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MINISTRY OF AGRICULTURE—NATIONAL AGRICULTURAL LABORATORIES
KENYA SOIL SURVEY

**SEMI-DETAILED SOIL SURVEY OF
THE OLENKASORAI(OYANI) AREA-PHASE 1
(KILGORIS DIVISION, NAROK DISTRICT)**

by

J.R.Rachilo, S.N.Wanjogu and T.R.Wachira

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TABLE OF CONTENTS

SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

INTRODUCTION	1
1 THE ENVIRONMENT	2
1.1 LOCATION, COMMUNICATION AND POPULATION	2
1.2 CLIMATE (F.M. NDARAIYA)	2
1.2.1 Data sources	2
1.2.1 Average annual and seasonal rainfall	2
1.2.2 Temperature, potential evaporation (Eo) and agro- climatic zonation	3
1.3 GEOLOGY, PHYSIOGRAPHY AND HYDROLOGY	4
1.3.1 Geology	4
1.3.2 Physiography	4
1.3.3 Hydrology	5
1.4 VEGETATION AND PRESENT LAND USE	5
2 THE SURVEY METHODS	6
2.1 OFFICE METHODS	6
2.2 FIELD METHODS	6
2.3 LABORATORY METHODS (N.P. OCHIENG).	7
3 THE SOILS	8
3.1 PREVIOUS WORK	8
3.2 GENERAL PROPERTIES OF THE SOILS	8
3.3 SYSTEMATICS AND NOMENCLATURE	9
3.4 DESCRIPTION OF THE SOIL MAPPING UNITS	9
3.4.1 Soils of the plains	10
3.4.2 Soils of the minor valleys	16
3.5 SOIL FERTILITY ASPECTS	16
3.5.1 General	16
3.5.2 Available nutrients	17
4 LAND EVALUATION FOR SUGAR CANE "OUTGROWING"	18
4.1 PROCEDURES	18
4.2 LAND QUALITIES	18
4.3 Suitability classes and their requirements	24
4.4 Suitability of all tracts of land for sugarcane "outgrowing" highlevel of technology	26
4.5 Conclusions and Recommendations	26
4.5.1 Conclusions	26
4.5.2 Recommendations	27
REFERENCES	27

TABLE OF CONTENTS

APPENDICES

	<u>PAGE</u>
1. Detailed description of representative soil profiles with analytical data.	29
2. Soils of the Olenkasorai (Oyani) area-phase I	in folder
3. Location of profile pits and augerings.	in folder

LIST OF TABLES

Table 1	Average monthly and annual rainfall (in mm) of the survey area	3
Table 2	Average water balance for the survey area	3
Table 3	Correlation between the soil units identified in the "Preliminary soil survey of the Transmara Division" the "Exploratory soil map and agro-climatic zone map of Kenya" and those of the present survey area.	8
Table 4	Available nutrients (0-30 cm)	17
Table 5	Relationship of depth and growing season	19
Table 6	Rating of Availability of water	19
Table 7	Subrating for slope length	20
Table 8	Subrating for steepness of slopes	20
Table 9	Subrating for stoniness/rockiness/shallowness of the soil	20
Table 10	Subrating for workability of the soil (cultivation)	20
Table 11	Subrating for minimum width of the mapping unit	20
Table 12	Final rating for the possibilities of mechanization.	21
Table 13	Rating for the availability of oxygen	21
Table 14	Rating climate factor	22
Table 15	Slopes factor ratings	22
Table 16	Subratings of organic C content and silt/clay ratio	22
Table 17	Subrating of bulk density and flocculation index	22
Table 18	Rating of soil factor	23
Table 19	Final rating for resistance to erosion	23
Table 20	Subrating for CEC	24
Table 21	Subrating for available nutrients of the topsoil	24
Table 22	Rated land qualities of the individual mapping units	24
Table 23	Land quality criteria for the suitability classification of soils for rainfed sugarcane "outgrowing" high level of technology ("conversion table")	25
Table 24	Mapping units with a moderate suitability for rainfed sugarcane "outgrowing"	25
Table 25	Suitability classification and major limitations of mapping units for rainfed sugarcane "outgrowing", high level of technology.	25

SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

The report describes the results of a semi-detailed soil survey of an area north of R.Oyani approximately 1918 hectares, situated in Kilgoria Division of Narok District, Rift Valley Province.

The survey area has rainfall throughout the year with peaks in the months of April and November. The mean annual rainfall in the survey area ranges from about 1315mm in the south to about 1380mm in the north. 1350mm may be assumed representative of the area (the climatic data given are representative for both phases 1 and 2 which have been taken as one whole area). The area has mean annual rainfall to evaporation ratio (r/E_o) of 73% which places the area in agro-climatic zone II classified as sub-humid with high potential for plant growth, soil conditions not limiting. The area generally lies above 1500m a.s.l. The mean annual temperature is 19.8°C which is classified as being warm temperate.

The area consists of Nyanzian System rocks predominantly rhyolites with a few occurrences of andesites along the river valleys. Alluvial and colluvial materials occur in the river valleys. Physiographically the area consists of plains and river valleys.

The soils show variations mainly due to Lithology(parent material) and physiography as activated by climate. The soils of the plains are predominantly developed on rhyolites and range from relatively young soils adjacent to river Oyani and in depressional areas to relatively well developed soils in the proper plain. Soils are well drained to poorly drained with depths ranging from very shallow to very deep. Very shallow soils occur on high lying parts of the plain.

About 41% (795 ha) of the area is moderately suitable for rainfed sugarcane outgrowing. 43% (820 ha) is marginally suitable. The unsuitable areas cover 16% (303 ha) of the survey area. Addition of appropriate fertilizers and farm yard manure to supplement phosphorus, calcium, magnesium and nitrogen levels and to improve soil Physical status is advisable as the soils have a moderate chemical fertility.

The major land limitations in the area are shallow soils, poorly drained soils and a moderate chemical fertility.

INTRODUCTION

On behalf of the South Nyanza (SONY) Sugar Company, Mr. H.O. Nyanga the Agricultural Manager in collaboration with Mr. Peter Du Boulay the Agricultural Development Manager, requested the Kenya Soil Survey to carry out a semi-detailed soil survey of an area north of the Oyani river. The survey was the first phase in an overall investigation of a much larger area.

The purpose of this survey was to carry out soil investigations and select about 500 hectares suitable for rainfed sugarcane growing for the expansion of the outgrowers area.

Fieldwork was done between 14th and 27th September, 1987. It was executed in collaboration with Messrs. B.K. Waruru and H. Onyono.

The set up of the report is as follows:

Chapter one describes the environment which incorporates location, communication and population, climate, geology, physiography and hydrology, vegetation and present land use.

Chapter two gives the details of the applied survey methods which include office, field and laboratory methods.

In chapter three, the soils occurring in the survey area are exhaustively described, whereas in chapter four the soils are evaluated for their suitability for rainfed sugarcane growing.

The authors are grateful to Mr. P. Du Boulay for his continued assistance and concern when carrying out the fieldwork as this enabled the smooth execution of the work. Acknowledgement is also extended to the other staff of South Nyanza (SONY) Sugar Company for their co-operation during field work and to the Chemistry Section of the National Agricultural Laboratories, Nairobi for their fast analyses of the soil samples.

1 THE ENVIRONMENT

1.1 LOCATION, COMMUNICATION AND POPULATION

The survey area is situated in Kilgoris Division, Narok District, Rift Valley Province. The boundary between Nyanza province and Rift Valley province forms the western boundary of the survey area while the eastern boundary is formed by the Oyani river which is also known as the Keiyan river near its source.

The area lies between latitudes $0^{\circ} 59'$ and $1^{\circ} 03'S$ and longitudes $34^{\circ} 35'$ and $34^{\circ} 41'E$. The area covers about 1900 hectares and has an average altitude of about 1500m above sea level.

The Awendo - Langata Sein murram road passes through the northern part of the survey area. The area is also easily accessible from the Awendo - Oyani murram road which is on the eastern side of the survey area. Accessibility inside the survey area could be described as being good during the dry seasons but poor during the rainy seasons. This is because the tracks passing through the area are impassable during the rainy seasons and some of the tracks pass across river valleys which can not be crossed when the water level rises beyond a certain level in the rainy seasons. The thick forest along some parts of the river valleys also reduces accessibility to some degree.

The area is sparsely populated. The Maasai people live in this area. However, the survey area is at the boundary between Narok District and South Nyanza District and is near the boundary between Kisii District and Narok Districts. Therefore people from these adjacent districts which are densely populated have hired land from the Maasai and grow maize although sugarcane growing is starting to take place. Thus both Kisii and Luo people are found in the area.

1.2 CLIMATE

1.2.1 Data sources

The rainfall data of Uriri (90.34047), Kilgoris D.O. (91.34011) and Kihancha Police Post (91.34015) rainfall stations have been used to estimate (by isohyetal method) the rainfall of the survey area. The stations are located at the west, east and south of the survey area respectively at altitudes of 1494, 1433 and 1982m. The distances of these stations to the centre of the survey area are respectively 10, 23 and 15km.

1.2.1 Average annual and seasonal rainfall

The mean annual and seasonal rainfall (r) in the survey area ranges from about 1315mm in the south to about 1380mm in the north. However, an average of 1350mm may be assumed to be representative of the area.

The area receives rainfall throughout the year with peaks in the months of

April and November. The average monthly rainfall is shown in table 1.

Table 1 Average monthly and annual rainfall (in mm) of the survey area

J	F	M	A	M	J	J	A	S	O	N	D	Year
76	94	189	112	155	91	48	76	109	108	134	123	1350

1.2.2 Temperature, potential evaporation (E_o) and agro-climatic zonation

The mean annual, mean annual minimum and mean annual maximum temperatures of the survey area are 19.8, 13.5 and 26.0°C (EAMD, 1970) respectively.

The mean annual potential evaporation (E_o) of the area is about 1848mm (Woodhead, 1968) and the mean annual potential evapotranspiration ($E_t = 2/3E_o$) is 1232mm. A monthly distribution of the potential evaporation was calculated from Braun (in prep).

The mean annual rainfall to evaporation ratio (r/E_o) is 73% which places the survey area in agro-climatic zone II (Sombroek et al., 1982) which has a high potential for plant growth assuming that soil conditions are not limiting.

Table 2 Average water balance for the survey area

	J	F	M	A	M	J	J	A	S	O	N	D
r	76	94	147	189	155	91	48	76	109	108	134	123
eff r	72	89	139	180	148	87	45	73	104	102	127	117
E_o	187	168	168	149	131	131	131	149	149	168	149	168
E_t	125	112	112	100	87	87	87	100	100	112	100	112
eff r- E_t	-53	-23	27	80	61	0	-42	-27	4	-10	27	5

S(mm)

50	0	0	27	50	50	50	8	0	4	0	28	33
80	0	0	27	80	80	80	38	11	15	5	32	37
120	26	3	30	110	120	120	78	51	55	45	73	78

(eff r+ds)/ E_t

50	.84	.80	1.24	2.07	2.27	1.57	1.09	.81	1.04	.95	1.28	1.30
80	.88	.80	1.24	2.07	2.61	1.91	1.44	1.11	1.15	1.05	1.33	1.34
120	1.21	1.03	1.27	2.10	2.96	2.37	1.90	1.51	1.55	1.41	1.73	1.70

interpretation (growing months)

soil depth (cm)

0-50	.5	.5	1	1	1	1	1	.5	1	.5	1	1
0-80	.5	.5	1	1	1	1	1	1	1	1	1	1
0-120	1	1	1	1	1	1	1	1	1	1	1	1

Notes: eff r = effective rainfall; S = storage; ds = surplus soil-water from previous month (mm); full growing month = 1, half growing month = .5
A water balance study for the area is shown in table 2. Since no soil physical data like moisture retention were directly determined, water storage

capacities of the various soils were assumed to be as below.

