organic Carbon:
  The Walkley Black method was used to determine the organic carbon %. In order to convert organic carbon figures to organic matter values,

the former should be multiplied by the factor 1.7 (approximate O.M. value!).

- Nitrogen

Total nitrogen % was determined by Kjeldahl method using a copper catalyst.

- Cation Exchange Capacity (C.E.C.) and Exchangeable Cations:

These were determined in an ammonium acetate extract at pH 7.0. C.E.C. values were measured by leaching out the excess ammonium acetate with alcohol and final leaching with a sodium chloride solution to replace absorbed ammonia. Exchangeable Ca and Mg were determined by atomic absorption; exchangeable K and Na on an EEL flame photometer.

- Base Saturation (B.S.P.)

The B.S.P. was calculated from C.E.C. and E.C. (TEB).

- pH

Soil reaction was measured by glass electrode in a 0.01 M $CaCl_2$ solution using a soil/$CaCl_2$ ratio of 1:5.

- Available Phosphorus

So called 'available P' was determined by Bray's no. 1 method.

(iii) Soil profile descriptions and analytical data

In the following part all soil descriptions and accompanying analytical data have been listed together.

N.B. Soil fertility has not been used for down grading the LUS Land Capability classes. The Mpongwe area is situated in an Intermediate Rainfall Zone (I.R.Z.).

PROFILE NO: N W P 1/76

Location: N.W. Province, Nyangombi Scheme; Line 1-600 m.

Physiography: very gentle sloping plateau

Slope: 1-3% to East

Elevation: approx. 1400 m.

Parent material: presumably Fe-rich schists with intercallations of dolomitic limestone

L.U. Class: C1 (H.R.Z.) *)

Mapping unit: 1

Drainage: well drained

Permeability: mod./rap.

Date sampled: 25-11-1976

Described by: Dr. P. Heilmann, W. Mtonga

Land Cap. Code: 1 D F F F - -
A--10R/2.5YR3/4

Vegetation/Land use: Miombo woodland

Horizon	Depth (cm)	Description
A	0 - 11	Dark reddish brown (2.5YR3/4) moist and dark red (2.5YR3/5) dry, clay loam; very weak, fine subangular blocky structure; hard dry, friable moist, plastic and sticky wet; many fine, few medium and coarse pores; many fine, few medium roots; clear and smooth boundary on,
B2.1	11 - 20	Dark reddish brown (2.5YR3/4) moist and dark red (2.5YR3/6) dry, clay loam; very weak, fine subangular blocky structure; hard dry, friable moist, sticky and plastic wet; common fine and few medium pores; common fine and medium roots; clear and smooth boundary on,
B2.2	20 - 40	Dark reddish brown to dusky red (10R/2.5YR3/4) moist and dark red (10R3/8) dry, clay; weak, fine and medium subangular blocky structure; hard dry, friable moist, plastic and sticky wet; common fine and medium pores; few fine and medium roots; gradual to diffuse and smooth boundary on,
B2.3	40 -200+	Dark reddish brown to dusky red (10R/2.5YR3/4) moist and dark red (10R3/8) dry, clay; weak, medium and coarse subangular blocky structure; hard dry, friable moist, plastic and sticky wet; common fine and medium pores; few to no roots.

*) H.R.Z.: High Rainfall Zone

ANALYTICAL DATA

Profile No: NWP 1/76

Grain size, mm

Lab. No.	Depth (cm)	Clay <0.002 %	Silt 0.002 -0.05 %	F.sand 0.05 -0.25 %	M.sand 0.25 -0.50 %	C.sand 0.50 -2.00 %	TEXTURE (USDA)
76/5096	0-11	26	31	23	16	4	L
97	11-20	34	23	27	13	3	CL
98	20-40	40	19	27	12	2	CL/C
99	40-90	48	19	21	9	3	C
5100	90-140	50	21	18	9	2	C
01	140-190	52	23	18	6	1	C

Chemical data:

Lab. No.	Depth (cm)	Ex.Ca m.e.%	Ex.Mg m.e.%	Ex.K m.e.%	Ex.Na m.e.%	C.E. m.e.%	C.E.C m.e.% 100g clay *)
76/5096	0-11	0.20	0.10	0.31	0.14	12.65	48.7
97	11-20	0.18	0	0.14	0.11	9.30	27.4
98	20-40	0.13	0	0.08	0.15	8.65	21.6
99	40-90	0.25	0	0.04	0.10	3.95	8.2
5100	90-140	0.23	0.05	0.04	0.08	4.00	8.0
01	140-190	0.10	0	0.04	0.07	4.90	9.4

Lab. No.	Depth (cm)	Org.C %	Total N %	Avail.P ppm	pH ($CaCl_2$)	Base Sat %
76/5096	0-11	3.35	0.17	10.35	4.1	6
97	11-20	1.91	0.11	6.60	4.1	5
98	20-40	1.37	0.08	1.95	4.1	4
99	40-90	0.55	0.05	2.00	4.2	10
5100	90-140	nd	0.04	0.85	4.4	10
01	140-190	nd	0.04	0.40	4.5	4

ND: Not determined.

*) No correction has been made for O.M.

PROFILE NO: N W P 2/76

Location: N.W. Province, Nyangombi Scheme; 1200 m NW of 2/76

Physiography: Plateau

Slope: 0-3%

Elevation: approx. 1400 m

Parent material: Ferrugineous schist

Vegetation/Land use: Miombo woodland

L.U. Class: C1 (H.R.Z.)

Mapping unit: 1

Drainage: well drained

Permeability: moderately rapid

Date sampled: 25-11-1976

Described by: Dr. P. Heilmann

Land Cap. Code: 1 F F F.F - -
A--2.5YR3/6

Horizon	Depth (cm)	Description
A1	0 - 8	Dark red (2.5YR3/7) moist and dry (2.5YR3/6), clay; very weak, fine subangular blocky structure; slightly hard dry, very friable moist, slightly plastic and slightly sticky wet; many very fine and fine, common med. m pores; common fine and medium roots; clear, smooth boundary on,
B2.1	8 - 29	Dark red (2.5YR3/6) moist and dry, clay; weak, fine and medium subangular blocky structure; slightly hard dry, very friable moist, plastic and sticky wet; common very fine, few medium pores; few fine an d medium roots; gradual, smooth boundary on,
B2.2	29 - 130	Dark red (2.5YR3/6) moist and dry (2.5YR3/8), clay; weak, medium and coarse subangular blocky structure; slightly hard dry, very friable moist, plastic and sticky wet; common very fine, few medium pores; very few roots; diffuse, smooth boundary on,
B2.3	130 -.200+	Dark red (2.5YR3.5/6) moist and dry (2.5YR3/8), clay; weak, medium and coarse subangular blocky structure; slightly hard dry, very friable moist and plastic and sticky wet; common very fine pores; very few to no roots.

ANALYTICAL DATA

Profile No: NWP 2/76

Grain size, mm

Lab. No.	Depth (cm)	Clay / 0.002 %	Silt 0.002 -0.05 %	F.sand 0.05 -0.25 %	M.sand 0.25 -0.50 %	C.sand 0.50 -2.00 %	TEXTURE (USDA)
76/5102	0-8	45	23	19	10	3	C
03	8-29	56	21	13	6	4	C
04	29-79	64	18	11	5	2	C
05	79-130	66	21	9	2	2	C
06	130-175	64	22	7	4	3	C

Chemical data.

Lab. No.	Depth (cm)	Ex.Ca m.e.%	Ex.Mg m.e.%	Ex.K m.e.%	Ex.Na m.e.%	C.E.C m.e.%	C.E.C m.e% 100g clay*)
76/5102	0-8	0.30	0.25	0.36	0.23	9.05	20.1
03	8-29	0.13	0.08	0.06	0.10	6.60	11.8
04	29-79	0.10	0	0.04	0.11	5.65	8.8
05	79-130	0.20	0	0.04	0.09	4.90	7.4
06	130-175	0.20	0.03	0.02	0.09	4.80	7.5

Lab. No.	Depth (cm)	Org. C %	Total N %	Avail. P ppm	pH ($CaCl_2$)	Base Sat %
76/5102	0-8	2.07	0.11	11.60	4.3	13
03	8-29	0.90	0.06	2.30	4.2	6
04	29-79	0.31	1.15	1.10	4.3	4
05	79-130	0.16	0.12	0.55	4.4	7
06	130-175	0.23	0.03	0.50	4.4	7

ND: Not determined

*) No correction has been made for O.M.