<u>Soil depth(cm)</u>	<u>Storage (mm)</u>
0-50	50
0-80	80
0-120	120

It can be observed from table 2 that soils whose depth is below 50cm have a 10 months growing season, those with a depth of upto 80cm have one of 11 months, while the soils with a depth of 120cm and over have a full year growing season on average.

1.3 GEOLOGY, PHYSIOGRAPHY AND HYDROLOGY

1.3.1 Geology

According to Huddleston (1951) most of western part of the survey area is covered by basalt with minor mudstone developments of the Nyanzian System. The eastern part of the survey area is covered by basalt with Kisii soapstone locally developed. Both are part of the Bukoban System. The northern part of the area is covered by andesitic tuffs and argillaceous feldspathic sandstones. Huddleston points that these two bands are separated by conglomerates and andesites but are probably one band separated by folding. Many andesite flows are intercalated with these bands but were too thin to be mapped separately.

However, when carrying out the soil survey, it was observed that rhyolites formed the dominant rock in the plains whereas andesite exposures were noted along the river valleys in places. Alluvial material has been deposited in the river valleys.

1.3.2 Physiography

Physiographically, the area can be divided into the plain and the river valleys. The plain is very gently undulating to gently undulating with slopes less than 4%. Some depressions occur in this plain and have moderately deep to deep and imperfectly drained soils. The flatter parts of the plain have generally deep and imperfectly drained soils whereas the sloping parts have shallow to deep and well drained soils. The plains adjacent to the river valleys are slightly lower in elevation than the plains further away from the river. On the shoulders between these two levels of plains, rock outcrops are generally observed.

1.3.3 Hydrology

The survey area is drained by the Oyani river and its tributaries. The western part of the area is also drained by a few tributaries of the Sare river which occurs on the northern part of the survey area. The Oyani and Sare rivers are perennial and drain their water into the Kuja river which drains its water into Lake Victoria.

The Oyani river is the main source of water for both home consumption and livestock. In some parts of the plain adjacent to the river valleys, water seepage takes place and these parts are waterlogged.

1.4 VEGETATION AND PRESENT LAND USE

The greater part of the plains is covered by shrubs but woodland occurs in some places. Thick forest occurs along the river valleys.

Land clearing for cultivation purposes has taken place in very few parts of the survey area. Maize is the major crop grown in the cultivated areas. Cultivation in the area is done by the Kisii and Luo people on land they have hired from the Maasai people. Land is also being hired for sugarcane production.

Most of the area is presently being used by the Maasai for grazing. Bush clearing for charcoal burning on commercial basis is taking place in the area.

2 THE SURVEY METHODS

2.1 OFFICE METHODS

The preparation for fieldwork has been divided into two parts:

- a) Collection of data on geology (parent material), geomorphology, hydrology, previous soil surveys, vegetation, land use, climate and communication of the area. Aerial photographs and topographical maps covering the survey area were also gathered. Two topographical map sheets 144/1 and 130/3 published by the Survey of Kenya at scale 1:50,000 and a set of aerial photographs at scale 1:15,000 were used. The photographs were flown in 1987 by Photomap for the SONY Sugar Co.
- b) Studying of the already collected information. This included the available literature and a physiographic photo-interpretation of the aerial photographs using a double mirror stereoscope.

2.2 FIELD METHODS

The fieldwork was carried out by two soil surveyors and two technical assistants in September 1987. The field investigation can be described under the following headings:

- a) Reconnaissance
- b) Routine augering
- c) Description and sampling of representative soil profile pits.

a) Reconnaissance

In order to get a proper orientation and to investigate the accessibility of the area, a day was spent in going through the survey area. This assisted in assessing the reliability and relevance of the photo interpretation. There was a good correlation especially between the physiographic units in the field and the interpreted units on the photographs. It was clear after the reconnaissance that driving would be limited in some parts of the survey area due to thick vegetation with at times non-motorable tracks.

b) Routine augering

This dominated the total volume of investigations. It involved a grid system of augerhole observations, sometimes with free survey to check the interpretation units.

The augerhole observations were located 150 to 300m apart and sometimes even more along transects spaced between 250 to 500m depending on the intricacy of the soil pattern. The augerholes were made to a depth of 120cm and above unless impenetrable layers occurred at shallower depth. A total of 102 augerhole observations were made in the survey area. For the location of the observation sites for augerings, see appendix 3.

c) Description and sampling of soil profile pits

After the final soil boundaries had been established on the basis of the general site characteristics (landscape features, geology, land use and vegetation among others) and soil characteristics (internal drainage conditions, depth, texture, colour, mottling, consistence, etc) one or two representative soil profile pits were located in each of the soil mapping units. For both routine augerings and soil profile descriptions, the Kenya Soil Survey standards and methods which are based on the "Guidelines for soil profile description" (FAO, 1977) were used. Soil colours including those of augerings were noted using "Munsell Soil Color Charts" (Munsell Color Co., 1977). Each soil horizon of the pits was sampled for analysis in the laboratory. Composite topsoil samples (0-30cm) were taken at various sites around the profile pit for analysis according to mass analysis method for soil fertility evaluation (Mehlich et al, 1962). A total of 10 soil profile pits were dug, described and sampled for analyses.

2.3 LABORATORY METHODS

Chemical, physical and fertility analyses of the samples were carried out by the National Agricultural Laboratories which use the methods outlined in detail by Hinga et al (1980). A brief breakdown of the methods is given below.

Texture (hydrometer): no dispersing agent was used.

pH H₂O/1N KCl in 1:2.5 soil - water/salt suspension was measured with a pH-meter.

Electrical conductivity (EC): was measured in a 1:2.5 soil - water suspension with an EC-meter.

%C: Walkely and Black method on A-horizons only.

%N: semi-micro Kjeldahl method on A-horizons only.

Exchangeable cations: successive leaching with 1N NH₄OAc at pH 7.0 solution. Exchangeable cations viz: Ca, Mg, K and Na were determined with a flamephotometer/atomic absorption spectrophotometer.

Cation exchange capacity (CEC): Following the leaching for exchangeable cations, the soils were leached with 95% ethyl alcohol, 1N sodium acetate at pH 8.2, 95% ethyl alcohol and lastly with 1N NH₄OAc pH 7.0 solution. CEC was determined in the last leachates by measuring the Na-concentration with a flamephotometer.

Exchangeable acidity: Determined titrimetrically in an unbuffered 0.6N BaCl₂ solution.

"Mass analysis" for available nutrients (on A-horizons only): extraction by shaking for 1 hour at 1:5 ratio with 0.1N HCl/0.025N H₂SO₄. Ca, Mg, K and Na were determined with a flamephotometer, after an anion resin treatment for Ca was done. Mg, P and Mn were determined calorimetrically.

3 THE SOILS

3.1 PREVIOUS WORK

Some soil information was obtained from the "Exploratory soil map and agro-climatic zone map of Kenya (Sombroek et al, 1982) and from the "Preliminary soil survey of the Transmara Division" (Wamicha et al, in prep). Both these surveys cover the present survey area.

Table 3 Correlation between the soil units identified in the "Preliminary soil survey of the Transmara Division" the "Exploratory soil map and agro-climatic zone map of Kenya" and those of the present survey area.

Exploratory soil map and agro-climatic zone map of Kenya (scale 1:1,000,000)	Preliminary soil survey of the Transmara Division (scale 1:100,000)	Present soil survey (scale 1:50,000)
Pn24	PXhM-PXa U4Yhp-U4Yg BXal	PYb2P, PYg, PYap, PYb4p PYrlm VXp

3.2 GENERAL PROPERTIES OF THE SOILS

The soils of the survey area show variations mainly due to lithology (parent material) and physiography as activated by climate, especially rainfall. Two main soil regions have been identified in the survey area and these are the plains and the minor valleys. Although the area has a rather high precipitation, most of the soils north of the Oyani river are less deep than in comparable areas elsewhere.

The soils of the plains are predominantly developed on rhyolites. They range from relatively young soils (adjacent to the Oyani river and in depressional areas) to relatively well developed soils in the plain proper.

The soils are well drained to poorly drained with depths ranging from very shallow to very deep. The very shallow to shallow soils occur on slightly high lying parts of the plain which in some mapping units are fairly rocky and fairly stony with good drainage conditions. The soils with poor drainage conditions occur in the slightly depressional areas and the rest of the flatter areas of the plain. They have a moderate soil fertility.

The soils of the minor valleys are developed on alluvial and colluvial materials derived from various parent materials. They are generally young soils which occur along the Oyani river and its tributaries. These soils are well drained to moderately well drained, moderately deep to deep and are characteristically covered by a thick forest vegetation. They have a moderate soil fertility.

3.3 SYSTEMATICS AND NOMENCLATURE

All soil mapping units are briefly described in the legend of the soil map (appendix 2). Physiography has been used as the highest level in the legend entry. The second level of separation is for geology and in both cases of separation they are indicated by capital letters. The third level may either have small letters with or without numerical figures which denote different soil mapping units within the same physiography-geology grouping.

Physiography

- P Plains (slopes less than 5%)
- V Minor valleys (slopes 0-8%)

Geology

- Y Rhyolites
- X Alluvium and colluvium derived from various parent materials

Soils

The soil mapping units have been described in terms of their drainage condition, depth, colour, consistence and texture. Other characteristics which include mottling and stratification have been mentioned where applicable. The soil classification according to the FAO-UNESCO of the "Soil map of the world" (1974) is given at the end of each soil mapping unit description. In the description of each soil mapping unit, the prevalent depth class is given. Soils which are less than 120 cm deep are identified by the following codes (see also "Key to depth classes" in appendix 2):

<u>Depth class</u>	<u>Depth (cm)</u>	<u>Code</u>
very shallow	0-25	P or M
shallow	25-50	P
moderately deep	50-80	p
deep	80-120	p or m
very deep	120-180	no code

The depth classes are also indicated by various screens in addition to these codes (see appendix 2). The slope class code is indicated along with the soil mapping unit on each identified unit of the map. The slope classes identified in the survey area are as follows (see also "Key to slope classes in appendix 2):

<u>Slopes class code</u>	<u>slopes (%)</u>
A	0-2
B	2-5
C	5-8

3.4 DESCRIPTION OF THE SOIL MAPPING UNITS

General remarks:

- colours are for moist conditions unless otherwise specified
- surface features like vegetation, erosion, rock outcrops, overwash/overflow, flooding, surface stoniness, surface runoff, surface sealing etc are only indicated where they are observed.

3.4.1 Soils of the plainsMapping unit PYrlm

Extent	:	193 ha
Parent material	:	rhyolites
Relief, macro	:	very gently undulating to gently undulating, slopes 0-3%
Vegetation	:	bushed grassland; in places cultivated
Land use	:	grazing and arable farming; maize cultivations
Erosion	:	some sheet erosion
Soils, general	:	well drained, deep to very deep, dark red to dark reddish brown, friable, gravelly clay to clay, over pisolitic material and petroplinthite (murrum). The soils have an ABC sequence of horizons with clear and smooth transitions. The soils show a clay increase with depth which is reflected by patchy and thin clay cutans in the B-horizon.
colour	:	A-horizon: dark reddish brown (5YR 3/2) to very dark greyish brown (10YR 3/2) B-horizon: dark red (2.5YR 3/6) to dark reddish brown (5YR 3/4)
texture	:	A-horizon: clay B-horizon: gravelly clay to clay
structure	:	moderate to strong, very fine, fine and medium subangular blocky
consistence	:	friable when moist, slightly sticky and slightly plastic when wet
Chemical properties	:	A-horizon: organic C ranges from 2.6 to 2.8%; pH-H ₂ O ranges from 5.6 to 6.1 and pH-KCl is 4.5; CEC-soil ranges from 26.8 to 34.5 me/100g and base saturation ranges from 35 to 40%. B-horizon: pH-H ₂ O ranges from 5.6 to 6.1; CEC-soil ranges from 21 to 28.7 me/100g and that of the clay fraction ranges from 29 to 43 me/100g; base saturation ranges from 21 to 94%.
Diagnostic properties	:	An umbric A-horizon; an argillic B-horizon and a base saturation ranging from 21 to 94%. Deep to very deep soils over pisolitic materials and petroplinthite.
Soil classification	:	humic ACROSOLS and orthic LUVISOLS; pisolitic and pisolitic phases

For the description of representative soil profiles with analytical data, see appendix 1, profile description nos. 1 and 2 (observation nos. 130/3-2588 and 144/1-229, respectively).

Mapping unit PYr2M

Extent : 401 ha
 Parent material : rhyolites
 Relief, macro : very gently undulating to gently undulating, slopes 2-4%
 Vegetation : bushed grassland
 Land use : arable farming - maize cultivation; and grazing.
 Erosion : moderate rain splash and sheet erosion.
 Soils, general : well drained, very shallow to shallow, yellowish red to dark reddish brown, clay loam to clay, over pisolitic material and petroplinthite (murram). The soils have an ABC sequence of horizons with abrupt and irregular transitions.

colour : A-horizon: dark reddish brown (5YR 3/4) to dark yellowish brown (10YR 3/4)
 B-horizon: yellowish red (5YR 4/6) to dark reddish brown (5YR 3/4)

texture : A-horizon: clay loam to clay over very gravelly material
 B-horizon: clay loam to clay

consistence : friable when moist, sticky and plastic when wet

Chemical properties : A-horizon: organic C is 1.0%; pH-H₂O is 5.7 and pH-KCl is 4.0; CEC-soil is 28 me/100g and base saturation ranges from 47 to 61%
 B-horizon: pH-H₂O ranges from 5.7 to 6.1 and pH-KCl ranges from 5.0 to 5.2; CEC-soil ranges from 13.5 to 22.5 me/100g decreasing with depth, and that of the clay fraction ranges from 30 to 40 me/100g; base saturation ranges from 47 to 61%.

Diagnostic properties : An ochric epipedon; a cambic B-horizon with a base saturation of more than 50%. Shallow soils over pisolitic materials and petroplinthite (murram).

Soil classification : eutric CAMBISOLS, pisolitic and petroferic phases

For the description of a representative soil profile with analytical data, see appendix 1, profile description no. 3 (observation no. 144/1-227).

Mapping unit PYb1P

Extent : 72 ha
 Parent material : rhyolites
 Relief, macro : very gently undulating, slopes 0-2%
 Vegetation : bushed grassland
 Land use : grazing
 Rockiness : rocky
 Erosion : nil
 Soils, general : well drained, very shallow, dark brown to dark greyish brown, fairly rocky and fairly stony, clay loam to clay. The soils have an AC sequence of horizons with abrupt and wavy transitions.

colour : A-horizon: dark greyish brown (10YR 4/2) to dark brown (10YR 3/3)

texture : A-horizon: clay

structure : weak to moderate, very fine, fine and medium subangular blocky, breaking into crumbs

consistence : friable when moist, slightly sticky and slightly

plastic when wet

Chemical properties : A-horizon: organic C is 2.1%; pH-H₂O is 5.3 and the pH-KCl is 4.1, CEC-soil is 25 me/100g and that of clay fraction is 26 me/100g; base saturation is 20%

Diagnostic properties : An ochric epipedon; very shallow soils over rock. A cambic B with base saturation less than 50%

Soil classification : dystric LITHOSOLS

For the description of a representative soil profile with analytical data, see appendix 1, profile description no. 4 (observation no. 130/3-2593).

Mapping unit PYb2P

Extent : 99 ha

Parent material : rhyolites

Relief, macro : flat to very gently undulating, slopes 0-1%

Vegetation : open bushed grassland

Land use : grazing

Rockiness : in places rocky

Erosion : nil

Flooding : seasonal

Soils, general : moderately well drained to imperfectly drained, shallow to moderately deep, dark yellowish brown to dark brown, mottled, friable to firm, loam to clay, over rock and petrophinthe (murrum). The soils have an ABC sequence of horizons with abrupt and smooth transitions.

colour : A-horizon: dark yellowish brown (10YR 3/4) to very dark greyish brown (10YR 3/2)
B-horizon: dark yellowish brown (10YR 3/4) to dark brown (10YR 3/3).

texture : A-horizon: sandy clay loam to clay
B-horizon: loam to clay

structure : weak, fine and medium subangular blocky

consistence : friable to firm when moist and slightly sticky to sticky and slightly plastic to plastic when wet

Chemical properties : A-horizon: organic C is 3.1%; pH-H₂O is 5.5 and pH-KCl is 3.9; CEC-soil is 21.3 me/100g and base saturation is 24%
B-horizon: pH-H₂O ranges from 5.6 to 5.8 increasing with depth; CEC-soil ranges from 11.8 to 12.5 me/100g decreasing with depth. The CEC of the clay fraction ranges from 30 to 34 me/100g. Base saturation ranges from 28 to 36%¹

Diagnostic properties : an ochric A-horizon; a cambic B-horizon with a base saturation of less than 50%; hydromorphic properties

Soil classification : gleyic CAMBISOLS, lithic phase

For the description of a representative soil profile with analytical data, see appendix 1, profile description no. 5 (observation no. 130/3-2590).

¹ The pH-H₂O looks too high for the base saturation indicated.

Mapping unit PYb3p

Extent	: 405 ha
Parent material	: rhyolites
Relief, macro	: flat to very gently undulating, slopes 0-3%
Vegetation	: grassland
Land use	: grazing
Erosion	: nil
Ground water level	: about 50 cm (most likely a perched groundwater level during rainy seasons in places)
Soils, general	: imperfectly drained, deep to very deep, dark greyish brown to dark grey, mottled, firm clay, underlying 10-30 cm of very dark grey, loam to silty clay topsoil. The soils have an ABC sequence of horizons with diffuse and smooth transitions, especially in the B-horizon.
colour	: A-horizon: very dark greyish brown (10YR 3/2) to very dark grey (10YR 3/1). There are common, fine and distinct dark reddish brown (5YR 3/3) mottles. B-horizon: dark greyish brown (10YR 4/2) to dark grey (10YR 4/1) with common medium and distinct reddish brown (10YR 5/8) mottles.
texture	: A-horizon: loam to silty clay B-horizon: clay
structure	: moderate, medium angular blocky
consistence	: firm when moist, sticky and plastic when wet.
Chemical properties	: A-horizon: organic C is 2.6%; pH-H ₂ O is 5.5 and pH-KCl is 4.0; CEC-soil is 18.7 me/100g and base saturation is 22% B-horizon: pH-H ₂ O ranges from 5.8 to 6.1; CEC-soil ranges from 25 to 51 me/100g and base saturation from 33 to more than 100%
Diagnostic properties	: an umbric epipedon; an argillic B-horizon with a base saturation of more than 50%; hydromorphic properties.
Soil classification	: gleyic LUVISOLS

For the description of a representative soil profile with analytical data, see appendix 1, profile description no. 6 (observation no. 130/3-2589).

Mapping unit PYap

Extent	: 197 ha
Parent material	: rhyolites
Relief, macro	: flat to very gently undulating, slopes 0-2%
Vegetation	: bushed grassland
Land use	: grazing
Erosion	: nil
Flooding	: seasonal
Soils, general	: imperfectly drained, deep to very deep, dark greyish brown to very dark greyish brown, mottled, firm clay, abruptly underlying 30 to 50 cm of loam to clay topsoil. The soils have an AEBC sequence of horizons with diffuse and smooth transitions in the B-horizon and abrupt and smooth transition between the top soil and the B-horizon.

colour : A-horizon: very dark brown (10YR 2/2) to very dark grey (10YR 3/1)
 E-horizon: dark brown (10YR 3/3)
 B-horizon: dark greyish brown (10YR 4/2) to very dark greyish brown (10YR 3/2)
 texture : A-horizon: loam to clay loam
 E-horizon: clay loam
 B-horizon: clay
 structure : moderate to strong, fine and medium subangular and angular blocky
 consistence : firm when moist, sticky and plastic when wet
 Chemical properties : A-horizon: organic C is 2.5%; pH-H₂O is 5.3 and pH-KCl is 3.8; CEC-soil is 20.3 me/100g and base saturation is 28%
 B-horizon: pH-H₂O ranges from 5.3 to 5.8; CEC-soil ranges from 10.5 to 38.5 me/100g and that of clay fraction from 25 to 56 me/100g¹
 Diagnostic properties : an umbric A-horizon; an argillic B-horizon with a base saturation generally less than 50%; abrupt transition between A-and B-horizons.
 Soil classification : dystric PLANOSOLS

For the description of a representative soil profile with analytical data, see appendix 1, profile description no. 7 (observation no. 130/3-2592).

Mapping unit PYb4p

Extent : 191 ha
 Parent material : colluvium
 Relief, macro : depressional
 Vegetation : grassland
 Land use : grazing
 Erosion : nil
 Flooding : during rainy season (frequent)
 Soils, general : imperfectly drained to poorly drained, moderately deep to deep, dark yellowish brown to black, mottled, firm to very firm, clay loam to clay, over rock and petroplinthite (murram). The soils have an ABC sequence of horizons with gradual to clear and smooth horizon transitions. There are pressure faces-like features.
 colour : A-horizon: very dark greyish brown (10YR 3/2) to very dark grey (10YR 3/1)
 B-horizon: dark yellowish brown (10YR 3/4) to black (10YR 2/1)
 texture : A-horizon: loam to clay
 B-horizon: clay loam to clay
 structure : moderate to strong, very fine, fine and medium sub-angular blocky
 consistence : firm to very firm when moist, slightly sticky to

¹Amount of %C (3.12) and hence organic matter at the depth of 90-120 cm is very high and off. This has resulted in low CEC clay compared to the high amount of clay analysed.

Chemical properties : sticky and plastic when wet
 A-horizon: organic C is 0.5%; pH-H₂O is 5.7 and pH-KCl is 3.6; CEC-soil is 30 me/100g; base saturation is 51%
 B-horizon: pH-H₂O ranges from 5 to 6.3; CEC-soil ranges from 16.5 to 23.7 me/100g increasing with depth. CEC of the clay fraction ranges from 45 to 67 me/100g. Base saturation ranges from 19 to 30%.

Diagnostic properties : An ochric A-horizon; a cambic B-horizon with base saturation of less than 50% and hydromorphic properties

Soil classification : dystic and gleyic CAMBISOLS

For the description of a representative soil profile with analytical data, see appendix 1, profile description no. 8 (observation no. 130/3-2591).

Mapping unit FYg

Extent : 228 ha
 parent material : rhyolites
 Relief, macro : flat to very gently undulating
 Vegetation : grassland (mainly sedge grass)
 Land use : grazing during dry season
 Erosion : nil
 Flooding : generally flooded, but more so during rainy seasons
 Soils, general : poorly drained, very deep, dark greyish brown to very dark grey, mottled, soft to firm, clay. The soils have an ABC sequence of horizons with clear to diffuse and smooth horizon transitions. They have some pressure faces.

colour : A-horizon: very dark greyish brown (10YR 3/2) to very dark grey (10YR 3/1)
 B-horizon: dark greyish brown (10YR 4/2) to very dark grey (10YR 3/1)

texture : A-horizon: clay loam
 B-horizon: clay

structure : moderate, very fine, fine and medium angular blocky
 consistence : soft to firm when moist, sticky and plastic when wet

Chemical properties : A-horizon: organic C is 4%; pH-H₂O is 4.8 and pH-KCl is 3.8; CEC-soil is 31.0 me/100g; base saturation is 8%
 B-horizon: pH-H₂O ranges from 5.5 to 6.0; CEC-soil ranges from 16.5 to 38.5 me/100g; CEC of the clay fraction ranges from 44 to 49 me/100g; base saturation ranges from 43 to 74%

Diagnostic properties : An umbric epipedon; a cambic B-horizon; hydromorphic properties within 50 cm from the surface

Soil classification : humic GLEYSOLS

For the description of a representative soil profile with analytical data, see appendix 1, profile description no. 9 (observation no. 130/3-2594).