PROFILE NO: N W P 11/77

Location: N.W. Province, Nyangombi Scheme; Line 5-1200 m.

Physiography: Plateau

Slope: 5-8%

Elevation: approx. 1325 m.

Parent material: Fe-rich schist (outcrop near by)

Vegetation/Land use: light to medium woodland

L.U. Class: C3s (H.R.Z.)

Mapping unit: 4

Drainage: well drained

Permeability: moderately rapid

Date sampled: 18-10-1977

Described by: Dr. P. Heilmann, B. Sitoolomo

Land Cap. Code: 1 F F F F - - C--2.5YR3/6

Horizon	Depth (cm)	Description
A	0 - 9	Dark reddish brown (5YR3/3) moist and reddish brown (5YR4.5/3) dry, clay; moderate, fine and medium subangular block structure; hard dry, friable moist, plastic and slightly sticky wet; many fine, medium and coarse pores; many fine roots, few medium; clear and smooth boundary on,
B1	9 - 22	Dark reddish brown (2.5YR3/5) moist and reddish brown (2.5YR4/4) dry, clay; weak and moderate, medium and coarse subangular blocky structure; very hard dry, friable moist, plastic and sticky wet; broken, moderately thick clay cutans; many fine and medium pores, common coarse; common fine roots, few medium; clear and smooth boundary on,
B2.1(t)	22 - 70	Dark red (2.5YR3/6) moist and dry, clay; moderate, medium and coarse subangular blocky structure; very hard dry, friable moist, plastic and sticky wet; broken, moderately thick clay (?) cutans; many fine, few medium and coarse pores; few roots; gradual and smooth boundary on,
B2.2(t)	70 - 190+	As B2.1(t) but somewhat weaker structure and few, fine rock fragments (green schist?).

ANALYTICAL DATA

Grain size, mm

Profile No: NWP 11/77

Lab. No.	Depth (cm)	Clay < 0.002 %	Silt 0.002 -0.05 %	F.sand 0.05 -0.25 %	M.sand 0.25 -0.50 %	C.sand 0.50 -2.00 %	TEXTURE (USDA)
77/4195	0-9	22	4	54	18	2	SCL x)
96	9-22	31	7	44	17	1	SCL x)
97	22-50	40	7	35	17	1	SC
98	50-70	66	28	5	1	0	C
99	70-120	68	24	5	2	1	C

x) : Dispersion not complete.

Chemical data

Lab. No.	Depth (cm)	Ex.Ca m.e.%	Ex.Mg m.e.%	Ex.K m.e.%	Ex.Na m.e.%	C.E.C. m.e.%	C.E.C.m.e.% 100g clay *)
77/4195	0-9	7.60	2.90	0.68	0.11	19.5	-
96	9-22	3.35	2.45	0.30	0.10	12.3	-
97	22-50	1.00	1.40	0.14	0.08	9.8	24.5
98	50-70	0.60	1.25	0.13	0.00	10.5	15.9
99	70-120	0.70	1.05	0.10	0.00	10.1	14.9

Lab. No.	Depth (cm)	Org. C %	Total N %	Avail. P ppm	pH ($CaCl_2$)	Base Sat %
77/4195	0-9	3.59	0.03	14.3	5.4	57
96	9-22	1.95	0.02	4.0	4.8	50
97	22-50	ND	ND	ND	4.4	27
98	50-70	ND	ND	ND	4.3	19
99	70-120	ND	ND	ND	4.3	18

ND : Not determined

*) No correction has been made for O.M.

PROFILE NO: N W P 12/77

L.U. Class: C1 (H.R.Z.)

Location: N.W.Province, Nyangombi Scheme; Line 8-900 m.

Mapping unit: 1

Drainage: well drained

Physiography: Lower slope

Permeability: moderat e

Slope: 0 - 3%

Date sampled: 18-10-1977

Elevation: Approx. 1525 m.

Described by: Dr. P. Heilmann, B. Sitooloma

Parent material: Not known

Vegetation/Land use: Miombo woodland

Land Cap. Code: I D F F-F- -
A--10R/2.5YR3/6

Horizon	Depth (cm)	Description
A	0- 10	Dark reddish brown (2.5YR3/4) moist and reddish brown (2.5YR4/5) dry, clay loam; moderate, fine, subangular blocky structure; hard dry, friable moist, sticky and plastic wet; many pores; many fine, few medium and coarse roots; clear and smooth boundary on,
B1	10- 30	Dark reddish brown (2.5YR3/4) moist and dry, clay; weak, medium subangular blocky structure; very hard dry, friable moist, sticky and plastic wet; many fine, common medium and coarse pores; common fine, few medium and coarse roots; gradual and smooth boundary on,
B2.1	30- 70	Dark red (10R/2.5YR3/6) moist and dry (2.5YR3/8) clay; weak, medium subangular blocky structure; very hard dry, friable moist, plastic and sticky wet; patchy, thick clay cutans; many fine, few medium and coarse pores; few fine and medium roots; diffuse and smooth boundary on,
B2.2	70-140	As B2.1 but weak and moderate, medium and coarse subangular blocky structure; clear and smooth boundary on,
B2.3	140-200+	As B2.1 but weak, medium and coarse subangular blocky structure; broken, moderately thick clay cutans (?); few to no roots; few, very fine spots with rock structure.

ANALYTICAL DATA

Grain size, mm.

Profile No: NWP 12/77

Lab. No.	Depth (cm)	Clay < 0.002 %	Silt 0.002 -0.05 %	F.sand 0.05 -0.25 %	M.sand 0.25 -0.50 %	C.sand 0.50 -2.00 %	TEXTURE (USDA)
77/4200	0-10	ND	ND	ND	ND	ND	--
01	10-30	64	14	20	1	1	C
02	30-70	50	14	29	4	3	C
03	70-105	60	11	28	1	0	C
04	105-140	49	18	27	4	2	C
05	140-200	52	20	23	3	2	C

Chemical data.

Lab. No.	Depth (cm)	Ex.Ca m.e.%	Ex.Mg m.e.%	Ex.K m.e.%	Ex.Na m.e.%	C.E.C m.e.%	C.E.C.*) m.e.% 100 g clay
77/4200	0-10	0.70	0.95	0.24	0.01	8.7	-
01	10-30	0.40	0.35	0.07	0	5.8	9.1
02	30-70	0.50	0.30	0.04	0.01	4.1	8.2
03	70-105	0.50	0.35	0.02	0	4.3	7.2
04	105-140	0.30	0.20	0.01	0	1.0	2.0
05	140-200	0.35	0.15	0.02	0	3.6	6.9

Lab. No.	Depth (cm)	Org.C %	Total N %	Avail.P ppm	pH ($CaCl_2$)	Base Sat %
77/4200	0-10	2.34	0.02	10.0	4.2	22
01	10-30	1.33	0.01	7.9	4.1	14
02	30-70	ND	ND	ND	4.3	21
03	70-105	ND	ND	ND	4.4	20
04	105-140	ND	ND	ND	4.4	51
05	140-200	ND	ND	ND	4.3	14

*) No correction has been made for O.M.

ND: Not determined

PROFILE NO: N W P 13/77 L . U. Class: C2 s (H.R.Z.)

Location: N. W. Province, Nyangombi Scheme, Line13-1200cm Mapping Unit: 1s

Physiography: Plateau, middle slope Drainage; well drained

Slope: 3 - 5% Permeability: mod.