3.4.2 Soils of the minor valleys

Mapping unit Vxp

Extent	: 132 ha
Parent material	: alluvium and colluvium
Relief, macro	: flat to undulating, slopes 0-8%
Vegetation	: bushland thicket
Land use	: woodcutting, browsing and grazing
Erosion	: nil
Flooding	: can be flooded in places seasonally
Soils, general	: well drained to moderately well drained, moderately deep to deep, dark reddish brown to dark greyish brown, friable to firm, clay; in places stratified. The soils have an ABC sequence of horizons. They have clear and smooth transitions.
colour	: A-horizon: dark yellowish brown (10YR 3/4) to dark reddish brown (5YR 3/2) B-horizon: dark reddish brown (5YR 3/3) to dark greyish brown (10YR 3/2)
texture	: A-horizon: sandy clay loam to clay loam B-horizon: sandy clay loam to clay
structure	: moderate to strong, fine, medium and coarse sub-angular blocky
consistence	: friable to firm when moist, sticky and slightly plastic to plastic when wet
Chemical properties	: A-horizon: organic C is 1.66%; pH-H ₂ O is 5.2 and pH-KCl is 3.8; CEC-soil is 20.5 me/100g; base saturation is 61% B-horizon: pH-H ₂ O ranges from 5.4 to 5.8; CEC-soil ranges from 14.5 to 35 me/100g and that of the clay fraction from 52 to 58 me/100g. Base saturation ranges from 49 to 64%
Diagnostic properties	: an ochric epipedon, stratified horizons and cambic B-horizon. Base saturation more than 50%
Soil classification	: eutric CAMBISOLS and FLUVISOLS

For the description of a representative soil profile with analytical data, see appendix 1, profile description no. 10 (observation no. 144/1-228).

3.5 SOIL FERTILITY ASPECTS

3.5.1 General

For fertility appraisal, composite samples of the topsoil (0-30 cm) have been considered. It is important to note that this appraisal is only based on chemical data of a limited number of sampling sites. The comments should therefore be treated as general.

The soil reaction varies from very strongly acid to medium acid with pH ranges of 4.7 to 5.7. Mapping units PYrlm, PYb3p and Vxp are sufficiently supplied with most of the basic plant nutrients viz Ca, Mg, K and N. The rest of the mapping units are deficient in calcium and magnesium. All the soils have an inadequate supply of phosphorus. Organic matter is on the

other hand adequately distributed in the soils of the survey area with the organic carbon content ranging from 2.1 to 3%. Nitrogen is generally low, ranging from 0.19 to 0.38%.

The survey area has a reasonable amount of rainfall and this has resulted in a substantial leaching of the nutrients down the profile. The generally low pH and CEC data corroborate this situation.

3.5.2 Available nutrients

Table 4 indicates the amount of available nutrients for the representative soil profiles of each of the mapping units.

Table 4 Available nutrients (0-30 cm)

soil mapping unit	pH	C %	N %	Na	K	Ca	Mg	P
				me/100g				ppm
PYrl _m	5.6	2.4	0.38	0.20	0.58	4.8	3.3	12
PYrl _m	5.2	2.9	0.28	0.29	0.54	8.4	5.5	8
PYr2M	5.7	2.5	0.28	0.22	1.40	3.6	4.8	14
PYb1P	5.2	2.7	0.19	0.22	0.46	1.6	2.2	8
PYb2P	5.1	2.6	0.21	0.36	0.14	1.2	0.3	8
PYb3 _p	5.3	3.3	0.28	0.43	0.29	2.0	1.9	8
PYap	5.1	2.8	0.20	0.54	0.14	1.6	1.6	4
PYb4 _p	5.2	2.6	0.24	0.46	0.26	1.2	0.4	6
PYg	4.7	3.0	0.23	0.40	0.18	2.0	1.6	12
VXp	5.0	2.1	0.22	0.26	0.22	5.6	5.0	8

For the rating of the above results, reference has been made to Mehlich et al (1964). About half of the soils of the survey area are sufficiently supplied with most of the basic plant nutrients except for phosphorus which is deficient in all the soils. Soils of mapping units PYb2P, PYb4_p, PYap and PYblP are deficient in calcium and those of mapping units PYb2P and PYb4_p are deficient in magnesium. Mapping units PYap and PYg have soils which are deficient in potassium.

Application of Ca, Mg, K and P containing fertilizers would be necessary to correct these deficiencies. This includes application of lime and single superphosphate. Although the soils are not deficient in nitrogen, application of farm yard manure or compost manure will improve the soil physical status.

4 LAND EVALUATION FOR SUGAR CANE OUTGROWING

4.1 PROCEDURES

The land evaluation method used by the Kenya Soil Survey closely follows the proposals of the "Framework for land evaluation" (FAO, 1976). A detailed account of this approach can be found in the "Soils of the Kindaruma area" (van de Weg and Mbuvi, 1975). A further updating of the ratings used in the Kindaruma area is in the Kenya Soil Survey Internal Communications, "Proposals for the rating of land qualities" (Braun and van de Weg, 1977) and "Rating of land qualities in Kenya" (Weeda, 1987). The following is a short summary of the basic concepts:

- land evaluation is based on land qualities that can be quantified and rated;
- land qualities usually are combinations of single land characteristics (as discussed below);
- these land qualities are used to establish specifications for each land suitability class for a specific land utilization type (conversion tables);
- for each "tract" of land, a rating of all relevant land qualities is made for all land utilization types under consideration.

For this survey area, land has been evaluated for only one land utilization type, namely rainfed sugarcane "outgrowing", high level of technology. This level of technology in this particular survey area implies the following:

- (a) Farm power - the machinery and equipment used for farm operations are mainly tractors. Apart from ploughing, harrowing and to a little extent weeding, planting and harvesting is done manually.
- (b) Technical know-how - the general knowledge is high enough such that the farm operators (SONY group) are in a position to use modern agricultural practices like application of fertilizers, use of the right cane variety, taking of soil conservation measures (terracing, contour ploughing, etc), timely planting and weeding among others.

4.2 LAND QUALITIES

The following land qualities were used for the land evaluation for rainfed sugar "outgrowing" in the survey area:

- (a) climatic characteristics (clim)
- (b) Availability of water (AoW)
- (c) Possibilities of mechanization (PoM)
- (d) Oxygen for plant roots growth (Ox)
- (e) Resistance to erosion (sheet and gully erosion after clearing (RE)
- (f) Soil fertility (Fert).

The ratings of all land qualities of all tracts of land (soil mapping units and slope class) are given in table 22

(a) Climatic characteristics (clim)

Climatic characteristics are very important in land evaluation as they relate to the amount of rainfall and temperature and their distribution over an

area. This subsequently has a significant influence on crop yields. The minimum annual average rainfall for optimum growth of sugarcane is 1500 mm (Acland, 1971). For optimum growth 75% of this should be available during the growing season. An altitude of 5200 ft (1600 m) is usually regarded as being the upper limit for commercial cane growing (Jaetzold and Schmidt, 1982). A mean annual temperature of 20°C to 30°C is considered ideal with an optimum of 25°C. The survey area falls in agro-climatic zone II which is classified as sub-humid with a mean annual rainfall to evaporation (r/E_o) ratio of 73% and an r-E_t value of 118 mm (where r is mean annual rainfall and E_t is the mean annual potential evapotranspiration).

(b) Availability of water (for plant growth) (AoW)

This land quality is expressed in terms of the length of the growing season(s). The growing season is the period during which the plant has enough available soil water to maintain its normal productive growth. It is measured in terms of the presence of humid growing months without limitations for the plant together with the existence of a more marginal growing month preceding or following a full growing month. The length of the accumulated growing months will determine the suitability for a specific plant or crop.

The total easily available soil moisture storage capacity is calculated for three different rooting depth classes of the particular soil as shown in table 2. Table 5 below shows the relation of soil depth to growing season.

Table 5 Relationship of depth and growing season

<u>Soil depth (cm)</u>	<u>growing season (months)</u>
0 - 50	10
0 - 80	11
0 - 120	12

The length of the individual growing season(s) can be grouped according to the land quality ratings as shown in the table below.

Table 6 Rating of Availability of water

<u>Month(s) per growing season</u>	<u>rating</u>
>11	1
9.5 - 11	2

(c) Possibilities of mechanization (PoM)

Consideration is made regarding the use of agricultural implements (tractors) in cane production as an aid in speeding up the farm operations in rating this land quality. Such farm practices as seedbed preparation, harvesting and general transportation have also been considered.

For the rating of the above land quality the following land characteristics were taken into account.

- length of slope
- steepness of slope
- width of the mapping unit
- rockiness/stoniness or shallowness of the soil
- workability of the soil (ease of cultivation). For practical purposes,

the subrating of "workability" of the soil was based on the moist consistence of the soil. It is also considered that the existing termite mounds which are 70-100m apart, 5-10m in diameter and 0.5-1m in height will be graded before farm operations.

The subratings of the above mentioned land characteristics are shown in tables 7 to 9

Table 7 Subrating for slope length

<u>Length of slope</u>	<u>subrating</u>
longer than 200m	1
from 50-200 m	2

Table 8 Subrating for steepness of slopes

<u>slope class</u>	<u>subrating</u>
AB -C (upto 8%)	1

Table 9 Subrating for stoniness/rockiness/shallowness of the soil

<u>description</u>	<u>subrating</u>
non-stony, non to little rocky and not shallow	1
fairly tony, fairly rocky and/or shallow	2

Table 10 Subrating for workability of the soil (cultivation)

<u>moisture consistence</u>	<u>subrating</u>
loose	1
very friable	2
slightly hard/friable/friable to firm	3
hard/firm	4
very hard/extremely hard/very firm/extremely firm	5

Workability is graded one class if sticky and plastic when wet and downgraded two classes if very sticky and very plastic when wet.

Table 11 Subrating for minimum width of the mapping unit

<u>width of mapping unit</u>	<u>subrating</u>
more than 100m	1
more than 50, less than 100m	2

The final rating for the possibilities of mechanization is given in table 12 below. The most limiting subrating determines the final rating of the land quality under consideration.

Table 12 Final rating for the possibilities of mechanization.

<u>final rating</u>	<u>steepness of slope</u>	<u>stoniness etc</u>	<u>work ability</u>	<u>slope length</u>	<u>width of mapping unit</u>
1 very good	1	1	3	1	1
2 good	1	2	4	2	2
3 moderate	2	3	5	3	3
4 poor	3	4	5	3	3
5 very poor	4	5	5	3	3

(d) Presence/hazard of water logging (availability of oxygen) (Ox)

The period which water takes while stagnating over a land surface will have a direct influence on the general aeration of the soils. Water logging results in soil air-water imbalance such that most of the soil pores become waterfilled. Since plant roots require oxygen contained in the air spaces, lack of it results in plants dying if not very drastic yields reduction. Most farm operations will not be possible at the same time with excessive water. For the rating of this land quality, the soil drainage class as determined in the field was used.

Table 13 Rating for the availability of oxygen

<u>drainage class</u>	<u>rating</u>	<u>description</u>
well to excessively drained soils	1	very good
moderately well drain soils	2	good
imperfectly drained	3	moderate
poorly drained soils	4	poor
very poorly drained	5	very poor

(e) Resistance to erosion (sheet and gully erosion after clearing) (RE)

The land characteristics which are considered for the rating of this land quality are as follows:

- climate factor
- slope factor
- soil factor

The rating of the land quality is obtained through summation of the individual factor ratings and the final result expressed in terms of high, moderate, low and very low resistance to erosion for base surfaces.

Table 14 Rating climate factor

rating	KE is >25 (J/m^2)	agro-climatic zone K.S.S
3	$>10,000$	I, II

The land quality slope factor was rated by means of slope length and steepness of slope.