Elevation: approx. 1525m. Date sampled: 18 - 10-1977

Parent material: not known Described by: Dr. P. Heilmann
B. Sitooloma

Vegetation/Land use: Old Chitemene field Land Cap. Code: I D F F F - -
B--2.5YR3/6

Horizon	Depth (cm)	Description
Ap	0 - 15	Dark reddish brown (2.5YR3/4) moist and red (2.5YR4/6)dry, clay loam;weak, fine, subangular blocky structure; hard dry, friable moist, slightly sticky and plastic wet; many pores; many fine, few medium roots; clear and smooth boundary on,
B1	15 - 30	Dark reddish brown (2.5YR3/5) moist and dark red (2.5YR3/6) dry, clay; weak and moderate, fine and medium subangular blocky structure; very hard dry, friable moist, ~~sticky and plastic wet~~; patchy, moderately thick clay cutans; many fine, common medium and coarse pores; common fine, few medium and coarse roots; gradual and smooth boundary on,
B2.1(t)	30 - 125	Dark red (2.5YR3/6) moist and dry (2.5YR3.6/6), clay; weak, moderate, medium and coarse subangilar blocky structure; very hard dry, friable moist, plastic and sticky wet; patchy, moderately thick clay cutans; many fine and medium roots; gradual and wavy boundary on,
B2.2(t)	125 - 200 +	Same as B2.1(t) moderate structure and increase in clay cutans; few to no roots.

ANALYTICAL DATA

Profile No: NWP 13/77

Grain size, mm

Lab. No.	Depth (cm)	Clay <0.002 %	Silt 0.002-0.05 %	F.sand 0.05-0.25 %	M.sand 0.25-0.50 %	C.sand 0.50-2.00 %	TEXTURE (USDA)
77/4206	0-15	ND	ND	ND	ND	ND	-
07	15-80	ND	ND	ND	ND	ND	-
08	30-60	69	10	17	3	1	C
09	60-90	65	24	6	4	1	C
10	90-125	61	29	6	2	2	C
11	125-165	72	18	8	1	1	C
12	165-200	64	18	13	3	2	C

Chemical data

Lab. No.	Depth (cm)	Ex.Ca m.e.%	Ex.Mg m.e.%	Ex.K m.e.%	Ex.Na m.e.%	C.E.C m.e.%	C.E.C m.e.% 100g Clay *)
77/4206	0-15	2.10	1.70	0.48	0.02	11.0	-
07	15-30	0.40	0.30	0.10	0.04	10.0	-
08	30-60	0.30	0.35	0.06	0.01	6.5	9.4
09	60-90	0.35	0.30	0.04	0.04	5.8	8.9
10	90-125	0.40	0.30	0.04	0.20	5.8	9.5
11	125-165	0.35	0.30	0.02	0	6.4	8.9
12	165-200	0.35	0.40	0.02	0.30	3.9	6.1

Lab. No.	Depth (cm)	Org.C %	Total N %	Avail.P ppm	pH ($CaCl_2$)	Base Sat %
77/4206	0-15	2.46	0.02	12.5	4.8	39
07	15-30	1.52	0.07	6.0	4.2	8
08	30-60	ND	ND	ND	4.2	11
09	60-90	ND	ND	ND	4.3	13
10	90-125	ND	ND	ND	4.3	16
11	125-165	ND	ND	ND	4.3	11
12	165-200	ND	ND	ND	4.3	27

ND: Not determined.

*) No correction has been made for O.M.

PROFILE NO: N W P 14/77

Location: N.W. Province, Nyangombi Scheme; Line 15-1800 m.

Physiography: plateau

Slope: 0 - 1%

Elevation: 1395m

Parent material: not known

Vegetation/Land use: medium Miombo woodland; pit on edge of cassava field

L.U. Class: S1

Mapping unit: 6

Drainage: well drained

Permeability: moderate

Date sampled: 18-10-1977

Described by: Dr. P. Heilmann, B. Sitoolomn

Land Cap. Code: 1 B C C C - - A--5YR4/8

Horizon	Depth (cm)	Description
Ap	0 - 17	Dark yellowish brown (10YR3/4) moist and yellowish brown (10YR5/4) dry, sandy loam; no macro structure; soft dry, very friable moist, non sticky non plastic wet; many fine, common medium and coarse pores; common fine roots; clear and smooth boundary on,
B1	17 - 33	Yellowish red (5YR4.5/6) moist and reddish yellow (5YR5.5/6) dry, sandy clay loam; no macro structure; slightly hard dry, friable moist, non sticky non plastic wet; many fine, few medium and coarse pores; few fine roots; gradual and smooth boundary on,
B2.1	33 - 75	Yellowish red (5YR4/8) moist and dry (5YR5/7), sandy clay loam; no macro structure; slightly hard dry, friable moist, non sticky non plastic wet; many fine, few medium and coarse pores; few to no roots; diffuse and smooth boundary on,
B2.2	75 - 130	Same as B2.1; slight difference in colour and texture; slightly sticky and slightly plastic; gradual and smooth boundary on,
B2.3	130 - 200 +	Yellowish red (5YR5/8) moist and reddish yellow (5YR6/7) dry, sandy clay loam; no macro structure; hard dry, friable moist, plastic and slightly sticky wet; many fine, few medium and coarse pores; few to no roots.

ANALYTICAL DATA

Profile No: NWP 14/77

Grain size, mm.

Lab. No.	Depth (cm)	Clay < 0.002 %	Silt 0.002 -0.05 %	F.sand 0.05 -0.25 %	M.sand 0.25 -0.50 %	C.sand 0.50 -2.00 %	TEXTURE (USDA)
77/4213	0-17	14	7	40	34	5	SL
14	17-33	21	8	41	29	1	SCL
15	33-75	24	8	38	29	1	SCL
16	75-130	29	10	39	21	1	SCL
17	130-180	28	11	36	24	1	SCL

Chemical data.

Lab. No.	Depth (cm)	Ex.Ca n.e.%	Ex.Mg n.e.%	Ex.K n.e.%	Ex.Na n.e.%	C.E.C n.e.%	C.E.C n.e% 100g clay*)
77/4213	0-17	0.45	0.35	0.06	0	2.2	15.7
14	17-33	0.75	0.60	0.02	0.02	1.8	8.6
15	33-75	0.65	0.60	0.06	0.06	1.5	6.2
16	75-130	0.30	0.50	0.04	0.01	1.9	6.6
17	130-180	0.40	0.50	0.02	0.06	1.9	6.8

Lab. No.	Depth (cm)	Org. C %	Total N %	Avail. P ppm	pH ($CaCl_2$)	Base Sat %
77/4213	0-17	0.99	0.02	7.4	4.4	39
14	17-33	0.27	ND	5.9	4.7	77
15	33-75	ND	ND	ND	4.5	91
16	75-130	ND	ND	ND	4.5	45
17	130-180	ND	ND	ND	4.5	52

ND: Not determined

*) No correct ion has been made for O.M.

PROFILE NO: N W P 16/77 L. U. Class: Gw

Location: N.W. Province, Nyangombi Scheme; Line 25-600 m Mapping Unit: 20

Physiography: Dambo Drainage: imperfectly drained

Slope: 1 - 3% Permeability: mod.