Table 15 Slopes factor ratings

slope length (m)	slope gradient (%)		
	A 0-2	B 2-5	C 5-8
<50	1	1	3
50-100	1	3	3
100-200	1	3	5
>200	1	3	5

The following characteristics were taken into account for the sub-rating of the land quality soil factor.

- Organic matter
- bulk density
- silt/clay ratio
- flocculation index (aggregate index)

If bulk density, silt/clay ratio and flocculation index have not been determined, substitute values are given which will influence the overall, rating neither positively nor negatively.

Table 16 Subratings of organic C content and silt/clay ratio

%C	Sub-rating r1	Silt/clay ratio	Subrating r2
>3	1	< 0.2	1
1.2-3.0	2	0.2-0.59	2
<1.2	3	0.6-1.0	3
		>1.00	4

If data unknown $r2=2$

Table 17 Subrating of bulk density and flocculation index

Bulk density (g/cm^3)	Subrating r3	flocculation index	Subrating r4
<1.2	1	>70	1
1.2-1.5	2	40-70	2
>1.5	3	15-39	4
		<15	6

If data unknown $r_3=2$

If data unknown $r_4=2$

If characteristics r_2 , r_3 and r_4 are not determined substitute values are given which will influence the overall rating neither positively nor negatively.

The total soil factor rating is obtained by adding subrating r_1 , r_2 , r_3 and r_4 as shown in the table below.

Table 18 Rating of soil factor

Rating	Subratings ($r_1 + \dots + r_4$)
1	4-6
2	7-9
3	>9

The final rating of resistance to erosion is the sum of the individual climate, slope, and soil. The final rating is classified as shown on table 19.

Table 19 Final rating for resistance to erosion

<u>rating</u>	<u>sum factors</u>
1. high	3-6
2. moderate	7-8
3. low	9-10
4. Very low	>10

(9) Soil fertility (Fert)

The ability of the soil to supply the required plant nutrients adequately is important for optimum growth and production. Low levels of soil fertility can be corrected by use of fertilizers and manure. Timely weeding and use of soil conservation measures e.g control of runoff which leads to soil erosion can maintain the status of the soil. Timely weeding reduces the chances of weed competition with crops for the nutrients available in the soil. The following characteristics were considered for the rating of the land quality soil fertility.

- CEC me/100g soil (NH_4 -acetate pH 8.2)
- organic carbon % (Walkely and Black)
- available P ppm (Mehlich or Olsen)
- exchangeable K, Ca and Mg me/100g soil (NH_4 -acetate pH 8.2)
- pH water 1:2.5

Table 20 Subrating for CEC

<u>me/100g</u>	<u>subrating</u>
>16	1. high
6-16	2. moderate
3-5.9	3. low
<3	4. very low

Table 21 Subrating for available nutrients of the topsoil

rating	% C. in temperature zone 4,5,6	avail P ppm Mehlich	<u>exchangeable(me/100g)</u> K Ca Mg			pH-H ₂ O 1:2.5
1. High	>2.5	>60	>0.5	>6.0	>3.0	5.6-6.8
2. moderate	1.6-2.5	21-60	0.21-0.5	3.0-60	1.1-3.0	4.8-5.5 or 6.9-7.5
3. low	1.0-1.5	10-20	0.10-0.20	1.0-2.9 7.6-8.7	0.5-1.0	4.0-4.7 or
4. very low	<1.0	<10	<0.10	1.0	<0.5	<4.0 or >8.7

The final rating for soil fertility is determined by the lowest subrating of the available nutrients.

Table 22 Rated land qualities of the individual mapping units

<u>TRACT OF LAND</u>	<u>LAND QUALITIES/CHARACTERISTICS</u>					
Soil mapping /slope unit /class	Area (ha)	AoW	PoM	Ox	RE	Fert
PYr1m/AB	193	1	1	1	2	3
PYr2M/AB	401	2	2	1	2	3
PYb1P/A	72	2	3	1	1	4
PYb2P/A	99	2	1	3	1	4
PYb3p/AB	405	1	2	3	1	3
PYap/A	197	1	1	3	1	4
PYb4p/A	191	1	3	3	1	4
PYg/A	228	1	2	4	1	3
VXp/AC	131	1	4	1	2	4

4.3 Suitability classes and their requirements

Land suitability is the fitness of a given tract of land for a defined use. Differences in the degree of suitability are determined by relationship, actual or anticipated, between benefits and required inputs associated with the use of the tract of land in question (FAO, 1976).

The suitability of the individual tracts of land for rainfed sugarcane "outgrowing" is expressed by the following classes (see also table 25)

- SI Highly suitable: Land suitable for sustained high yields with minimum costs of development associated with the land.
- S2 Moderately suitable: Land of moderate productivity, or requiring moderate costs for development and management because of slight to moderate limitations in land characteristics.
- S3 Marginally suitable: Land of restricted productivity or land requiring relatively high costs for development and management because of moderate to severe limitations in land characteristics.
- NS Unsuitable: Land which has qualities that appear to preclude sustained use of sugarcane growing.

The suitability class defining criteria (requirements) are given in table 25.

Table 23 Land quality criteria for the suitability classification of soils for rainfed sugarcane "outgrowing" high level of technology ("conversion table")

Suitability class	<u>LAND QUALITIES/CHARACTERISTICS</u>				
	<u>AoW</u>	<u>PoM</u>	<u>Ox</u>	<u>RE</u>	<u>Fert</u>
Highly suitable (S1)	1	1	1	2	1-2
Moderately suitable (S2)	2-3	2	2-3	2	3
Marginally suitable (S3)	4-5	3	4	3	4
Unsuitable (NS)	6-7	4-5	5	5	4

Table 24 Mapping units with a moderate suitability for rainfed sugarcane "outgrowing".

<u>Mapping unit</u>	<u>Extent (ha)</u>
PYr1m	193
PYb3p	405
PYap	197

Table 25 Suitability classification and major limitations of mapping units for rainfed sugarcane "outgrowing", high level of technology.

<u>Tract of land</u>				
<u>Soil mapping unit</u>	<u>ha</u>	<u>% of total area</u>	<u>Suit. class</u>	<u>major limitations</u>
PYr1m/AB	193	10	S2	-moderate soil fertility
PYr2M/AB	401	21	S3	-very low soil moisture storage capacity
PYb1P/A	72	4	NS	-moderate fertility
				-very low soil moisture storage capacity
				-low possibilities of mechanization due to

table 25 continued

<u>Tract of land</u> Soil mapping unit	ha	% of total area	Suit. class	major limitations
PYb2P/A	99	5	NS	rockiness and stoniness -moderate soil fertility. -very low soil moisture storage capacity
PYb3p/AB	405	21	S2	-moderate soil fertility
PYap/A	197	10	S2	-moderate soil fertility -hard pan in the subsoil should be broken by a subsoiler
PYb4p/A	191	10	S3	-low possibilities of mechanisation due to small and scattered areas
PYg/A	228	12	S3	-lack of enough available oxygen due to poor drainage conditions
VXp/AC	132	7	NS	-moderate soil fertility -low possibilities of mechanisation due to rather steep slopes; -moderate resistance to erosion -moderate soil fertility.

4.4 Suitability of all tracts of land for sugarcane "outgrowing" highlevel of technology

By matching the ratings of table 22 with the suitability class defining criteria of table 23 (conversion table) the suitability of each tract of land can be assessed. The suitabilities of all tracts of land are shown in table 25.

Out of a total of 1918 ha of land surveyed for rainfed sugarcane growing approximately 795 ha are considered moderately suitable. This includes mapping units PYr1m, PYb3p and PYap. The breakdown of these tracts of land is shown in table 24.

The marginally suitable areas occupy 820 ha and consist of mapping units PYr2M, PYb4p and PYg. The unsuitable areas constitute 303 ha and include mapping units PYb1P, PYb2P and VXp.

4.5 Conclusions and Recommendations

4.5.1 Conclusions

The area receives rainfall throughout the year with peaks in the months of April and November. The mean annual rainfall ranges from 1315mm in the south to 1380mm in the north.

However, an average of 1350 mm of rainfall has been considered for the area. This amount of rainfall is less than the optimum (1500 mm) required for

commercial sugarcane production. The high altitude (about 1500m asl) reduces the rates of evapotranspiration in this area. This makes the soils store more water than if the case was otherwise. Thus the deep soils have longer growing months than the shallow ones at the same altitude despite the area having less than optimum rainfall for sugarcane growing. The mean annual temperature for the area is 19.8°C, with the mean annual minimum of 13.5°C and mean annual maximum of 26°C. The area has an average altitude of 1500m above Sea Level.

The area falls in agro-climatic zone II which is classified as sub-humid. The above mean annual temperature of 19.8° places the area in temperature zone 4 which is warm temperate and is moderately suitable for sugarcane growing.

The survey area is dominantly a plain with minor valleys. Very low soil moisture storage capacity due to shallow soil depths (mapping units PYr2M, PYb1P and PYb2P) and low possibilities of mechanisation due to rockiness, shallow soil depth, steep slopes and small scattered areas (Mapping units PYb1P, PYb4p and VXp) are limiting factors. Other limiting factors include lack of available oxygen (PYg), moderate resistance to erosion (VXp) and moderate soil fertility (the whole survey area).

About 41% (795ha) of the survey area is moderately suitable for rainfed sugarcane "outgrowing" high level of technology. The marginally suitable areas constitute 43% (820 ha). The unsuitable areas comprise 16% (303 ha).

4.5.2 Recommendations

Commercial rainfed sugarcane outgrowing high level of technology is only feasible in mapping units PYr1m, PYb3p and PYap. These are moderately suitable areas. They constitute 795 ha.

Addition of appropriate fertilizers to supplement Ca, Mg, K and P where they are deficient is advisable for sugar cane growing.

The minor valleys - the Oyani river and its tributaries which have rather steep slopes should be left under the natural vegetation.

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APPENDIX 1

1. Detailed description of representative soil profiles with analytical data.

<u>Profile description No.</u>	<u>Observation No.</u>	<u>Mapping Unit</u>	<u>Page</u>
1	130/3-2588	PYrl m	32
2	144/1-229	PYrl m	34
3	144/1-227	PYr2 M	36
4	130/3-2593	PYb1P	38
5	130/3-2590	PYb2P	40
6	130/3-2589	PYb3 p	42
7	130/3-2592	PYap	44
8	130/3-2591	PYb4 p	46
9	130/3-2594	PYg	48
10	144/1-228	VXp	50

LABORATORY DATA OF PROFILE DESCRIPTION No.1

Observation no: 130/1-2588 Mapping unit: PYrl¹ Soil classification: humic ACRISOL, pisolitic phase

pH 8.2						
Laboratory no.	/87	8941	8942	8943		
Horizon		Ap	Bt	Bc		
Depth (cm)		0-15	15-60	60-80		
pH-H ₂ O (1: 2½ v/v)		6.1	6.1	6.0		
pH-KCl	"	4.5	4.3	4.5		
EC (mmho/cm)	"	0.07	0.04	0.02		
CaCO ₃ (%)						
CaSO ₄ (%)						
C (%)		2.63	1.30	0.61		
N (%)		0.22				
C/N						
CEC (me/100g), pH 8.2		26.8	21.0	9.8		
CEC " " pH 7.0						
Exch. Ca (me/100g)		5.8	3.4	1.6		
" Mg "		2.9	0.5	0.5		
" K "		0.64	0.30	0.16		
" Na "		0.13	0.22	0.14		
Sum of cations		9.47	4.42	2.4		
Base sat. %, pH 8.2		35	21	24		
" " %, pH 7.0						
ESP at pH 8.2		0.48	1.04	1.42		
<u>Texture (limited pretreatment)</u>						
Gravel % (>2.0mm)						
Sand % (2.0-0.05mm)		30	24	68		
Silt % (0.05-0.002mm)		24	20	8		
Clay % (0.002-0mm)		46	56	24		
Texture class		C	C	SCL		
<u>Fertility aspects</u> 0 - 30 cm Laboratory no. 8979 /87						
<u>General</u>		<u>Available nutrients</u>				
pH-H ₂ O (1: 1 v/v)	5.6	Na (me/100g)	0.26	Mn (me/100g)	0.76	
Exch. acidity (me/100g)		K	0.58	P (ppm)	12	
C %	2.46	Ca	4.8	P-Olsen (ppm)		
N %	0.38	Mg	3.3			
<u>Remarks:</u>						