Elevation: Approx. 1550m Date sampled: 21- 10-1977

Parent material: not known Describe by: Dr. P. Heilmann
B. Sitooloma

Vegetation/Land use: grassland Land Cap. Code: I B B C E - -
A W21OYR5/1.5

Horizon	Depth (cm)	Description
A	0 - 25cm	Black (10YR2/1) moist and dark gray (10YR4/1) dry, sandy loam; no macro structure; slightly hard dry, very friable moist, non sticky non plastic wet; common medium, few fine and coarse pores; many fine roots; gradual and wavy boundary on,
AB	25 - 50cm	Dark gray (10YR4/1) moist and gray (10YR5.5/1) dry, sandy loam; no macro structure; hard dry, very friable moist, non sticky non plastic wet; common fine, few medium pores; few fine roots; diffuse and smooth boundary on,
B2.1	50 - 110cm	Grayish brown (10YR5/1.5) moist and gray (10YR5.5/1) dry, sandy clay loam; no macro structure; hard dry, very friable moist, slightly sticky and slightly plastic; wet; common fine few medium pores; no macro diffuse and smooth boundary on,
B2.2	110 - 150cm.	Light brownish gray (10YR6/2) moist and light gray (10YR6.5/1) dry, sandy clay loam to sandy clay; no macro structure; very hard dry, friable moist, slightly sticky and plastic wet; many fine pores; diffuse and smooth boundary on,
B2.3	150 -200 +	Light gray (2.5Y7/2) moist, sandy clay; few, fine, faint mottles; no acro structure; very hard dry, friable moist, sticky and plastic wet; many fine, few medium pores; common bur owing channels filled with A material.

ANALYTICAL DATA

Grain size, mm.

Profile No: NWP 16/77

Lab. No.	Depth (cm)	Clay <0.002 %	Silt 0.002 -0.05 %	F.sand 0.05 -0.25 %	M.sand 0.25 -0.50 %	C.sand 0.50 -2.00 %	TEXTURE (USDA)
77/4222	0-25	8	18	44	21	9	SL
23	25-50	11	17	32	28	12	SL
24	50-80	16	11	52	12	9	SL
25	80-110	16	10	44	21	9	SL
26	110-150	20	10	45	16	9	SCL/SL
27	150-200	24	10	45	16	5	SCL

Chemical data.

Lab. No.	Depth (cm)	Ex.Ca m.e.%	Ex.Mg m.e.%	Ex.K m.e.%	Ex.Na m.e.%	C.E.C. m.e.%	C.E.C m.e.% 100g clay *)
77/4222	0-25	0.40	0.30	0.04	0.10	2.0	25.0
23	25-50	0.50	0.40	0.04	0	2.3	20.9
24	50-80	0.40	0.40	0.01	0	2.3	14.4
25	80-110	0.25	0.25	0.01	0	2.3	14.4
26	110-150	0.60	0.15	0.02	0.12	1.5	7.5
27	150-200	0.60	0.20	0.02	0.06	1.6	6.7

Lab. No.	Depth (cm)	Org.C %	Total N %	Avail. P ppm	pH (CaCl2)	Base Sat %
77/4222	0-25	0.86	0.05	6.1	4.2	42
23	25-50	0.47	0.03	5.8	4.3	41
24	50-80	ND	ND	ND	4.2	35
25	80-110	ND	ND	ND	4.2	22
26	110-150	ND	ND	ND	4.2	59
27	150-200	ND	ND	ND	4.2	55

*) No correction has been made for O.M.

ND: Not determined

PROFILE NO: N W P 17/77

Location: N.W. Province; Nyangombi Scheme; Line 18-300 m.

Physiography: Plateau

Slope: 1-3%

Elevation: approx. 1550 m.

Parent material: not known

Vegetation/Land use: medium Miombo woodland

L.U. Class: S2w (H.R.Z.)

Mapping unit: 17

Drainage: moderately well drained

Permeability: rapid

Date sampled: 21-10-1977

Described by: Dr. P. Heilmann, B. Sitooloma

Land Cap. Code: I X X X X - - / A-W1 10YR5/5

Horizon	Depth (cm)	Description
A	0 - 12	Light olive brown (10YR5.5/3) moist and light yellowish brown (10YR5.5/4) dry, loamy sand; no macro structure; loose dry, very friable moist, non sticky non plastic wet; many fine, few medium and coarse roots; gradual and smooth boundary on,
B1	12 - 36	Olive brown (10YR5.5/4) moist and light olive brown (10YR5.5/4) dry, loamy sand; no macro structure; slightly hard dry, very friable moist, non sticky, non plastic wet; many fine, few medium and coarse pores; common fine and coarse, few medium roots; gradual and smooth boundary on,
B2.1	36 - 80	Light olive brown (10YR5/5) moist and light yellowish brown (10YR6/4) dry, loamy sand; no macro structure; few, fine, distinct 7.5YR5/8 mottles; hard dry, friable moist, non sticky non plastic wet; many fine, few coarse and medium roots; gradual and smooth boundary on,
B2.2	80 - 140	Same as B2.1 but light olive brown (10YR5.5/6) moist and yellow (10YR7/5) dry; few roots.
B2.3	140 - 200+	Same as B2.1 but light olive brown (10YR5.5/6) moist and olive yellow (10YR6/6) dry; common distinct mottles and few to no roots.

ANALYTICAL DATA

Profile No: NWP 17/77

Grain size, mm

Lab. No.6	Depth (cm)	Clay <0.002 %	Silt 0.002 -0.05 %	F.sand 0.05 -0.25 %	M.sand 0.25 -0.50 %	C.sand 0.50 -2.00 %	TEXTURE (USDA)
77/4228	0-12	7	7	44	38	4	LS
29	12-36	7	4	55	26	3	LS/S
30	36-80	9	5	66	17	4	LS
31	80-110	7	4	59	26	4	LS/S
32	110-140	8	3	56	29	4	LS
33	140-190	7	4	56	29	4	LS/S

Chemical data.

Lab. No.	Depth (cm)	Ex.Ca m.e.%	Ex.Mg m.e.%	Ex.K m.e.%	Ex.Na m.e.%	C.E.C. m.e.%	C.E.C. m.e.% 100g clay *)
77/4228	0-12	0.60	0.40	0.08	0.06	1.5	21.4
29	12-36	0.75	0.20	0.05	0.06	1.3	18.6
30	36-80	0.60	0.20	0.04	0.08	1.0	11.1
31	80-110	0.60	0.20	0.02	0.08	0.8	11.4
32	110-140	0.60	0.10	0.02	0.06	1.0	12.5
33	140-190	0.80	0.10	0.03	0.09	0.9	12.9

Lab. No.	Depth (cm)	Org.C %	TotalN %	Avail.P ppm	pH ($CaCl_2$)	Base Sat %
77/4228	0-12	0.86	0.03	24.4	4.6	76
29	12-36	0.66	0.02	5.9	4.4	81
30	36-80	ND	ND	ND	4.3	92
31	80-110	ND	ND	ND	4.4	100
32	110-140	ND	ND	ND	4.3	78
33	140-190	ND	ND	ND	4.3	100

ND: Not determined

*) No correction has been made for O.M.

PROFILE NO: N W P 18/77

L. U. Class: C1 (H.R.Z.)

Location: N. W. Province, Nyangombi Scheme; Line 15-0m

Mapping Unit: 1

Physiography: Plateau

Drainage: well drained

Slope: 1 - 3%

Permeability: mod. rap.

Elevation: Approx. 1550m

Date sampled: 2 - 11-1977

Parent material: not known

Described by: Dr. P. Heilmann
B. Sitooloma

Vegetation/Land use: Tree savannah (old cassava garden)

Land Cap. Code: I C C C E - -
A--2.5YR3/4

Horizon	Depth (cm)	Description
A	0 - 15	Dark reddish brown (5YR3/5) moist and yellowish red (5YR4/6)dry, sandy clay loam; no macro structure; loose dry, very friable moist, slightly sticky and slightly plastic wet; many fine and medium, few coarse pores; many fine, few medium roots; gradual and smooth boundary on,
AB	15 - 60	Dark reddish brown (2.5YR3/4) moist and dry (2.5YR3/5, sandy clay loam; weak, medium and coarse subangular blocky stucture; slightly hard dry, friable moist, slightly sticky and slightly plastic wet; many fine and medium, common coarsepores; many medium common fine roots; clear and wavy boundary on,
IIB2.1	60 - 95	Dark red (2.5YR3/6) moist and red (2.5YR4/6) dry, sandy clay; weak, medium and coarse subangular blocky structure; hard dry, friable moist, plastic and sticky wet; many fine, few medium and coarse pores; few fine and medium roots; diffuse and smooth boundary on,
IIB2.2	95 - 170 +	As B2.1, less porous, less biological activity.