PROFILE DESCRIPTION NO 1General site information

Mapping unit : PYrl
 Soil classification : humic ACRISOL, pisolitic phase
 Observation No/date : 130/3-2588, 24/9/87
 Location/altitude : E34° 39.07', S0° 59.73', 1572m
 Agro-climatic zone : II
 Geological formation : Nyanzian system
 Parent material : Rhyolites
 Physiography : Plain
 Relief : Flat to very gently sloping slopes 1-3%
 Slope gradient : 1.5%
 Erosion : Nil
 Vegetation/land use : Bushed grassland, grazing and cultivation of maize
 Surface stoniness : Nil
 Internal drainage class : Well drained

Profile description

- Ap 0-15cm Dark reddish brown (5YR3/2 moist), clay; fine and medium, crumbly; friable when moist, slightly sticky and slightly plastic when wet; many medium pores, many bio-pores; clear and smooth transition to:
 (sample no. 130/3-2588a).
- Bt 15-60cm Dark reddish brown (2.5YR3/4 moist), clay; moderate, fine and medium, subangular blocky; friable when moist, slightly sticky and slightly plastic when wet; many medium pores, common bio pores; abrupt and smooth transition to:
 (sample no. 130/3-2588b).
- BC 60-80cm Dark red (2.5YR 3/6 moist), gravelly sandy clay loam; weak, fine and medium, subangular blocky; friable when moist, non sticky and non plastic when wet; common biopores; diffuse and irregular transition to:
- C 80-120cm Pisolitic material.

LABORATORY DATA OF PROFILE DESCRIPTION No. 2

Orthic LUVISOL

Observation no: 144/1-229¹⁾ Mapping unit: PYrlm Soil classification: pisolitic phase

Laboratory no. /87	8970	8971	8972	8973	8974	
Horizon	Au	AB	Bcs	Btcs1	Btcs2	
Depth (cm)	0-16	16-32	32-50	50-64	64-96	
pH-H ₂ O (1:2½ v/v)	5.6	5.6	5.9	5.8	5.9	
pH-KCl "	4.5	4.3	4.1	4.4	5.2	
EC (mmho/cm) "	0.08	0.08	0.05	0.07	0.17	
CaCO ₃ (%)						
CaSO ₄ (%)						
C (%)	2.81	1.85	0.65	1.05	2.90	
N (%)	0.25	0.12				
C/N						
CEC (me/100g), pH 8.2	34.5	29.9	17.5	28.7	29.8	
CEC " " pH 7.0						
Exch. Ca (me/100g)	8.4	9.4	9.0	10.8	8.2	
" Mg "	4.9	6.9	7.0	7.4	7.4	
" K "	0.47	0.30	0.20	0.32	2.38	
" Na "	0.14	0.14	0.19	0.14	0.14	
Sum of cations	13.91	16.74	16.39	18.66	18.12	
Base sat. %, pH 8.2	40	56	94	65	61	
" " %, pH 7.0						
ESP at pH 8.2	0.41	0.47	1.1	0.49	0.47	

Texture (limited pretreatment)

Gravel % (>2.0mm)						
Sand % (2.0-0.05mm)	32	25	57	21	40	
Silt % (0.05-0.002mm)	24	29	13	21	20	
Clay % (0.002-0mm)	44	46	30	58	40	
Texture class	C	C	SCL	C	C/CL	

Fertility aspects

0 - 30 cm

Laboratory no. 8987 /87

General		Available nutrients			
pH-H ₂ O (1:1 v/v)	5.2	Na (me/100g)	0.29	Mn (me/100g)	0.76
Exch. acidity (me/100g)	0.2	K "	0.54	P (ppm)	8
C %	2.88	Ca "	8.4	P-Olsen (ppm)	
N %	0.28	Mg "	5.5		

Remarks:

1) Previously indicated as profile No. 130/3-2595

PROFILE DESCRIPTION NO.2General site information

Mapping unit : PYrlm
 Soil classification : orthic LUVISOL, pisolitic phase
 Observation No/date : 130/3-2595, 25/9/87
 Location/Altitude : E34° 39.10', S0° 59.80; 1563m
 Agro-climatic zone : II
 Geological formation : Nyanzian system
 Parent material : Rhyolites
 Physiography : Uplands
 Relief : 1% flat, straight, regular
 Slope gradient : 1%
 Erosion : Some sheet erosion
 Vegetation/land use : Bushed grassland/open for grazing
 Surface stoniness : Nil
 Internal drainage class : Well drained

Profile description

- Au 0-16cm Very dark greyish brown (10YR 3/2 moist), clay; slightly plastic when wet; friable when moist; many very fine pores common fine pores; gradual and smooth transition to: (sample no.130/3-2595a).
- AB 16-32cm Dark brown (10YR 3/3 moist), clay; moderate, very fine and fine, subangular blocky; friable when moist, sticky and plastic when wet; common very fine and fine pores, very few medium pores; common very fine, few fine and very few coarse roots; clear and smooth transition to: (sample no.130/3-2595b).
- Bu 32-50cm Dark reddish brown (5YR3/3 moist), few black mottles; sandy clay loam; strong, very fine, fine and medium, subangular blocky; friable when moist, sticky and plastic when wet; common very fine to fine pores, few very fine, very few fine and very few coarse roots; clear and smooth transition to: (sample no. 130/3-2595c).
- Btcs1, 50-64cm Dark reddish brown (5YR 3/4 moist), few black mottles; clay; strong, very fine, fine and coarse, subangular blocky; friable when moist, sticky and plastic when wet; common very fine and fine pores; few very fine and very few coarse roots; gradual and wavy transition to: (sample no.130/3-2595d).
- Btcs2 64-96cm Reddish brown (5YR 4/4 moist), clay/clay loam; strong, very fine, fine and medium subangular blocky; friable when moist, sticky and plastic when wet; common very fine and fine pores; clay cutans, (sample no.130/3-2595e).
- 96cm+ Pisolitic material.

eutric CAMBISOL,
*pisoferic phase

[illegible]

PROFILE DESCRIPTION NO.3General site information

Mapping unit : PYr2M
 Soil classification : eutric CAMBISOL, pisolitic phase
 Observation no/date : 144/1-227, 25/9/87
 Location/Altitude : E34° 38.57', S0° 59.23; 1569m.
 Agro-climatic zone : II
 Geological formation : Nyanzian system
 Parent material : Rhyolites
 Physiography : Plain
 Relief : gently undulating 3-4%
 Slope gradient : 3%
 Erosion : slight splash
 Vegetation/landuse : Bushed grassland/maize cultivation
 Surface stoniness : Nil
 Internal drainage class : Well drained

Profile description

- Ap 0-15cm Dark yellowish brown (10YR 3/4 moist), clay; porous massive; friable when moist, sticky and plastic when wet; many medium, many bio and many macro pores; common very fine roots, few fine roots; clear and smooth transition to:
 (sample no.144/1-227a).
- ABcs 15-28cm Strong brown (7.5YR 4/6 moist), clay; moderate to weak, medium subangular blocky to angular blocky; friable when moist, sticky and plastic when wet; many micro, many bio and many macro pores; manganese concretion, 1%, 2 to 5mm; few very fine roots; abrupt and irregular transition to:
 (sample no.144/1-227b).
- BCcs 28-54cm Yellowish red (5YR4/6 moist), very gravelly sandy clay loam; massive; friable when moist, slightly sticky and non plastic when wet, many micro pores; loose murram.
- C 54-100cm Weathering rock.

Laboratory no.	87	2593				
Horizon	AC					
Depth (cm)	0-23					
pH-H ₂ O (1: 2½ v/v)	5.3					
pH-KCl "	4.1					
EC (mmho/cm) "	0.04					
CaCO ₃ (%)						
CaSO ₄ (%)						
C (%)	2.13					
N (%)	0.14					
C/N						
CEC (me/100g), pH 8.2	25.0					
CEC " " pH 7.0						
Exch. Ca (me/100g)	3.0					
" Mg "	1.4					
" K "	0.32					
" Na "	0.19					
Sum of cations	4.91					
Base sat. %, pH 8.2	20					
" " %, pH 7.0						
ESP at pH 8.2	0.76					

Gravel % (>2.0mm)						
Sand % (2.0-0.05mm)	24					
Silt % (0.05-0.002mm)	8					
Clay % (0.002-0mm)	68					
Texture class	C					

Laboratory no.8984 /87

General		Available nutrients			
pH-H ₂ O (1: 1 v/v)	5.2	Na(me/100g)	0.22	Mn(me/100g)	0.48
Exch. acidity (me/100g)	0.8	K	"	P (ppm)	8
C %	2.69	Ca	"	P-Olsen (ppm)	
N %	0.19	Mg	"		

Remarks:

PROFILE DESCRIPTION NO.4General site information

Mapping unit : PYb1P
 Soil classification : dystic LITHOSOL
 Observation no/date : 130/3-2593, 25/9/87
 Location/Altitude : E34°37.48', S0°59'S; 1543m
 Agro-climatic zone : II
 Geological formation : Nyanzian system
 Parent material : Rhyolites
 Physiography : Plain
 Relief : Flat, 0%
 Slope gradient : 0%
 Erosion : Nil
 Vegetation/land use : Bushed grassland/grazing
 Surface stoniness : Nil
 Internal drainage class : Well drained

Profile description

AC 0-23cm Dark brown (10YR 3/3 moist), clay; fine and medium crumbly; friable when moist, slightly sticky and slightly plastic when wet; many medium pores; common biopores; abrupt and wavy transition to:
 C 23cm+ Rock.

PROFILE DESCRIPTION NO.5**General site information**

Mapping unit : PYb2P
 Soil classification : gleyic CAMBISOL, Lithic phase
 Observation no/date : 130/3-2590, 24/9/87
 Location/Altitude : E34°38.57', S0°59.46'; 1571m
 Agro-climatic zone : II
 Geological formation : Nyanzian system
 Parent material : Rhyolites
 Physiography : Plain
 Relief : Flat, 1%
 Slope gradient : 1%
 Erosion : Nil
 Vegetation/land use : Bushed grassland/grazing
 Surface stoniness : Nil
 Internal drainage class : Imperfectly drained

Profile description

- Ag 0-10cm** Very dark greyish brown (10YR 3/2 moist), many fine, distinct, dark reddish-brown (5YR 3/3 moist) mottles; sandy clay loam; weak to moderate, fine, crumbly; friable when moist, slightly sticky, slightly plastic when wet; many very fine and common fine pores; many very fine, common medium and few coarse roots; clear and smooth transition to:
 (sample no.130/3-2590a).
- ABg 10-35cm** Dark brown (10YR 3/3 moist), many fine and medium, distinct, dark reddish brown (2.5YR 3/4) mottles; loam; friable when moist, slightly sticky, slightly plastic when wet; many very fine, common fine and few coarse pores; many very fine, few medium and few coarse roots; abrupt and smooth, transition to:
 (sample no.130/3-2590b).
- BC 35-45cm** Cambic B, gravelly sandy clay loam; friable when moist, non sticky and non plastic when wet.