ANALYTICAL DATA

Grain size, mm

Profile No: NWP 18/77

Lab. No.	Depth (cm)	Clay < 0.002 %	Silt 0.002 -0.05 %	F.sand 0.05 -0.25 %	M.sand 0.25 -0.50 %	C.sand 0.50 -2.00 %	TEXTURE (USDA)
77/5240	0- 15	24	7	28	37	4	SCL
41	15- 35	32	8	37	20	3	SCL
42	35- 60	38	9	30	17	6	SC
43	60- 95	36	8	37	15	4	SC
44	95-130	34	9	34	20	3	SCL
45	130-170	42	10	30	16	2	SC

Chemical data

Lab. No.	Depth (cm)	Ex.Ca m.e.%	Ex.Mg m.e.%	Ex.K m.e.%	Ex.Na m.e.%	C.E.C. m.e.%	*) C.E.C.m.e.% 100g clay
77/5240	0- 15	1.00	0.50	0.21	-	6.3	28.3
41	15- 35	0.30	0.10	0.06	-	5.4	16.8
42	35- 60	0.30	0.10	0.03	-	4.0	10.5
43	60- 95	0.10	0.10	0.03	-	5.8	7.8
44	95-130	0.10	0.10	0.03	-	ND	-
45	130-170	0.10	0.10	0.02	-	-	-

Lab. No.	Depth (cm)	Org.C %	Total N %	Avail.P ppm	pH ($CaCl_2$)	Base Sat. %
77/5240	0- 15	2.11	0.14	10.9	4.4	25
41	15- 35	0.90	0.10	7.5	4.2	9
42	35-60	ND	ND	ND	4.2	11
43	60- 95	ND	ND	ND	4.2	8
44	95-130	ND	ND	ND	4.1	-
45	130-170	ND	ND	ND	4.3	-

*) No correction has been made for O.M.

ND: Not determined

PROFILE NO: N W P 19/77 — L. U. Class: C1 (H.R.Z.)

Location: N. W. Province, Nyangombi Scheme; AreaII, Line4A-1800m — Mapping Unit: 1

Physiography: Plateau — Drainage: well drained

Slope: 1 - 3% — Permeability: mod.

Elevation: Approx. 1575m — Date sampled: 2 -11 -1977

Parent material: not known — Described by: Dr. P. Heilmann, B. Sitooloma

Vegetation/Land use: Medium Miombo woodland — Land Cap. Code: I C D F F - - A--2.5YR 3/6

Horizon	Depth (cm)	Description
A	0 - 10	Dark reddish brown (2.5YR3/4) moist and dry (2.5YR3/5), sandy clay loam; moderate, fine and medium subangular blocky structure; hard dry, friable moist, slightly sticky slightly plastic wet; common pores; many fine, few medium roots; clear and wavy boundary on,
B1	10 - 25	Dark red (2.5YR3/5) moist and dry (2.5YR3/6), clay loam to clay; weak, medium subangular blocky structure; very hard dry, friable moist, sticky and plastic wet; many fine, common medium and coarse pores; common fine, few medium and coarse roots; gradual and smooth boundary on,
B2.1	25 - 55	Dark red (2.5YR3/6) moist and dry, clay loam to clay; weak, medium and coarse subangular blocky structure; hard dry, friable moist and plastic wet; patchy thin clay cutans; common pores; few fine and medium roots; diffuse and smooth boundary on,
B2.2	55 - 105	Same as B2.1, but 2.5YR2/6 in colour; somewhat less pores; few to no roots; gradual and smooth boundary on,
B2.3	105 - 170 +	Same as B2.1, but 2.5YR2/6 in colour; weak and moderate structure and broken moderately thick clay cutans.

ANALYTICAL DATA

Profile No: NWP 19/77

Grain size, mm

Lab. No.	Depth (cm)	Clay <0.002 %	Silt 0.002 -0.05 %	F.sand 0.05 -0.25 %	M.sand 0.25 -0.50 %	C.sand 0.50 -2.00 %	TEXTURE (USDA)
77/5246	0-10	32	19	35	10	4	SCL
47	10-25	33	25	32	7	3	CL
48	25-55	32	25	32	7	4	CL
49	55-105	38	22	33	4	3	CL
50	105-140	34	27	31	6	2	CL
51	140-170	36	24	33	5	2	CL

Chemical data

Lab. No.	Depth (cm)	Ex.Ca m.e.%	Ex.Mg m.e.%	Ex.K m.e.%	Ex.Na m.e.%	C.E.C m.e.%	C.E.C m.e.% 100g clay *)
77/5246	0-10	0.30	0.25	0.24	C...	9.2	28.8
47	10-25	0.10	0.10	0.04	0.00	7.0	21.2
48	25-55	0.10	0.10	0.02	0.00	6.0	18.8
49	55-105	0.10	0.10	0.02	0.00	4.0	10.5
50	105-140	0.10	0.10	0.02	0.00	3.8	11.2
51	140-170	ND	ND	ND	ND	ND	--

Lab. No.	Depth (cm)	Org.C %	Total N %	Avail.P ppm	pH ($CaCl_2$)	Base Sat %
77/5246	0-10	1.79	0.08	18.8	4.2	9
47	10-25	1.05	0.09	6.5	4.2	3
48	25-55	ND	ND	ND	4.2	4
49	55-105	ND	ND	ND	4.4	6
50	105-140	ND	ND	ND	4.5	6
51	140-170	ND	ND	ND	4.5	-

ND: Not determined.

*) No correction has been made for O.M.

PROFILE NO: N W P 20/77

L. U. Class: C2 s (H.R.Z.)

Location: N. W. Province; Nyangombi Scheme; AreaII, Line 9B 1200m

Mapping Unit: 1s

Physiography: Plateau slope

Drainage: well drained

Slope: 3 - 5%

Permeability: mod.

Elevation: Approx. 1575m

Date sampled: 2 - 11-1977

Parent material: not known

Described by: Dr. P. Heilmann
B. Sitooloma

Vegetation/Land use: Light Miombo woodland

Land Cap. Code: I C C E E --
B--2.5YR3/6

Horizon	Depth (cm)	Description
A	0 - 12	Dark reddish brown (2.5YR2.5/5) moist and dry, (2.5YR3/4), sandy clay loamy; no macro structure; slightly hard dry, very friable moist, slightly sticky slightly plastic wet; many pores; many fine, few medium and coarse roots; gradual and smooth boundary on,
BA	12 - 35	Dark red (2.5YR3/5) moist and dry (2.5YR3/6), sandy clay loam; very weak, fine subangular blocky structure; slightly hard dry, very friable moist, slightly sticky slightly plastic wet; many pores; many fine, few medium and coarse pores; gradual and wavy boundary on,
B2.1	35 - 65	Dark red (2.5YR3/6) moist and dry (2.5YR3.5/6), sandy clay loam to sandy clay; weak, medium subangular blocky structure; slightly hard dry, friable moist, plastic and slightly sticky wet; many fine common medium and coarse pores; common fine, few medium roots; clear and wavy boundary on,
B2.2	65 - 90	As B2.1, but medium and coarse subangular blocky structure; less pores and roots; gradual and smooth boundary on,
B2.3	90 - 170 +	As B2.1 very weak structure and few to no roots.

ANALYTICAL DATA

Grain size, mm

Profile No: N W P 20/77

Lab. No.	Depth (cm)	Clay < 0.002 %	Silt 0.002 -0.05 %	F.sand 0.05 -0.25 %	M.sand 0.25 -0.50 %	C.sand 0.50 -2.00 %	TEXTURE (USDA)
77/5252	0-12	23	11	39	21	6	SCL
53	12-35	27	5	38	24	6	SCL
54	35-65	27	11	33	24	5	SCL
55	65-90	29	11	41	14	5	SCL
56	90-130	31	11	38	16	4	SCL
57	130-180	31	8	39	16	6	SCL

Chemical data

Lab. No.	Depth (cm)	Ex.Ca m.e.%	Ex.Mg m.e.%	Ex.K m.e.%	Ex.Na m.e.%	C.E.C. m.e.%	*) C.E.C. m.e. % 100g clay
77/5252	0-12	5.40	3.30	0.56	0.00	12.00	52.2
53	12-35	0.35	0.20	0.14	0.00	6.8	25.2
54	35-65	0.58	0.15	0.10	0.00	6.0	22.2
55	65-90	0.50	0.30	0.06	0.00	4.6	15.9
56	90-130	0.35	0.80	0.06	0.00	4.0	12.9
57	130-180	0.30	0.15	0.06	0.00	3.4	11.0

Lab. No.	Depth (cm)	Org. C %	Total N %	Avail. P p pm	pH ($CaCl_2$)	Base Sat %
77/5252	0-12	2.61	0.17	34.4	5.6	77
53	12-35	1.44	0.07	28.2	4.4	10
54	35-65	ND	ND	ND	4.5	14
55	65-90	ND	ND	ND	4.6	19
56	90-130	ND	ND	ND	4.9	30
57	130-180	ND	ND	ND	4.4	15

*) No correction has been made for O.M.

ND: Not determined

PROFILE NO: N W P 21/77

L. U. Class: C1 (H.R.Z.)

Location: N. W. Province; Nyangombi Scheme AreaII, Line 10B-1500m

Mapping Unit: 1

Physiography: Plateau

Drainage: well drained

Slope: 0 - 1%

Permeability: moderate

Elevation: Approx. 1600m

Date sampled: 2 - 11-1977

Parent material: not known

Described by: Dr. P. Heilmann
B.. Sitooloma

Vegetation/Land use: light Miombo woodland

Land Cap. Code: 1 C E E E - -
A--2.5YR3/6

Horizon	Depth (cm)	Description
A	0 - 10	Dark reddish brown (2.5YR2/4) moist and reddish brown (2.5YR3.5/4) dry, sandy clay loam; no macro structure; slightly hard dry, very friable moist, slightly sticky and slightly plastic wet; many fine and medium, common coarse pores; many fine, few medium roots; clear and smooth boundary on,
AB	10 - 30	Dark reddish brown (2.5YR3/4) moist and dry (2.5YR3/5), sandy clay; very weak, medium subangular blocky structure; hard dry, very friable moist, plastic and slightly sticky wet; many fine and medium, common coarse roots; clear and wavy boundary on,
B2.1	30 - 80	Dark red (2.5YR3/6) moist and dry (2.5YR3.5/6), sandy clay; weak, medium and coarse subangular blocky structure; hard dry, friable moist, plastic and sticky wet; patchy thick clay cutans; many fine, few medium and coarse pores; common fine, few medium roots; diffuse and smooth boundary on,
B2.2	80 -1 130	As B2.1, clay; few to no roots; diffuse and smooth boundary on,
B2.3	130 - 180	As B2.1, dark red (10/2.5YR3/6) moist clay; broken, moderately thick cutans; few to no roots.

ANALYTICAL DATA

Grain size, mm.

Profile No: NWP 21/77

Lab. No.	Depth (cm)	Clay <0.002 %	Silt 0.002-0.05 %	F.sand 0.05-0.25 %	M.sand 0.25-0.50 %	C.sand 0.50-2.00 %	TEXTURE (USDA)
77/5258	0-10	33	17	32	14	4	SCL
59	10-30	37	14	33	13	3	SC
60	30-55	37	17	33	8	5	SC
61	55-80	37	16	33	10	4	SC
62	80-130	41	16	31	7	5	C
63	130-180	43	17	31	5	4	C

Chemical data.

Lab. No.	Depth (cm)	Ex.Ca m.e.%	Ex.Mg m.e.%	Ex.K m.e.%	Ex.Na m.e.%	C.E.C m.e.%	C.E.C m.e.% 100g clay *)
77/5258	0-10	0.60	0.50	0.41	0.00	9.2	27.9
59	10-30	0.20	0.10	0.17	0.00	6.8	18.4
60	30-55	0.25	0.10	0.16	0.00	6.0	16.2
61	55-80	0.10	0.10	0.18	0.14	5.4	14.6
62	80-130	0.10	0.10	0.12	0.01	4.2	10.2
63	130-180	0.10	0.10	0.08	0.13	4.8	11.2

Lab. No.	Depth (cm)	Org.C %	Total N %	Avail. P ppm	pH (CaCl2)	Base Sat %
77/5258	0-10	2.03	0.14	17.0	4.2	16
59	10-30	1.40	0.09	7.3	4.2	7
60	30-55	ND	ND	ND	4.2	9
61	55-80	ND	ND	ND	4.3	10
62	80-130	ND	ND	ND	4.4	8
63	130-180	ND	ND	ND	4.3	9

*) No correction has been made for O.M.

ND: Not determined

PROFILE NO: N W P 22/77 L. U. Class: S2w

Location: N.W. Province, Nyangombi Scheme; AreaII, Line14B-1800m Mapping Unit: 15

Physiography: Lower Slope Drainage: Imperfectly drained

Slope: 1 - 3% Permeability: mod.

Elevation: Approx. 1625m Date sampled: 4 - 11-1977

Parent material: not known Described by: Dr. P. Heilmann
B. Sitooloma

Vegetation/LAnd use: Light Miombo woodland Land Cap. Code: I X B B B—
A-W310YR6/2

Horizon	Depth (cm)	Description
A	0 - 15	Black (10YR2/1) moist and very dark grayish brown (10YR3/2)dry, loamy sand ; very weak, fine subangular blocky structure; loose dry, very friable moist, non-sticky non plastic wet; common pores; many fine, common medium and coarse roots; gradual and smooth boundary on,
AB	15 - 27	Dark grayish brown (10YR4/2) moist and grayish brown (10YR5/2)dry, loamy sand ; few, fine, faint 7.5YR5/6 mottles; no macro structure; slightly hard dry, very friable moist, non sticky non plastic wet; many fine, common fine, few medium and coarse roots; clear and smooth boundary on,
B2.1	27 - 80	Light brownish gray (10YR6/2) moist and light gray (10YR7/2)dry, sandy loam; many coarse, distinct 7.5YR5/7 mottles; no macro structure; slightly hard dry, very friable moist, non sticky non plastic wet; many fine few medium and coarse pores; few fine roots; gradual and smooth boundary on,
B2.2	80 - 120	Light yellowish brown (10YR6.5/4) moist and very pale brown (10YR7/3)dry, sandy loam; few fine prominent 7.5YR5/7 and many, coarse, faint, 10YR6/6 mottles; no macro structure; slightly hard dry, very friable moist, non sticky non plastic wet; many fine, few, medium and coarse pores; few roots; gradual add smooth boundary on,
B2.3	120 - 175+	Very pale brown (10YR7/3) moist sandy loam; many, coarse, faint 10YR6/6 mottles; structure, consistency and pores as B2.2; no roots.

ANALYTICAL DATA

Profile No: NWP 22/77

Grain size, mm.

Lab. No.	Depth (cm)	Clay < 0.002 %	Silt 0.002 -0.05 %	F.sand 0.05 -0.25 %	M.sand 0.25 -0.50 %	C.sand 0.50 -2.00 %	TEXTURE (USDA)
77/5264	0-15	10	8	49	28	5	LS
65	15-27	10	6	49	31	4	LS
66	27-80	13	7	57	21	2	SL
67	80-120	12	10	51	24	3	SL
68	120-175	15	15	43	22	5	SL

Chemical data.