Laboratory no.	/87	8944	8445	8946	8947	8948
Horizon		A	ABg	Bg1	Bg2	BCg
Depth(cm)		0-10	10-40	40-55	55-95	95-175
pH-H ₂ O(1: 2½ v/v)		5.5	6.0	5.8	5.9	6.1
pH-KCl "		4.0	4.0	4.0	3.9	4.2
EC(mmho/cm) "		0.07	0.10	0.04	0.19	0.50
CaCO ₃ (%)						
CaSO ₄ (%)						
C (%)		2.55	1.03	1.28	0.77	0.41
N (%)		0.23	0.07			
C/N						
CEC(me/100g), pH 8.2		18.7	17.5	10.5	33.5	34.5
CEC " " pH 7.0						
Exch.Ca(me/100g)		2.8	6.7	2.4	13.2	20.4
" Mg "		0.8	3.3	0.6	5.7	14.2
" K "		0.30	0.22	0.14	0.28	0.95
" Na "		0.24	0.42	0.35	1.67	1.85
Sum of cations		4.14	10.64	3.49	20.85	37.4
Base sat. %, pH 8.2		22	61	33	62	100+
" " %, pH 7.0						
ESP at pH 8.2		1.28	2.4	3.3	4.99	5.36
Texture (limited pretreatment)						
Gravel % (>2.0mm)						
Sand % (2.0-0.05mm)		44	34	44	26	20
Silt % (0.05-0.002mm)		36	20	32	14	12
Clay % (0.002-0mm)		20	46	24	60	68
Texture class		L	C	L	C	C
Fertility aspects O - 30 cm Laboratory no. 898Q / 87						
General		Available nutrients				
pH-H ₂ O (1: 1 v/v)	5.3	Na/me/100g	0.43	Mn(me/100g)	0.34	
Exch. acidity (me/100g)	1.0	K "	0.29	P (ppm)	8	
C %	3.27	Ca "	2.0	P-Olsen(ppm)		
N %	0.28	Mg "	1.9			
Remarks:						

PROFILE DESCRIPTION NO.6General site information

Mapping unit : PYb3p
 Soil classification : gleyic LUVISOL
 Observation no/date : 130/3-2589, 24/9/87
 Location/Altitude : E34° 38.12', S0° 59.75; 1542m
 Agro-climatic zone : II
 Geological formation : Nyanzian System
 Parent material : Rhyolites
 Physiography : Plain
 Relief : Flat to very gently undulating, 0-1%
 Slope gradient : 1%
 Erosion : Nil
 Vegetation/land use : Bushed grassland/grazing
 Surface stoniness : Nil
 Internal drainage class : Well drained

Profile description

- A 0-10cm Very dark grey (10YR3/1 moist) common, fine and distinct dark reddish brown (5YR3/3) mottles; loam; moderate, fine and medium crumbly; friable when moist, slightly sticky and slightly plastic when wet; many very fine and many fine roots; clear and smooth transition to:
 (Sample no.130/3-2589a).
- ABg 10-40cm Dark brown (10YR 3/3 moist), many fine, distinct, dark red (2.5YR 3/6), mottles; clay; moderate, medium angular blocky; firm when moist, sticky and plastic when wet; abrupt and smooth transition to:
 (sample no.130/3-2589b).
- Bg1 40-55cm Dark greyish brown (10YR 3/2 moist), many medium, distinct, yellowish brown (10YR 5/8), mottles; loam; moderate, medium angular blocky; firm when moist, sticky and plastic when wet; clear and smooth transition to:
 (sample no.130/3-2589c).
- Bg2 55-95cm Dark brown (10YR 4/3 moist), many medium, distinct, yellowish brown (10YR 5/6), mottles; clay; moderate, medium angular blocky; firm when moist, sticky and plastic when wet.
 (sample no.130/3-2589d).
- BCg 95-175cm Dark brown/dark yellowish brown (10YR 3.5/3 moist), clay; very firm when moist, sticky and plastic when wet. (augered).

LABORATORY DATA OF PROFILE DESCRIPTION No. 7

Observation no: 130/3-2592 Mapping unit: PYaP Soil classification: dystic PLANOSOL

Laboratory no.	/87	8956	8957	8958	8959	8960	8961
Horizon		Ag	AEg	Btg1	Btg2	Btg3	Btg4
Depth (cm)		0-10	10-34	34-64	64-90	90-120	120-190
pH-H ₂ O (1:2½ v/v)		5.3	5.5	5.8	5.8	5.3	5.6
pH-KCl	"	3.8	3.8	3.7	3.6	3.9	3.5
EC (mmho/cm)	"	0.05	0.04	0.08	0.10	0.05	0.16
CaCO ₃ (%)							
CaSO ₄ (%)							
C (%)		2.54	1.15	0.98	0.86	3.12	0.33
N (%)		0.19	0.09				
C/N							
CEC (me/100g), pH 8.2		20.3	18.8	38.5	33.7	29.0	10.5
CEC " " pH 7.0							
Exch. Ca (me/100g)		4.2	4.6	7.5	13.6	3.0	2.7
" Mg "		0.9	0.7	0.9	4.6	0.7	1.3
" K "		0.18	0.14	0.26	0.35	0.26	0.52
" Na "		0.45	0.45	0.88	0.98	0.43	0.30
Sum of cations		5.73	5.89	9.54	19.53	4.39	4.82
Base sat. %, pH 8.2		28	31	25	59	15	46
" " %, pH 7.0							
ESP at pH 8.2		2.22	2.39	2.28	2.9	1.48	2.90

Texture (limited pretreatment)

Gravel % (>2.0mm)						
Sand % (2.0-0.05mm)	46	44	26	24	24	44
Silt % (0.05-0.002mm)	30	26	12	8	6	36
Clay % (0.002-0mm)	24	30	62	68	70	20
Texture class	L	CL	C	C	C	L

Fertility aspects

0 - 30 cm

Laboratory no. 8983 /87

GeneralAvailable nutrients

pH-H ₂ O (1:1 v/v)	5.1	Na/me/100g)	0.54	Mn (me/100g)	0.20
Exch. acidity (me/100g)	2.2	K "	0.14	P (ppm)	4
C %	2.79	Ca "	1.6	P-Olsen (ppm)	
N %	0.20	Mg "	1.6		

Remarks:

PROFILE DESCRIPTION NO.7General site information

Mapping unit : PYap
 Soil classification : dystric PLANOSOL
 Observation no/date : 130/3-2592, 25/9/87
 Location/altitude : E34°38.54', S0°59.90'; 1540m
 Agro-climatic zone : II
 Geological formation : Nyanzian system
 Parent material : Rhyolites
 Physiography : Plain
 Relief : Flat to very gently undulating, slopes, 0-1%
 Slope gradient : 0.5%
 Erosion : Nil
 Vegetation/land use : Grassland, Bushland and cattle grazing
 Surface stoniness : Nil
 Internal drainage class : Imperfectly drained

Profile description

- Ag 0-10cm Very dark brown (10YR 2/2 moist), dark reddish brown (2.5YR3/4) mottles; loam; fine and medium, crumbly; firm when moist, sticky and slightly plastic when wet; many medium pores, few biopores, many very fine, many fine and few coarse roots; clear and smooth transition to:
 (sample no.130/3-2592a).
- AEg 10-34cm Dark brown (10YR 3/3 moist), dark yellowish brown (10YR 3/6) mottles; clay loam; weak to moderate, medium, subangular blocky; friable when moist, sticky and slightly plastic when wet; many medium pores, few biopores; many very fine and few fine roots; clear and smooth transition to:
 (sample no.130/3-2592b).
- Btg1 34-64cm Very dark yellowish brown (10YR 3/2 moist), dark yellowish brown (10YR 4/6) mottles; clay; moderate to strong, fine and medium, subangular blocky and angular blocky; firm when moist, sticky and plastic when wet; few medium pores; common very fine and few fine roots; pressure faces; clear and smooth transition to:
 (sample no.130/3-2592c).
- Btg2 64-90cm Dark brown (10YR 3/3 moist), dark yellowish brown (10YR 4/4) mottles; clay, moderate, fine and medium, angular blocky and subangular blocky, firm when moist, sticky and plastic, when wet; few biopores; few very fine roots; pressure faces; diffuse and smooth transition to:
 (sample no.130/3-2592d).
- Btg3 90-120cm Dark brown (10YR 3/3 moist), strong brown (10YR 5/8) mottles; clay; moderate, fine and medium, angular blocky and subangular blocky; firm when moist, sticky and plastic when wet; few medium pores.
 (sample no.130/3-2592e).
- Btg4 120-190cm Greyish brown (2.5Y 5/2 moist) strong brown (10YR 5/8), mottles; clay; moderate, fine and medium, angular blocky and subangular blocky; firm when moist, sticky and plastic when wet. (augered)

LABORATORY DATA OF PROFILE DESCRIPTION No.8

Observation no: 130/3-2591 Mapping unit: PYb4p Soil classification: dystric CAMBISOL

Laboratory no. /87	8952	8953	8954	8955		
Horizon	Au	Bg1	Bg2	Bg3		
Depth (cm)	0-10	10-23	23-53	53-100		
pH-H ₂ O (1: 2½ v/v)	5.7	6.3	5.9	5.0		
pH-KCl "	3.6	3.9	3.9	3.8		
EC (mmho/cm) "	0.17	0.04	0.04	0.07		
CaCO ₃ (%)						
CaSO ₄ (%)						
C (%)	0.53	2.03	1.00	2.19		
N (%)	0.04	0.10				
C/N						
CEC (me/100g), pH 8.2	30.0	16.5	18.9	23.7		
CEC " " pH 7.0						
Exch. Ca (me/100g)	8.7	2.0	4.6	4.8		
" Mg "	5.7	0.5	0.5	1.3		
" K "	0.36	0.16	0.16	0.18		
" Na "	0.52	0.45	0.51	0.12		
Sum of cations	15.28	3.11	5.77	6.4		
Base sat. %, pH 8.2	51	19	30	27		
" " %, pH 7.0						
ESP at pH 8.2	1.73	2.73	2.70	0.51		

Texture (limited pretreatment)

Gravel % (>2.0mm)						
Sand % (2.0-0.05mm)	32	46	44	26		
Silt % (0.05-0.002mm)	2	32	22	38		
Clay % (0.002-0mm)	66	22	34	36		
Texture class	C	L	CL	CL		

Fertility aspects

0 - 30 cm

Laboratory no. 8982 /87

General		Available nutrients			
pH-H ₂ O (1:1 v/v)	5.2	Na/me/100g)	0.46	Mn (me/100g)	0.14
Exch. acidity (me/100g)	1.4	K "	0.26	P (ppm)	6
C %	2.58	Ca "	1.2	P-Olsen (ppm)	
N %	0.24	Mg "	0.4		

Remarks:

PROFILE DESCRIPTION NO.8General site information

Mapping unit : PYb4p
 Soil classification : dystic CAMBISOL
 Observation no/date : 130/3-2591, 24/9/87
 Location/altitude : E34°38.33', S0°0.4; 1520m
 Agro-climatic zone : II
 Geological formation : Nyanzian system
 Parent material : Colluvium
 Physiography : Depression
 Relief : Flat and concave, 0%
 Slope gradient : 0%
 Erosion : Nil
 Vegetation/land use : cattle grazing/bushed grassland
 Surface stoniness : Nil
 Internal drainage class : Imperfectly drained

Profile description

- Au 0-10cm Very dark brown (10YR 2/2 moist), clay; moderate, very fine and fine, subangular blocky; friable when moist, slightly sticky, slightly plastic when wet; common very fine pores, common fine pores; many very fine, common fine and few coarse roots; clear and smooth transition to:
 (sample no.130/3-2591a).
- Bg1 10-23cm Dark yellowish brown (10YR 3/4 moist), yellowish red (5YR 5/8) mottles; loam; moderate, very fine and fine, subangular blocky; friable when moist, slightly sticky, slightly plastic when wet; common very fine, common fine and few coarse pores; common very fine, common fine and few coarse roots; gradual and smooth transition to:
 (sample no.130/3-2591b).
- Bg2 23-53cm Brown to dark brown (10YR 5/3 moist), common, very fine and fine, distinct, yellowish red (5YR 5/8) mottles; clay loam; weak, very fine, fine and medium, subangular blocky; firm when moist, sticky and plastic when wet; common very fine, common fine and few coarse pores; few very fine roots, very few fine roots; abrupt and wavy transition to:
 (sample no.130/3-2591c).
- Bg3 53-100cm Dark yellowish brown (10YR 3/4 moist), common, fine to medium, distinct, yellowish red (5YR 5/8) mottles; clay loam; very firm when moist, sticky and plastic when wet; common very fine, common fine and few coarse pores; very few, very fine roots.
 (sample no.130/3-2591d).
- 100+cm Rocks.