Lab. No.	Depth (cm)	Ex.Ca m.e.%	Ex.Mg m.e.%	Ex.K m.e.%	Ex.Na m.e.%	C.E.C. m.e.%	C.E.C *) m.e.% 100g clay
77/5264	0-15	1.0	0.35	0.16	0.00	7.0	70.0
65	15-27	0.10	0.10	0.02	0.00	2.8	28.0
66	27-80	ND	ND	ND	ND	3.2	24.6
67	80-120	0.20	0.05	0.02	0.04	4.0	33.3
68	120-175	0.30	0.05	0.02	0.06	5.2	34.7

Lab. No.	Depth (cm)	Org. C %	Total N %	Avail. P ppm	pH ($CaCl_2$)	Base Sat %
77/5264	0-15	2.03	0.13	18.9	4.4	22
65	15-27	0.58	0.07	7.1	4.6	8
66	27-80	ND	ND	ND	4.4	-
67	80-120	ND	ND	ND	4.4	8
68	120-175	ND	ND	ND	4.4	8

ND: Not determined

*) No correction has been made for O.M.

PROFILE NO: N W P 23/77

Location: N.W. Province, Nyangombi Scheme; Area II, Line 16B-600 m.

Physiography: Plateau

Slope: 1-3%

Elevation: approx. 14 50 m.

Parent material: not known

Vegetation/Land use: medium Miombo woodland

L.U. Class: S1 (H.R.Z.)

Mapping unit: 6

Drainage: well drained

Permeability: moderate

Date sampled: 4-11-1977

Described by: Dr. P. Heilmann, B. Sitooloma

Land Cap. Code: I C C E E - - / A--10YR5/5

Horizon	Depth (cm)	Description
A	0 - 12	Grayish brown (10YR5/2) moist, sandy loam to sandy clay loam; no macro structure; hard dry, friable moist, slightly sticky slightly plastic wet; common fine and medium, few coarse pores; common fine, few medium roots; clear and smooth boundary on,
B1	12 - 30	Dark yellowish brown (10YR4/4) moist, sandy clay loam to sandy clay; weak, medium subangular blocky structure; very hard dry, friable moist, plastic and sticky wet; many fine, common medium, few coarse pores; few fine roots; gradual and smooth boundary on,
B2.1	30 - 65	Yellowish brown (10YR5/5) moist, sandy clay loam to sandy clay; weak, medium and coarse subangular blocky structure; very hard dry, friable moist, plastic and sticky wet; many fine, few medium and coarse pores; few to no roots; diffuse and smooth boundary on,
B2.2	65 - 100	As B2.1 but brownish yellow (10YR5.5/6) moist.
B2.3	100 - 170+	Yellowish brown to light olive brown (10YR/2.5Y5/4) moist, sandy clay loam to sandy clay; no macro structure; very hard dry, friable moist, plastic and sticky wet; many fine, few medium and coarse pores; no roots.

ANALYTICAL DATA

Profile No: NWP 23/77

Grain size mm

Lab. No.	Depth (cm)	Clay / 0.002 %	Silt 0.002 -0.05 %	F.sand 0.05 -0.25 %	M.sand 0.25 -0.50 %	C.sand 0.50 -2.00 %	TEXTURE (USDA)
77/5269	0-12	21	5	50	22	2	SCL
70	12- 30	34	6	38	19	3	SCL
71	30- 65	34	9	38	17	2	SCL
72	65-100	31	8	41	17	3	SCL
73	100-140	35	13	36	11	4	SCL
74	140-170	35	15	36	11	3	SCL

Chemical data

Lab. No.	Depth (cm)	Ex.Ca m.e.%	Ex.Mg m.e.%	Ex.K m.e.%	Ex.Na m.e.%	C.E.C. m.e.%	C.E.C.m.e.% 100g clay *)
77/5269	0- 12	ND	ND	ND	ND	3.0	14.3
70	12- 30	ND	ND	ND	ND	2.6	7.6
71	30- 65	0.20	0.40	0.03	0.04	1.2	3.5
72	65-100	0.25	0.15	0.02	0.06	1.0	3.5
73	100-140	0.20	0.15	0.04	0.05	1.2	3.4
74	140-170	0.20	0.10	0.04	0.08	1.4	4.1

Lab. No.	Depth (cm)	Org.C %	Total N %	Avail.P ppm	pH ($CaCl_2$)	Base Sat. %
77/5269	0- 12	0.82	ND	13.3	4.2	-
70	12- 30	0.39	ND	8.9	4.2	-
71	30- 65	ND	ND	ND	4.2	6
72	65-100	ND	ND	ND	4.2	4
73	100-140	ND	ND	ND	4.1	37
74	140-170	ND	ND	ND	4.1	30

*) No correction has been made for O.M.

ND: Not determined

APPENDIX 2

SOIL ANALYSIS

The Soils Advisory Section at Mount Makulu has issued a pamphlet: "A guide to the meaning of Soil Analyses from which the following data are largely used as to interprete the soil analyses and assess the nutrient status for the profile descriptions given in this report.

pH

The Calcium chloride method gives much more accurate laboratory results and gives a truer measure of what the soil acidity will be under field conditions during the growing season.

Values obtained by this method are on average about 0.7 units lower than the water pH (1.5) but in individual soils the difference may be considerably more or less.

It is therefore necessary to draw up an entirely new scale of desirable and critical pH ranges by which to interpret the significance of calcium-chloride pH values. Local experience shows that the following may be safely used as a broad guide:

Above 7.5	Strongly alkaline. Usually unsatisfactory and requiring further investigation.
6.5 - 7.5	Alkaline, usually on account of the presence of free lime. Satisfactory for most crops, though higher than desirable.
6.0 - 6.5	Neutral. Highly satisfactory for lucerne, clovers, wheat and barley. Satisfactory for most other crops, but higher than desirable for tobacco.
5.5 - 6.0	Slightly acid. Highly satisfactory for almost all crops, including tobacco. Lime is not required except in special circumstances.
5.0 - 5.5	Medium acid. Satisfactory for most crops, but to maintain the pH in this range under regular cultivation liming will be necessary at a suitable stage in the rotation, especially in the better rainfall areas.
4.5 - 5.0	Strongly acid. There is a progressive risk of fertility being adversely affected, and the need for lime is becoming urgent.
Below 4.5	Very strongly acid. Severe infertility is likely and liming is essential before planting.

Organic Carbon

The organic carbon values can be interpreted as follows:

Low $< 1\%$
Medium 1-2%
High $> 2\%$

Total Nitrogen

The total N content of a soil is related to its organic matter content. It varies greatly with texture, rainfall, topsoil-subsoil etc. The following are characteristic ranges of total nitrogen in soils of Zambia.

Texture	Total Nitrogen per cent
Sands	0.02 - 0.05
Sandy loams	0.04 - 0.07
Sandy clay loams	0.06 - 0.10
Clays	0.10 - 0.15

C.E.C.

The cations exchange capacity (C.E.C.) is a measure of the capacity of the soil to hold nutrients against leaching. Calcium is the most tightly held being followed by Mg, K, N. C.E.C. is dependent on the type and amount of clay and of organic matter. For comparison reasons it is useful to express them in m.e.%/100gr clay.
Following is a guide line for C.E.C./100gr clay:

Low 16 m.e.%
Medium 16 - 24 m.e.%
High 24 m.e.%

Base Saturation Percentage (B.S.P.)

This is the relative proportion of the absorbed H and Al and the exchangeable cations. A rather definite correlation exists between the B.S.P. and its pH.
Following are approximate figures for B.S.P.:

Low $< 35\%$
Medium 35 - 50%
High $> 50\%$

Available Phosphorus

Available Phosphorus (Resin extract) p.p.m. P	Available Phosphorus Status	Yield increases that may be expected with adequate dressings of phosphatic fertilizer, if other nutrients are also adequate
Less than 3	Acutely deficient	Very large (up to double the yield)
3 - 7	Deficient	Large (increases of one to two thirds)
7 - 15	Marginal	Small (increases of less than one third)
15 - 25	Adequate	No appreciable response likely with general crops, but maintenance dressings desirable
Above 25	Rich	No response likely

Exchangeable Potassium

Potash Status	Exchangeable Potassium (mg-equiv./100gr. of Soil) Sands	Sandy loams	Typical reddish-brown clay
Deficient (responses to potash likely) ..	Below 0.05	Below 0.[illegible]	Below 0.15
Marginal (some response likely, if other conditions are suitable for high yields).	0.05 - 0.1	0.[illegible] - 0.[illegible]	0.15 - 0.3
Adequate (responses unlikely but maintenance dressings usually desirable)	0.1 -0.25	0.2 - 0.[illegible]	0.3 - 0.5
Rich (no potash required)	Above 0.25	Above 0.[illegible]	Above 0.5

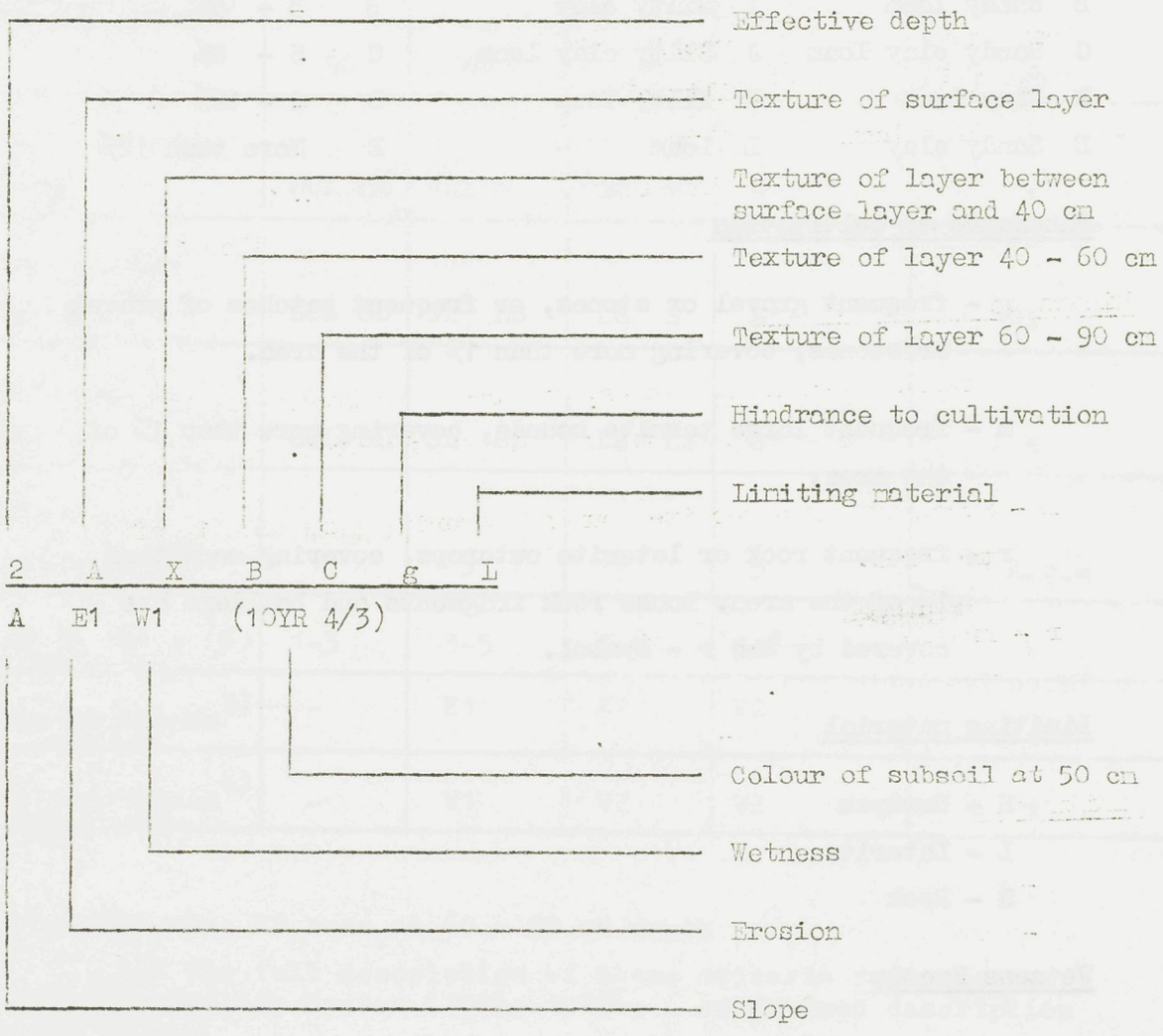
APPENDIX 3

THE LUS CODE FOR SOIL DESCRIPTION

This code has replaced the older CONEX code and is the one currently used by the Land Use Branch (previously Land Use Services Division LUS) of the Ministry of Agriculture and Water Development.

The Code Symbol

The soil and land characteristics are described according to standard codes and the code symbol for each characteristic is arranged in a standard order to provide a code description.



A range of symbols describes each of the above characteristics. These are described below. For further details see: "A guide to Agricultural Planning"; compiled and published by:

Land Use Branch,
Ministry of Agriculture and Water Development,
P.O. Box RW 291,
Lusaka, Zambia.

Effective depth

The effective depth is the thickness of soil available for satisfactory root development.

Symbol		Designation
1	More than 90 cm deep	Deep
2	60 - 90 cm deep	Moderately deep
3	30 - 60 cm deep	Moderately shallow
4	< 30 cm deep	Shallow
5	Rock and/or gravel to surface	

Texture Symbols				Slope Classes	
A	Sand	F	Clay	0	0 - 1%
X	Loamy sand	G	Cracking clay	A	1 - 3%
B	Sandy loam	I	Silty clay	B	3 - 5%
C	Sandy clay loam	J	Silty clay loam	C	5 - 8%
D	Clay loam	K	Silty loam	D	8 - 12%
E	Sandy clay	L	Loam	E	More than 12%

Hindrance to cultivation

g - frequent gravel or stones, or frequent patches of gravel or stones, covering more than 1% of the area.

m - frequent large termite mounds, covering more than 1% of the area.

r - frequent rock or laterite outcrops, covering more than 1% of the area. Loose rock fragments and boulders are covered by the r - symbol.

Limiting material

H - Hardpan
L - Laterite
R - Rock

Wetness Factor

-	No wetness limitation
W1	Slight wetness limitation
W2	Severe wetness limitation
W3	Very severe wetness limitation

Colour

A piece of soil taken from approx. 50 cm (or from just above the limiting layer where this occurs between 20 - 50 cm) is moistened and a colour code given by comparison with MUNSELL Standard Soil Colour Charts.

APPENDIX 4

CRITERIA FOR DETERMINING LAND CLASSES
AND ACCOMPANYING SYMBOLS FOR SUBCLASSES

Type of land	Arable		Marginal Arable		Subclass Symbol
Land class	good	mod.good	poor	very poor	
clayey/sandy class	C1 S1	C2 S2	C3 S3	S4	
minimum effective[1] depth	90	60	30	90	d
lightest texture 0 - 20 cm	SCL LS	SCL S	SCL S	S	t
lightest texture 20 - 40 cm	SCL SL	SL LS	LS S	S*	t
lightest texture 40 - 60 cm	SCL SL	SL SL	LS LS	S*	t
max. hindrance[2] to cultivation (%)	1	5	10	5	g,r,m
max. slope class (%)	1-3	3-5	5-8	5-8	s
max. erosion class[3]	-	E1	E2	E2	e
max. wetness class[4]	-	W1	W2	W2	w

* not heavier than LS even at 60 - 90 cm depth

1), 2), 3), 4): for full description of these criteria refer to LUS Land Capability System (1974, 1978). A summarized description follows below:

1) depth at which soil conditions are met which impede root development within 90 cm (e.g. rock, laterite gravel etc.); some corrections are made for gravelly soils;

2) occurrence of gravel/stones on the surface, large termite mounds or rock/laterite outcrops covering more than 1% of the area;

3) 4 classes: -: none; E1: slight; E2: moderate; E3: severe;

4) 4 classes: -: none; W1: slight; W2: moderate; W3: severe.