LABORATORY DATA OF PROFILE DESCRIPTION No. 9

Observation no: 130/3-2594 Mapping unit: PYg Soil classification: humic GLEYSOL

[illegible]

PROFILE DESCRIPTION NO.9General site information

Mapping unit : PYg
 Soil classification : humic GLEYSOL
 Observation no/date : 130/3-2594, 25/9/87
 Location/Altitude : E34°36.85', S1°0.5; 1510m
 Agro-climatic zone : II
 Geological formation : Nyanzian system
 Parent material : Rhyolites
 Physiography : Plain (Bottomland)
 Relief : Flat to very gently undulating, slopes 0-1%
 Slope gradient : 1%
 Erosion : Nil
 Vegetation/land use : Bushed grassland/grazing
 Surface stoniness : Nil
 Internal drainage class : Imperfectly drained

Profile description

- Ah 0-12cm Black (2.5YR 2/0 moist), many medium, distinct, dark reddish brown (5YR 3/3) mottles; silty clay; weak to moderate, fine and medium, subangular blocky; friable when moist, sticky and plastic when wet; clear and smooth transition to:
 (sample no.130/3-2594a).
- Ag 12-27cm Very dark grey (10YR 3/1 moist), clay; weak to moderate, fine and medium, subangular blocky; firm when moist, sticky and plastic when wet; clear and smooth transition to:
 (sample no.130/3-2594b).
- Btg1 27-60cm Dark greyish brown (2.5YR 4/5 moist), many, medium, prominent strong brown (7.5YR 5/8) mottles; clay loam; moderate, very fine, fine and medium, angular blocky; firm when moist, sticky and plastic when wet; diffuse and smooth transition to:
 (sample no.130/3-2594c).
- Btg2 60-150cm+ Dark greyish brown (2.5YR 4/2 moist), many, medium to coarse, prominent, yellowish red (5YR 5/8) mottles; clay loam; moderate, very fine, fine and medium, angular blocky; firm when moist, sticky and plastic when wet.
 (sample no.130/3-2594d).

LABORATORY DATA OF PROFILE DESCRIPTION No. 10

Observation no: 144/1-228 Mapping unit: Vxp Soil classification: eutric FLUVISOL

Laboratory no. / 87	8975	8976	8977	8978		
Horizon	Au	Bu1	Bu2	Bu3		
Depth (cm)	0-18	18-34	34-91	91-116		
pH-H ₂ O (1: 2½ v/v)	5.2	5.8	5.4	5.5		
pH-KCl "	3.8	4.0	3.8	4.3		
EC (mmho/cm) "	0.07	0.06	0.05	0.09		
CaCO ₃ (%)						
CaSO ₄ (%)						
C (%)	1.66	0.85	1.05	1.46		
N (%)	0.16	0.05				
C/N						
CEC (me/100g), pH 8.2	20.5	14.5	20.5	35.4		
CEC " " pH 7.0						
Exch. Ca (me/100g)	6.2	4.3	7.0	10.2		
" Mg "	6.0	3.6	5.8	6.6		
" K "	0.24	0.14	0.22	0.30		
" Na "	0.12	0.13	0.13	0.11		
Sum of cations	12.56	8.17	13.15	17.21		
Base sat. %, pH 8.2	61	56	64	49		
" " %, pH 7.0						
ESP at pH 8.2	0.59	0.90	0.63	0.31		

Texture (limited pretreatment)

Gravel % (>2.0mm)						
Sand % (2.0-0.05mm)	46	42	46	24		
Silt % (0.05-0.002mm)	24	24	20	24		
Clay % (0.002-0mm)	30	34	34	52		
Texture class	SCL	CL	SCL	C		

Fertility aspects

0 - 30 cm

Laboratory no. 8988 / 87

General		Available nutrients			
pH-H ₂ O (1: 1 v/v)	5.0	Na/me/100g)	0.26	Mn (me/100g)	1.06
Exch. acidity (me/100g)	0.6	K "	0.22	P (ppm)	8
C %	2.13	Ca "	5.6	P-Olsen (ppm)	
N %	0.22	Mg "	5.0		

Remarks:

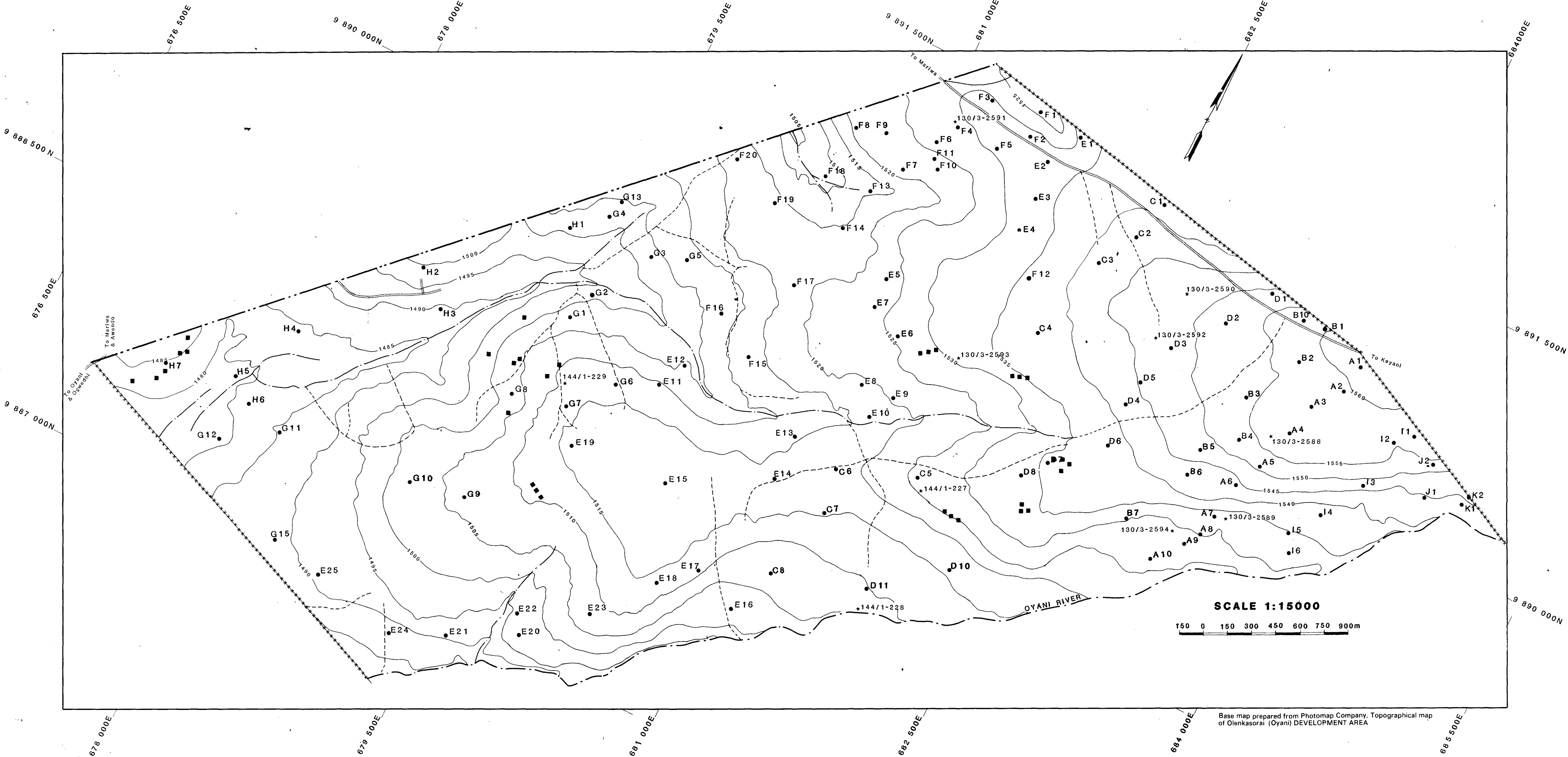
PROFILE DESCRIPTION NO.10General site information

Mapping unit : Vxp
 Soil classification : eutric FLUVISOL
 Observation no/date : 144/1-228 25/9/87
 Location/Altitude : E34°37.91', S1°0.7'; 1515m
 Agro-climatic zone : II
 Geological formation : Nyanzian system
 Parent material : Alluvium
 Physiography : River valley
 Relief : Flat to very gently undulating, 2%
 Slope gradient : 2%
 Erosion : Nil
 Vegetation/land use : Forest/none
 Surface stoniness : Nil
 Internal drainage class : Well drained

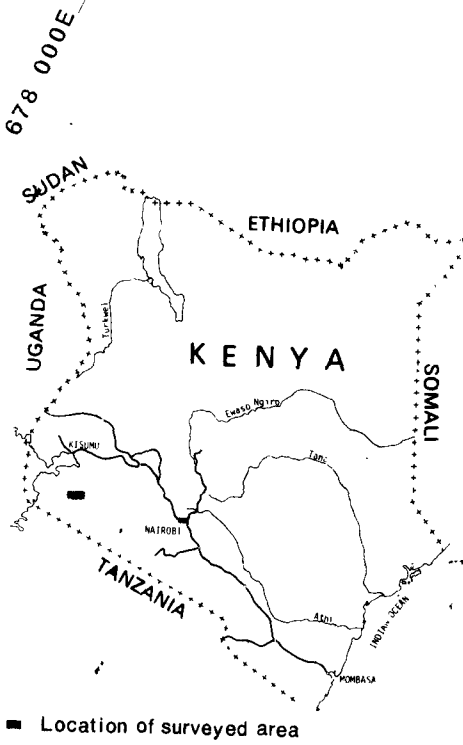
Profile description

- Au 0-18cm Dark yellowish brown(10YR 3/6 moist), sandy clay loam; weak, fine and medium, subangular blocky; friable when moist, slightly sticky, slightly plastic when wet; many very fine and common fine pores; clear and smooth transition to:
 (sample no.144/1-228a).
- Bul 18-34cm Dark reddish brown (5YR 3/3, moist), clay loam; moderate, fine and medium, subangular blocky, friable when moist, sticky and plastic when wet; many very fine, common fine and few coarse pores; many very fine, common fine and few coarse roots; clear and smooth transition to:
 (sample no.144/1-228b).
- Bu2 34-91cm Dark reddish brown (5YR3/3 moist), sandy clay loam; strong, fine, medium and coarse, subangular blocky; friable when moist, sticky and plastic when wet; many very fine, common fine and few coarse pores; many very fine and common coarse roots; clear and smooth transition to:
 (sample no.144/1-228c).
- Bu3 91-116cm Reddish brown (5YR 4/4 moist), clay; strong, fine, medium and coarse, subangular blocky; friable when moist, sticky and plastic when wet; common very fine, common fine and few coarse pores; common black mottles.

LOCATION OF PROFILE PITS AND AUGERINGS OF THE OLENKASORAI (OYANI) AREA - PHASE I
(KILGORIS DIVISION NAROK DISTRICT)



Base map prepared from Photomap Company, Topographical map of Olenkasorai (Oyani) DEVELOPMENT AREA



- KEY**
- 130/3-2594
• D10
 - 1cm²
 - 25ha
 - provincial boundary
 - main road
 - track
 - river/stream
 - contours, V.1.5m
 - building
 - survey area boundary

SOIL SURVEY AND MAP PREPARATION (1987)

Survey	J.R. Rachilo, S.N. Wanjogu, B.K. Waruru, T.J. Wachira and H. Onyono
Soil correlation	S.N. Wanjogu and J.R. Rachilo
Map compilation	J.R. Rachilo
Map correlation	V.W.P. van Engelen
Cartography	D.M. Olulo

